Everyday stressors and cognitive processes: An investigation into the impact negative emotions can have on our processing speed and attention.

Jordan O'Connor

18348833

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Name: Jordan O'Connor

Student Number: 18348833

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Abstract

Aims: The current study attempted to address a gap in research by investigating whether everyday negative moods can impact sensory system processing and related cognitive function. The study gathered individual's level of stress, depression and anxiety, and compared the levels to performance in three psychometric tasks used for measuring perception, attention and cognition. **Methods:** Participants were recruited through social media platforms as well as through the use of posters. Levels of depression, anxiety and stress were measured through the use of the DASS-42 questionnaire. They would also complete the Stroop, Four-Choice Reaction Time and Symbol Search tasks. The DASS-42 scores were then compared with the mean reaction times and number of correct answers given in the three perception based tasks. **Results:** Overall, results suggest that DASS-42 scores in the general population could not significantly predict poorer performances in the three tasks, although there were exceptions. **Conclusion:** The current study may have been impacted by the limited sample size (n = 39), which impacted the significance of results. Further research should be conducted in order to verify the results found in this study. Furthermore, research should also investigate other sensory systems to see whether they can be impacted by negative mood.

Contents

Literature review

The Visual System

The visual cortex refers to the pathways in which our eyes take in sensory information, which is then converted into certain neural impulses, and is transported to the primary and secondary visual cortex, via the lateral geniculate nucleus located in the thalamus. It is believed that 80% of optic nerve fibres project to the lateral geniculate nucleus, while a large percentage of the remaining 20% project to the superior colliculus. (Klein & Thorne, 2006). However, it is worth noting that visual information is directed to other regions of the brain, which include the Amygdala and the Hippocampus. It was found in a study of identifying facial expressions, the amygdala would be activated during implicit (unconscious) processing, while the temporal lobes were activated for explicit (conscious) processing (Critchley et al, 2000). Through the study of the amygdala in terms of sensory processing, it was found that lesions to the lateral geniculate nucleus and the lateral posterior nucleus of the thalamus caused rats to be unaffected to a stimulus that had previously been visually conditioned to invoke the fear response (Shi and Davis 2001). Research like this began greater investigation into how our emotional processes were connected to sensory perception.

Sensory Processing & Mental Health

Over the years, there has been growing research into sensory system dysfunction in those who are considered neurodivergent (Harrison et al, 2019). There have been certain sensory characteristics associated with autism (Pellicano & Burr, 2012), schizophrenia and psychosis (Powers et al. 2017), ADHD, obsessive compulsive disorder and pain disorders (Hoskin et al. 2019). Adams et al 2013, Clark et al 2018. Much of the literature investigating sensory processing with mental health conditions has used Dunn's Four-Quadrant Model of Sensory Processing framework (Dunn 2001) to identify the differences.

The model is based around the idea that an individual's response to sensory events is based on that person's sensory threshold and their response strategy. These 2 main factors have 2 quadrants associated with them, where there can be a high or low neural threshold for sensory stimuli, and there can either be passive or active response strategies. Those with a low sensory threshold tend to be more reactive to stimuli, as they are easily activated from sensory stimuli, while those with a high sensory threshold are more likely to demonstrate inhibition. In terms of behavioural responses, those who use more passive responses tend to respond to stimuli internally, while those who are more active tend to engage to change their environment (Metz et al. 2019).

The four quadrants include low registration, sensation seeking, sensation sensitivity and sensation avoidance. Each quadrant is a continuum, and so every individual will score somewhere on the scale between the two extremes. Low registration refers to a high neural threshold and a passive response, sensation seeking involves a high neural threshold with an active response, sensation sensitivity refers to a low threshold and a

passive response strategy, and sensation avoidance refers to a low threshold and an active response strategy.

Sensory registration and Depression/anxiety.

Although everyone is unique on where the fall on the four different quadrants, certain sensory characteristics have been noted in those who experience mood disorders. In the case of depression, low registration of sensory inputs was correlated with depression, impulsivity, attentional and motor impulsivity, and alexithymia. More specifically, greater levels in sensation seeking was positively correlated with motor impulsivity (acting without thinking of the consequences), higher sensory sensitivity and sensory avoidance was correlated to depression, alexithymia and impulsivity (Serafini et al. 2017). Similarly, another study found that 70% of participants who suffered from a major affective disorder, scored low for sensation seeking (Enger-Yager et al. 2016).

It is believed that the relationship between affective mood disorders and the sensory system is related to dysfunction in serotonin, dopamine and noradrenaline neuromodulators as well as decreased grey matter and white matter volumes in the prefrontal cortex, the limbic system, the hypothalamus and the basil ganglia brain regions (Heimer 2003; Drevets et al 2008; Price and Drevits 2010; Foneksa et al 2018). Each disorder seems to have its own perception and cognitive deficit characteristics. While sensory processing abnormalities have been found to be more concrete in conditions like schizophrenia, the impact of affective mood disorders on sensory and related cognitive processing have been more difficult to measure.

The sensory system and attention

Attention is an aspect of sensory processing that has been well documented in being negatively impacted by depression and anxiety. Attention is a complex process which has two distinct ways of working. Endogenous attention (or top-down processing) relies on internal cognitive processes to decide what should be attended to, and exogenous attention (or bottom-up processing), where the sensory system detects a stimuli that needs to be identified and addressed. Research has shown endogenous attention has been notably poor in those who suffer with an affective mood disorder (Dalgliesh, 1990). The relationship appears to be related to the brain regions impacted by mood disorders. Both the prefrontal cortex and posterior parietal cortex play pivotal roles in endogenous attention (Baluch & Itti, 2011), which have been found to be abnormal in those with depression and anxiety. The physiological difference in these regions for those with depression or anxiety usually have reduced grey-matter in these regions, as well as the amygdala and the thalamus (Lener & Iosifescu, 2015). The same study found that the activity in communication between these brain regions was lower than what would be considered normal. However, there could be two distinct different reasons as to why this outcome occurs in both for those with depression and anxiety. Depression has been associated with a decrease in brain plasticity. The belief being that long exposure to stress causes hippocampal dystrophy, meaning the brain adjusts its functioning due to fatigue, which leads to a decrease in neuronal activity, inhibiting neuroplasticity (Pittenger & Duman, 2008). In terms of anxiety, the brain decreases its capacity endogenous attention due to brain focusing on exogenous attention in order to be able react to threats (Carretie, 2014). As exogenous attention is prioritised, endogenous attention becomes more difficult due to its lack of use. As endogenous attention decreases, it

is plausible those with depression and anxiety will struggle to actively attend to anything that involves any cognitive thought, which could lead to abnormal use of the sensory system.

