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Comprehension of Legal Language by Adults with and without Traumatic Brain Injury

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Abstract

Objective—To characterize comprehension of written legal language in adults with and without traumatic brain injury (TBI).

Participants—19 adults with moderate-to-severe TBI (11 females) and 21 adults without TBI (13 females), ages 24–64 years.

Methods—Participants completed a multiple-choice assessment of legal-language comprehension, with written stimuli presented either in their original legal form or manipulated to simplify syntax or use more-frequently occurring words.

Results—Across stimulus types, TBI group participants were significantly less accurate and slower than comparison peers, with no effect of linguistic manipulation. Working memory and reading fluency test scores correlated with task accuracy and speed in both groups.

Conclusions—Adults with TBI underperformed their uninjured peers in both accuracy and speed on a task of legal -language comprehension, and these differences were attributable in part to differences in working memory and reading fluency. Results highlight the potential costs of TBI-related communication problems in criminal proceedings, and the need to formally evaluate language comprehension in individuals with TBI who are in the criminal justice system.

Keywords

traumatic brain injury; language; language comprehension tests; criminal law; constitutional law; adult; working memory; cognition

INTRODUCTION

Research on legal language suggests that “legalese” is both difficult to understand and difficult to act on,^{1–5} particularly for populations that are overrepresented within penal legal systems.^{6–9} For example, nearly 50% of juvenile participants who were able to accurately define the “right to silence” nevertheless believed that a judge could force them to discuss any wrongdoing later in court.¹⁰ Additionally, individuals with diagnoses of mental

illnesses who were recruited from competency-to-stand-trial wards had difficulty incorporating information such as the right to legal assistance into their decision-making,³ and adults with intellectual disabilities not only scored poorly on comprehension assessments but also tended to change their responses based on friendly feedback.¹¹ Given the social and financial costs associated with legal adjudication, these findings underscore the need to better understand how conditions associated with poor language comprehension affect the ability to understand legal language.¹²

Individuals with traumatic brain injury (TBI) are a group that may be at risk for poor comprehension of legal language. TBI can impair word-level processing speed,¹³ inference-making,¹⁴ the ability to resolve ambiguous or non-literal language^{15–19} and creation of mental representations of comprehended language. Deficits in working memory, processing speed, and working memory–driven metacognition are thought to underlie these language impairments.^{20–24} Individuals with TBI are also over-represented within legal systems: rates of TBI among incarcerated individuals are well above rates in the general population, even approaching one hundred percent in some reports.^{7,25–27} The over-representation of individuals with TBI within legal systems, high prevalence of cognitive-communication disorders in this group, and poor legal-language comprehension of groups with similar cognitive profiles all point to the need to better understand relationships among TBI, cognition, and legal language.

One example of legal language that may present comprehension challenges for individuals with TBI is the *plea colloquy*, a formal courtroom dialogue in which a judge engages a defendant in a conversation to determine whether the defendant is capable of entering a plea to a crime.^{28,29} Plea colloquies are critically important to considerations of due process and substantive justice,^{30–32} but because colloquies concern complex legal ideas such as giving up one's right to representation and one's right to a trial by jury, they generally use low-frequency, abstract words, complicated verbiage such as nominalizations, and stilted, stylized syntax. It is unclear, however, how these linguistic features affect plea colloquy comprehensibility. Plea-colloquy language may be particularly difficult for individuals with TBI, who may have deficits in cognitive functions necessary to comprehend abstract and complex language. An estimated 95% of US criminal cases end in plea deals, so knowledge about how they are understood by people with TBI would inform a critically important aspect of US law.

To investigate the relationships between TBI and legal-language comprehension, we asked: (1) whether individuals with TBI would demonstrate poorer and slower comprehension than their uninjured peers when reading plea-colloquy language; (2) whether simplifying plea-colloquy language would improve comprehension accuracy and speed, particularly in the TBI group; and (3) whether cognitive measures would predict comprehension accuracy and speed. Results would contribute to the literature at an important intersection of law, science, and policy and provide valuable empirical findings for policy and future investigations.

METHODS

Participants

Participants were 19 adults with moderate-to-severe TBI (11 females) and a healthy comparison group of 21 adults without TBI (13 females) matched group-wise for age, $t(38) = -0.24$, $p = 0.83$; and education or educational trajectory (if education was interrupted by the TBI), $t(32) = -0.71$, $p = 0.45$. All participants were from the US Midwest and were recruited as part of a larger study of social communication in adults with and without TBI. Participants with TBI were recruited based on self-reported history of moderate-to-severe TBI and then confirmed through medical records from time of injury or other documentation (e.g., participants' own copies of medical records).

Injury severity for the TBI group was defined using standard injury criteria.³³ For participants with TBI, average time post injury was 16.53 years ($SD = 14.15$), and mechanisms of injury were: motor vehicle accident ($n = 10$), fall ($n = 4$), assault ($n = 1$), sports-related injury ($n = 2$), or other injury ($n = 2$). A priori power calculations assuming moderate between-group effect sizes estimated that we had recruited a participant pool sufficient to power findings at $\beta = 0.8$. Table 1 shows participant characteristics.

Inclusion criteria for both groups were self-identification as a native English speaker and no self-reported history of a diagnosis of language or learning disability or neurological disorder affecting the brain (pre-injury for the TBI group). Exclusion criteria were: failing a pure-tone audiometric screening test at 20 dB at 500, 1000, 2000, and 4000 Hz; failing standard screening for far and near vision; testing within the aphasic range of the Western Aphasia Battery Bedside Screening Test (WAB);³⁴ and prior participation in a criminal plea hearing in a state court, indicated by self-report. This final exclusion criterion was to ensure that participants had not previously been exposed to the plea-colloquy language used in the experimental stimuli. Relevant ethics boards approved all procedures. All participants signed a written consent form before participating and received compensation.

