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Individual Differences in Processing of Garden-Path Sentences: The Role of Obsessive-
Compulsive Personality Traits

by

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Honors Thesis

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Department of Psychology

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Abstract

A great deal of previous research has investigated the real-time processing and offline interpretation of garden path (GP) sentences. This work has shown that GP sentences cause substantial processing disruptions, as revealed by regressive eye movements during reading, as well as incorrect answers to comprehension questions. The current study was designed to investigate whether variability in the processing of GP sentences could be explained by individual differences in personality traits, specifically obsessive-compulsive personality traits. In an eyetracking while reading experiment, participants read GP sentences with both a comma manipulation and a verb type manipulation. Results replicated previous findings in that participants made more regressions and misinterpreted GP sentences at a higher rate than control sentences. Importantly, results of the individual differences analysis revealed that individuals with higher rates of obsessive-compulsive personality traits tended to regress more in a spillover region of the sentence following the disambiguating verb. These results show that individual differences in personality traits have the potential to explain variability in sentence processing.

Many personality disorders remain understudied and not fully understood. Specifically, obsessive-compulsive personality disorder (OCPD) is often misunderstood and confused with obsessive-compulsive disorder (OCD). Although both disorders have some overlap in symptomatology, OCPD is often characterized by extreme perfectionism and can affect simple daily tasks. In contrast, OCD is characterized by compulsions that tend to take up a significant amount of one's time (Mancebo et al., 2005). Both disorders require a clinical diagnosis; however, the goal of the current study is to examine the relationship between obsessive-compulsive personality traits and eye movements during reading in a non-clinical, college student sample.

There have been several studies that have examined the personality traits among those with a clinical diagnosis of OCPD. The disorder involves maladaptive behaviors of excessive perfectionism, extreme attention to detail, and the need to have control over certain aspects of their life (Pinto, 2019). Many individuals with OCPD also tend to be more indecisive about making the right decision. The Pathological Obsessive-Compulsive Personality Scale (POPS) has been the most widely used measurement to assess these personality traits. The POPS contains five subscales for each of the different personality trait groups: difficulty with change, emotional over-control, rigidity, maladaptive perfectionism, and reluctance to delegate. For each item, participants are instructed to select their answer using a Likert scale from 1 (strongly disagree) to 6 (strongly agree). Additionally, the POPS has been shown to be a measure with strong reliability and convergent and discriminant validity (Sadri et al., 2019). Furthermore, previous studies have used the POPS measure in a community sample which is applicable to the current study as participants are undergraduate students with no previous diagnosis (Wheaton & Ward, 2020). Sample items from the POPS are presented below:

1. I get lost in the details.
7. My need to be perfect affects how much I get done.
9. I spend too much time on something in order to get it just right.
33. People tell me that I am inflexible.

Each sample item of the POPS is assigned to correlate to one of the five subscales mentioned above. For instance, regarding the four sample items listed above: 1, 7, and 9 pertain to the maladaptive perfectionism subscale while 33 pertains to the rigidity subscale.

Many characteristics of these personality traits have the potential to cause frustration in certain tasks and could lead to interruptions in one's daily routine. Pinto (2019) conducted a case study with a 26-year-old graduate student with a clinical diagnosis of OCPD. The graduate student, John, showcases how the symptoms of OCPD have impacted his daily routine. John reported that he tends to be very focused on details and oftentimes needs to reread materials numerous times in order to be certain he did not miss any information. John estimated that he takes twice as much time to complete reading assignments in comparison to his graduate school peers (Pinto, 2019). Thus, it is evident that these personality traits characterized by OCPD may have the potential to slow down reading and can cause excessive rereading. Pinto (2019) attributes this to the fear of "missing" something which leads many individuals with OCPD to process information slower.

The idea that many individuals with obsessive-compulsive personality traits exhibit the need to feel in control often leads to repetitive behaviors and repetitive checking. There have been studies which have attempted to analyze this relationship among patients with a clinical

diagnosis of OCD. Lee et al. (2018) recruited OCD patients from a local Korean hospital to assess their eye movements while reading paragraph passages. Eye-tracking measures, such as total duration, number of regressions, and fixation duration were studied between two groups: OCD patients and healthy controls. Results demonstrated that OCD patients exhibited significantly more regressions while reading in comparison to the healthy controls. However, there was no significant difference in the total duration of reading nor was there a significant difference in fixation duration (Lee et al., 2018). These results suggest that individuals with OCD show greater difficulty with language processing. These regressions can be attributed to the repetitive behaviors that seek to check for certainty.