Recent Literature

Research investigating the impact depression can have on sensory and cognitive processes has often done so with the use of the Stroop task. These results have been mixed, with some finding individuals with depression demonstrating signs of cognitive impairment (Trichard et al., 1995; Lememin et al., 1996), and some finding there was no significant difference in performance in those with a major depression disorder compared to the general population (Degl'Innocenti et al., 1998; Lerenc et al., 2006). There are a number of reasons why studies have found different effects, which include what Stroop test format was used and the variation in the chosen sample. Different Stroop task designs included adding motor controlled responses (Lememin et al., 1996), adding auditory response testing (Hartog et al., 2003), and using emotional Stroop tasks (Hill & Knowles, 1991).

Another issue which has caused varying results was the sample size used. Some studies have used a sample waiting to be hospitalised with an affective disorder (Tarsia et al., 2003), studies have used inpatient populations who were not medicated (Pier et al., 2003) and others have used inpatient populations who were medicated (Lerenc et al., 2006). Further research into the impact antidepressants can have on cognition has found that depressed individuals on antidepressants are correlated with longer reaction times compared but greater accuracy, while non-medicated depressed patients demonstrate the opposite, as they had quicker response times but decreased accuracy (Kalb et al., 2006). Although there has been inconsistency with the research methods employed, conclusions from the research seems to

indicate that the specific depression disorder dictates the extent at which sensory and cognitive deficits are seen (Airaksinen et al., 2004).

Anxiety is similar to depression, in that the subtype of anxiety can influence the extent to which someone's sensory and cognitive processes are effected. A meta-analysis found that while completing a reaction time task, individuals with generalised anxiety disorders demonstrated slower reaction times but similar accuracy rates compared to the general population, while individuals with panic disorders demonstrated slower reaction times but had greatly improved accuracy rates (Majeed et al., 2023). Research on anxiety and the Stroop task has mainly focused performance on the emotional Stroop variant (Mathews & Klug 1993; Mogg et al., 2003; Becker et al 2001), as well as focusing on specific panic disorders such as obsessive-compulsive disorder and post-traumatic stress disorder (Kaspi et al., 1995; Mcnally et al., 1992). Only one research paper was found to have measured executive function in those with generalised anxiety disorder and found there was no statistical significance with those who met the requirements for a generalised anxiety disorder compared to the control group (Leonard & Abramovitch 2019).

As noted above, mixed depression and anxiety have been noted to be its own area for investigation. The exact comorbidity rate between depression and anxiety is still disputed, however some studies suggest it could be as high as 60% (Zhou et al 2017). Research into the impact mixed depressive and anxious symptoms have found varying degrees of cognitive deficits in individuals. While mixed depression and anxiety seem to impact older people more, cognitive deficits seem dependent on the levels of anxiety and depression the individual reports, as either low or high levels of anxiety can cause impairment, moderate levels of anxiety with depression seems to have caused no real deficit (Dotson et al 2014). Interestingly, the same paper found a higher rate of cognitive impairment in those with sub threshold anxiety and depression.

The current study

As seen above, almost all literature into how the sensory system can be impacted by moods has solely involved clinically significant affective mood disorder. This study therefore will attempt to fill the gap between whether or not lower, everyday moods can impact the sensory system, and relevant cognitive processes. In an age where rates of depression and anxiety are increasing, it is important to understand fully what the implications can be of negative moods. If sensory system and cognition can be impacted by negative mood at an earlier stage, it will be important to develop strategies to ensure support is given. Individuals with negative moods could be struggling with maintaining jobs, staying in education, meeting deadlines and so on, yet their reasoning of feeling low or anxious would not be deemed a sufficient enough reason to rest. Therefore this study's goal is to measure symptoms of nonclinical symptoms of depression, stress and anxiety, and attempt to measure whether the feelings can negatively impact that persons sensory attenuation, cognitive processing and executive functioning.

Methods

Participants

A total number of 39 participants (n = 39) were recruited using an opportunistic sampling technique. When G*Power was used to calculate the required sample size, the needed sample size was 150. Therefore, it is important to note that the possibility of a type II error in statistical analysis was high. Participants age range was from 18-57, with a total mean age of 33 (SD = 11.95). A total of 31 participants (79.5%) completed the study online, while the remaining 8 participants (20.5%) completed the study in person. Gender was not measured in this study, as it was not considered relevant to the current research. Participants were recruited through the Facebook and Instagram social media sites, as well as being recruited via posters. In an attempt to improve numbers for those who took part in person, each participant who completed the study in person was offered to be entered in a draw to win a generic gift voucher worth 150 euro.

Materials

Measurement scale:

The Depression Anxiety Stress Scale (Dass-42) was chosen to measure the level of stress, depression and anxiety the participant had be feeling in the previous 2-3 days. The DASS-42's function is to measure the degree to which an individual is being impacted by

depression, anxiety and stress symptoms, rather than assessing if the individual meets a diagnostic criterion (Lovibond & Lovibond 1995). There are 14 questions for the three symptom clusters (depression, anxiety and stress), and are rated on a 4-point Likert scale. The lowest response score, 0 would indicate that the statement does not apply to the individual at all, while a response score of three would indicate that the statement is something the individual feels almost all of the time. The end score is calculated by adding up all of the questions that relate to a symptom cluster which can then be used to assess the severity level. (See appendix I). The DASS-42 has been found to have good internal reliability across the three subscales (a = 0.91 for depression; a = 0.90 for stress; a = 0.84 for anxiety). (Lovibond & Lovibond 1995).

A Cronbach's alpha was conducted to test the reliability of the results for the three subscales in the DASS-42. a= .936 for stress, a = .903 for anxiety and a = .955 for depression.

Experimental Stimuli:

The three psychometric tests chosen for this study were used to measure selective attention, processing speed, visual perception, cognition and executive functions. All three experiments used in this project were downloaded from the Inquisit 6 test library [computer software]. (2022) and were completed on a laptop or computer.

i. Stroop task: The Stroop task used (Based on Stroop, 1935), was a mixed trial design, in which the participant would have to correctly identify a colour via the ‘D’, ‘F’, ‘J’ and ‘K’ keys. The four colours in the test were green, red, blue and black. The Stroop task consisted of three stimuli: the control stimuli, which was a coloured rectangle, the

congruent stimuli, where the font colour matched the word, and the incongruent stimuli where the font colour would not match the word. The Stroop task was randomised, meaning each time the test was completed, and the order of the control, congruent and incongruent words would be different. The objective for each trial was to correctly identify what colour was shown as quickly and accurately as possible using the associated response keys. Each stimulus consisted of 28 trials, for a total of 84 trials. Each trial would remain on screen indefinitely until an answer was given to the word. When the trial was answered correctly, there was a 2 second delay before the next trial began. Each wrong answer would cause a rec 'X' to appear on screen, and the delay would last 4 seconds before the next trial began. The Stroop task has been used in similar studies which involved clinically depressed patients (Den Hartog et al., 2003; Lemelin et al., 1996). (See appendix II).

