Chapter 6

Impaired Mental Processing Speed With Moderate to Severe Symptoms of Depression

Tabitha W. Payne and Madeline Thompson

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/59597

1. Introduction

One way to better understand clinical disorders is to combine research from cognitive experiments to dissociate information processing impairments for various conditions, such as major depressive disorder. Ruminations, which are associated with depression, place an increased load on basic cognitive processes, such as working memory and attention, which are necessary for more advanced reasoning and problem solving. Research has revealed a connection between performance decrements in an array of activities requiring effortful processing, or processes that rely on working memory and controlled attention [1]. Depression impairs such cognitive functions as verbal fluency [2,3], verbal memory [4], mental flexibility [5], effortful processes and executive functions [6].

While working memory and attention are important contributing processes to fluid intelligence [7], mental processing speed also contributes to variance in higher level reasoning and problem solving [8,9], yet little research has been devoted to understanding mental speed in the depressed individual. Measures of mental processing speed can include reaction time for decision making. For example, in a study by Kalb, Dorner, and Kalb (2006), depressed patients were administered both simple and choice reaction time measures [10]. Depressed patients were slower than control participants on measures using briefly presented stimuli. After administration of antidepressants, the depressed patients showed decrease in reaction time, linking the medication to better speed of processing, however, performance errors increased. The results of this research indicate differences in information processing occurring very early at the stage of pre-attentive processing.

Another way to examine mental speed and depression is to use inspection time measures [11]. Inspection time assessments entail manipulating the exposure duration of stimuli. Most inspection time measures require a decision, such as auditory or visual discrimination of

masked stimuli. Inspection time is considered to be an indirect measure of neural firing speed in the brain, specifically for the processes necessary for an accurate decision. Individuals with fast neural speed can make an accurate representation of the stimulus in less time, which could facilitate subsequent decision making and problem solving. If depression is characterized by slowed mental speed on inspection time measures, then decision making is also impaired. Depressive symptoms, as characterized by the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-V), include feeling slowed down, fatigued, and inhibited concentration and thinking [12]. According to **cognitive slowing theory** [13], depression is linked to neural slowing in the brain, as opposed to the **dysfunctional basal ganglia theory** proposed by Lohr and colleagues (2013), in which sluggishness in depression is due to motor impairment, similar to Parkinson's Disease in which mental speed is not impaired, only movement [14]. Evidence for the later theory comes from a sample of patients with depression that performed simple reaction time tasks that involved detection of a visual target. Patients performed similar to controls on reaction time measures, however, still performed more poorly on a number of movement measures [14]. A criticism of this research is the lack of variation in mental speed measures used. It is possible that performance deficits are specific to the speeded decision, for example detection versus discrimination judgments. Mental speed differences could be associated with depression, but researchers need to examine a more expansive set of mental speed paradigms.

Evidence for cognitive slowing has been found in a study by Tsourtos, Thompson, and Stough (2002), in which inpatients with depressive disorder were compared with controls on visual inspection time tasks using various sizes of lines [13]. Here, the depressed patients showed decrements on mental speed tasks with exposure durations as short as 60 ms. The visual inspection time measures required discrimination judgments for briefly presented lines.

The focus of the current research endeavor was to examine the potential relationship between depression and mental speed using inspection time measures, and expanding the variation to speeded detection, identification, and discrimination of letters presented at durations of 80 to 16 ms. Since inspection time for line discrimination was found to be impaired in depressed patients [13], letter discrimination is also expected to be impaired in the current study. Since the other measures, detection and identification, are unexplored, it is unknown whether they will be impacted by depression. Unlike the existing research examining inspection time, this study used a college student population, and self-report on the Beck Depression Inventory [15]. It is important to examine the potential impairments in a non-clinical sample, especially students, who must rely on peak cognition to maintain academics in a college setting.

2. Methods

2.1. Participants

The sample consisted of 217 college student participants from a highly selective liberal arts college in the Midwest. Age ranged 18-23, with a gender distribution of 144 females, 73 males.

http://dx.doi.org/10.5772/59597

Participants signed up online or called for individual appointments, and were given the option of receiving monetary compensation or research credit in a psychology course, if enrolled.

2.2. Measures

Beck Depression Inventory. After a detailed demographic survey with medical history, participants were given the computerized version of the mood inventory in a private setting and were encouraged to work at their own pace. The BDI asks patients to respond to 21 scales from 0-3. As an example item on the BDI, participants note which correspond to their life with (0) I do not feel sad; (1) I feel sad; (2) I am sad all the time and I can't snap out of it; (4) I am so sad and unhappy that I can't stand it. Scores range from 0-63, with 14-19 qualifying for mild depression, 20-28 for moderate depression, and 29 and up for severe depression. Reliability of the BDI is quite high, with a test-retest correlation of 0.93, and it also correlates with other depression measures, indicating a reliable concurrent validity [15].

