Mental Health and Language: Anxiety and Depression Impact Sentence Recall Differently

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Abstract

The present study examined how two mental health disorders (anxiety and depression) impact people's ability to process language. Participants ($N = 64$) were asked to read and recall sentences. A secondary naming task was used to prompt lexical rehearsal of the second noun in the stimulus sentence that was either part of the subject (e.g., *Tania and the glass moved…*) or final phrase (e.g., *… above the glass and the donkey*). Corrections during writing and recall mistakes were modelled in generalized mixed models. In line with the hypothesis that mental health disorders impair language processing, both anxiety and depression affected sentence recall accuracy but only anxiety impacted the execution process. Understanding the impact of mental health disorders on language processing is crucial to develop targeted support for individuals who would otherwise be systematically disadvantaged in educational, social, and professional life. Future research may benefit from separating samples dependent on symptom severity and comorbidity.

Keywords: Depression, anxiety, sentence recall, mental health, language processing

Mental health conditions such as anxiety and depression affect a large part of the world population (Demyttenaere et al., 2004). Globally, anxiety is prevalent in 264 million (3.6%) people, while depression affects 322 million (4%; World Health Organization, 2017). Depression is characterized by low moods, sadness, fatigue, a lack of self-esteem, and feelings of hopelessness (Beck et al., 1998). The prevalence of depression increases every year (Skovlund et al., 2017), specifically among adolescents and young adults (Twenge et al., 2018). Likewise, anxiety is more prevalent in younger than older adults (Bandelow & Michaelis, 2015; Flint et al., 2010) with a higher prevalence among students, who often experience symptoms of restlessness, constant fear or worry, difficulty concentrating, irritability and sleep disturbances (American Psychiatric Association [APA], 2013; Stallman, 2010; Storrie et al., 2010).

Both depression and anxiety are known to impact cognitive skills. Individuals with higher levels of depression endure cognitive dysfunctions, which influence their ability to attend to (Duque & Vázquez, 2015), recall (Dillon & Pizzagalli, 2018), and process information at average speed (Beats et al., 1996; Diamond et al., 2008; Tsourtos et al., 2002). Similarly, anxiety disorders impair information-processing (Mogg & Millar, 2000; Wilson et al., 2006) and cognitive performance (Derakshan & Eysenck, 2009) due to restrictions on attentional capacity (Christopher & MacDonald, 2010; Eysenck et al., 2007). Anxiety further results in mind blanking (APA, 2013), which is a disconnect of attention from perception whereby an individual's focus may wander outside of their environment or simply disappear, with attention failing to bring stimuli into conscious awareness (Ward & Wegner, 2013). Mind blanking impairs people's memory and ability to concentrate (Derouesne et al., 1993). Yet little is known about how anxiety and depressive disorders influence language processing.

Austin and colleagues (2001) explored the idea that mood disorders such as depression may be associated with a distinct pattern of cognitive- and language-related impairments. They reported impairments in both verbal recall (Austin et al., 1999) and verbal recognition (in automatic tasks) in subjects with depression (Brown et al., 1994). Similarly, depressed participants have been found to perform poorly on information processing tasks in terms of processing speed and flexibility (Jones et al., 2010). Gronwall (1997) found that this occurred when a motor response, in particular, was required for the Paced Auditory Serial Addition Test (PASAT) task. Participants suffering from a depressive disorder not only made more mistakes on information processing tasks but were also more likely to display non-task-related pupil dilation during a task, which suggests of difficulty in coping with a high cognitive load or information processing beyond the task at hand (Jones et al., 2010).

Researchers have sought to explain the neurocognitive deficits attributed to anxiety and depression through motivational impairments (Barch et al., 2019; Cohen et al., 1982; Porter et al., 2007). However, neuropsychological tasks conducted on depressed participants indicate problems in specific brain regions (Siegle et al., 2007), particularly difficulties in cognitive processing speed and executive function (Sheline et al., 2006; Venezia et al., 2018). Cognitive dysfunctions have been commonly identified amongst individuals with anxiety and depressive disorders, impacting various domains such as attention (Duque & Vázquez, 2015; Keller et al., 2020, memory (Dillon & Pizzagalli, 2018), problem solving (Jones et al., 2017; Remmers et al., 2015), and motor functioning (Bennabi et al., 2013; Buyukdura et al., 2011; Felger et al., 2016). For example, Rose and Ebmeier (2006) examined working-memory performance in patients with major depressive disorder and found slower reaction times and reduced recall accuracy, revealing an impairment of central-executive functions. Deficits in executive functions are well known in individuals with depression (Degl'Innocenti et al., 1998; Grant et al., 2001) and comorbid anxiety (Airaksinen et al., 2004).

All the aforementioned cognitive domains are involved in language processing. These findings suggest that cognitive functions which relate to language processing are impaired in individuals with mental health problems. Researchers have found that depression is linked to increased sentence-onset durations (De Lissynder et al., 2010), frequent pausing (Mundt et al., 2007), poor fluency (Akiyama et al., 2018), prolonged latency of response (Abas et al., 1990), and more production errors (Gohier et al., 2009; Vilgis et al., 2015), which is further exacerbated by depression chronicity (Vilgis et al., 2015). This indicates a primary link between depression and people's ability to produce language. For individuals with anxiety, researchers report a dominating impact on the language comprehension system, i.e., anxiety has been linked to a top-down processing bias (Bradley et al., 2000; Mogg & Bradley, 2005; Wilson et al., 2006) leading to shallow representations of meaning during reading. Crucially, the current review suggests that anxiety and depression may affect language processing differently.