Although there is some overlap in the symptomatology of OCD and OCPD, it is important to note the differences between the two. As mentioned above, OCPD is a personality disorder that is characterized by distinct personality traits such as rigidity, perfectionism, and over attention to detail. In comparison, OCD is an anxiety disorder characterized by obsessions and intrusive thoughts that often cause fear or a severe concern, coupled with compulsions, behaviors that may help the individual reduce the anxiety that is caused by their obsessions (Mancebo et al., 2005).

Considering the Lee et al. (2018) results demonstrating that individuals with a clinical diagnosis of OCD exhibited higher rates of regressions and rereading, the goal of the current study was to assess whether individual differences in reading could be accounted for by analyzing obsessive-compulsive personality traits in a non-clinical sample. Furthermore, Lee et al. (2018) presented participants with long passages of text. In contrast, participants in the current study were presented with garden path (GP) sentences, which are known to elicit processing difficulty during reading. GP sentences contain a temporary syntactic ambiguity

which often leads readers to develop the wrong structure which leads to the wrong meaning. Frazier and Rayner (1982) were among the first to use eyetracking measures to show that regressive eye movements result from reading structurally ambiguous sentences. Many additional studies have shown that GP sentences are associated with processing disruptions. For example, Pickering and Traxler (1998) used a series of eyetracking experiments to study processing difficulty of GP sentences in real-time. Results of this study demonstrated that readers have difficulty on initial analysis if the noun phrase seems implausible. However, it was assumed that upon reanalysis, readers would eventually interpret these sentences correctly (Pickering & Traxler, 1998). Furthermore, other eyetracking studies have shown that readers who encounter GP sentences often do not fully “clean up” the incorrect structure, which may then lead to a lingering incorrect interpretation of the sentence (Slattery et al., 2013).

Whereas the vast majority of the early literature on GP sentences (e.g., Frazier & Rayner, 1982; Pickering & Traxler, 1998) focused on how these sentences are processed in real-time, Christianson et al. (2001) took a different approach. Specifically, Christianson et al. carefully probed comprehension of GP sentences to assess whether readers were engaging in a full process of reanalysis to ultimately derive the correct interpretation of the meaning of the sentence. Through their experiments, the overall results suggested that initial misanalysis of the sentence tends to influence the final interpretation. To measure this, there were two different sentence types: optionally transitive verb sentences and reflexive absolute transitive (RAT) verb sentences. Optionally transitive verbs are those that can be used to refer to the object in the sentence or be used as a stand-alone that does not refer to the given object. RAT verbs are those that are semi reflexive and usually denote actions dealing with personal hygiene (Christianson et al., 2001). Example stimuli from the Christianson et al. (2001) experiment for each of these

sentence types can be seen below, where the first is optionally transitive and the second a RAT verb sentence:

1. While Susan wrote the letter that was long and eloquent fell off the table.
2. While Anna dressed the baby that was small and cute spit up on the bed.

As a further manipulation, there was a comma present condition and a comma absent condition. The purpose of this comma was to serve to disambiguate the sentence after the given verb. Therefore, the study compared GP sentences with the same sentence that contained a disambiguating comma after the verb. Following each sentence, participants were presented with a comprehension question. For example, if the sentence was: *While Anna dressed the baby that was small and cute spit up on the bed* the comprehension question was: *Did Anna dress the baby?*. Participants were instructed to respond “yes” or “no” to these questions. Results from these comprehension questions showed that even with a disambiguating comma, individuals still tend to have trouble in interpreting the correct meaning of optionally transitive verb sentences in comparison to the RAT verb sentence. With the sentence given above, readers must understand that “Anna dresses herself and not the baby” thus this makes it easier when it is reflexive. Part of the reason that participants tend to have worse accuracy for the optionally transitive verbs versus the RAT verbs is that sentences with optionally transitive verbs allow an inference. In sentence (1), for example, readers are much more likely to infer that “Susan must have been writing the letter”, even though the sentence does not explicitly state this. The basic findings reported by Christianson et al. (2001) have been replicated many times using different methods. For example, Patson et al. (2009) showed that incorrect interpretations of GP sentences persisted

even when participants were given a paraphrasing task instead of a yes-or-no comprehension question. The current eyetracking while reading study used the same stimuli as Christianson et al. (2001), including manipulations of comma presence and verb type (optionally transitive and RAT verbs). The key prediction is that individuals with higher POPS scores will have higher rates of regressive eye movements compared to individuals with lower POPS scores.