Snellen Test for Visual Acuity Screening. After informed consent each participant was administered a visual acuity test using a standardized Snellen eye chart to identify individuals with visual deficits, with a criterion of 20/20 vision required for inclusion in the mental speed measures. Participants read letters of varying sizes (line by line). All participants were informed prior to the session to wear corrective eyewear for this assessment.

Visual Inspection Time for Letter Detection and Identification. This computerized assessment measures two variables: accuracy for detection of briefly presented letters and accuracy for the verbal identification of the letters present. Additionally this measure required participants to identify letters appearing in the center of the computer screen for varying amounts of exposure or "inspection" time, with the durations decreasing in trial blocks. There were a total of 5 blocks, with each including 15 trials. For each block, 5 trials were "blank" trials in which no letter appeared, while 10 trials contained a target letter. Each target letter was presented twice within a block of trials, with the target letters including X, Z, H, K, and E, in size 18 font. Prior to actual test trials the participants were provided with practice trials to demonstrate, with a 500 ms inspection time. After practice, inspection time for the target letters was 80, 50, 30, 20, and 16 ms, with blocks presenting inspection times for decreasing amounts as the task continued.

For each trial a "Ready" screen appeared with a prompt for participants to self-initiate the trial sequence. Once a trial was initiated there was a refractory period of 500ms. Next a forward visual mask, a"#" sign, was displayed for 30 ms, followed by a potential letter presentation or a blank screen for either 80, 50, 30, 20, or 16 ms, depending on the block. A backward visual mask followed, which was another "#" sign for 300ms. The general perception in this task is you must decide if a letter is present between the "#". Presence of blank trials was random for each specific inspection time block. Responses for letter detection were indicated by a key press on a computer key pad, with designated keys marked ("1" for yes or "3" for no). If participants indicated a letter was detected, the next instruction was to attempt to identify the letter by choosing it on the keyboard. Feedback was provided on accuracy at the end of each trial. Measures attained by this task are accuracy for detection and identification, for each presentation duration block (80-16 ms). Refer to Figure 1 for a representation of stimulus events.

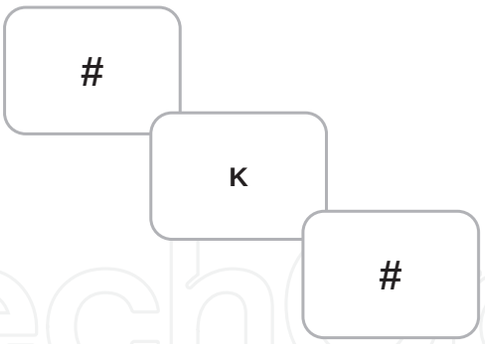

Figure 1. Inspection Time Event Sequence. The boxes represent the series of stimulus events that appear on the computer screen in the mental speed assessment for letter detection and identification. The target letter stimulus is embedded between the presentation of a forward and backward mask (#).

Visual Inspection Time for Letter Discrimination. A second computerized task for visual inspection time was given to assess speeded discrimination. This assessment required participants to decide whether two briefly presented letters pairs are comprised of same or different letters. Similar to the detection/identification tasks, blocks included 15 trials, with descending inspection time durations of 80, 50, 30, 20, and 16 ms. The target letter pairs were XX, KX, EH, ZZ, or XK presented in size 18 font. Also, a practice block was provided in which the target letter pair appeared for 500 ms. Trial parameters were similar to those in the initial detection version, however, with the larger area of two letters, the mask was designed larger (36 font) in order to mask the stimuli. Participants indicated a decision by pressing either "1" for same or "3" for different.

2.3. Procedure

Participants were tested in individual appointments at the Kenyon College Cognition Lab, in sound attenuated rooms, and were instructed to work at a comfortable pace. After completing surveys, participants were screened on the Snellen Eye Chart. The participants then completed the first computerized inspection time task for detection and identification. For the performance measures, each participant was seated in a stationary chair 17 inches from the monitor to control for visual angle. The participants then completed the first computerized inspection time task for detection and identification, which lasted approximately 10 to 15 minutes. Then after a break, a second computerized task was administered for discrimination. At debriefing, participants were provided with contact information for counseling services in the local area and encouraged to seek support if concerned about survey responses.