Understanding how mental health disorders impact language processing is important because individuals with anxiety and depression may otherwise be systematically disadvantaged in various every-day contexts that require linguistic skills, e.g., exams, job interviews, academic conferences, communication, etc. For example, attrition rates and poorer outcomes in higher education are significantly greater amongst individuals diagnosed with anxiety and/or depression (Cogburn et al., 2015; Dyrbye et al., 2006). Enhanced understanding could positively improve outcomes for such individuals, as appropriate measures could enhance the delivery of communication and tools to ensure that individuals receive the support they require. Adaptations could also be made where necessary. This would increase inclusivity and life satisfaction, and ensure a sustainable future by providing equal opportunities for everyone.

To summarize, existing research has shown that depression impacts people's ability to formulate sentences, while anxiety is related to a poorer ability to understand language. A form of language processing where language production and comprehension intersect is sentence-recall tasks, in which participants are asked to read short sentences and subsequently recall the sentence from memory. In order to recall the linguistic form of a stimulus, people need to decode the sentence in sufficient detail before reassembling its linguistic form from a conceptual memory representation (Lombardi & Potter, 1992; Potter & Lombardi, 1998; Potter, 2012; Roeser et al., 2020). Sentence recall tasks are used to understand to what extent this occurs. The method used in the present study is a sentence recall task combined with a manipulation used in language production research (Roeser et al., 2019; Martin et al., 2010; Martin et al., 2014) whereby arrays of images are used to elicit sentences that either start with a conjoined phrase and finish with a simple noun (e.g., [N1] *and the* [N2] *moved above the* [N3]) or vice versa (e.g., [N1] *moved above the* [N2] *and the* [N3]) while keeping the overall complexity of the sentence (e.g., number of content words and phrases) constant. This manipulation allows the researcher to test hypotheses about how sentences are chunked during encoding, i.e., into individual picture names or syntactic phrases. In addition, authors have used this paradigm to test how information associated with lexical items interacts with syntactic units (Griffin, 2001; Roeser et al., 2019). In particular, in this study, the ease of recalling the second noun (N2) contained in the sentence was manipulated; importantly, N2 was either part of the sentence-initial phrase (e.g., [N1] *and the* [N2] *moved*…) or the sentence-final phrase (e.g., … *above the* [N2] *and the* [N3]). This manipulation helps to determine whether recall is sensitive to syntactic and lexical factors.

To the authors' knowledge, no research at present has investigated to what extent anxiety and depression impact people's ability to recall sentences at different linguistic levels. That is, language recall in individuals with anxiety or depression could be sensitive to the syntactic form of the sentence, its lexical contents, or perhaps both. To explore which level of linguistic representation is affected by anxiety and depression, the syntactic structure and the lexical content of the target sentence was manipulated. As discussed, an understanding of how mental health disorders specifically impact language processing is crucial in supporting individuals who face mental health challenges. In particular, an identification of which linguistic aspect(s) is impacted could result in modifications and targeted treatments for such individuals.

The present study explored how anxiety and depression impact people's ability to recall sentences. It was hypothesized that both disorders would affect language processing differently. In particular, anxiety was expected to impair people's ability to comprehend sentences, and thus affect the accuracy of the recalled sentence. While the product of the recall was expected to be impacted by anxiety, no effects on the writing execution process were predicted. In contrast, for depression, increased difficulty with language encoding and thus the execution of writing was hypothesized.

Method

Participants

The current study recruited 64 students (19 males, 45 females; median age = 20 years; range = 18-27) from Nottingham Trent University and University of Nottingham in the UK. All participants were native English speakers and reported no reading or writing impairments. Other demographics (e.g., race, ethnicity, social economic status) were not recorded.

The study was approved by the Social Sciences Research Ethics Committee of Nottingham Trent University. Participants were recruited through the university research studies platform with four research-participation credits offered as incentives for participation. All participants were able to access the information sheet online and in-person when attending to complete the study. All participants signed consent forms and were provided with debriefing sheets at the conclusion.