Legal-Language Stimuli

1. Plea-Colloquy Stimuli—We constructed experimental stimuli using the State of Wisconsin Plea Questionnaire/Waiver of Rights Form ("PQF")(CR-227, Wisconsin Statutes § 971.08, see Figure S1). The PQF is the written form on which plea-colloquy dialogues are based, and contains questions and prompts that ask a defendant about various legal topics related to criminal law, including rights, understanding of legal procedures, and consequences of a plea. To test the hypothesis that language complexity affects comprehension, we prepared three stimulus versions for each item on the PQF form. The first version was the original item (unmodified manipulation, "UNM"). The second was a manipulated item in which words were replaced with more-frequently occurring synonyms (frequency manipulation, "FREQ"). We chose word substitutions from a language corpus derived from 40 transcripts of plea hearings observed by the first author: after purchasing official copies of the transcripts, we used a language-analysis software³⁵ to code the transcripts' content and produce a word corpus of the language used by judges during plea colloquies.

For the third version, the item's clause-level syntax was simplified, again using the language corpus derived from the court transcripts of plea hearings (the syntax manipulation, "SYNC"). An example is shown in Figure 1A. The final stimulus set comprised 26 separate items, each with the three versions. Based on the interaction between syntax and meaning,³⁶ we predicted that FREQ stimuli would facilitate comprehension through simplified meaning, while SYNC stimuli would facilitate comprehension through both simplified meaning and simplified syntax. Additional information on stimulus construction is provided in the Supplementary Materials.

2. Experimental Task—We constructed the experimental task using a forced multiple-choice format modeled on a commonly used standardized language test.³⁷ Each plea-colloquy stimuli item had four possible answers: 1) the correct interpretation of the item; 2) the opposite interpretation; (3) an alternative but incorrect interpretation; and (4) a literal/nonsense interpretation. Order of the four choices was randomized. Participants completed PQF items 1–26 sequentially, with the manipulation category (UNM, FREQ, or SYNC) randomized for each item across participants. An example is shown in Figure 1B and additional task information is presented in the Supplementary Materials.

3. Procedure—We automated the task using PsyScopeX software³⁸ on a MacBook Pro laptop computer. To facilitate participants' comprehension of instructions, the examiner read instructions aloud as the participants viewed them on the screen, and then asked participants if they had any questions before beginning the task. Participants received as much time as they needed to complete the task; however, to explore whether TBI affected response times, we recorded completion times for every item.

Additional Measures

Participants completed two standardized tests of language comprehension: the Woodcock-Johnson (WJ) Sentence Reading Fluency Task, which measures "narrow" reading comprehension;³⁹ and the WAB Bedside Screening Test, which measures word, sentence, and paragraph comprehension.³⁴ In addition to excluding individuals who scored in the aphasic range, we excluded participants who scored less than 6 on WAB Reading, the cutoff for passing scores. Participants completed the Wechsler Adult Intelligence Scale-Revised Digit Span (WAIS-DIGIT) task as a measure of working memory.⁴⁰ To characterize the sample, we also administered tests recommended by the Common Data Elements (CDE) working group⁴¹ for TBI research: the WAIS Processing Speed Index (WAIS-PSI), a measure of processing speed;⁴⁰ the California Verbal Learning Test (CVLT);⁴² and Trailmaking Tests A and B.⁴³

Participants completed the protocol in two testing sessions. In the first session, participants completed the WAB and CDE tests, in addition to other tasks as part of a larger study of social communication in adults. In the second session, participants completed the WJ, the WAIS-DIGIT, and the experimental task. Each session was approximately 1.5 hours, with a formal break approximately halfway through, and patients were encouraged to take breaks as needed.

Data Analysis

For our first aim, whether individuals with TBI were poorer comprehenders, we hypothesized that there would be a main effect of group, with individuals with TBI obtaining both lower comprehension-accuracy scores and slower response times than comparison-group individuals. For our second aim, whether modified plea-colloquy language improved comprehension, we hypothesized a main effect of manipulation type, with comprehension accuracy being lowest for UNM items, higher for FREQ items, and highest for SYNC items; and with response times being longest for UNM items, shorter for FREQ items, and shortest for SYNC items. We also hypothesized an interaction of group and manipulation type, with the item-manipulation effect being greater for individuals with TBI. For our third aim, whether cognitive measures predicted performance on plea-colloquy comprehension, we hypothesized that scores on working memory and processing speed tests would predict comprehension accuracy and task-completion time, i.e., that participants with lower cognitive test scores would have lower accuracy scores and take longer to complete the entire plea-colloquy test. We further hypothesized an interaction between cognitive measures and group, with larger effects of working memory and processing speed for the TBI group than the comparison group.

Hypotheses for aims one and two were analyzed using linear mixed-effects models regressing comprehension accuracy or comprehension response time on group, manipulation type, and the interaction term, with by-item effects for manipulation and a by-subject random intercept. Hypotheses one and three were analyzed using general linear models to regress comprehension accuracy or task-completion time on group, working memory and processing speed, and the interaction term, with reading fluency as a covariate to control for standardized reading-comprehension measures. Statistical analyses were conducted in R 3.1.2 (<http://www.R-project.org/>).⁴⁴ The criterion alpha level was 0.05. Mixed-effects models used contrasts to test the predicted pattern of means and residual between-group variance.⁴⁵

RESULTS

Results of neuropsychological tests are listed in Table 1. There were statistically significant between-group differences on every measure, with higher comparison-group scores: WAIS-DIGIT subtest, $t(36) = -4.27$, $p < 0.01$; the WAIS Processing Speed Index, $t(37) = -4.14$, $p < 0.01$; the WJ Total score, $t(30) = -3.79$, $p < 0.01$; Trailmaking Test A, $t(23) = -3.49$, $p < 0.01$, and B, $t(26) = -2.17$, $p < 0.05$; and California Verbal Learning Test 5-Trials, $t(31) = -5.51$, $p < 0.01$; Short Delay, $t(31) = -6.06$, $p < 0.01$; and Long Delay scores, $t(30) = -6.21$, $p < 0.01$. Additional details about error patterns are described in the Supplementary Materials (Table S1).