Method

Participants

Fifty-two students at the University of Richmond enrolled in an undergraduate Introductory Psychology course participated in the experiment for course credit. All participants had normal or corrected-to-normal vision.

Materials

Experimental items for this study were adapted from the experimental stimuli in Christianson et al. (2001). The stimuli presented by Christianson et al. (2001) presented both RAT verb sentences and optionally transitive verb sentences. These two different verb structures were maintained along with a comma manipulation in order to allow for disambiguation of certain sentences. Experimental items were counterbalanced across two lists. For instance, as seen below sentence (1) and sentence (3) have no comma present and sentence (2) and sentence (4) contain a disambiguating comma:

RAT verb sentences:

1. While Anna dressed the baby that was small and cute spit up on the bed.

2. While Anna dressed, the baby that was small and cute spit up on the bed.

Optionally transitive verb sentences:

3. While the man hunted the deer that was brown and grateful ran into the woods.

4. While the man hunted, the deer that was brown and grateful ran into the woods.

Each participant was presented with 24 experimental sentences, like the given examples above, and 92 filler sentences. All sentences (experimental and filler) were the same as those used by Christianson et al. (2001). A true/false comprehension question about the content of the sentence followed each item.

The Pathological Obsessive-Compulsive Personality Scale (POPS) was also administered to all participants. The POPS is a 49-item questionnaire that asks the participant to respond to each item on a Likert scale from 1 (strongly disagree) to 6 (strongly agree). The scale is scored from 49 to 294, the response to each item is summed to calculate a participant's total score. A score of 294 would be considered the greatest severity of obsessive-compulsive personality traits. Participants were not told at the time of completion what the POPS was measuring.

Procedure

Participants' eye movements were recorded with an EyeLink 1000 Plus eyetracker (SR Research) at a sampling rate of 1,000 Hz. A chinrest and headrest were used to minimize head movement. Participants were instructed to read at a natural pace. At the start of each trial, a fixation point was presented near the left edge of the monitor, marking the location where the first word of the sentence would appear. When the participant's gaze was steady on this point,

the experimenter presented the sentence. The first four sentences were warm-up sentences and were not included in analysis. After reading the sentence, the participant pressed a button, which caused the sentence to disappear and a true-false comprehension question to appear in its place. Participants pressed one button to answer “true,” and another button to answer “false.” After the participant answered the comprehension question, the fixation points for the next trial appeared. Each participant saw an equal number of experimental items from each of the comma manipulation conditions. Following the completion of the eye-tracking task, participants completed the POPS measure and were then debriefed.

Analysis

Data analysis from the eyetracking portion of the experiment focused on two common and standard eye movement measures: proportion of regressions and regression-path duration. *Proportion of regressions* refers to the proportion of experimental trials in which the participant made a regressive eye movement from a specific region of a sentence to an earlier part of the sentence. *Regression-path duration* is the sum of all fixations starting with the first fixation on a region and ending when gaze advances forward from that region, this accounts for the time the reader looks back to earlier parts of the sentence. Two regions were analyzed: the disambiguating verb and the spillover region. The *spillover region* consists of the two words that follow the disambiguating verb. The example stimulus below shows the disambiguating word in bold, and the spillover region underlined:

While the man hunted the deer that was brown and graceful **ran** into the woods.

Furthermore, comprehension question accuracy from the true/false comprehension questions that followed each experimental sentence was analyzed.

Results

Experimental Manipulations

Analysis of comprehension question accuracy revealed a significant main effect ($F(1, 50) = 84.62, p < 0.001$) such that participants were more likely to answer correctly when presented with a sentence containing a disambiguating comma compared to no comma present. Additionally, there was a significant main effect of verb type ($F(1, 50) = 103.94, p < 0.001$) such that the RAT verb sentences produced higher mean accuracy among participants compared to the optionally transitive verb sentences. Furthermore, there was also a significant interaction ($F(1, 50) = 13.19, p = 0.001$) between comma presence and verb type such that the effect of the comma manipulation was larger in the RAT verb sentences than in the optionally transitive verb sentences (see Figure 1).