Design & Materials

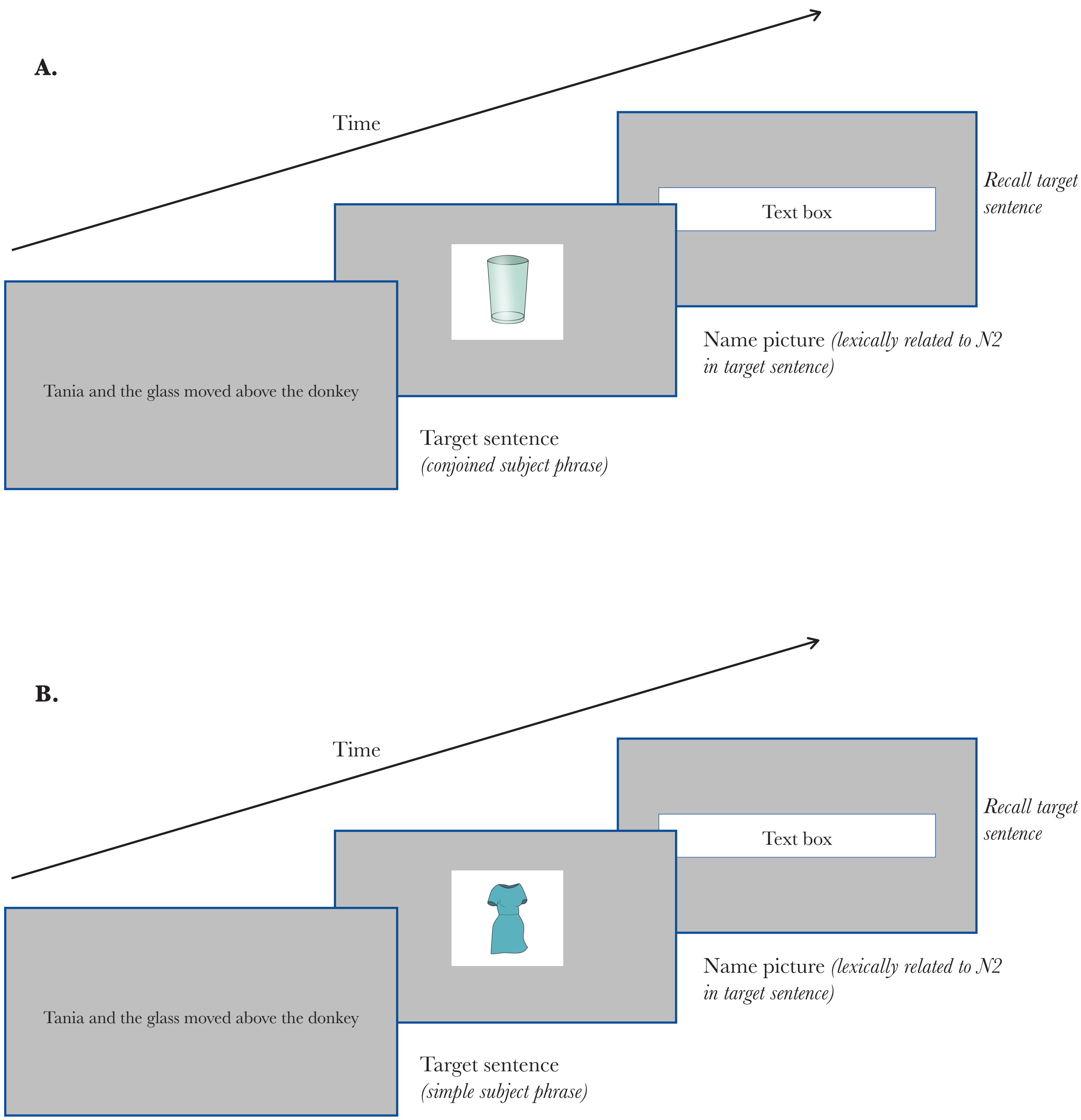
Participants took part in a sentence recall task. Participants were asked to read a sentence and subsequently recall it in writing (i.e., typing) after responding to a secondary picture-naming task. The study used a 2 x 2 factorial within-subjects design and manipulated the syntactic configuration of the target sentence and the ease of recalling one lexical item of the sentence (see Figure 1). As for the syntactic manipulation, shown in Figure 1A and 1B, the stimulus sentence either started with a simple subject noun phrase and ended with a conjoined noun phrase (e.g., *Tania moved above the glass and the donkey*) or started with a conjoined noun phrase and ended with a simple noun (*Tania and the glass moved above the donkey*). In a secondary picture-naming task, lexical recall of the second noun in each sentence (henceforth, N2) was either facilitated (Figure 1A) or not (Figure 1B): between presentation of the target sentence and recall, participants either saw and named a picture that was *related* to N2 (picture of a glass in the example) or unrelated (picture of a dress).

Note that the lexical manipulation was always part of a conjoined noun phrase but either in the sentence initial subject position or sentence final. Importantly, the overall complexity of the sentence was held constant. The dependent variables were product and process-oriented recall measures operationalized as the number of mistakes in the recalled sentence and the number of corrections during the writing process. Psychometric scales were used to assess anxiety and depression levels for every participant (see Measures). These were administered after the sentence-recall task was completed.

Twenty-four stimulus items were created. Items were counterbalanced across four Latin square lists so that every participant saw one condition of each item, but all participants saw the same number of conditions. Furthermore, items were counterbalanced for the first name used in the target sentence (e.g., *Tania* or *Peter*); names were used to avoid determiners in the first position of the sentence (see Roeser et al., 2019). A colored version of the Snodgrass (1980) picture set (as cited in Rossion & Pourtois, 2004) was used for the naming component; pictures were selected using naming norms collected for the same student population (Torrance et al., 2018). Related and unrelated N2 images were matched with regards to naming diversity, British National Corpus frequency, and

Figure 1

Schematic Overview of Experimental Paradigm



Note. The target sentence was presented first for participants to read. The next screen shows a picture that had to be named. The picture shown was either related (A) to the second noun in the target sentence or not (B). The final screen required participants to recall the target sentence by writing it into a textbox.

length of the most commonly used name used for the picture. The noun that was used in the center position of the sentence was also involved in the secondary picture naming task in the "related" condition. Naming norms were used for these pictures to support the effectiveness of the manipulation. In particular, the aim of the picture naming task was to facilitate memory rehearsal of the noun used in the target sentence. Participants would be assumed to use the anticipated name for the picture that corresponds to the noun in the target sentence. Therefore, names used in the target sentence were selected from the most commonly used name for the respective pictures as indicated by the naming norms. Because there is some variance associated with how well people remember short or long words, typically related to the corpus frequency of these words (Baddeley et al., 1975; Tehan & Tolan, 2007), both word length and frequency of the picture names were controlled.