Effects of Item Manipulation and Group

Comprehension accuracy and response times are shown in Table 2. Analysis of accuracy revealed a significant main effect of group, with higher comparison-group scores across item types, $F(1,43) = 8.85$, $p < 0.01$, semi-partial $R = 0.17$; but no effect of manipulation, $F(1, 23) = 0.50$, $p = 0.48$; or interaction of group and manipulation, $F(1,23) = 2.87$, $p = 0.10$ (Figure

2A). Similarly, analysis of response time revealed a significant main effect of group, with faster response times in the comparison group across item types, $F(1,41) = 8.77$, $p < 0.01$, semi-partial $R = 0.18$; but no main effect of manipulation, $F(1,23) = 0.23$, $p = 0.63$, or the group–manipulation interaction, $F(1,76) = 1.33$, $p = 0.36$ (Figure 2B). Post-hoc power calculations from group means and standard deviations showed sufficient power assuming $\beta = 0.8$.

Effects of Working Memory and Processing Speed

Analysis of overall plea-colloquy comprehension accuracy with WAIS-DIGIT as a measure of working memory revealed a significant effect of working memory, $t(35) = 2.32$, $p < 0.05$, $\eta^2_p = 0.13$, but no main effect of group, $t(35) = 1.14$, $p = 0.26$, reading fluency, $t(35) = 0.737$, $p = 0.47$, or the group–working memory interaction, $t(35) = -1.54$, $p = 0.13$ (Figure 3A). Analysis of total plea-colloquy completion time with WAIS-DIGIT as a measure of working memory revealed a significant effect of reading fluency, $t(35) = -4.62$, $p < 0.01$, $\eta^2_p = 0.38$; but no significant effect of group, $t(35) = -1.12$, $p = 0.27$, working memory, $t(35) = 0.96$, $p = 0.35$, or group–working memory interaction, $t(35) = -1.21$, $p = 0.24$ (Figure 3B). Post-hoc power analysis of full-model R^2 to baseline for estimated number of parameters showed the model was sufficiently powered assuming $\beta = 0.08$. Adding processing speed as a covariate did not alter the significance of the effect of working memory on overall plea-colloquy accuracy, $t(34) = 2.10$, $p < 0.05$, $\eta^2_p = 0.11$, or the effect of reading fluency on total plea-colloquy completion time, $t(34) = -3.73$, $p < 0.01$, $\eta^2_p = 0.29$ (Figures S2A and S2B).

Analysis of overall plea-colloquy comprehension accuracy with WAIS-PSI as a measure of processing speed revealed a significant effect of group, $t(35) = 2.15$, $p < 0.05$, $\eta^2_p = 0.11$. There were no significant effects of processing speed, $t(35) = 1.32$, $p = 0.19$, reading fluency, $t(35) = -0.27$, $p = 0.84$, or the group–processing speed interaction, $t(35) = -1.87$, $p = 0.07$, $\eta^2_p = 0.19$ (Figure 3C). Analysis of effects of WAIS-PSI scores on total plea-colloquy completion time revealed a significant main effect of reading fluency, $t(35) = -2.84$, $p < 0.01$, $\eta^2_p = 0.19$. There were no significant effects of group, $t(35) = -1.08$, $p = -0.29$, processing speed, $t(35) = 0.30$, $p = 0.77$, or the group–processing speed interaction, $t(35) = 0.81$, $p = 0.43$ (Figure 3D). Post-hoc power analysis of full-model R^2 to baseline for number of estimated parameters showed the model was sufficiently powered assuming $\beta = 0.08$. Adding working memory as a covariate eliminated the significant effect of group on overall accuracy, but did not change the significance of reading fluency on overall completion time, $t(34) = -2.77$, $p < 0.01$, $\eta^2_p = 0.18$ (Figures S2C and S2D).

DISCUSSION

Effects of Group

Our findings of an effect of group on comprehension accuracy and response times supported our first aim's hypothesis. Not only do these results indicate that individuals with TBI are more likely to be poorer, and slower, comprehenders of legal language, they suggest that individuals with TBI are at an increased risk of misunderstanding language within legal contexts, which could negatively affect legal outcomes, whether in the form of adjudications, convictions, or restricted participation in legal proceedings. These findings parallel earlier

data on legal-language comprehension in other populations with cognitive deficits or disabilities,^{3-5,10,11,44} and contribute new evidence about potential obstacles within judicial proceedings for individuals with TBI.

Effect of Linguistic Manipulation

For our second aim, we found neither an effect of item -manipulation category nor an interaction between group and item manipulation. These findings did not support our hypotheses: in both groups there were no statistically significant differences in accuracy across the three categories of item manipulations. The lack of significant manipulation effects could reflect several factors. First, the manipulations types may have been too subtle to affect comprehension. We constructed our word corpus from highly educated legal professionals speaking in technical legal contexts, and given the complex nature of the original plea-colloquy form's language, it is possible that neither word frequency nor clause-level syntax alone was sufficient to improve comprehension. This explanation is consistent with the finding of high error rates among adults with TBI across all three manipulation categories, and the lack of a ceiling effect in the uninjured group. Second, it is possible that our experimental condition, which allowed participants as much time as needed to thoroughly read every stimulus, avoided the trade-off between accuracy and speed that has been noted in individuals with TBI on timed tasks.⁴⁷ In real-world legal settings, where time pressure is often intense, such a trade-off may be necessary, and effects of linguistic manipulation may emerge accordingly. If time pressure impedes an individual's ability to understand legal language there could be risks of violating legal rules or ethical guidelines; for individuals with TBI, who may have fewer cognitive resources to accommodate external pressures, these risks could be even greater.