ii. The symbol search task provided by Inquisit is based on the WAIS-IV symbol search task (Wechsler, 2003). The task involves being given two symbols in a row, which is then next to a row of five symbols. The individual is required to identify whether one of the two symbols have a match with the other five symbols. If there is no match, the individual would click on a 'no' button. A practice trial is provided before the test commences consisting of three sets of symbols. If a wrong answer is given in the trial task, the practice trial would reset. Once all rows were answered correctly, the task would begin. The task has a two-minute timer, in which the individual must complete as many rows as they can, as accurately as possible. The WAIS assessment tool has been used to measure the impact affective mood disorders can have on cognition. In particular, when the Symbol Search task was administered in depressed patients, it

was found that depression negatively impacted processing speed (Bowler et al., 2001; Gorlyn et al., 2006). (See appendix V).

iii. The Four-Choice Reaction Time task was based on the task provided by Armstrong in 2012. The task consists of four linear, grey blocks that remain on screen for the duration of the experiment. Each box is corresponded to the 'D', 'F', 'J' and 'K' computer keys, the 'D' key being the first box and the 'K' key being the last box in the line. The goal is to use the correct key response to indicate which of the four boxes has turned red. The time latency between a box turning red is randomised. A practice sequence is provided consisting of 10 trials. During this period feedback on incorrect answers is given. The feedback will tell the individual whether they have given a wrong answer, in which an 'X' will appear on the screen, or if they prematurely hit a key before a box has turned red. After the practice trials, the task will begin. There are a total of 100 trials in the task, and no feedback is given if an individual answers incorrectly or answers prematurely. Once a block turns red, the individual has a total of 5 seconds to answer before the next trial automatically commences. Although the Four-Choice Reaction Time task has not been used in similar research, reaction time tasks have been used frequently (Eagle et al., 2008; Nebes et al., 2001). (See appendix III)

Design

The present research is of a cross-sectional, quantitative design. The data provided by the participant was recorded at one time and was used to investigate if there was a correlation between greater DASS scores (including the three variables of stress, anxiety and depression, as well as a DASS42 sum score) and poorer results in the Stroop, four choice

reaction and symbol search tasks. The stress, anxiety, stress and total DASS42 scores were used as the criterion variables. The criterion variable scores were analysed as a continuous scale, rather than dividing the sample size into groups based on severity.

The data derived from the Stroop, Four-Choice Reaction Time and Symbol Search tasks that were included in analysis were the mean reaction time and the correct response rate for both congruent and incongruent words in the Stroop task. The four-choice reaction variables included were the mean reaction time, premature errors and the incorrect answer response rate. The symbol search variable included was the total number of correct responses given in two minutes. These were used as the dependant variables.

For the purpose of counterbalancing, the sample size was divided into two separate groups. One group completed the DASS42 questionnaire first, followed by the three experimental tasks, while the second group completed the three experimental tasks first followed by the DASS42 questionnaire.

Procedure

Initially, the completion of the DASS42 questionnaire was put before the 3 experimental trials. The DASS42 questionnaire was provided via the use of google forms. The link to the google form page was shared online to recruit participants. The first page of the form included a brief description of the purpose of the research, what was involved in taking part, the researchers contact information and a list of support lines in case the questionnaire caused the participant any form of stress. Below this a consent form was provided, which the two agreement statements at the end required a response in order to move onto the questionnaire.

The participant was then required to fill complete the DASS-42, which was specifically measuring the person's level of stress, anxiety and depression over the previous few days. Once completed, the completion page provided a link to the 3 experimental trials, which were hosted by the online version of inquisit6. The trials were run in a set order which was the Stroop task, followed by the four-choice reaction task, and finally the symbol search task. Each trial provided an explanation before it began, which allowed participants to take a break for an indefinite amount of time if they wished to do so. After the three trials, a debrief form would be provided, restating what the research was measuring, and provided helplines in case the DASS42 invoked any negative feelings. The completion message would then appear on their screens.

When the order of the experiment was changed, the information page and consent form was moved to the 3 trials on the inquisit6 platform, while the debrief page was added to the Google form page. The experiment would take roughly 20 minutes to complete, between answering the DASS-42 and completing all three trials took roughly 10 minutes.

Results

Descriptive statistics

The sample included 39 participants in total (n=39). The mean age of the sample was 33, with the range being 18-57. 19 of the participants (48.7%) completed the study in the order of the DASS42 followed by the 3 perceptual tasks, while 20 of the participants (51.3%) completed the study in reverse order. Descriptive statistics on the 3 variable scores in the DASS42 can be found in table 1.

Table 1: *Descriptive statistics for continuous variables including DASS42 scores.*

	N	Mean	Std. deviation	Skewness	Kurtosis	Minimum	Maximum
Age	39	33	11.58	.794	-.751	18	57
Depression score	39	13.46	10.08	.767	-1.51	0	39
Anxiety score	39	12.59	8.34	.369	-.972	1	30
Stress score	39	18.51	9.83	.122	-.912	3	41
Total DASS score	39	44.56	26.37	.410	-.605	4	110
Valid N (listwise)	39						

Inferential Statistics

1.1. Stroop Task.

A hierarchal multiple regression was used to investigate whether reported levels of depression, anxiety and stress would negatively impact an individual's attention, processing speed and executive processing by ways of the Stroop task. As age may have an impact on processing speed, it was included in the analysis as a controlled variable. The results the Stroop task generated were the number of correct answers given for congruent words (PC.congruent), the number of correct answers for incongruent words (PC.incongruent), the mean reaction time (MRT), the mean reaction time for congruent words (MRTcongruent), and the mean reaction time for incongruent words (MRTincongruent). When preliminary analyses were conducted to ensure there were no violations of linearity, collinearity and homoscedasticity, PC.congruent was in breach of linearity and had no correlation with any of the other variables (see table 2), and so was not included in the analysis. Total DASS scores were also highly correlated with depression, anxiety and stress scores and so it also was not used for analysis.

In total, 4 hierarchal regressions were completed comparing Stroop task results against DASS42 scores when age was controlled for. Age had significant, negative correlations with depression scores ($r = -.280$, $p = .042$), anxiety scores ($r = -.366$, $p = .011$), and stress ($-.385$, $p = .008$). This would suggest that as age increased within the sample, scores in all three DASS variables decreased. There was one significant negative correlation between correct incongruent words and age ($r = -.314$, $p = .026$). Age was also associated with slower overall reaction time ($r = .439$, $p = .003$) and reaction time for incongruent words ($r = .351$, $p = .014$).

