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Impaired theory of mind in adults with traumatic brain injury: A replication and extension of findings

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Abstract

Objective—To replicate a previous study of Theory of Mind (ToM) task performance in adults with traumatic brain injury (TBI) under different working memory (WM) demands, and determine if there are sex-based differences in effects of WM load on ToM task performance.

Method—58 adults with moderate-severe TBI (24 females) and 66 uninjured adults (34 females) matched group-wise for age, sex, and education viewed a series of video vignettes from the Video Social Inference Task (VSIT) (Turkstra, 2008) and answered ToM questions. Vignette presentation format required updating and maintenance of information, and WM load was manipulated by varying presence of distracters.

Results—There were main effects of group and WM load, no significant effect of sex, and a marginal interaction of group by WM load, with larger between-group differences in conditions with higher WM load. VSIT scores for the condition with the highest WM load were significantly correlated with scores on the first trial of the California Verbal Learning Test.

Conclusions—We replicated findings of lower scores in adults with TBI on a video-based ToM task, and provided additional evidence of the effect of WM load on social cognition task performance. There were no significant accuracy differences between men and women, inconsistent with prior evidence – including our own data using the same test. There is strong evidence of a female advantage on other social cognition tasks, and the parameters of this advantage remain to be discovered.

Keywords

adult; brain injuries; cognition; female; theory of mind; human

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1.0 Introduction

Social cognition is a critical area of assessment for adults with traumatic brain injury (TBI), as impairments in this domain have been linked to negative outcomes such as low ratings of communication competence (Watts & Douglas, 2006), less progress in rehabilitation (Spikman, Boelen, et al., 2013), and inability to maintain employment (Meulenbroek & Turkstra, 2016). Theory of Mind (ToM) is one aspect of social cognition that is of particular concern for adults with TBI, as deficits on ToM tasks have been well documented in adults with moderate-severe TBI, both early after injury (Spikman, Milders, et al., 2013) and in the chronic stage (Bibby & McDonald, 2005; Bosco, Angeleri, Sacco, & Bara, 2015; Channon & Crawford, 2010; McDonald, 2013; Spikman, Timmerman, Milders, Veenstra, & van der Naalt, 2012).

ToM typically is tested by presenting the examinee with spoken or written short stories followed by several questions. The following is an example from a published ToM battery (Zhang, et al., 2015):

> Liu bought her friend Zhang a crystal bowl for a wedding gift. Zhang had a big wedding and there were a lot of presents to keep track of. About a year later, Liu was over at Zhang's for dinner. Liu dropped a wine bottle by accident and the bowl shattered. She said, 'I'm really sorry I've broken the bowl'. Zhang replied 'I've never liked it anyway. Somebody gave it to me for my wedding.' (Supplemental Digital Content, Appendix 5)

The story is followed by four questions: 1) Did somebody say something they shouldn't have or something awkward? 2) Who said something they shouldn't have? 3) Why did they say it? and 4) How would Liu feel? Stories are read aloud and the authors do not state if written text also is provided, although other tasks in the same battery include written copies to "minimize memory load" (Zhang, et al., 2015, p. 9).

The preceding example shows that the *story+questions* format can place high demands on working memory (WM). In that example, examinees must process more than 24 semantic content units (e.g., Zhang, Liu, purchase, crystal, bowl, wedding, gift, big), implied relations among these content units (e.g., that the bottle dropped on the bowl), lexical ties (e.g., "She" = Liu), and grammatical features such as verb tense markers and embedded clauses (e.g., I'm really sorry [I've broken the bowl]), in addition to deriving mental state inferences from both within the narrative itself (e.g., a "lot of presents to keep track of" implies some might be forgotten) and also social knowledge (e.g., that one year is long enough to forget who gave a gift but not to forget giving one). The story also requires a series of perspective shifts, from Liu (sentence 1), to Zhang (sentence 2), back to Liu (sentence 5), and then to Zhang (sentence 6), so WM contents must be updated. The four questions are asked in sequence, and each could interfere with keeping story information in WM to answer the next. A written copy may be provided, but writing does not eliminate the WM load associated with processing complex language (Carpenter & Just, 1989) and individuals with TBI may lack the metacognitive skills to recognize that they need to use written aids (Ylvisaker &

Szekeres, 1989). In addition to the complexity of the language, the passage is quite lengthy, which potentially limits the ecological validity of the task.