3. Results

3.1. Beck depression inventory

Scores on the BDI had a mean of 9.67, with a standard deviation of 7.87, a range of 0-39, and high internal consistency with Chronbach's Alpha of 0.895. BDI scores were positively skewed,

http://dx.doi.org/10.5772/59597

with 92 participants qualifying for minimal depression, 97 for mild depression, 27 for moderate, and 5 for severe (see Figure 2 for participant frequencies on BDI categories). With so few participants meeting criterion for severe depression, all subsequent analyses for hypothesis testing compared those in both the moderate and severe group, giving a total of 32 in the depressed group to compare with those not qualifying at that intense of a criterion level on the BDI. For this sample, 14.75% fall into the category of moderate to severe depression.

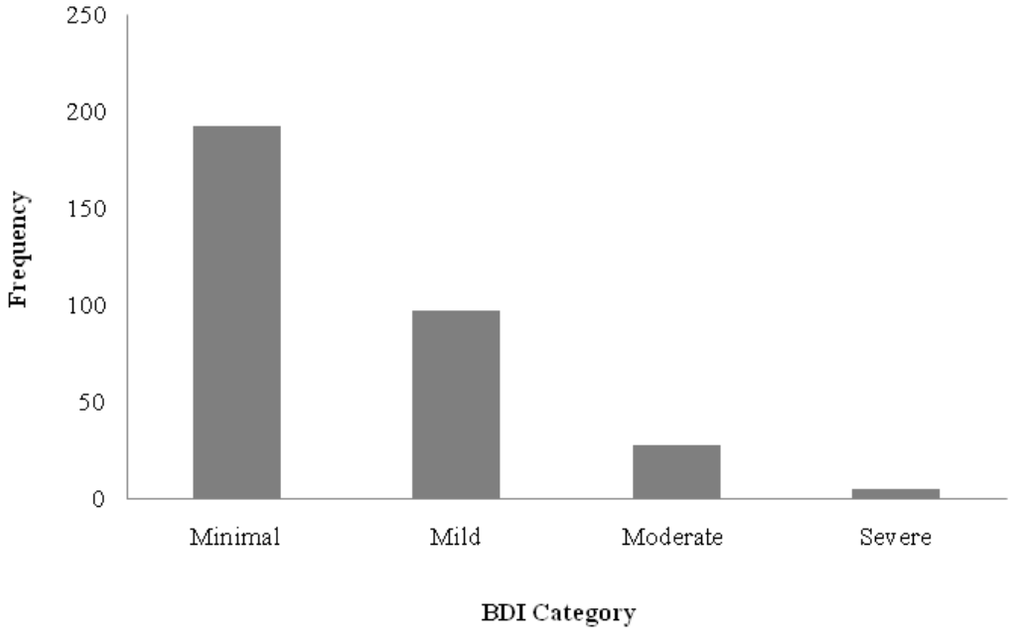

Figure 2. Beck Depression Inventory Scores. Frequency of participants meeting criterion for each identified group on the BDI assessment.

3.2. Inspection time measures

Letter Detection, Identification, and Discrimination Speed. Total performance for all participants for each of the 3 inspection time measures is shown in Figure 3 (means and standard error as a function of stimulus exposure duration). A General Linear Model ANOVA with repeated measures, with a 3 x 5 within-subject design was used to examine how performance accuracy on the 3 speed measures varies with inspection time (80, 50, 30, 20, and 16 ms). There was a significant main effect of task type ($F(2,209)=475.80$, $p <.001$), as well as a significant main effect of inspection time duration ($F(4,209)=100.95$, $p <.001$). A significant interaction was present between task type and inspection time duration ($F(8,209)=32.50$, $p <.001$). Refer to Figure 3 for data on all 3 speed measures. Note that the detection version has much higher accuracy overall, with identification and discrimination having lower accuracy. All tasks were significantly different from one another. Exposure time led to decreased accuracy as it got shorter, and there seems to be a more drastic drop in identification on the 16 ms condition than the discrimination task. In summary, these findings are consistent with the notion that the 3 inspection time measures are unique in that they measure different cognitive

processes, and each has a unique relationship with exposure duration. Since the more difficult processing would occur in the identification and discrimination versions, perhaps group differences are more likely to appear in those tasks.