Table 2: *Pearson's correlation between DASS42 scores and Stroop task results*

Variable	1	2	3	4	5	6	7	8	9	10
1.TDASS	1									
2.Depression	.924**	1								
3.Anxiety	.941**	.805**	1							
4.Stress	.936**	.769**	.851**	1						
5.Age	-.366*	-.280*	-.366*	-.385**	1					
6.Pccongruent	-.029	.012	.086	-.018	.068	1				
7. PCincongruent	.180	.114	.170	.222	-.314*	-.064	1			
8. MRT	-.289*	-.236	-.238	-.331*	.439**	.102	-.450	1		
9.MRT congruent	.008	-.062	.059	.036	.129	.231	-.057	-.077	1	
10.MRT incongruent	-.301*	-.231	-.284*	-.330*	.351*	.061	-.496**	.937**	-.074	1

Finally, stress scores were associated with faster response times to overall mean reaction time ($r = -.331$, $p = .020$), and both anxiety ($r = -.284$, $p = .040$) and stress ($r = -.330$, $p = .020$) scores were associated with better response times for incongruent words.

Hierarchal Regressions

A hierarchal regression was used to assess if the 3 DASS-42 subscales had the ability to predict the total correct answers for incongruent words in the Stroop task, while controlling for age. Preliminary analyses were conducted to ensure there was no violation to the assumptions of normality, linearity, multicollinearity and homoscedasticity. When age was entered at step 1, it could not significantly explain 1% of the variance in scores, $F (1, 37) = 4.055$, $p = .051$. When depression, anxiety and stress scores were entered in step 2, the

result was also insignificant, F (4, 34) = 1.318, p = .355. None of the predictor variables made a significant contribution to predicting the dependant variable. (See appendix VIII for table)

Table 3: *Hierarchal multiple regression for predicting correct answers for incongruent words.*

Variable	R^2	Adj. R^2	*B*	*SE*	*β*	*t*	CI 95%		*p*
							LB	UB	
Step 1	.314	.074							
Age			-.002	.001	-.314	-2.014	-.004	.000	.051
Step 2	.344	.014							
Age			-.002	.001	-.268	-1.530	-.004	.001	.135
Depression score			-.001	.002	-.113	-.400	-.005	.003	.692
Anxiety score			.000	.003	-.044	-.128	-.006	.005	.899
Stress score			.002	.002	.243	.754	-.003	.006	.456

A hierarchal regression was used to assess if the 3 DASS-42 subscales had the ability to predict the mean reaction times in the Stroop task, while controlling for age. Preliminary analyses were conducted to ensure there was no violation to the assumptions of normality, linearity, multicollinearity and homoscedasticity. When age was entered at step 1, it explained 19% of the variance in mean reaction time scores. When depression, anxiety and stress scores were entered in step 2, they explained 24% of the variance F (4, 34) = 2.648, p = .050, however, the change in variance was not significant, R square change = .044, F change

(3, 34) = .660, p = .582. This meaning the three control measures were unable to contribute to explaining the variance in reaction times.

Table 4: *Hierarchal multiple regression predicting mean reaction times in Stroop task.*

Variable	R^2	Adj. R^2	*B*	*SE*	*β*	*t*	CI 95%		*p*
							LB	UB	
Step 1	.193	.171							
Age			17.232	5.791	.439	2.976	5.498	28.996	.005
Step 2	.238	.148							
Age			14.831	6.398	.378	2.318	1.829	27.832	.027
Depression score			-2.579	11.829	-.057	-.218	-26.619	21.46	.829
Anxiety score			13.285	17.449	.244	.761	-22.175	48.745	.452
Stress score			-16.137	13.846	-.349	-1.165	-44.276	12.002	.252

A hierarchal regression was used to assess if the 3 DASS-42 subscales had the ability to predict the mean reaction times for congruent words in the Stroop task, while controlling for age. Preliminary analyses were conducted to ensure there was no violation to the assumptions of normality, linearity, multicollinearity and homoscedasticity. When age was entered at step 1, it was unable to explain any of the variance in mean reaction time, F (1, 37) = .662, P = .435. When DASS-42 scores were added to the model, the model still failed to explain any of the variance, F (4, 34) = .621, P = .651. (See table 5 for details).

Table 5: *Hierarchal multiple regression predicting mean reaction times in Stroop task.*

Variable	R^2	Adj. R^2	*B*	*SE*	*β*	*t*	CI 95%	*p*

							95% CI for B		
							LB	UB	
Step 1	.193	.171							
Age			17.232	5.791	.439	2.976	5.498	28.996	.005
Step 2	.238	.148							
Age			14.831	6.398	.378	2.318	1.829	27.832	.027
Depression score			-2.579	11.829	-.057	-.218	-26.619	21.46	.829
Anxiety score			13.285	17.449	.244	.761	-22.175	48.745	.452
Stress score			-16.137	13.846	-.349	-1.165	-44.276	12.002	.252

A hierarchal multiple regression was used to assess if the 3 DASS-42 subscales had the ability to predict the mean reaction times for incongruent words in the Stroop task, while controlling for age. Preliminary analyses were conducted to ensure there was no violation to the assumptions of normality, linearity, multicollinearity and homoscedasticity. When age was entered at step 1, it explained 12% of the variance in mean reaction time scores, $F(1, 37) = 5.200$, $p = .028$. When depression, anxiety and stress scores were entered in step 2, the model as a whole was unable to predict any variance in reaction times, $F(4, 34) = 1.727$, $p =$

.167, concluding that age was the only predictor in explaining variance in reaction times. (See table 6 for details.)

Table 6: *Hierarchal regression predicting mean reaction times for incongruent words*

Variable	R^2	Adj. R^2	*B*	*SE*	*β*	*t*	CI 95%		*p*
							LB	UB	
Step 1	.123	0.1							
Age			16.648	7.301	.351	2.28	-9.943	22.621	.028
Step 2	.169	.071							
Age			12.429	8.078	0.262	1.539	-3.987	28.845	.133
Depression score			2.472	14.936	.045	.166	-27.881	32.826	.870
Anxiety score			.044	22.031	.001	.002	-44.729	44.817	.998
Stress score			-14.802	17.483	-.265	-.847	-50.331	20.726	.403

1.2. Four-Choice Reaction Time task and Symbol Search task.

Hierarchal multiple regressions were used to investigate whether reported levels of depression, anxiety and stress would negatively impact an individual's attention, processing speed and reaction time by ways of the Four Choice Reaction Time task and the Symbol Search task. As age may have had an impact on cognition, it was included in the analysis as a controlled variable. The results generated by the Four-Choice Reaction Time task were the

total number of correct answers (Propcor4Choice), the mean reaction time of answers (MRT 4Choice), the number of premature answers given (Premature error) and the number of incorrect answers (Incorrect answers). The Symbol Search task consisted of the number of correct answers given in 2 minutes (Symbol Search). When preliminary analyses were conducted to ensure there were no violations of linearity, collinearity and homoscedasticity. Due to the high correlation with other variables, total DASS scores were not included in the analysis.