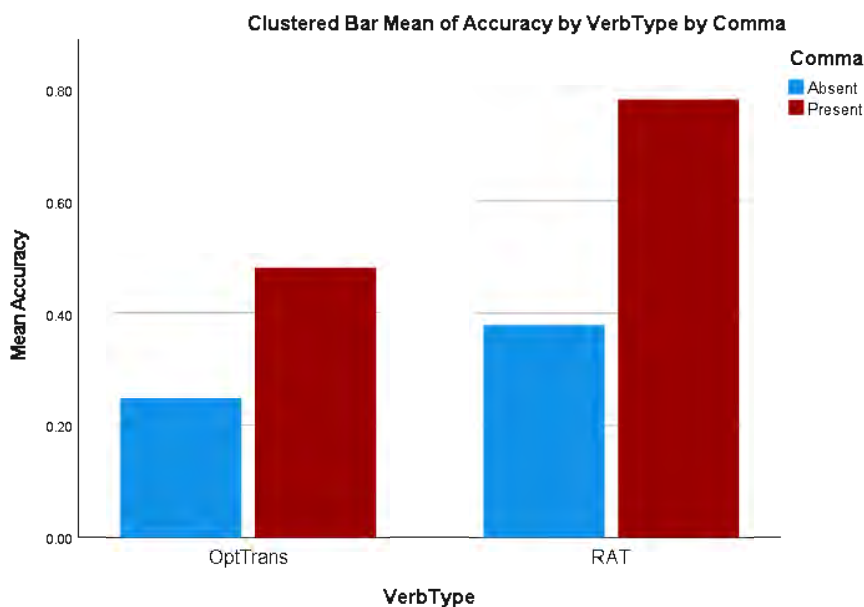


Figure 1. Comprehension Question Accuracy by Comma Presence and Verb Type

Table 1 shows mean values for proportion of regressions and regression-path duration on the two key regions of the sentence across the four experimental conditions.

Table 1

| Proportion of Regressions | <u>Verb</u> | <u>Spillover Region</u> |
|--------------------------------------|-------------|-------------------------|
| OptTrans – Comma Absent | 0.21 | 0.54 |
| OptTrans – Comma Present | 0.16 | 0.46 |
| RAT – Comma Absent | 0.28 | 0.54 |
| RAT – Comma Present | 0.18 | 0.53 |
| Regression-Path Duration (ms) | | |
| OptTrans – Comma Absent | 453.70 | 1382.74 |
| OptTrans – Comma Present | 371.24 | 800.17 |
| RAT – Comma Absent | 634.20 | 1179.75 |
| RAT – Comma Present | 436.94 | 812.59 |

Analysis of proportion of regressions on the disambiguating verb revealed a marginally significant main effect of comma presence ($F(1, 50) = 3.60, p = 0.06$) such that there were more regressions in the comma absent condition than in the comma present condition. There was a significant main effect of verb type on the disambiguating verb in proportion of regressions ($F(1, 50) = 6.39, p = 0.02$) such that the difference in regressions was significantly higher among the RAT sentences compared to the optionally transitive sentences. Furthermore, there was no

significant interaction between comma presence and verb type in proportion of regressions on the disambiguating verb ($F(1, 50) = 2.30, p = 0.136$). Analysis of proportion of regressions on the spillover region revealed a marginally significant main effect of verb type. ($F(1, 50) = 3.68, p = 0.06$) such that there were more regressions in the RAT verb condition than in the optionally transitive condition. There was no significant main effect of comma presence on the spillover region in proportion of regressions ($F(1, 50) = 1.58, p = 0.21$) nor was there an interaction between comma presence and sentence verb type ($F(1, 50) = 0.76, p = 0.39$).