Twenty-four filler items were added, including sentences with structural ambiguities, taken from Van Gompel et al. (2001). These included sentences such as "Peter yelled at the protester with the loudspeaker," which can have two different interpretations (i.e., Peter used the loudspeaker, or the protester had a loudspeaker). Adding filler sentences was intended to prevent participants from adapting strategies to reproduce target sentences with structural similarities.

Measures

Anxiety

Participants' levels of anxiety were measured using the Beck Anxiety Inventory (BAI; Beck et al., 1988). The BAI consists of 21 items addressing symptoms common to anxiety (e.g., unable to relax, fear of worst happening, fear of losing control) with responses measured on a 4-point Likert scale (0 = *not at all*; 3 = *severely, it bothered me a lot*). Items prompted participants to respond to questions about the intensity of cognitive, affective, and somatic symptoms of anxiety experienced within the last month. The by-participant sum of scores can range from 0-63, with scores between 0-21 indicating low levels of anxiety, 22-35 moderate levels, and 36 and above suggesting potentially concerning levels of anxiety (Beck et al., 1988). The BAI has been reported to have high internal consistency with a Cronbach's α of .94 (Fydrich et al., 1992) and a high test-retest reliability ($r = .75$; Muntingh et al., 2011).

Depression

The Beck Depression Inventory (BDI; Beck et al., 1961) was used to estimate levels of depression. The BDI consists of 21 items measured on a four-point scale. Each question involves statements to measure the intensity, severity, and depth of depression on a 4-point scale (0 = *I do not feel sad*; 3 = *I am so sad and unhappy that I can't stand it*). By-participant totals range between 0-63; 0-11 is considered normal, 11-16 indicates mild mood disturbances, 17-20 borderline clinical depression, 21-30 moderate depression, 31-40 severe depression, and 40 and above extreme levels of depression. Pace (1995) reported a high internal consistency ($\alpha = 0.92$) for the BDI using a sample of American undergraduate students.

Procedure

Participants were tested individually in soundproof lab cubicles on a computer screen. The experiment was created and presented in Experiment Builder and keystroke data were recorded using EyeWrite (Torrance, 2012). Participants were instructed to read a sentence at their own pace. After finishing reading the sentence, participants pressed ENTER and a picture was presented that had to be named using a headset. Finally, after finishing the naming task, participants had to write the sentence they read before on the computer keyboard. For that purpose, a text box appeared on the screen.

The experiment started with three practice items to familiarize the participant with the task. Each participant saw 6 blocks which each contained 8 trials, rendering a total of 48 trials per participant (24 items and 24 fillers). Trials were presented in a randomized order within and across blocks. Participants were offered short optional breaks after each block. After completion of the experiment, participants were asked to complete the BAI and BDI questionnaires presented in Qualtrics (Qualtrics, Provo, UT). The study took approximately 35 minutes to complete.

Data Analysis

Two dependent variables were operationalized as indicators of sentence-recall difficulty: (1) the number of correction operations (backspaces, deletions) during typing was used as an indicator of writing-process related recall difficulty; (2) the Levenshtein distance was calculated using the *R* package stringdist (Van der Loo, 2014) as a measure of mistakes made in the final recalled sentence. The Levenshtein distance is a frequently used string metric from machine learning that measures the number of single-character edits (i.e., insertions, deletions, or substitutions) that are needed to change one string to the other: in this case, the produced sentence to the previously displayed sentence (Levenshtein, 1966). In other words, the Levenshtein distance indicates the inaccuracy or mistakes made in the recalled sentence that were not edited. The Levenshtein distances provides a gradual measure of inaccuracies with low values indicating minor mistakes, such as typographical errors, and large values indicating more severe mistakes, such as word omissions or substitutions.

Outcome variables (i.e., the number of corrections and the Levenshtein-distance) were modelled through generalized mixed-effects models using the *R* package glmmTMB (Brooks et al., 2017). Models were fitted using a zero-inflated Poisson distribution (Lee & Wagenmakers, 2014). This was important to capture properties of the distribution of both outcome variables: the outcome variables were discrete count data, followed an exponential function, and showed a relatively large number of zero observations. Model predictors were the main effects of subject noun phrase(s) (i.e., conjoined, simple), N2 (i.e., related, unrelated), BAI and BDI scores, and all two-way interactions and three-way interactions of each BDI and BAI with subject noun phrase and N2 name. Continuous predictors were standardized, and categorical predictors were centered (sum-coded) to estimate the effect magnitudes and to reduce collinearity between predictor variables. Centering predictor variables has two advantages over standard treatment contrasts (see Schad et al., 2020): (1) multicollinearity between predictors is reduced; (2) main effects can be interpreted independently of other predictors. Random intercepts were included for participants and items with by-participant and by-item random slope adjustments for subject noun phrase and N2 (Barr et al., 2013; Bates et al., 2015).