In the Pearson's correlation, both anxiety (r = .359. p = .012) and stress (r = .285, p = .008) were correlated with higher rates of premature errors. Age was also correlated with greater accuracy, as higher age was associated with making less mistakes (r = -.282, p = .042) and less premature errors (r = -.311, p = .027). However, the mean reaction time also increased with age (r = .473, p =.001). More details can be found on table 7.

Table 7: *Correlations for all continuous variables for Four-Choice and Symbol Search task.*

A hierarchal regression was used to assess if the 3 DASS-42 subscales had the ability to predict the number of correct answers in the Four-Choice Reaction Time task while controlling for age. Preliminary analyses were conducted to ensure there was no violation to the assumptions of normality, linearity, multicollinearity and homoscedasticity. When age was entered at step 1, it was unable to explain any of the variance in a statistical way, F (1,

37) = 2.195, p = .147. When depression, anxiety and stress scores were entered in step 2, the

Variable	1	2	3	4	5	6	7	8	9	10
1.TDASS	1									
2.Depression	.924**	1								
3.Anxiety	.934**	.800**	1							
4.Stress	.939**	.764**	.846**	1						
5.Age	-.349*	-.266*	-.350*	-.367	1					
6. Propcor4Choice	-.120	-.027	-.136	-.179	.237	1				
7.MRT 4Choice	.007	.089	-.087	.000	.473**	.100	1			
8.Premature error	.281*	.160	.359*	.285*	-.311*	-.653**	-.268*	1		
9.Incorrect answer	-.076	-.208	-.052	.054	-.282*	-.701*	-.499**	.412*	1	
10.Symbol Search	.072	.076	.038	.080	-.285	.016	-.443**	.183	.086	1

model still failed to explain any of the variance significantly F (4, 34) = .886, p = .483. Therefore neither age nor DASS42 scores had an influence on the number of correct answers an individual would make.

A hierarchal regression was used to assess if the 3 DASS-42 subscales had the ability to predict mean reaction times in the Four-Choice Reaction Time task, while controlling for age. Preliminary analyses were conducted to ensure there was no violation to the assumptions of normality, linearity, multicollinearity and homoscedasticity. When age was entered at step 1, it explained 22% of the variance in mean reaction time scores. When depression, anxiety and stress scores were entered in step 2, the model as a whole explained 32% of the variance F (4, 34) = 4.006, p = .009. The change in variance however, was not significant, R square change = .096, F change (3, 34) = .096, p = .205. Therefore, the

DASS42 scales could not explain any of the variance in reaction times. (See table 7 for more details).

Table 7: *Hierarchal multiple regression predicting reaction times in Four-Choice*

Variable	R^2	Adj. R^2	*B*	*SE*	*β*	*t*	CI 95%		*p*
							LB	UB	
Step 1	.224	.203							
Age			3.044	.932	.473	3.267	1.156	4.933	.002
Step 2	.320	.240							
Age			3.405	.991	.529	3.435	1.391	5.419	.002
Depression score			2.643	1.832	.358	1.443	-1.081	6.368	.158

Anxiety score	-3.907	2.703	-.437	-1.446	-9.401	1.586	.157
Stress score	2.280	2.145	.301	1.063	-2.079	6.639	.295

A hierarchal regression was used to assess if the 3 DASS-42 subscales had the ability to predict the number premature errors made in the Four-Choice Reaction Time task while controlling for age. Preliminary analyses were conducted to ensure there was no violation to the assumptions of normality, linearity, multicollinearity and homoscedasticity. When age was entered at step 1, it was unable to explain any of the variance in a statistical way, F (1, 37) = 3.972, p = .054. When depression, anxiety and stress scores were entered in step 2, the model still failed to explain any of the variance, F (4, 34) = .2.72, p = .084. Therefore neither age nor DASS42 scores had an influence on the number of errors made in the Four-Choice Reaction Time task. (See table 8).

Table 8: *Hierarchal multiple regression predicting premature errors in Four Choice task*

Variable	R^2	Adj. R^2	*B*	*SE*	*β*	*t*	CI 95%		*p*
							LB	UB	
Step 1	.097	.073							
Age			-.049	0.025	-.311	-1.993	-.099	.001	.054
Step 2	.211	.118							
Age			-.032	.026	-.204	-1.229	-.086	.021	.227

Depression score	-.064	.049	-.351	-1.314	-.162	.035	.198
Anxiety score	.128	.072	.584	1.793	-.017	.274	.082
Stress score	-.004	.057	-.021	-.068	-.119	.112	.946

A hierarchal regression was used to assess if the 3 DASS-42 subscales had the ability to predict the number of incorrect answers made in the Four-Choice Reaction Time task while controlling for age. Preliminary analyses were conducted to ensure there was no violation to the assumptions of normality, linearity, multicollinearity and homoscedasticity. When age was entered at step 1, it was unable to explain any of the variance in a statistical way, $F (1, 37) = 3.193$, $p = .082$. When depression, anxiety and stress scores were entered in step 2, the model still failed to explain any of the variance, $F (4, 34) = .2.554$, $p = .057$. Therefore neither age nor DASS42 scores had an influence on the number of incorrect answers made in the Four-Choice Reaction Time task. (see table 9 for more details).

A hierarchal regression was used to assess if the 3 DASS-42 subscales had the ability to predict the number of correct answers made in the Symbol Search task while

controlling for age. Preliminary analyses were conducted to ensure there was no violation to the assumptions of normality, linearity, multicollinearity and homoscedasticity. When age was entered at step 1, it was unable to explain any of the variance in a statistical way, F (1, 37) = 3.275, p = .078. When depression, anxiety and stress scores were entered in step 2, the model still failed to explain any of the variance, F (4, 34) = .887, p = .482. Therefore neither age nor DASS42 scores had an influence on the number of correct answers made in the Symbol Search task. (See table 10 for more details).

Table 10: A hierarchal multiple regression predicting total correct answers in Symbol Search

Variable	R^2	Adj. R^2	*B*	*SE*	*β*	*t*	CI 95%		*p*
							LB	UB	
Step 1	.081	.056							
Age			-.202	.111	-.285	-1.810	-.428	.024	.078
Step 2	.094	-.012							
Age			-.220	.126	-.311	-1.749	-.476	.036	.089
Depression score			.109	.233	.134	.468	-.364	.582	.643
Anxiety score			-.222	.343	-.226	-.646	-.919	.475	.522

Stress score	.041	.272	.050	.152	-.512	.595	.880

Discussion

The present study aimed to investigate whether daily negative emotions can impact sensory processing related cognitive function. The study focused on the perceptual system and associated cognitive processes to try identify specific aspects of perception and cognition that are influenced by negative mood. The three psychometric tasks used were the Stroop task, the Four-Choice Reaction Time task and a Symbol Search task. They were used to measure visual perception by the way of reaction time, attention, processing speed, cognition and executive function.