Effect of Cognitive Mechanisms

Our findings revealed significant effects of cognitive mechanisms on our comprehension outcomes, a finding that was partially consistent with our third aim's hypotheses. However, we also found that group differences in comprehension measures of plea-colloquy language disappeared when controlling for working memory, processing speed, and reading fluency: effectively, differences between the two groups were explained by working memory in the case of total comprehension accuracy, and reading fluency in the case of total completion time. While we did not anticipate these results, we believe that they align with both the literature on language comprehension post-TBI and also the current understanding of language comprehension processes in typical adults. Because language comprehension is highly distributed throughout human neural architecture,^{48,49} it may be particularly sensitive to the diffuse damage that is caused by TBI and that is known to affect other distributed cognitive functions.^{50,51} Additionally, because language comprehension recruits domain-general functions (including working memory and processing speed),²¹⁻²⁴ diffuse post-TBI damage may compromise not just legal-language comprehension's underlying neural architecture but also legal-language comprehension's underlying cognitive architecture that relies on intact, whole-brain connectivity. Taken together, our findings suggest a crucial role of working memory and reading fluency in explaining the comprehension deficits seen in individuals with TBI. Regardless of the mechanisms underlying comprehension problems, adults with TBI made more errors in comprehension,

and this finding has critical legal implications if those errors contribute to an impaired ability to participate in legal proceedings or communicate with legal professionals.

Limitations and Future Directions

Our study had several limitations. First, our language manipulations were relatively subtle. More extreme language modifications that are not bound by the strict *a priori* guidelines we set may be able to create manipulations that are more divergent. For example, using a word corpus that was standardized across the general public, or at a basic reading-level difficulty, could allow for word substitutions better able to simplify meaning. While our study's stimuli effectively identified problems in legal language, and suggest that simplifying legal language is not necessarily a straightforward task, the results underscore the need for additional studies to better identify ways to simplify language and promote comprehension.

Second, while the lack of a manipulation effect cannot be attributed to the small sample size (mean differences were very small and estimated sample sizes for significant interactions were very large), sample characteristics could have had other effects. Perhaps most important, participants were a relatively homogeneous sample of adults from the US Midwest, and overall were a relatively well-educated sample. Also, because the inclusion and exclusion criteria participants did not represent the range of language and other communication impairments that can be associated with TBI, these factors likely resulted in underestimation of the impact of TBI on language comprehension in legal contexts.

Third, we underscore that the purpose of this study was to investigate the relationship between TBI and legal-language comprehension. It was not our intention to investigate the relationship between comprehension outcomes of legal language and comprehension outcomes of non-legal language. We show that one measure of "domain-general" language comprehension, the Woodcock-Johnson Sentence Fluency task, predicts comprehension measures of plea-colloquy legal language; based on this finding, and the broader literature, we assume that individuals who are better at comprehending non-legal language will be better at comprehending legal language, and vice-versa. Future studies could very well devise experimental designs to reliably test this question. See the Supplementary Materials for additional interpretation of the results.

CONCLUSION

Adults with TBI made significantly more comprehension errors on a task of legal language derived from plea colloquies than did their uninjured peers, even in a highly controlled and supportive environment. These findings are an informative first step in identifying relationships among TBI, cognition, and legal-language comprehension, and they point to potential interventions and accommodations that could be adopted to better facilitate comprehension by individuals with TBI in legal contexts.

METHODS

Stimulus Construction

The first author attended 40 plea hearings from 11 circuit courts in the state of Wisconsin. Variability is a well-described characteristic of Miranda-warning language,^{1,2} and we wanted to capture as much variability as possible within our stimuli to ensure that they were as ecologically valid as possible. Plea hearings were chosen based on scheduling availability, and neither author had any background knowledge about the defendants present in the hearings or about specific details of the cases. The first author either attended proceedings unannounced or informed court staff beforehand that he was a student performing courtroom observations as part of his degree program. Because court rules prohibited video or audio recording, the first author recorded start and end times for the plea-colloquy portion of the hearings and took notes about both verbal features of the dialogues (e.g., the pronunciation of proper nouns) and non-verbal communication (e.g., gestures).

We then purchased official transcripts for each of the 40 proceedings from the court reporters, and then used CHAT/CLAN language-analysis software³ to code the transcripts. We first segmented the transcripts into C-Units, defined as independent clauses with modifiers.⁴ The first author coded all transcripts, and then a trained undergraduate research assistant performed reliability coding on four transcripts (10%) to ensure that the C-Unit segmentation method was reliable. Inter-rater agreement was 95% or higher for all transcription and coding measures. We used C-Units as the unit of analysis for two reasons. First, from a theoretical standpoint, we wanted a unit of analysis based on linguistic meaning. Second, from a practical standpoint, we did not have audio recordings so we could not use prosodic elements as part of the discourse segmentation process. C-Units were appropriate from both standpoints because they cannot be further divided without loss of essential meaning, and they can be determined entirely from grammar.