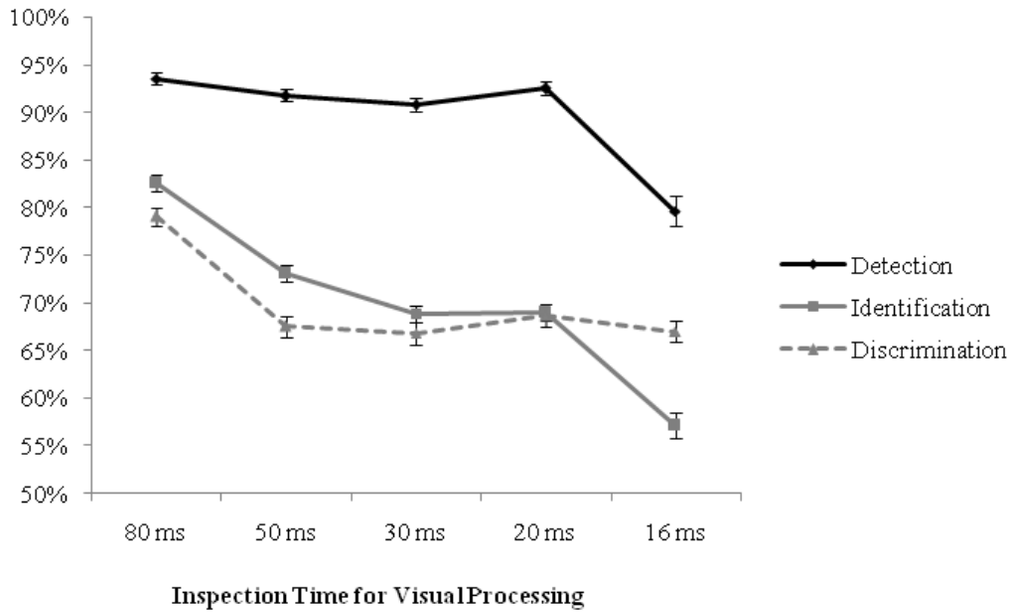

Figure 3. Inspection Time Measures. Mean accuracy with standard error bars for each inspection time task as a function of stimulus exposure duration. Note the near ceiling performance on speeded letter detection, while the more complex speed measures have lower accuracy.

3.3. Group performance data

Overall Inspection Time Accuracy. The central hypothesis was that mental speed, as measured by performance accuracy on inspection time tasks, would be different for those meeting criterion for severe depression on the BDI than those who did not meet criterion. Specifically, those with depression were predicted to perform worse, at least for the discrimination speed measure. A 3 x 2 General Linear Model ANOVA with repeated measures design was used with 3 levels of task type (detection, identification, and discrimination) and 2 participant groups (no diagnosis and moderate to severe depression). Refer to Figure 4 for mean accuracy by group. A significant effect of test type was found, (F(2,203)=261.76, p <.001). Although there was no significant main effect of participant group found on overall speed, (F(1,203)=1.58, p=.21), there was a significant interaction between participant group status and test type, (F(2,203)=3.93, p=.02), with post hoc analysis revealing a significant group difference for the discrimination version only, with the depressed group performing worse (p <.05). More specific analyses were conducted to examine group performance on each speed measure as a function of inspection time below.

http://dx.doi.org/10.5772/59597

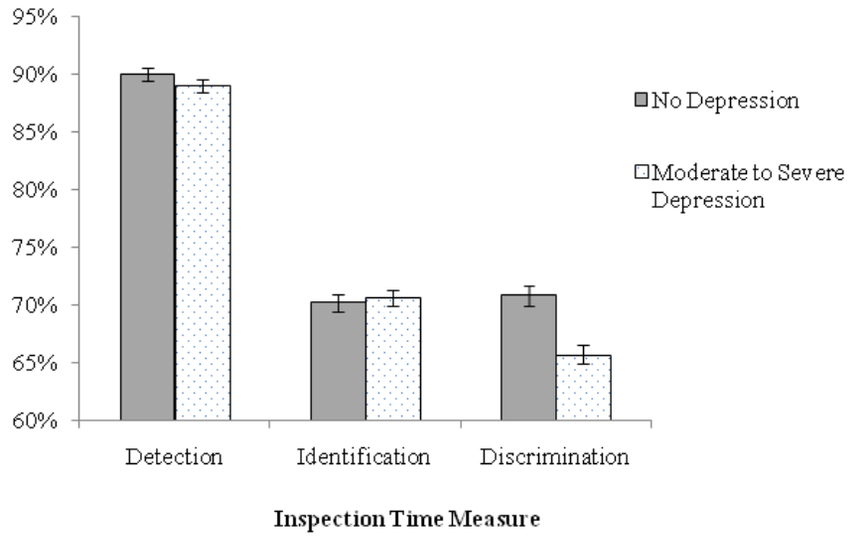

Figure 4. Group Differences in Overall Inspection Time. Mean accuracy for 2 participant groups is depicted for all 3 visual inspection time measures with standard error bars. Note the difference in overall accuracy between the 3 tasks, with accuracy being significantly lower on the identification and discrimination versions. Most notably, the participants meeting criterion for severe depression on the BDI score significantly lower on the speeded discrimination task in comparison to the non-depressed group.