There were four hypotheses derived from previous research that this study addressed. All four hypotheses predicted that as scores for depression, stress, anxiety and the accumulation of these scores in the DASS-42 increased, performance in the three psychometric tasks would be negatively impacted. Each hypothesis was investigated using a

hierarchical multiple regression in relation to the psychometric measurement scores that were used for analysis.

Based on the results from the regressions, DASS-42 scores were unable to predict psychometric results after age was controlled. Although the model that included age and DASS-42 scores were significant for mean reaction times in the Four-Choice Reaction time task, $F(4,34) = 4.006$, $p = .009$ and mean reaction times in the Stroop task, $F(4,34) = 2.648$, $p = .50$, Age by itself was a stronger predictor in both the Four-Choice Reaction Time task, $F(1,37) = 10.672$, $p = .002$ and the Stroop task, $F(1,37) = 8.854$, $p = .005$. The model with DASS scores and age also failed to make any change in the variance explained on a statistical level compared to age on its own.

The strongest result found was for total incorrect choices for the Four-Choice Reaction Time task, where the model including DASS42 scores and age were a stronger predictor compared to age on its own. However, both age ($p = .082$) and DASS42 scores with age ($p = .057$) failed to produce significant results. This regression was the only time any of the DASS42 scores made a significant contribution to explaining the variance in incorrect answers, which was depression ($\beta = -.556$, $p = .039$). Although research seems to contradict this result, as it seems depression is associated with greater inaccuracy (Lo & Allen 2011), studies of this nature have involved clinically depressed samples. Although the result was insignificant, higher depression scores were associated with slower reaction times in the Four-Choice Reaction Time task ($\beta = .358$). The delay in reaction time, possibly due to slower cognition and motor speed that's associated with higher depression scores, may have allowed for greater accuracy compared to those with lower depression scores. However, as the association between higher depression scores and reaction time was insignificant, there is no clear evidence this is the case.

A reason for the lack of significant results could be due to the smaller sample size. When G*Power was calculated, a sample size of 152 participants were required to meet a significant power size. As this study was only able to recruit 39 participants, the likelihood of finding significant results were low. So, while the results generated would indicate there is no relationship between negative moods and cognitive deficits in a nonclinical sample, the results generated in this study should be considered with caution.

Other Results

A variable that was not expected to be so impactful on results was age. Greater age significantly increased response times for incongruent words and the average response time in the Stroop task as well as response times in the Four-Choice Reaction Time task. Although higher age was correlated with slower reaction times, greater age as a whole was correlated with greater accuracy, demonstrated in the premature error, incorrect answer, and total correct answers in the Four-Choice Reaction Time task. Greater age was also associated with decreased depression, anxiety and stress scores. The strongest relationship between age and negative mood was stress ($p = .008$), which explained 15% of the variance in stress level scores. This relationship has been reported in other studies, finding that as an individual ages, their levels of stress, anxiety and depression decrease until the age of 60 (Carstensen et al., 2000). Another study found similar findings, the test used to assess negative mood being the DASS-42 (Yu et al., 2022).

Correlation tests also found that both anxiety ($r = 3.59$, $p = .012$) and stress ($r = .285$, $p = .035$) were correlated with higher rates of premature errors in the Four-Choice Reaction Time task. Anxiety ($r = .284$, $p = .040$) and stress ($r = -.330$, $p = .020$) were also correlated

with faster response times for incongruent words in the Stroop task. A reason for this could be related to there being a point where anxiety and stress can be beneficial for awareness, attention, and responding to stimuli meaning they would perform better in the Stroop task. Highlighted in research, it was found that those who show moderate signs of stress are more likely to perform better compared to low or high stress groups (Henderson et al., 2012).

An analysis which was not included in the results section was the test for counterbalancing. Two independent sample t-tests were conducted to investigate whether the order of the experiment (either the DASS-42 questionnaire or the 3 psychometric were first) impacted the 4 DASS questionnaire scores and any of the results from the 3 psychometric tasks. The results indicated that the order of the study did not impact the DASS42 scores. However, there was a statistical significance on the number of incorrect answers in the Four Choice Reaction Time task between completing the DASS42 first ($M = 2.42$, $SD = 1.98$) and completing the psychometric task first ($M = 4.40$, $SD = 3.24$; $t(39) = 2.317$, $p = .027$, two-tailed). The magnitude of differences was of medium effect (Cohen's $D = .07$)

Limitations and future research

Stated above, a limitation of this study was the small sample size. When a sample size of 152 participants is needed, attempting to find significant, generalizable results with 39 participants is statistically unlikely. Therefore, repeating the experiment with a more appropriate sample size is encouraged. As the study stands, it fails to find any statistical evidence that there is a relationship between negative moods and difficulties in sensory processing and cognition. Yet study cannot commit to rejecting the null hypothesis due to the

high probability of a type II error. Smaller indications in the results suggest that there is (albeit limited) possible evidence that negative moods can impact perception and cognition, via the correlations, significance in regression models, and depression scores being a significant, unique contributor for variance in incorrect answers.

Although the overall aim for this research was to look at the impact negative, daily moods can have on our sensory system, the current research focused on perception to conduct a more detailed evaluation on one sensory system, rather than attempt to measure multiple sensory systems at once. Therefore, future research can be conducted into whether negative moods can impact other sensory systems. In fact, research has found that the auditory system can be more dysfunctional in comparison to the perceptual system in those with depression (Kahkonen et aal., 1990).

To build upon this study's findings, measuring negative moods over a longer period of time should be investigated. This study focused on the measurement of mood over the course of 2-3 days, however, negative emotions experienced for 1-2 weeks may have more impact on an individual's sensory and cognitive processing abilities. Using the General Adaption System as a model, the body will eventually hit exhaustion, where the mind and body fatigue from producing cortisol, epinephrine and norepinephrine (Seyle, 1950)

Strengths of the study

While the sample size was a major limitation, there are a number of strengths with this study. One being the reflective sample size. With a mean age of 33, and a range of 18-57, the sample used would consist of a wide range of individuals from a variety of backgrounds. Similarly, the means for all three DASS42 subscales were within the mild to moderate

severity range, with minimal participants accounted as experiencing severe depression, anxiety or stress.

Furthermore, this study attempted to include a wide variety of tests in order to get a greater overall picture of how perception could be impacted by negative mood. It also means the participants were not given the opportunity to adjust to a single task, where in previous studies that have focused on one testing parameter such as the Stroop task, results are limited to selective attention, and the longer the task lasts, it is likely the individual will perform better.