To construct the experimental stimuli, we used the word corpus of the 40 plea colloquies. First, we used CHAT/CLAN to obtain a total list of all words used by the judges during the 40 plea colloquies. We specifically isolated words used by the judges because the judge is the actor during the plea colloquy who delivers, or otherwise uses, the legal language used in the plea colloquy. We established the following rules for constructing the corpus: we ignored verb and noun morphology, although we included participial adjectives and gerunds as separate items; we excluded proper nouns and numbers; and we counted only the specific parts of speech in which each word occurred (e.g., “face” occurred as a verb, but not as a noun). Our final corpus contained approximately 900 words. Next, we used items taken from the State of Wisconsin Plea Questionnaire/Waiver of Rights Form (hereafter PQF)(CR-227, Wisconsin Statutes § 971.08. See Figure SI). The PQF contains approximately 40 items that ask the defendant about constitutional rights, understandings of the proceeding, and the voluntariness of the plea. We excluded 14 items relating to personal history or the PQF document format (e.g., “I have reviewed and understand this entire document”), leaving 26 items for the experimental task. We selected a charge of *disorderly conduct* as the “crime” in the plea-colloquy stimuli, as this was the most common offense that the first author observed in the plea hearings.

For each of the 26 PQF items, we performed four linguistic manipulations. First, we manipulated word abstraction. Using concreteness ratings from the corpus of Brysbaert et al.,⁵ we replaced words in the PQF items with more concrete synonyms from our plea-colloquy word corpus (e.g., “disorderly conduct” became “disorderly behavior.”). Second, we manipulated word frequency, again using the Brysbaert et al. (2014) corpus data. We replaced words in the PQF items with more frequently occurring synonyms from our plea-colloquy word corpus. The more-frequent synonyms included synonyms that were also more concrete (e.g., “entering this plea” became “making this plea.”). Third, we manipulated verb-level syntax. While keeping vocabulary consistent, we simplified verb voice (e.g., from active to passive) and/or verb tense and aspect (e.g., present perfect to simple past). Fourth and finally, we manipulated clause-level syntax. Again keeping vocabulary consistent, we simplified overall item syntax by separating compound sentences, replacing nominalizations with verbs (e.g., “exclusion” to “exclude”), or replacing noun phrases with subordinate clauses (e.g., “by entering this plea” to “when I enter this plea”). For each item in all four manipulations, we substituted every component that had legal importance unless it was impossible to do so without substantively altering sentence meaning. The resulting item set contained 208 manipulated stimuli.

Next, we obtained pilot data on the manipulated stimuli. Six individuals who had no legal training or expertise were asked to rate each stimulus on a scale of 1–5 for overall abstractness (for abstraction and frequency manipulation) or grammatical difficulty (for verb-level and clause-level syntax manipulations). Pilot ratings indicated that items manipulated for word frequency and clause-level syntax were less abstract and less grammatically difficult, respectively. We compiled a final stimulus set ($n=52$) by selecting one word-frequency manipulated item and one clause-level – syntax manipulated item for each of the 26 PQF items. The selection criterion was pilot scores within a range of ± 1 , or, if that was not possible, pilot scores with the least variability.

The final stimulus set consisted of three versions of each of the 26 PQF items: (1) the original item without any manipulation to word choice or syntax (unmodified, UNM); (2) the item modified for word frequency (frequency manipulation, FREQ); and (3) the item modified for clause-level syntax (syntax manipulation, SYNC). Test items were a forced-multiple choice format with the following response choices: (1) the correct interpretation of the item; (2) the opposite interpretation of the item; (3) an alternative but incorrect interpretation of the item; and (4) a literal/nonsense interpretation of the item. Each item’s three manipulations (UNM, FREQ, and SYNC) had answer choices that overlapped as much as possible; for example, an item would use the same “alternative but incorrect” answer choice for the UNM, FREQ, and SYNC manipulations.

Error Patterns

Table S1 shows error types by group. Error patterns were summarized by calculating the number of errors in each error category: opposite meaning, literal meaning, or alternate legal interpretation. Paired-samples *t*-tests showed that the TBI group made significantly more errors than CG participants overall, $t(34) = 23.13$, $p < 0.01$; and significantly more opposite-type errors, $t(20) = 3.01$, $p < 0.01$, and alternate legal-type errors, $t(29) = 2.72$, $p < 0.05$,

than CG participants. The two groups were not significantly different on number of literal-type errors, or on the proportion of each error type.

DISCUSSION AND LIMITATIONS

We want to emphasize that even though we designed this study to be as ecologically valid as possible, actual courtroom contexts would introduce substantial additional working-memory and speed-of-processing challenges. For example, the first author's observations suggest that actual plea hearings present legal language approximately four times faster than our participants' average completion times. That is, if our participants had been participating in an actual plea hearing, they would have had only a quarter of the time to experience, comprehend, and respond to the plea-colloquy language. In addition, the communication demands of a courtroom setting (e.g., navigating social communication demands) could tax cognitive resources. All plea hearings use a written plea form (which the defendant fills in and submits to the judge before the plea colloquy), and we presented legal language in a written format to minimize working-memory demands, to standardize the experimental delivery, and to ease data collection. Nevertheless, plea colloquies are conducted as a verbal dialogue, and so they require not just language but also communication. Finally, actual criminal defendants are often asked to simply indicate whether or not they understand a given question. While simpler than our multiple-choice design, this yes/no format assumes that the individual has (1) the working memory (and possibly processing-speed) resources necessary to construct a situation model in real time; and (2) the metacognition necessary to monitor that model to decide whether or not it is correct. Because participants made errors on items that they ostensibly thought they had answered correctly, these assumptions within the legal system may not always be valid. Even though it would be near-impossible to model these courtroom conditions in a valid experimental design, if anything, this study underrepresents the cognitive demands of comprehending plea-colloquy legal language, for individuals with or without TBI. Knowing that individuals with TBI show poorer, slower comprehension even under relatively ideal conditions highlights the difficulties that they are likely to face in real-world legal settings and accentuates the need to develop policies and safeguards to ensure that individuals with TBI can reach the legally mandated levels of understanding when they participate in a plea hearing.