Inspection Time for Letter Detection. Additional analyses were performed to examine specific group data patterns across the 5 inspection time durations (80-16 ms) for each of the mental speed assessments. A 2 x 5 General Linear Model Anova with repeated measures was used to examine performance accuracy for all 2 participant types, (no diagnosis and moderate to severe depression), as a function of inspection time intervals. The analysis resulted in no significant main effect of diagnostic criterion on overall detection accuracy, (F(1,205)=.41, p=. 21). A main effect was found for inspection time duration, (F(4.205)=24.62, p <.001), with accuracy dropping for all participants with shorter exposure durations. There was no interaction between participant status and inspection time durations, (F(4,205)=.13, p=.97). Refer to Figure 5 for means accuracy for groups across inspection times for the speeded letter detection version.

Inspection Time for Letter Identification. Again, a 2 x 5 (group diagnostic status by inspection time duration) General Linear Model ANOVA with repeated measures design resulted in no significant main effect of group on accuracy overall, (F(1,205)=.053, p=.82), however there was a main effect of stimulus exposure duration, (F(4,205)=74.11, p <.001), indicating that participant accuracy decreased as the stimulus duration decreased. No significant interaction was found, (F(4,205)=1.46, p=.21) between group and duration on accuracy for identification of letters. Figure 6 shows the highly similar performance pattern between the 2 groups on speeded letter identification. Although the depressed group is actually better at 80 ms at the beginning of the task, no performance differences occur afterward.

Inspection Time for Letter Discrimination. A final 2 x 5 (group by exposure time) General Linear Model ANOVA with repeated measures did result in a significant main effect of diagnostic group with the depressed group performing worse, (F(1, 203)=5.13, p=. 025), as well

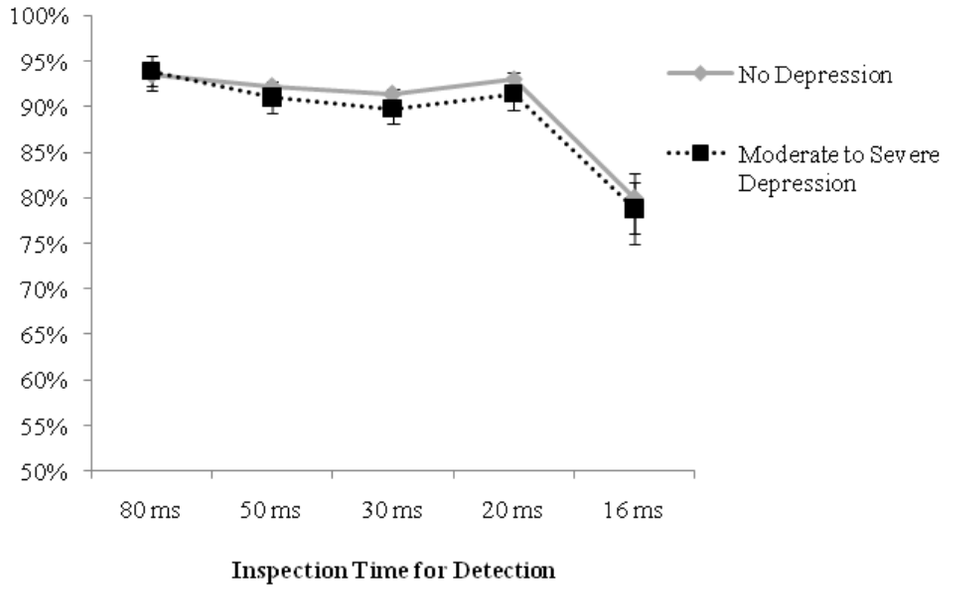

Figure 5. Inspection Time for Letter *Detection*. Mean accuracy for letter detection as a function of exposure duration is shown with standard error bars.