Conclusion

In summary, the study was unable to produce evidence that everyday negative moods can impact perception and cognitive processes. It does however fill in the gap between normal, negative emotions and clinically significant affective mood disorders. While the current research does not offer results that can be applicable to the world, it lays foundation for a topic that should be further investigated, whether it be a study of similar design to the current research, or to investigate other sensory system functioning, or increasing the length of time negative emotions have been present.

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Appendices

Appendix I

Dass-42 Questionnaire

Please read each statement and pick a number 0, 1, 2 or 3, which indicates how much the statement applied to you over the last week.
The rating scales is as follows:

0- Did not apply to me at all
1- Applied to me to some degree
2- Applied to me a considerable degree
3- Applied to me very much

1. I found myself getting upset by quite trivial things.
2. I was aware of dryness in my mouth.
3. I couldn't seem to experience any positive feeling at all.
4. I experienced breathing difficulty
5. I just couldn't seem to get going.
6. I tended to over-react to situations.
7. I had a feeling of shakiness.
8. I found it difficult to relax.
9. I found myself in situations that made me so anxious I was most relieved when it ended.
10. I felt I had nothing to look forward to.
11. I found myself getting rather upset easily.
12. I felt I was using a lot of nervous energy.
13. I felt sad and depressed.
14. I found myself getting impatient when I was delayed in any way.
15. I had a feeling of faintness.
16. I felt that I had lost interest in just about everything.
17. I felt I wasn't worth much as a person

18. I felt that I was rather touchy
19. I perspired noticeably in the absence of high temperatures or physical exertion
20. I felt scared without any good reason
21. I felt that life wasn't worthwhile
22. I found it hard to wind down
23. I had difficulty in swallowing
24. I couldn't seem to get any enjoyment out of the things I did
25. I was aware of the action of my heart in the absence of physical exertion
27. I found that I was very irritable
28. I felt I was close to panic
29. I found it hard to calm down after something upset me
30. I feared that I would be "thrown" by some trivial but unfamiliar task
31. I was unable to become enthusiastic about anything
32. I found it difficult to tolerate interruptions to what I was doing
33. I was in a state of nervous tension
34. I felt I was pretty worthless
35. I was intolerant of anything that kept me from getting on with what I was doing
36. I felt terrified
37. I could see nothing in the future to be hopeful about
38. I felt that life was meaningless
39. I found myself getting agitated
40. I was worried about situations in which I might panic and make a fool of myself
41. I experienced trembling (eg, in the hands)
42. I found it difficult to work up the initiative to do things

Appendix II

Stroop task

d = red f = green j = blue k = black

D | F | J | K

In the following trials you will see words presented in different colors. Your task is to indicate the COLOR in which each word is printed in while ignoring what the words actually say.

Indicate the color of the word by pressing either of the following response buttons:

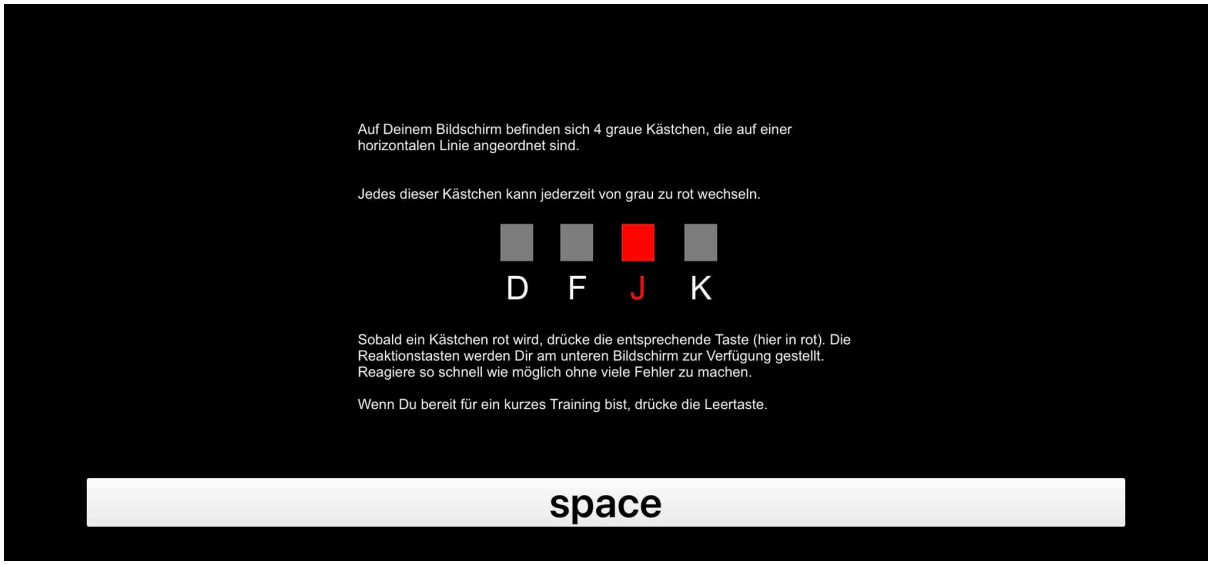
- - d for **red** words
- - f for **green** words
- - j for **blue** words
- - k for **black** words

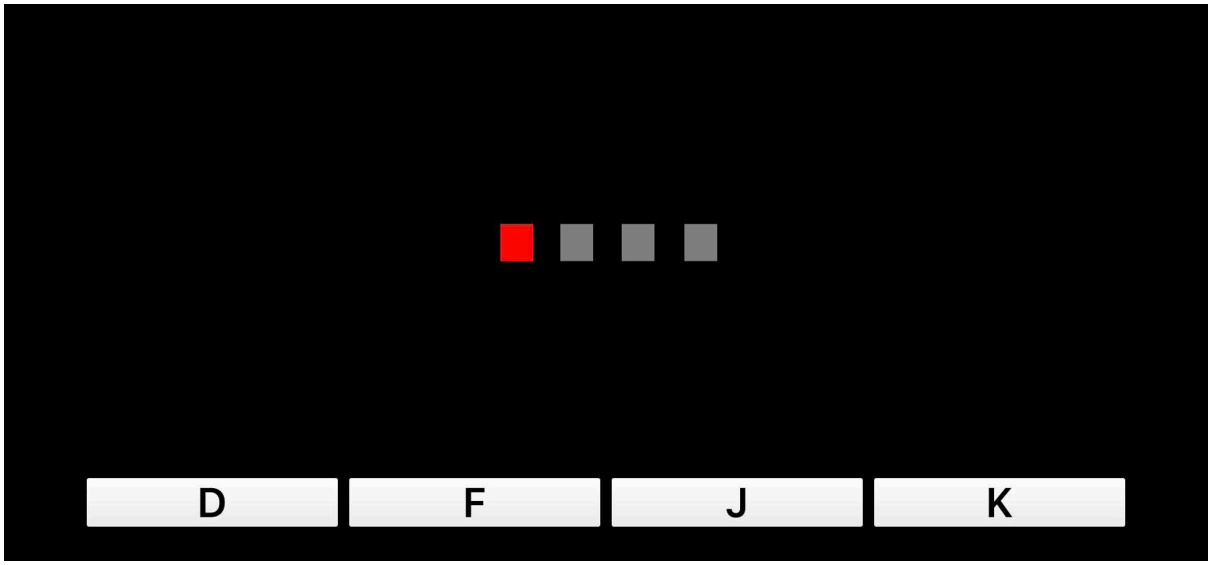
Example: if you see the word **RED** printed in the color GREEN press 'f' for green words regardless of the meaning of the word.