All analyses were completed in R. Both data and scripts, in R-markdown format, are available at the OSF (https://osf.io/aemcu/).

Results

Firstly, the BDI and BAI scores were tested for internal consistency. Reliability coefficients were established using McDonald's (Dunn et al., 2014). McDonald's omega is a reliability coefficient, similar to Cronbach's alpha, that takes into account the strength of association between items (Dunn et al., 2014). High internal consistency was found for both the BAI =0.93, 95% CI [0.9–0.95]) and the BDI = 0.9, 95% CI [0.86–0.93]). By-participant sums were obtained for all items of the BDI (median = 30, *IQR* = 12.25) and the BAI (median = 33.5, *IQR* = 18). Kendall's rank correlation showed evidence for a moderate positive correlation for the BAI and BDI = 0.47, 95% CI [0.34–0.61]).

A descriptive summary of the number of correction operations during writing and the number of mistakes in the final sentence can be found in Table 1.

Table 1

Descriptive Overview of the Number of Correction Operations and Recall Mistakes (Measured as Levenshtein Distance Between Target Sentence and Recalled Sentence)

		Correction operations				Recall mistakes				
Subject phrase	N2	*M*	*SD*	*IQR*	*Max*	*M*	*SD*	*IQR*	Max	*N*
conjoined	related	3.96	3.96	5	22	2.6	5.51	2	37	383
conjoined	unrelated	4.81	4.81	5	38	4.88	8.37	6	48	384
simple	related	3.67	3.67	4	23	2.01	4.33	2	35	384
simple	unrelated	4.61	4.61	5	29	4.41	7.61	5	40	383

Note. M = mean; SD = standard deviation; IQR = interquartile range; N = number of observations

Results are summarized in Table 2. A main effect of BAI on the correction rate ($p = 0.015$) was found with a ratio smaller than 1; this effect indicates that overall, individuals with a higher anxiety score showed less text editing while recalling the target sentence. For the recall accuracy, results showed a main effect of N2 ($p = 0.006$) depicting fewer mistakes in the recalled sentence when the picture used in the secondary naming task was related to the noun in the second position of the target sentence. Further, for the correction rate, a two-way interaction was observed between subject noun phrase and N2 ($p < 0.001$). Pairwise comparisons with Tukey's correction showed a lower correction rate for nouns related to the naming task than for unrelated nouns, but only when the sentence started with a simple phrase (= 0.78, 95% CI [0.65 - 0.92], $p = 0.004$), not when the sentence started with a conjoined subject noun phrase (= 0.99, 95% CI [0.84 - 1.17], $p = 0.91$).

Importantly, three statistically significant three-way interactions were found: the factors subject noun phrase and N2 affected (1) the correction rate as a function of anxiety scores ($p = 0.006$), and both the recall mistakes as a function of (2) anxiety scores ($p < 0.001$) and (3) depression scores ($p < 0.001$).

Table 2

Results of the Generalized Linear Mixed-Effects Model Analysis for Correction Rate (Number of Correction Operations) and Recall Accuracy (Difference Between Produced Sentence and Target Sentence)

	Correction operations			Recall mistakes		
Predictors	Rate ratio($\hat{\beta}$)	95% CI	*p-value*	Rate ratio($\hat{\beta}$)	95% CI	*p-value*
Main effects						
Subject phrase	1.05	0.84 – 1.27	0.639	1.02	0.76 – 1.29	.853
N2	0.88	0.74 – 1.01	0.096	0.65	.45 – .85	**0.006**
BAI (anxiety)	0.82	0.69 – 0.95	**0.015**	1.00	0.8 – 1.21	0.994
BDI (depression)	1.05	0.88 – 1.21	0.563	1.01	0.82 – 1.21	0.885
Two-way interactions						
Phrase x N2	1.28	1.1 – 1.45	**<0.001**	0.90	0.76 – 1.03	0.164
Phrase x BAI	1.06	0.87 – 1.25	0.516	0.89	0.66 - 1.12	0.37
Phrase x BDI	0.97	0.8 – 1.14	0.741	1.12	0.85 – 1.39	.35
N2 x BAI	0.97	0.81 – 1.13	0.679	1.02	0.72 – 1.31	0.911
N2 x BDI	1.00	0.83 – 1.17	0.991	0.91	0.66 – 1.16	0.503
Three-way interactions						
Phrase x N2 x BAI	1.30	1.06 – 1.55	**0.006**	0.60	0.48 – 0.73	**<0.001**
Phrase x N2 x BDI	0.95	0.77 – 1.12	0.561	1.65	1.34 – 1.94	**<0.001**