Finally, we caution that framing the question as "Are individuals with TBI better at understanding non-legal language than they are at legal language?" may have narrow translational value. Because the US legal system does not provide people with the option to request non-legal alternatives to legal language (indeed, the plea-colloquy language we used is mandated by state statute), simply demonstrating that an individual would do better with an entirely different set of language circumstances may not have empirical or practical utility.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

References

1. Rogers R, Rogstad JE, Gillard ND, Drogin EY, Blackwood HL, Shuman DW. "Everyone knows their Miranda rights": Implicit assumptions and countervailing evidence. *Psychology, Public Policy, and Law*. 2010; 16(3):300–318.
2. Rogers R, Hazelwood LL, Sewell KW, Shuman DW, Blackwood HL. The comprehensibility and content of juvenile Miranda warnings. *Psychology, Public Policy, and Law*. 2008; 14(1):63–87.
3. Rogers R, Harrison KS, Hazelwood LL, Sewell KW. Knowing and Intelligent: A Study of Miranda Warnings in Mentally Disordered Defendants. *Law and Human Behavior*. 2007; 31:401–418. [PubMed: 17245635]
4. Rogers R, Fiduccia CE, Drogin EY, Steadham JA, Clark JW III, Cramer RJ. General Knowledge and Misknowledge of Miranda Rights: Are Effective Miranda Advisements Still Necessary? *Psychology, Public Policy, and Law*. 2013; 19:432–452.
5. Rogers R, Blackwood HL, Fiduccia CE, Steadham JA, Drogin EY, Rogstad JE. Juvenile Miranda Warnings: Perfunctory Rituals or Procedural Safeguards? *Criminal Justice and Behavior*. 2012; 39(3):229–249.
6. Fazel S, Seewald K. Severe mental illness in 33,588 prisoners worldwide: systematic review and meta-regression analysis. *Br J Psychiatry*. 2012; 200(5):364–373. [PubMed: 22550330]
7. Fazel S, Lichtenstein P, Grann M, Langstrom N. Risk of violent crime in individuals with epilepsy and traumatic brain injury: a 35-year Swedish population study. *PLoS Med*. 2011; 8(12):e1001150. [PubMed: 22215988]
8. Fazel S, Danesh J. Serious mental disorder in 23 000 prisoners: a systematic review of 62 surveys. *The Lancet*. 2002; 359(9306):545–550.
9. Snow PC, Powell MB. Oral language competence in incarcerated young offenders: links with offending severity. *Int J Speech Lang Pathol*. 2011; 13(6):480–489. [PubMed: 21682546]
10. Zelle H, Romaine CL, Goldstein NE. Juveniles' Miranda comprehension: Understanding, appreciation, and totality of circumstances factors. *Law Hum Behav*. 2015; 39(3):281–293. [PubMed: 25495714]
11. O'Connell MJ, Garmoe W, Goldstein NE. Miranda comprehension in adults with mental retardation and the effects of feedback style on suggestibility. *Law Hum Behav*. 2005; 29(3):359–369. [PubMed: 15965633]
12. Wszalek JA. Ethical and Legal Concerns Associated With the Comprehension of Legal Language and Concepts. *AJOB Neuroscience*. 2017; 8(1):26–26. [PubMed: 30918742]
13. Russell KC, Arenth PM, Scanlon JM, Kessler L, Ricker JH. Hemispheric and executive influences on low-level language processing after traumatic brain injury. *Brain Inj*. 2012; 26(7–8):984–995. [PubMed: 22571331]
14. Johnson JE, Turkstra LS. Inference in conversation of adults with traumatic brain injury. *Brain Inj*. 2012; 26(9):1118–1126. [PubMed: 22642382]
15. Angeleri R, Bosco FM, Zettin M, Sacco K, Colle L, Bara BG. Communication impairment in traumatic brain injury: A complete pragmatic assessment. *Brain & Language*. 2008; 107:229–254. [PubMed: 18267340]
16. Baldo JV, Kacirik NA, Moncrief A, Beghin F, Dronkers NF. You may now kiss the bride: Interpretation of social situations by individuals with right or left hemisphere injury. *Neuropsychologia*. 2016; 80:133–141. [PubMed: 26546561]
17. Honan CA, McDonald S, Gowland A, Fisher A, Randall RK. Deficits in comprehension of speech acts after TBI: The role of theory of mind and executive function. *Brain & Language*. 2015; 150:69–79. [PubMed: 26335998]
18. Turkstra LS. Conversation-based assessment of social cognition in adults with traumatic brain injury. *Brain Injury*. 2008; 22(5):397–409. [PubMed: 18415720]
19. McDonald S. Exploring the Process of Inference Generation in Sarcasm: A Review of Normal and Clinical Studies. *Brain and Language*. 1999; 68:486–506. [PubMed: 10441190]
20. Sandry J, DeLuca J, Chiaravalloti N. Working memory capacity links cognitive reserve with long-term memory in moderate to severe TBI: a translational approach. *J Neurol*. 2015; 262(1):59–64. [PubMed: 25287019]