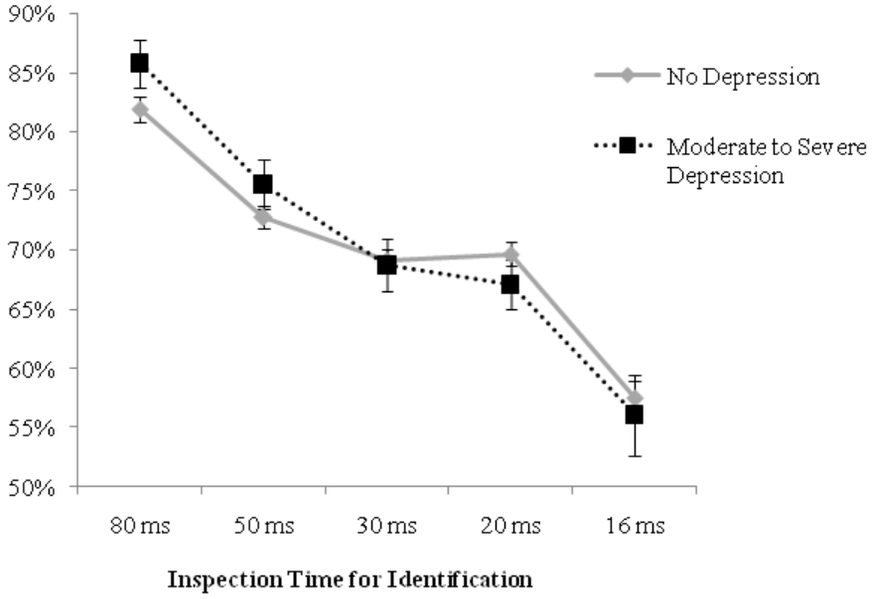

Figure 6. Inspection Time for Letter *Identification*. Mean accuracy for letter identification as a function of inspection time is presented with standard error bars.

as a main effect of exposure duration ($F(4,203)=22.16$, $p < .001$), indicating that participant accuracy decreased as the stimulus duration decreased. Similar to the data pattern with the other inspection time measures, there was no significant interaction between group and stimulus duration, ($F(4,203)=.43$, $p=.79$). Refer to Figure 7 for speeded letter discrimination accuracy by participant group and inspection time. Post hoc analyses reveal the two groups

http://dx.doi.org/10.5772/59597

are significantly different on all conditions of the discrimination version except the initial 80 ms condition ($p < .05$).

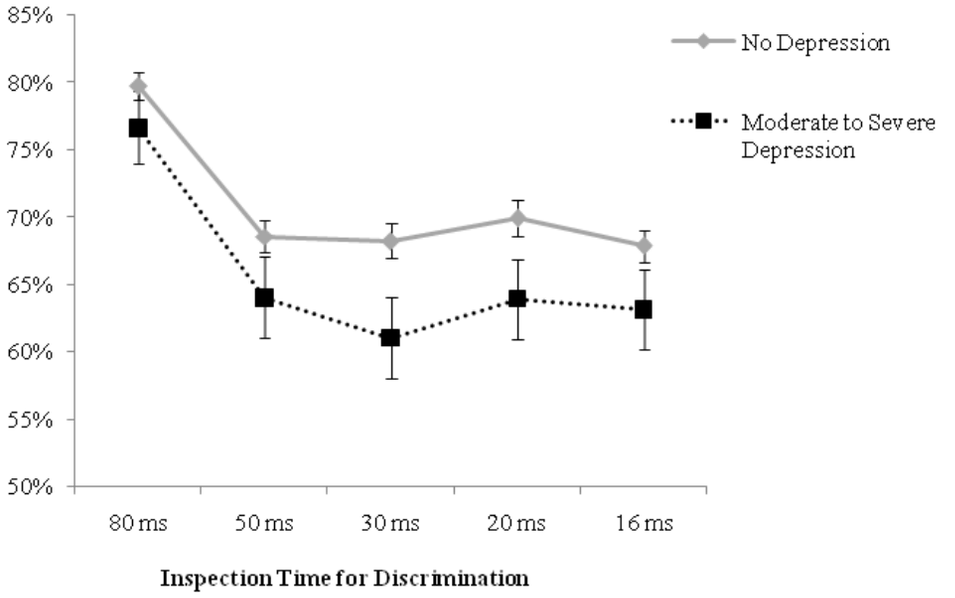

Figure 7. Inspection Time for Letter *Discrimination*. Mean accuracy is presented, along with standard error bars for accuracy at discriminating simultaneously presented letter pairs. Depressed participants are lower in accuracy in all conditions with inspection times shorter than 80 ms.

4. Discussion

Results of this study confirm that individuals reporting symptoms of moderate to severe depression, based on the Beck Depression Inventory criterion, do have impaired mental speed, as measured by the discrimination version of the inspection time measure. By including the additional speed measures for detection and identification, the goal was to see if depression would also be associated with changes in the more basic speed measures.