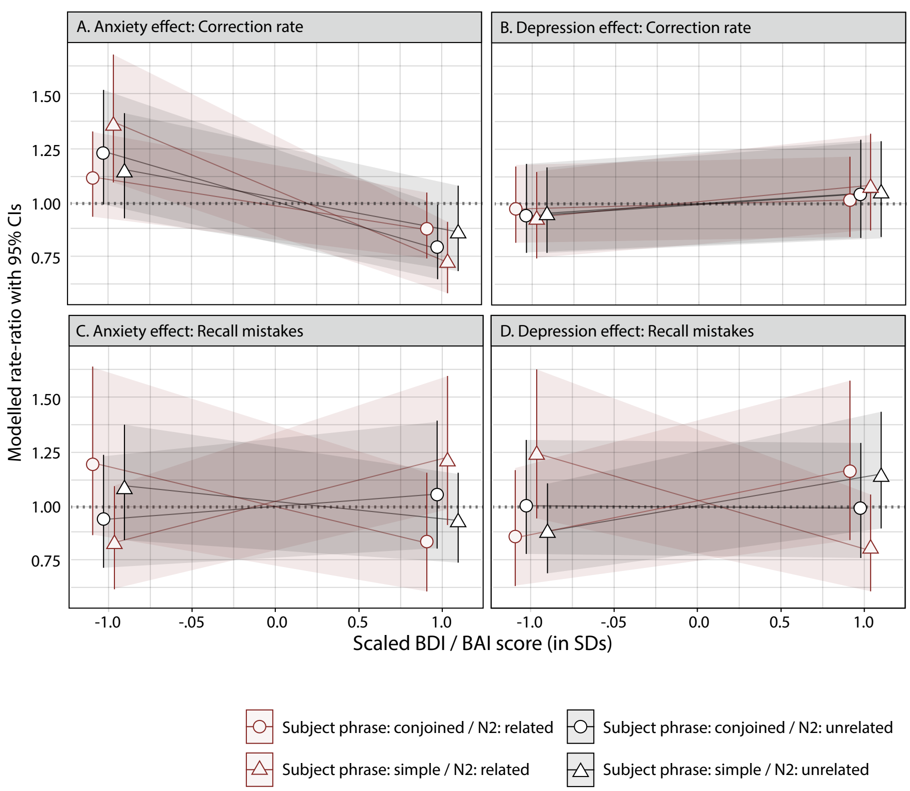
Note. Subject phrase was dummy coded to render the additional difficulty for conjoined phrases as opposed to simple phrases; N2 was dummy coded to render the advantage for related pictures as opposed to unrelated pictures seen in the secondary task. Results are presented for all main effects and interactions. Presented values indicate the rate-ratio (i.e., change in the outcome variable) where a value of 1 indicates the absence of change, values smaller than 1 indicate a reduced change, and values larger than 1 indicate a positive change.

Overall, these interactions indicate that the impact of anxiety and depression on sentence recall depends on the linguistic configuration of the target sentence, in particular the ease of recalling the noun in the second position and whether it was part of the subject phrase of the sentence or not. This was found for both the recall process (editing) and the product (mistakes) in anxiety measures; however, for depression this did not relate to editing throughout the recall process but only affected the number of mistakes in the final text. These results are illustrated in Figure 2 for the modelled correction rate and the recall mistakes. Shown are the rate-ratio changes (y-axis) on BAI and BDI scores (x-axis) displayed for each condition separately. The rate-ratio indicates how many times a score on the outcome variable is larger for individuals with higher BDI / BAI scores. For example, a rate ratio of 1 indicates no change and a rate ratio of 2 indicates that for every increase of 1 on the BDI / BAI scale, the outcome score is two times larger, indicating a positive effect. Scores lower than 1 indicate a reduced effect.

Three-way interactions were inspected in nested contrasts with Tukey's correction for multiple comparisons. Nested differences will be addressed in the order shown in Figure 2. First, as visualized in Figure 2A, participants with anxiety scores of 1 SD below sample average showed significantly more editing throughout recall than participants with anxiety scores of 1 SD above sample average, but only for target sentences that started with a simple noun and matched the picture name used in the secondary naming task (= 1.85, 95% CI [1.2 - 2.86], p = 0.01); all other conditions were non-significant (p > 0.05). In other words, participants with higher anxiety levels showed a tendency to refrain from editing during recall; this resulted in more editing when the sentence started with a conjoined phrase compared to a simple phrase in which the second noun matched the picture seen in the naming task (= 1.44, 95% CI [1.05 - 1.96], p = 0.022) with no difference for unrelated picture (p > 0.05) and less editing when the sentence started with a simple phrase and included a noun that was related to the picture name compared to an unrelated picture name (= 0.66, 95% CI [0.5 -

Figure 2

Modelled Rate-Ratio Changes for Number of Corrections and Mistake-Rate in the Recalled Sentence (Measured as Levenshtein Distance)



Note. Effects are shown for the scaled BAI (anxiety) and BDI (depression) scores. Ribbons show 95% CIs.

0.86], $p = 0.003$) and no difference for sentences that started with a conjoined phrase ($p > 0.05$). It was observed that anxiety interacted with linguistic factors, impacting the frequency of editing during the recall process. This effect was absent for depression, as shown in Figure 2B, which suggests that depression did not impact how participants recall sentences.