In the above example, WM load is a *measurement factor*, which is a factor related to the way a construct is measured rather than the construct itself (Sabers, 1996). There are several reasons to suspect that WM load can be a measurement factor in ToM studies in adults with TBI: WM problems are common in people with TBI (e.g., Busch, McBride, Curtiss, & Vanderploeg, 2005; Perlstein, et al., 2004; Serino, et al., 2006). There is evidence of intact performance on ToM tasks when WM demands are minimized vs. errors when WM demands are increased (Turkstra, 2008; Honan, McDonald, Gowland, Fisher, & Randall, 2015). In addition, there are larger group differences when WM demands are increased (Matsuoka, Kotani, & Yamasato, 2012), and reduced between-group differences on ToM tasks when effects of WM are controlled (Bibby & McDonald, 2005). Overall, adults with TBI make fewer errors on first-order ToM tasks than on second-order, faux pas, and indirect speech tasks (Martin-Rodriguez & Leon-Carrion, 2010), which typically employ multiple embedded clauses (e.g., what did he think about what she thought) and, like the story from Zhang and colleagues (2015), require participants to track perspective changes across agents.

The classic approach to studying WM effects on ToM has been to correlate standardized WM test scores with scores on experimental or standardized ToM tasks. While correlative approaches have significantly advanced our knowledge about links between cognition and ToM, standardized WM tests have limitations: most were designed for other purposes (e.g., diagnosis) and thus might not be scaled appropriately for correlations; researchers are limited to testing constructs based on how they were defined and operationalized by the test authors, which might not align with research goals (e.g., might not differentiate among constructs of interest); and tests have error variance that can mask construct effects (e.g., language demands, low internal consistency) (Turkstra, et al., 2005).

An alternative is to manipulate WM demands on a ToM task, and directly measure effects on task performance. To do this, we created the Video Social Inference Task (VSIT) (Turkstra, 2008), a video-based task designed to minimize WM as a measurement factor, and manipulate WM as a construct factor. Test development is described in detail elsewhere (Turkstra, 2000, 2008; Turkstra, McDonald, & DePompei, 2001). The general structure of the VSIT was modeled after The Assessment of Social Inference Test (Flanagan, McDonald, & Rollins, 1998; McDonald & Saunders, 2005). The test includes 16 pairs of brief video vignettes depicting adolescent actors in conversation (Turkstra, 2008). Videos were improvised by the actors rather than scripted or rehearsed, so that interactions were as natural as possible. To minimize language demands and non-ToM measurement factors, all language is at a third-grade level, questions are in a yes/no forced-choice format and are displayed on the screen during the entire video, and no proper names were used.

For each video, the participant answered a ToM-related question about one actor in the video. The two videos in each pair showed the same actors, and the correct answer for the second video (e.g., Is this an appropriate request?) depended on the answer for the first (e.g., Do they know each other well?). Thus, the participant had to keep his or her answer for the first video in mind to answer the question for the second video in each pair. Example video stills are shown in Figure 1. For eight of the video pairs, the second video followed immediately after the first (Immediate Items); for the other eight, the first video was followed by a 30-second distracter and then the second video (Delayed Items). Distracters were non-ToM tasks such as counting backward from 100 by 3's.

In a study of 19 adults with TBI and 19 uninjured adults matched for age and sex (Turkstra, 2008), scores for adults with TBI were significantly lower than comparison group scores for the first video in each pair (First Items) as well as items in the two delayed conditions (effect sizes = .87 First Items, 1.00 Immediate Items, .54 Delayed Items), and Immediate Item scores were significantly correlated with scores on a WM test (r = .40). Women had higher scores overall and it appeared that this was due primarily to high scores in women without TBI and low scores in men with TBI, but the study was insufficiently powered to detect interaction effects. There also were only nine women in each group, making it difficult to draw conclusions about sex-based effects. A larger sample size, well balanced for sex, would allow for examination of these issues as well as serve as an important replication of the previous work. Replication of findings is particularly critical in TBI, given the heterogeneity of this population and small sample sizes of many existing studies.