This finding is consistent with previous research using patient samples [13]. Speeded discrimination is a standard paradigm for inspection time measurement, is widely used, and has been found to be sensitive to participant variables, such as age and other diagnostic criteria, and has now been found to be sensitive to depression symptoms.

With multiple studies now concluding that depressive disorder is associated with impairments in mental processing speed, it is important to focus on why the relationship exists. Based on both the description in the DSM-V, and reported symptoms of patients and volunteer participants, the experience of depression is that of feeling slowed, lethargic, and fatigued. In this sense, depression may be categorized by a general nervous system slowing in the brain, which impacts neural firing necessary for processing briefly presented stimuli, (as measured by the

inspection time tasks). A depressed individual needs more time with the stimuli in order to make an accurate decision about features. It may possibly take more time to form an accurate, detailed representation of stimuli when depression is more severe. The findings of this study are consistent with the **cognitive slowing hypothesis** [13], in which mental speed is disrupted, and in turn, may lead to psychomotor slowing. Another possibility is that depression, as a ruminative disorder, like anxiety, leads to detriments in working memory and attention, which in turn, leads to difficulty on any cognitive assessment that requires sustained or heightened focus. Since we know that depression and anxiety are both ruminative conditions, it would be beneficial to examine how these two disorders are related to mental speed. No research has yet been conducted on anxiety (state or trait) and mental speed. Dissociation in group performance, based on either depression or anxiety disorder would indicate that the two mood disorders may be unique in associated cognitive impairments, while similar performance decrements would indicate that the rumination hypothesis, which puts load on working memory and focus of attention, might be why depressed individual are showing impaired discrimination speed. The challenge in conducting such a study would require an adequate sample size to compare mental processing speed for depressed, anxious, and perhaps a comorbid depression-anxiety group, along with a comparison group that has no mood diagnosis. High rates of comorbidity exist between anxiety and depression [16], and studies place the rate of individuals diagnosed with both depressive and anxiety disorders at over 50 percent [17]. Individuals with anxiety and depression comorbidity experience more severe levels of symptoms associated with both conditions [18]. Comorbidity results in not only greater severity of symptoms, but also less effective treatments and treatment outcomes [19] and greater impairment of functioning [20]. The neural effects of the comorbidity of the two disorders have gone relatively unstudied, and gaps exist in literature addressing cognitive functioning in individuals with both anxiety and depression symptoms.

What some may identify as a central limitation of this study, the student sample, may also be considered a strength. The participants had to meet strict academic criterion to enroll in a selective private liberal arts college, and should score high in intelligence and reasoning. Even though the sample is not comprised of patients in clinical treatment institutions, differences in performance are consistent with previous findings [13], and it is likely that depression symptoms and cognitive deficits should be exacerbated in a more representative community or patient sample. Even with a seemingly healthy, capable subject pool, moderate to severe symptoms are associated with reduced mental speed performance. We assume that the differences found in discrimination speed would have a larger effect size with a sample more representative of the general public. Since there were only 5 individuals meeting criterion for severe depression, the fact that moderate depression symptoms yield impaired discrimination speed performance is an indication that one does not need to be an extreme case or patient in a clinic in order for cognition to be impaired. It is also important to note that with a patient sample, clinicians may be more able to assess the length of the depressive episodes and possibly gather more information as to whether depressed symptoms are a first time experience or related to isolated events, and thus attributed to state depression as opposed to trait depression. Knowing if the depression is a first time episode may also be critical to determine because research has shown that the first incidence may not impair cognition on a visual search

paradigm [21]. The value of examining a student population is that the sample requires good cognition for everyday problem solving related to the goal of achieving a diploma. Therefore, any problems that are observed with basic cognitive processes are notable, as they may be associated with difficulty in higher-order decision making and reasoning necessary to complete assignments for courses.

Although participants provided only self-reported symptoms for depression, the findings are consistent with other research using undergraduate samples and self-reported data on the BDI finding cognitive impairments [22], as well as research using patient populations that have been assessed for depressive disorder via a structure diagnostic interview from a clinician [13]. Results of a study comparing medicated and non-medicated patients with depression indicate that both show impairments in relation to non-patient controls, however, those who were medicated performed better than those not [13]. Future research should examine potential changes in performance before and after medication as a treatment to better understand the potential for intra-individual improvements in mental speed. Findings of the current research with student samples indicate that this population is also vulnerable to depression and cognitive impairment, and thus administrators and educators should be aware that young adult college students also suffer, and that the impact may be seen in academics.