Analysis of regression-path duration on the disambiguating verb revealed a main effect of comma presence ($F(1, 50) = 7.11, p = 0.01$) such that there were longer regression-path duration times in the comma absent condition than in the comma present condition. Also, analysis of regression-path duration on the disambiguating verb revealed a main effect of verb type ($F(1, 50) = 7.44, p = 0.01$) such that there were longer times in the RAT verb condition than in the optionally transitive condition. However, there was no significant interaction between comma presence and sentence verb type on the disambiguating verb for regression-path duration ($F(1, 50) = 0.81, p = 0.37$). For regression-path duration on the spillover region, there was a significant main effect of comma presence ($F(1, 50) = 40.75, p = 0.00$) such that when the comma was absent there were longer times compared to when the disambiguating comma was present. There was no significant main effect of sentence verb type of regression-path duration on the spillover region ($F(1, 50) = 0.97, p = 0.33$) nor was there a significant interaction ($F(1, 50) = 1.22, p = 0.28$).

Individual Differences Assessed by POPS

The POPS was used to assess whether individual differences can explain differences in sentence processing in GP sentences. In terms of the comprehension questions, there was no significant correlation between comprehension question accuracy and POPS scores ($r = 0.18, p = 0.21$).

Although there was no significant correlation between proportion of regressions and POPS scores on the disambiguating verb ($r = 0.23, p = 0.11$), there was a significant positive correlation on the spillover region ($r = 0.33, p = 0.02$). This pattern shows that higher POPS scores are associated with higher rates of regressions during reading (see Figure 2). Furthermore, there was no significant correlation between regression-path duration and POPS scores on the disambiguating verb ($r = 0.18, p = 0.21$). However, as was the case with proportion of regressions, there was a significant positive correlation on the spillover region between regression-path duration and POPS scores ($r = 0.31, p = 0.03$) such that higher POPS scores correlated with greater regression-path duration times in reading GP sentences (see Figure 3).

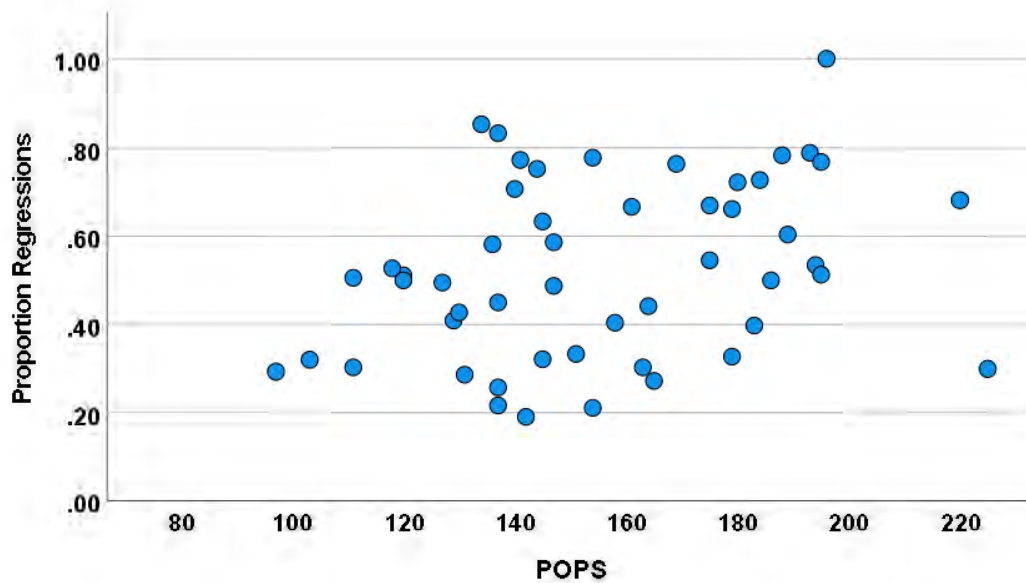


Figure 2. Scatterplot showing correlation between POPS scores and proportion of regressions on the spillover region