Continue

Appendix III

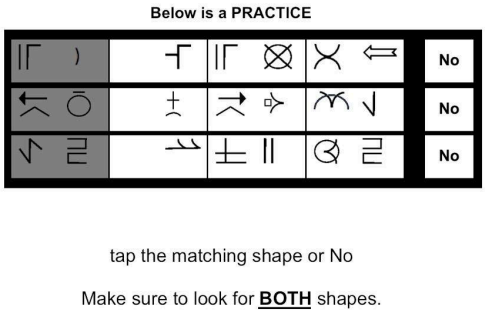
Four Choice Reaction Time task





Appendix IV

Symbol Search task



Appendix V

Information sheet

You are being invited to take part in a research study. Before deciding whether to take part, please take the time to read this document, which explains why the research is being done and what it would involve for you.

What is this study about?

I am a final year psychology student in the National College of Ireland. I am currently conducting research into how daily, negative emotions can impact how we process information (in this case, how we process what we see and hear).The first part of your involvement will require you to fill out a questionnaire on your levels of low mood, anxiety and stress. At the end of this questionnaire, a link will be provided which will allow you to complete the auditory and coloured stroop test.

What will taking part in the study involve?

You will first have to complete the DASS-21 measurement tool, followed by the coloured and auditory stroop test. This process will roughly take 20 minutes to complete.

Who can take part?

Anyone can take part in this study as long as they are over eighteen years of age.

Do I have to take part?

You do not have to take part in this study, and you can request to leave the experiment at any stage. You can also request the data you provide be removed from the final year project up until you leave the experiment session, as then your information will be made anonymous.

There is a small risk that the DASS questionnaire may cause some individuals upset or distress. If you feel that these questions may cause you to experience an undue level of distress, you should not take part in the study.

What are the possible risks and benefits of taking part?

There will be no direct benefits to engaging with this study, however your results will help explore how negative emotions can impact our day to day living. Some may find the DASS-21 questionnaire distressing due to the questions asked relating to low mood and stress, so if you feel this may negatively impact you, please do not engage with this study. Help lines will also be provided at the end of this sheet.

Will taking part be confidential and what will happen to my data?

To ensure you stay anonymous, a unique ID code will be given to the data you provide. Only the researcher and academic supervisor will have access to the data collected. However, in the unlikely event that the researcher or academic supervisor believes that there is a significant risk of harm or danger to the participant or another individual, or a law has been broken, they would then be required to share this information with the relevant authorities. In this very unlikely event, the researcher would discuss this with you first, but they may be required to breach confidentiality with or without your permission. Responses to the questionnaire will be fully anonymised and stored securely in a password protected/encrypted file on the researcher's computer. Data will be retained and managed in accordance with the NCI data retention policy. Note that anonymised data may be archived on an online data repository and may be used for secondary data analysis. The results of this study will be presented in my final dissertation, which will be submitted to National College of Ireland. The results of the project may be presented at conferences and/or submitted to an academic journal for publication.

Who should you contact for further information?

For further information please contact:

Jordan O'Connor (student) at 18348833@student.ncirl.ie.

Or

(Supervisor) Doctor Michelle Kelly at Michelle.Kelly@ncirl.ie

Helplines and health services:

Aware: ***Telephone***: 1800 80 48 48

Email: supportmail@aware.ie

Pieta House: ***Telephone:*** 1800 247 247

Website: www.pieta.ie

NCI Counselling services: counselling@ncirl.ie

Alternatively**,** all NCI students can access **silvercloud** through the NCI student support hub, which is an online mental health hub with a number of self-guided programmes for your mental health.

Appendix VI

Consent form

In agreeing to participate in this research I understand the following:

· The method proposed for this research project has been approved in principle by the Departmental Ethics Committee, which means that the Committee does not have concerns about the procedure itself as detailed by the student. It is, however, the above-named student's responsibility to adhere to ethical guidelines in their dealings with participants and the collection and handling of data.

· If I have any concerns about participation, I understand that I may refuse to participate or withdraw at any stage by exiting my browser.

·I understand that once my participation has ended, that I cannot withdraw my data as it will be fully anonymised.

· I have been informed as to the general nature of the study and agree voluntarily to participate.

· All data from the study will be treated confidentially. The data from all participants will be compiled, analysed, and submitted in a report to the Psychology Department in the School of Business.

·I understand that my data will be retained and managed in accordance with the NCI data retention policy, and that my anonymised data may be archived on an online data repository and may be used for secondary data analysis.

·I understand that the data I provide will be presented in the final year project and will be included in future presentations.

· At the conclusion of my participation, any questions or concerns I have will be fully addressed.

1. Please tick this box if you have read and agree with all of the above information.

2. Please tick this box to indicate that you are providing informed consent to participate in this study.

Appendix VII

Debriefing sheet

Debriefing sheet:

- You have just taken part in a study in relation to how our moods can impact our sensory system process via a stroop test. It is important to note that your score on the measurement scale used does not mean you have a formal diagnosis in any of the related illnesses of depression and anxiety. However, if you feel the questionnaire has brought up negative
- feelings for you, a list of help lines will be provided for you, or alternatively, you can always seek to speak to a professional like your local GP or the student counselling services.
- Understand that this is your final opportunity to retract the information you have given, as after this your results will be fully autonomised.
- If you have any questions now you can ask the investigator now, or via email at: 18348833@student.ncirl.ie

Helplines and health services:

Aware: ***Telephone***: 1800 80 48 48
Email: supportmail@aware.ie

Pieta House: ***Telephone:*** 1800 247 247
Website: www.pieta.ie

NCI Counselling services: counselling@ncirl.ie
Alternatively, all NCI students can access **silvercloud** through the NCI student support hub, which is an online mental health hub with a number of self-guided programmes for your mental health.