Author details

Tabitha W. Payne* and Madeline Thompson

*Address all correspondence to: paynet@kenyon.edu

Kenyon College Cognition Lab, Depts of Psychology & Neuroscience, Gambier, Ohio, USA

References

[1] Gallassi R, Morreale A, Pagni P. The relationship between depression and cognition. Arch Gerontol Geriatr Suppl. 2001;7:163-171.

[2] Fossati P, Guillaume IB, Ergis AM, Allilaire JF. Qualitative analysis of verbal fluency in depression. Psychiatry Res. 2003;117(1):17-24.

[3] Videbech P, Ravnkilde B, Kristensen S, et al. The Danish PET/depression project: poor verbal fluency performance despite normal prefrontal activation in patients with major depression. Psychiatry Res. 2003;123(1):49-63.

[4] Hermens DF, Naismith SL, Redoblado Hodge MA, Scott EM, Hickie IB. Impaired verbal memory in young adults with unipolar and bipolar depression. Early Interv Psychiatry. 2010;4(3):227-233.

[5] Airaksinen E, Larsson M, Lundberg I, Forsell Y. Cognitive functions in depressive disorders: evidence from a population-based study. Psychol Med. 2004;34(1):83-91.

[6] McIntyre RS, Cha DS, Soczynska JK, et al. Cognitive deficits and functional outcomes in major depressive disorder: determinants, substrates, and treatment interventions. Depress Anxiety. 2013;30(6):515-527.

[7] Kane MJ, Hambrick DZ, Tuholski SW, Wilhelm O, Payne TW, Engle RW. The generality of working memory capacity: a latent-variable approach to verbal and visuospatial memory span and reasoning. J Exp Psychol Gen. 2004;133(2):189-217.

[8] Payne TW, Smith G. Inspection time for verbal stimuli: Letter detection, identification, and discrimination speed. Nova Science Publishers: NY: In L.T. Klein & V. Amato (Eds.), Language Processing: New Research; 2013:87-104.

[9] Sheppard LD, Vernon PA. Intelligence and speed of information-processing: A review of 50 years of research. Personality and Individual Differences. 2008;44(3): 535-551.

[10] Kalb R, Dorner M, Kalb S. Opposite effects of depression and antidepressants on processing speed and error rate. Prog Neuropsychopharmacol Biol Psychiatry. 2006;30(2):244-250.

[11] O'Connor TA, Burns NR. Inspection time and general speed of processing. Personality and Individual Differences. 2003;35(3):713-724.

[12] American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders (5th ed.). Arlington, VA: American Psychiatric Publishing; 2013.

[13] Tsourtos G, Thompson JC, Stough C. Evidence of an early information processing speed deficit in unipolar major depression. Psychol Med. 2002;32(2):259-265.

[14] Lohr JB, May T, Caligiuri MP. Quantitative assessment of motor abnormalities in untreated patients with major depressive disorder. J Affect Disord. 2013;146(1):84-90.

[15] Beck AT, Ward CH, Mendelson M, Mock J, Erbaugh J. An inventory for measuring depression. Arch Gen Psychiatry. 1961;4:561-571.

[16] Kessler RC, Chiu WT, Demler O, Merikangas KR, Walters EE. Prevalence, severity, and comorbidity of 12-month DSM-IV disorders in the National Comorbidity Survey Replication. Arch Gen Psychiatry. 2005;62(6):617-627.

[17] Mineka S, Watson D, Clark LA. Comorbidity of anxiety and unipolar mood disorders. Annu Rev Psychol. 1998;49:377-412.

[18] Kleiman EM, Riskind JH. Cognitive vulnerability to comorbidity: looming cognitive style and depressive cognitive style as synergistic predictors of anxiety and depression symptoms. J Behav Ther Exp Psychiatry. 2012;43(4):1109-1114.

[19] Lydiard RB, Brawman-Mintzer O. Anxious depression. J Clin Psychiatry. 1998;59 Suppl 18:10-17.

[20] Hofmeijer-Sevink MK, van Oppen P, van Megen HJ, et al. Clinical relevance of comorbidity in obsessive compulsive disorder: the Netherlands OCD Association study. J Affect Disord. 2013;150(3):847-854.

[21] Hammar A, Kildal AB, Schmid, M. Information processing in patients with first episode major depression. Scandinavian J Psychology. 2012;53: 445-449.

[22] Sullivan B, Payne TW. Affective disorders and cognitive failures: a comparison of seasonal and nonseasonal depression. Am J Psychiatry. 2007;164(11):1663-1667.

IntechOpen