21. Kendeou P, Smith ER, O'Brien EJ. Updating during reading comprehension: why causality matters. *J Exp Psychol Learn Mem Cogn*. 2013; 39(3):854–865. [PubMed: 22845069]
22. Kendeou P. Validation and Comprehension: An Integrated Overview. *Discourse Processes*. 2014; 51(1–2):189–200.
23. Hacker, DJ. Self-regulated comprehension during normal reading. In: Hacker, DJ, Dunlonsky, J, Graesser, AC, editors. *Metacognition in Educational Theory and Practice*. Mahwah, NJ: Lawrence Erlbaum Associates; 1998. 165–191.
24. McNamara, DS, Magliano, J. *Psychology of Learning and Motivation*. Vol. 51. Elsevier; 2009. Toward a Comprehensive Model of Comprehension; 297–384.
25. Farrer TJ, Hedges DW. Prevalence of traumatic brain injury in incarcerated groups compared to the general population: a meta-analysis. *Prog Neuropsychopharmacol Biol Psychiatry*. 2011; 35(2): 390–394. [PubMed: 21238529]
26. Farrer TJ, Frost RB, Hedges DW. Prevalence of traumatic brain injury in juvenile offenders: a meta-analysis. *Child Neuropsychol*. 2013; 19(3):225–234. [PubMed: 22372420]
27. Williams WH, Cordan G, Mewse AJ, Tonks J, Burgess CN. Self-reported traumatic brain injury in male young offenders: a risk factor for re-offending, poor mental health and violence? *Neuropsychol Rehabil*. 2010; 20(6):801–812. [PubMed: 21069616]
28. Wszalek JA, Turkstra LS. Language impairments in youths with traumatic brain injury: implications for participation in criminal proceedings. *J Head Trauma Rehabil*. 2015; 30(2):86–93. [PubMed: 25734839]
29. *Godinez v. Moran*, (US Supreme Court 1993).
30. *Brady v. U.S.*, (US Supreme Court 1970).
31. *Miranda v. Arizona*, (US Supreme Court 1966).
32. Malec JF, Brown AW, Leibson CL, et al. The mayo classification system for traumatic brain injury severity. *J Neurotrauma*. 2007; 24(9):1417–1424. [PubMed: 17892404]
33. Kertesz, A. *Western Aphasia Battery - Revised (WAB-R): Examiner's Manual*. Pearson PsyCorp; 2006.
34. MacWhinney B, Wagner J. Transcribing, searching and data sharing: the CLAN software and the TalkBank data repository. *Gesprächforschung*. 2010; 11:154–173.
35. Hughes, D, McGillivray, L, Schmidek, M. *Guide to narrative language: Procedures for assessment*. Eau Claire, WI: Thinking Publication; 1997.
36. McKoon G, Ratcliff R. Interactions of meaning and syntax: Implications for models of sentence comprehension. *Journal of Memory and Language*. 2007; 56(2):270–290.
37. Semel, W, Wiig, EH, Secord, WA. *Clinical Evaluation of Language Fundamentals-Metalinguistics*. 5. San Antonio, TX: Pearson Assessments; 2014.
38. Cohen JD, MacWhinney B, Flatt M, Provost J. *PsyScope: A new graphic interactive environment for designing psychology experiments*. *Behavioral Research Methods, Instruments, and Computers*. 1993; 25(2):257–271.
39. Wechsler, D. *Wechsler Adult Intelligence Scale*. 4. San Antonio, TX: Pearson; 2008.
40. Schrank, FA, Mather, N, McGrew, KS. *Woodcock-Johnson IV Tests of Achievement*. Rolling Meadows, IL: Riverside; 2014.
41. Wilde EA, Whiteneck GG, Bogner J, et al. Recommendations for the use of common outcome measures in traumatic brain injury research. *Arch Phys Med Rehabil*. 2010; 91(11):1650–1660. [PubMed: 21044708]
42. Team RC. *R: A Language and Environment for Statistical Computing*. Vienna, Austria: R Foundation for Statistical Computing; 2014.
43. Abelson RP, Prentice DA. Contrast Tests of Interaction Hypotheses. *Psychological Methods*. 1997; 2(4):315–328.
44. Cooper VG, Zapf PA. Psychiatric Patients' Comprehension of *Miranda* Rights. *Law and Human Behavior*. 2008; 32:390–405. [PubMed: 17674169]
45. Turken AU, Dronkers NF. The neural architecture of the language comprehension network: converging evidence from lesion and connectivity analyses. *Front Syst Neurosci*. 2011; 5:1. [PubMed: 21347218]

46. Price CJ. A review and synthesis of the first 20 years of PET and fMRI studies of heard speech, spoken language and reading. *Neuroimage*. 2012; 62(2):816–847. [PubMed: 22584224]
47. Bigler ED. Systems Biology, Neuroimaging, Neuropsychology, Neuroconnectivity and Traumatic Brain Injury. *Front Syst Neurosci*. 2016; 10:55. [PubMed: 27555810]
48. Hayes JP, Bigler ED, Verfaellie M. Traumatic Brain Injury as a Disorder of Brain Connectivity. *J Int Neuropsychol Soc*. 2016; 22(2):120–137. [PubMed: 26888612]
49. Battistone M, Woltz D, Clark E. Processing speed deficits associated with traumatic brain injury: processing inefficiency or cautiousness? *Appl Neuropsychol*. 2008; 15(1):69–78. [PubMed: 18443943]

References

1. Rogers R, Blackwood HL, Fiduccia CE, Steadham JA, Drogin EY, Rogstad JE. Juvenile Miranda Warnings: Perfunctory Rituals or Procedural Safeguards? *Criminal Justice and Behavior*. 2012; 39(3):229–249.
2. Rogers R, Hazelwood LL, Sewell KW, Shuman DW, Blackwood HL. The comprehensibility and content of juvenile Miranda warnings. *Psychology, Public Policy, and Law*. 2008; 14(1):63–87.
3. MacWhinney B, Wagner J. Transcribing, searching and data sharing: the CLAN software and the TalkBank data repository. *Gesprachforschung*. 2010; 11:154–173.
4. Hughes, D, McGillivray, L, Schmidek, M. Guide to narrative language: Procedures for assessment. Eau Claire, WI: Thinking Publication; 1997.
5. Brysbaert M, Warriner AB, Kuperman V. Concreteness ratings of 40 thousand generally known English word lemmas. *Behav Res Methods*. 2014; 46(3):904–911. [PubMed: 24142837]

Figure 1.