Anxiety levels, but not depression levels, impacted editing behavior. Higher scores on both trait scales, however, changed the number of mistakes made in the recalled sentence (i.e., mistakes that were not edited). For participants with anxiety scores of 1 SD above sample average, fewer mistakes were found for sentences in which the N2 noun related to the picture seen in the naming task compared to unrelated pictures for sentences starting with a conjoined phrase (= 0.49, 95% CI [0.31 - 0.77], $p = 0.002$); the same effect was observed for participants with an anxiety score of 1 SD below sample average for sentences starting with a simple phrase (= 0.53, 95% CI [0.34 - 0.82], $p = 0.004$). No other contrasts were statistically significant. This effect is shown in Figure 2C. Figure 2D shows that this pattern observed for anxiety was reversed for depression scores: participants with depression scores that were 1 SD below sample average showed fewer mistakes after seeing a picture related to N2 for sentences that started with a conjoined phrase (= 0.53, 95% CI [0.34 - 0.81], $p = 0.004$), while participants with depression scores of 1 SD above sample average showed the same effect when the sentence started with a simple phrase (= 0.49, 95% CI [0.32 - 0.75], $p = 0.001$). No other contrasts were statistically significant.

This last result suggests that recall involved some linguistic grouping of the first phrase in the sentence and the second/last phrase; whether or not this grouping facilitated recall differed across participants with anxiety and depression. Participants with higher anxiety scores in particular benefitted from lexical match only when the facilitated noun was part of the subject (e.g., "chair" in *Tania and the chair moved...*), but not when the facilitated noun was in the last phrase of the sentence (e.g., ... *above the chair and the donkey*). This was the reverse for depression: participants with higher depression scores benefitted from lexical match when N2 was in the last phrase of the target sentence but not when it was in the first phrase.

Discussion

The present study aimed to examine the effects of anxiety and depression on people's ability to recall a sentence. It was hypothesized that both disorders would differently impact language processing. Anxiety was hypothesized to impact people's ability to comprehend sentences and thus impact the accuracy of the recalled sentence. However, no difficulty during the recall process (i.e., during writing) was anticipated. For depression, problems with the execution of writing were predicted. Specifically, this issue originates from difficulty with language encoding rather than a poorly decoded sentence.

The study found that individuals with increased levels of anxiety showed a lower correction rate but there was no evidence of an inhibited ability to recall the sentence. This, however, was observed for individuals with increased levels of depression who displayed a reduced ability to recall the stimulus correctly but conveyed no evidence of difficulty during the production process. The current findings are in line with the hypothesis that anxiety and depression differently impact language processing. However, the effect of each disorder on language processing contrasts with the existing literature. These conflicting results will be addressed in the remainder of the discussion followed by possible explanations of how, based on the current findings, anxiety and depression impact language processing.

Results showed that depression decreased recall accuracy but did not affect the writing process. This is in contrast with existing research that predicts execution errors but not necessarily a reduced sentence recall (Abas et al., 1990; De Lissynder et al., 2010; Mundt et al., 2007). Production errors were predicted based on deficits resulting from an impairment (Austin et al., 2001) or a limitation of cognitive resources (Cohen et al., 2014). The results of the current study show that this is not the case for sentence recall. More text editing or links to the lexical and syntactic manipulation were not observed for individuals with higher levels of depression. The reduced recall accuracy observed for individuals with higher levels of depression can be attributed to a limited working-memory capacity (Rose & Ehmeier, 2006). This is supported by the lower accuracy when the secondary naming task involved the naming of a picture depicting one of the sentence items. The overlap in meaning may have caused similarity-based interference in verbal working memory (e.g., Oberauer & Lange, 2008) and thus reduced sentence-recall accuracy. In other words, when participants were asked to name a picture that shows an item used in the target sentence, the similarity of their names reduced the memory trace of the sentence item, causing difficulty during memory retrieval. As lower recall was observed only when the critical sentence item was part of the first syntactic phrase, trace decay over time may have had a combined effect with memory interference. However, it must be noted that these explanations are merely post-hoc. Explanations discussed could be considered in future research to clarify the impact of depression on sentence recall or, alternatively, memory. Memory impairments have often been reported by individuals suffering from symptoms of depression and have in fact impaired participants' recall ability in previous experiments (Schweizer et al., 2018).

There are two differences that might explain the contrast between the current results and existing research (e.g., De Lissynder et al., 2010; Mundt et al., 2007). First, participants in the present study did not have to create sentences on a semantic level but rather had to buffer meaning in memory. In other words, the task is taxing on memory because sentences had to be encoded from a conceptual representation of meaning but did not involve the generation of meaning. Second, writing execution deficits in depression might only arise in extreme levels of depression (Vilgis et al., 2015). Vilgis et al. (2015) emphasized that differences in neuropsychological functioning depend on the severity of experienced depression, although the authors also highlighted a lack of consistency within related research. The present sample did not show extreme levels of depression, which might explain the absence of effects on writing execution. An interesting avenue for future research might be to directly test whether the inhibition of the production execution process in individuals with depression is based on difficulty to create meaning in combination with memory limitations. This may provide useful insight into the effects of mental health disorders on language processing and its interaction with memory retrieval, particularly among individuals with clinical levels of depression.

There was no evidence found to suggest that individuals with anxiety show a reduced sentence comprehension ability. This would have been reflected in a lower recall accuracy. Instead, there was an unexpected observation that higher anxiety levels resulted in less editing during sentence recall with no impact on the accuracy of the recalled sentence. Little is currently known about the effects of anxiety on language processing; therefore, any post-hoc explanation needs to be taken cautiously. At least for simple stimulus sentences, the present finding conflicts with the idea that high levels of anxiety lead to a superficial comprehension (Wilson et al., 2006). A possible explanation for this recall advantage is that anxiety disorders can result in high alertness (Pacheco-Unguetti et al., 2009). Higher levels of anxiety may therefore increase attention to the decoding of the stimulus sentence, memory rehearsal, and a more careful writing execution.