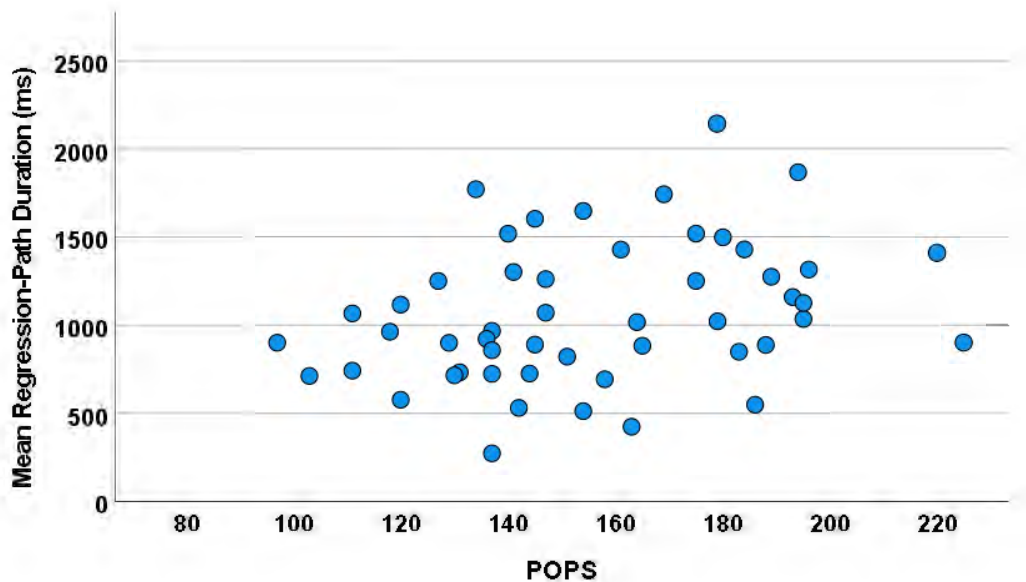


Figure 3. Scatterplot showing correlation between POPS scores and regression-path duration on the spillover region.

Discussion

The results of the current study replicate the results of Christianson et al. (2001) such that there is a much greater misunderstanding of GP sentences based on the analysis of comprehension questions. Thus, the current study extends this research by showing that both comma presence and verb type have a large influence on how the sentence is interpreted despite reanalysis after misinterpretation. This shows that with a simple disambiguating comma present ambiguous sentences are more easily understood than with the comma absent. Furthermore, differences in sentence verb type also had an impact on GP interpretation where RAT verb

sentences were more likely to be interpreted correctly than the optionally transitive verb sentence types.

This interpretation difficulty is also explained through proportion of regressions where readers tend to regress and reread more often when they land on the disambiguating verb that were influenced by the comma and verb manipulations. This shows similar results of regressive eye movements for reanalysis that was concluded by both Frazier and Rayner (1982) and Pickering and Traxler (1998). On the spillover region, it was observed that more people tend to regress when the sentence is a RAT verb. This indicates that although they read through the disambiguating verb, reanalysis might not take place until directly after the verb is processed. Similar results were obtained with regression-path duration measures where the comma manipulation and the verb type had an impact on the interpretation of GP sentences.

Overall, the results with the POPS show similarities with the Lee et al. (2018) study in a non-clinical college student sample measuring obsessive-compulsive personality traits. Those who showed higher rates of regressions and longer regression-path durations on the spillover region also tended to have higher POPS scores. This suggests that those who tend to have more obsessive-compulsive personality traits may have increased difficulty with processing of GP sentences and are more likely to be triggered to reanalyze, as seen through regressions. This connects back to the case study presented by Pinto (2019) where a graduate student diagnosed with OCPD reported higher rates of rereading of material compared to other graduate student counterparts. This was attributed to the fear of missing important information in the sentence and the need for perfectionism (Pinto, 2019).

More regressions and longer regression-path durations on the spillover region instead of on the disambiguating verb can be explained by a few factors. First, readers may regress and

process the interpretation just after looking at the disambiguating verb. This means that once they land on the spillover region only then do they decide to go back and reread. This also could be the case because many of the verbs used in the study were short consisting of only three or four letters each. Additionally, verbs were not assessed for frequency of use in the English language which could introduce variability among the different sentences presented.

Although these regressions could partly be explained by the POPS, there was little significance among the subscales of perfectionism and rigidity which was previously thought to be the most relevant for rereading and processing difficulty. Although the POPS has great internal validity, there is a wide range of statements that have to do with other personality traits, such as difficulty with change and emotional overcontrol. Potential future directions could be to use or develop a questionnaire that specifically focuses only on perfectionism and rigidity to have a wider range of those measures in regard to obsessive-compulsive personality traits.