Experimental stimuli based on plea-colloquy language. **(A)** Example of experimental PDQ item (1_*) showing unmodified (UNM), frequency manipulation (FREQ), and syntax manipulation (SYNC) options. **(B)** Scree-capture of task stimuli as completed by participants using the PsyScope software. The Q, R, U, and P keys on the computer keyboard were labeled with stickers showing the symbols ¥, Δ, ≈, and ø; these symbols corresponded to the four options in the forced multiple-choice question. Participants were asked to press the key corresponding to the option they thought best matched the bolded sentence at the top of the screen.

Figure 2.

Average comprehension accuracy (**A**) and response time (**B**) by group and manipulation. Bars are mean percent accuracy or response time in seconds with 95% confidence intervals. (**A**) A LMEM regressing accuracy on group and item type, $R^2c = 0.39$, showed a main effect of group, $F(1,43) = 8.85$, $p < 0.01$, but no main effect of manipulation, $F(1, 23) = 0.50$, $p = 0.48$ or the interaction term, $F(1,23) = 2.87$, $p = 0.10$. (**B**) A LMEM regressing accuracy on group and item type, $R^2c = 0.62$, showed a main effect of group, $F(1,41) = 8.77$, $p < 0.01$, but no main effect of manipulation, $F(1,23) = 0.23$, $p = 0.63$ or the interaction term, $F(1,76) = 1.33$, $p = 0.36$. ** $p < 0.01$

Figure 3.

Effects of cognitive mechanisms on comprehension measures of plea-colloquy language.

Plots show overall comprehension accuracy (A) or completion time (B) by group and working memory; and comprehension accuracy (C) or completion time (D) by group and processing speed. (A) a linear model regressing accuracy on group and working memory with reading fluency as a covariate showed a significant effect of working memory, $t(35) = 2.32$, $p < 0.05$, $\eta^2_p = 0.13$, but no main effect of group, $t(35) = 1.14$, $p = 0.26$, reading fluency, $t(35) = 0.737$, $p = 0.47$ or the interaction between group and working memory, $t(35) = -1.54$, $p = 0.13$. (B) a linear model regressing total comprehension time on group and working memory with reading fluency as a covariate showed a significant effect of reading fluency, $t(35) = -4.62$, $p < 0.01$, $\eta^2_p = 0.38$; there was no significant effect of group, $t(35) = -1.12$, $p = 0.27$, working memory, $t(35) = 0.96$, $p = 0.35$, or the interaction term, $t(35) = -1.21$, $p = 0.24$. (C) a linear model regressing accuracy on group and processing speed with reading fluency as a covariate showed a significant effect of group, $t(35) = 2.15$, $p < 0.05$, $\eta^2_p = 0.11$, and a trend toward significance for the interaction term, $t(35) = -1.87$, $p = 0.07$, $\eta^2_p = 0.06$, but no main effect of processing speed, $t(35) = 1.32$, $p = 0.19$, or reading fluency, $t(35) = -0.27$, $p = 0.84$. (D) a linear model regressing total comprehension time on group and processing speed with reading fluency as a covariate showed a significant main effect of reading fluency, $t(35) = -2.84$, $p < 0.01$, $\eta^2_p = 0.19$. There were no significant effects of group, $t(35) = -1.08$, $p = 0.29$, processing speed, $t(35) = 0.30$, $p = 0.77$, or the group/processing speed interaction, $t(35) = 0.81$, $p = 0.43$.

Table 1

Participant demographic and neuropsychological characteristics.

	TBI Group (n = 19)	Comparison Group (n = 21)
Age in Years	42.27 (12.56)	43.29 (14.50)
Age Range	24.75 – 64.50	19.17 – 64.67
Females (n, %)	11 (58%)	13 (62%)
Highest Level of Education (n)		
High School/GED	2	2
Some College/Associates Degree/Technical Degree	7	3
Bachelors Degree	6	13
Graduate Degree	3	3
WAIS-DIGIT		
Raw	14.53 (3.49)	19.52 (4.17) **
Scaled	8.42 (2.22)	11.90 (3.13) **
WJ		
Total	66.00 (25.73)	89.81 (15.05) **
Grade Estimate	8.89 (4.69)	12.21 (1.57) **
WAIS-PSI	91.89 (19.93)	114.62 (16.48) **
Trailmaking A	–0.61 (1.87)	0.92 (0.60) **
Trailmaking B	–1.63 (4.49)	0.72 (1.95) *
CVLT – 5 trials	43.53 (11.75)	60.10 (7.42) **
CVLT – Short delay	–0.97 (1.09)	0.68 (0.63) **
CVLT – Long delay	–1.16 (1.21)	0.72 (1.95) **

Data are mean (SD) unless otherwise noted.

*
p < 0.05;**
p < 0.01

Table 2

Comprehension accuracy (% correct) and response time by group and condition for plea-colloquy stimuli. Values are mean (SD).

	TBI Group (n = 19)	Comparison Group (n = 21)
Total accuracy	0.71 (0.22)	0.90 (0.08)
Total response time (min)	19.24 (9.96)	12.96 (3.89)
Unmodified stimuli (UNM)		
Accuracy	0.77 (0.51)	0.94 (0.10)
Response time (sec)	46.51 (25.90)	29.76 (8.36)
Frequency-manipulated stimuli (FREQ)		
Accuracy	0.74 (0.27)	0.90 (0.12)
Response time (sec)	45.05 (22.08)	29.22 (9.65)
Syntax-manipulated stimuli (SYNC)		
Accuracy	0.67 (0.24)	0.87 (0.13)
Response time (sec)	43.62 (19.37)	30.08 (12.58)