In contrast, individuals with lower levels of anxiety showed more text editing depending on the linguistic manipulation. More editing was found for sentences in which the picture naming task involved a name similar to the second item in the target sentence when that item was not part of the subject phrase. A possible explanation for this finding is the following: the recall process seems to be subject to memory interference depending on the syntactic position of the item. As text editing was highest for sentences in which the critical item was not part of the subject phrase, one explanation is that memory interference was strongest when lexical recall had to happen in parallel with writing execution rather than prior to writing onset (see Martin et al., 2014; Roeser et al., 2019; Swets et al., 2014).

An alternative explanation for the increased number of mistakes presented among participants exhibiting higher levels of depression and lower levels of anxiety could be a motivational impairment. Various research studies convey an association between depression and core deficits in motivation (Cléry-Melin et al., 2011; Scheurich et al., 2008; Moritz et al., 2017). Anxiety has been known to impair processing abilities but not necessarily performance (Eysenck, 1979). Nevertheless, if motivation was an influencing factor in the present study, then a larger number of mistakes overall would be displayed. This was not the case. Although a larger number of mistakes associated with both anxiety and depression were found, this was dependent on the syntactic configuration of the target sentence (i.e., whether the conjoined phrase was sentence-initial or final) and was reversed across individuals with higher levels of anxiety and depression. Due to these differences, the present findings cannot be explained on grounds of motivation alone.

There is one important limitation to the current results. Different effects for anxiety and depression on language processing were hypothesized, and these effects have been discussed independently. However, these two mental health disorders show stark comorbidity (Hirschfield, 2001; Moffitt et al., 2007), share overlapping symptoms (APA, 2013), and have a similar psychopathology (Zbozinek et al., 2012). Therefore, it is difficult to draw conclusions about anxiety or depression that are not influenced by the other. The results of this study support the idea that anxiety and depression have different effects on language processing and can, to some extent, be considered independently. Future research focusing on the effects of anxiety and depression on cognitive domains may want to categorize their sample into individuals with anxiety, individuals with depression, and individuals with a high extent of comorbidity. This might help to distinguish between effects that are more general in nature and effects that are specific to either anxiety or depression. It was outside the scope of the current study to distinguish comorbidity samples.

Another possible limitation to the current study is the use of the BAI and BDI psychometric tools. Both have received criticism over the years due to the measurement of overlapping symptoms (Lovibond & Lovibond, 1995; Muntingh et al., 2011; Richter et al., 1998; Ruscio & Ruscio, 2002). However, the high levels of comorbidity between anxiety and depression, as reported in the introduction, are well established (Airaksinen et al., 2004; Hirschfield, 2001; Moffitt et al., 2007). Therefore, tools measuring anxiety and depression levels may generally experience difficulty in distinguishing symptoms that are present across both disorders, such as concentration and processing impairments (Eysenck & Fajkowska, 2018; Zbozinek et al., 2012). While this is a notable limitation to the BAI and BDI tools, this did not impact the present findings as different outcomes were discovered for anxiety and depression overall. Each disorder had distinct effects on sentence recall in the current study. Model diagnostics, particularly the variance inflation factor, also showed that neither the BAI or BDI were subject to multi-collinearity violations. Nonetheless, this study did not group participants separately according to the presence of anxiety and/or depression, as scores were alternatively considered as continuous. Future research may benefit from researching anxiety and depression as separate entities and from addressing different populations. Because the present study involved undergraduate students, the findings may not be applicable to other populations such as children or seniors. Future research will determine the cognitive mechanism that underlies these findings and is impacted by mental health factors, while contributing towards knowledge on the impact of mental health on cognitive functions and in particular, linguistic processes.

The present findings suggest that anxiety and depression impact linguistic factors involved in sentence recall in different ways. This is important because this finding has real-world implications for how individuals with mental health problems should be supported in, for example, educational and professional contexts. Particularly situations that they would otherwise be systematically disadvantaged in, such as exams, presentations, job interviews and even social fulfilment. Developing an understanding of how anxiety and depression impact linguistic processes is an important step to support these individuals in contexts where comprehending and recalling language is fundamentally important. Accordingly, modifications and adjustments could be tailored to this population to improve outcomes across various contexts, thereby enhancing life satisfaction. Enhanced awareness of the potential linguistic struggles that individuals with anxiety and depression face could be addressed using practical adjustments in order to reduce stress and improve outcomes for such individuals, e.g., extra time in exams or altering interview conditions and questions.

Conclusion

The present study explored the impact of anxiety and depression on people's ability to process language. Results show that anxiety and depression affect language processing in different ways. Higher levels of depression impaired recall accuracy, but higher anxiety levels did not. Existing literature suggests that anxiety impacts language comprehension while depression influences language production. In contrast with this view, the present findings show that production was only impaired by lower levels of anxiety. The accuracy of the sentence recalled, however, was a function of anxiety levels, depression levels, and the linguistic properties of a sentence. The reduced recall accuracy in individuals with higher levels of depression was attributed to working-memory limitations. As for individuals with higher levels of anxiety, reduced text editing during writing may be due to increased attention to the stimulus resulting from higher levels of alertness.

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