Overall, this study showed that individual differences in personality traits can partly explain variability in the processing of garden-path sentences. There is very little previous work suggesting that personality characteristics are associated with sentence processing. As such, the results of this study suggest that future attempts to relate other types of personality characteristics to other types of language processing outcomes might be particularly fruitful.

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Appendix

Experimental Items

RAT Verb Sentences:

- 1a. While Jim bathed the child that was blond and pudgy giggled with extreme delight.
- 1b. While Jim bathed, the child that was blond and pudgy giggled with extreme delight.

- 2a. While the chimps groomed the baboons that were large and hairy sat in the grass.
- 2b. While the chimps groomed, the baboons that were large and hairy sat in the grass.

- 3a. While Frank dried off the car that was red and shiny sat in the driveway.
- 3b. While Frank dried off, the car that was red and shiny sat in the driveway.

- 4a. While Betty woke up the neighbor that was old and cranky coughed in the bedroom.
- 4b. While Betty woke up, the neighbor that was old and cranky coughed in the bedroom.

- 5a. While the thief hid the jewelry that was elegant and expensive sparkled brightly in the corner.
- 5b. While the thief hid, the jewelry that was elegant and expensive sparkled brightly in the corner.

- 6a. While Anna dressed the baby that was small and cute spit up on the bed.
- 6b. While Anna dressed, the baby that was small and cute spit up on the bed.

- 7a. While the boy washed the dog that was white and furry barked loudly and furiously.
- 7b. While the boy washed, the dog that was white and furry barked loudly and furiously.

- 8a. While the jockey settled down the horse that was sleek and brown stood in the stall.
- 8b. While the jockey settled down, the horse that was sleek and brown stood in the stall.

- 9a. While the mother undressed the baby that was bald and helpless cried softly and quietly.
- 9b. While the mother undressed, the baby that was bald and helpless cried softly and quietly.

- 10a. While the nurse shaved the patient that was tired and weak watched TV in bed.
- 10b. While the nurse shaved, the patient that was tired and weak watched TV in bed.

- 11a. While the girl scratched the cat that was gray and white stared at the dog.
- 11b. While the girl scratched, the cat that was gray and white stared at the dog.

- 12a. While the mother calmed down the children that were tired and irritable sat on the bed.
- 12b. While the mother calmed down, the children that were tired and irritable sat on the bed.

Optionally Transitive Verb Sentences:

- 13a. While the man hunted the deer that was brown and graceful ran into the woods.
13b. While the man hunted, the deer that was brown and graceful ran into the woods.
- 14a. While the skipper sailed the boat that was small and leaky veered off course completely.
14b. While the skipper sailed, the boat that was small and leaky veered off course completely.
- 15a. While the reporter photographed the rocket that was silver and white sat on the launch pad.
15b. While the reporter photographed, the rocket that was silver and white sat on the launch pad.
- 16a. While the orchestra performed the symphony that was short and simple played on the radio.
16b. While the orchestra performed, the symphony that was short and simple played on the radio.
- 17a. While the student read the notes that were long and boring blew off the desk.
17b. While the student read, the notes that were long and boring blew off the desk.
- 18a. While Jack ordered the fish that was silver and black cooked in a pot.
18b. While Jack ordered, the fish that was silver and black cooked in a pot.
- 19a. While Susan wrote the letter that was long and eloquent fell off the table.
19b. While Susan wrote, the letter that was long and eloquent fell off the table.
- 20a. While the secretary typed the memo that was clear and concise neared completion on the email.
20b. While the secretary typed, the memo that was clear and concise neared completion on the email.
- 21a. While the farmer steered the tractor that was big and green pulled the plough the entire length.
21b. While the farmer steered, the tractor that was big and green pulled the plough the entire length.
- 22a. While the lawyer studied the contract that was old and wrinkled lay on the roll-top desk.
22b. While the lawyer studied, the contract that was old and wrinkled lay on the roll-top desk.
- 23a. As Henry whittled the stick that was long and bumpy broke in half entirely.
23b. As Henry whittled, the stick that was long and bumpy broke in half entirely.
- 24a. While Rick drove the car that was red and dusty veered into a ditch.
24b. While Rick drove, the car that was red and dusty veered into a ditch.