In summary, there is strong evidence of poor ToM task performance in adults with TBI, but existing assessment methods limit our ability to dissociate true ToM impairments from errors on ToM tasks due to WM demands of the tasks. Results of one previous study revealed direct effects of WM manipulation on ToM task performance (Turkstra, 2008), but that study had not been replicated. Thus, here we report data from a new group of adults with moderate to severe TBI and their uninjured peers. We adopted a hybrid approach, with WM load manipulation as our primary variable and an exploratory correlation with scores on a standardized test. The study was in part a replication, thus we expected the same main effect of group. In addition, we asked if there was an interaction of group by sex on ToM task scores. We expected a main effect of sex given strong evidence of sex-based differences in social cognition, including behavioral evidence of a female advantage on ToM and emotion recognition tasks (e.g., Rahman, Wilson, & Abrahams, 2004; Rigon, Turkstra, Mutlu, & Duff, 2016; Russell, Tchanturia, Rahman, & Schmidt, 2012; Rutherford, et al., 2012). It was possible, however, that the female advantage would be mitigated by WM load, as some studies of typical adults show a male advantage on WM tests (Evans & Hampson, 2015; Rahman, Abrahams, & Jussab, 2005). Others have found no significant sex-based differences in typical adults (Astur, Tropp, Sava, Constable, & Markus, 2004; Haut & Barch, 2006), however, and one study in TBI did show a female advantage (Ratcliff, et al., 2007). Despite these mixed results, the preponderance of evidence suggested a female advantage for social cognition tasks, so we expected higher accuracy scores in women with or without TBI.

2. Material and Methods

2.1 Participants

Participants were adults with moderate-to-severe TBI (n=58, 24 females) and a healthy comparison (HC) group of adults without TBI (n=66, 34 females) matched group-wise for age and education. All were from the Midwestern United States and were recruited from the community as part of a larger study of social cognition in adults with and without TBI. Injury severity for the TBI group was defined according to standard injury criteria (Malec, et al., 2007): loss of consciousness of 30 minutes or more, post-traumatic amnesia of 24 hours or more, and worst Glasgow Coma Scale full score in the first 24 hours of less than 13, or 13 or higher with evidence of brain damage. All participants were more than 6 months post injury and out of post-traumatic amnesia. Participant characteristics are shown in Table 1. Inclusion criteria 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 HL at 500, 1000, 2000, and 4000 Hz; failing standard screenings for far and near vision; or testing in the aphasic range on the Western Aphasia Battery Bedside Screening Test (Kertesz, 2006). The relevant institutional review boards approved all procedures.

2.2 Measures

2.2.1 Video Social Inference Test (VSIT)—The VSIT was constructed as described in the introduction. A practice item at the beginning of the test showed the distracter and demonstrated that the two videos in each pair were linked, so participants knew in advance that they would need to hold information about the first video in WM to answer a question about the second. Order of items with vs. without distracters was randomized prior to the study then fixed, so all participants viewed items in the same order. The task yielded three scores: total correct for First Items ($n = 16$), Immediate Items ($n = 8$), and Delayed Items ($n = 8$). All scores were converted to percent correct.

2.2.2 Measures to Characterize the Sample—To compare the present study to previous publications, participants completed a series of tasks recommended by the Common Data Elements Committee for TBI research (Wilde, et al., 2010): the California Verbal Learning Test (CVLT; Delis, Kramer, Kaplan, & Ober, 2000), Wechsler Adult Intelligence Scales Processing Speed Index tests (WAIS-PSI; Wechsler, 2008), and Trailmaking Tests A and B (Tombaugh, 2004). Results for TBI and HC groups are shown in Table 2. Analysis of variance (ANOVA) revealed a significant between-groups difference on all neuropsychological measures (see Table 1), no significant sex-based differences on any measure (all p’s > .05), and no significant interaction of group and sex (all p’s > .05).

2.3 Procedures

After providing informed consent, participants completed an intake interview to obtain basic demographic data, as well as injury details for the TBI group. Participants then completed the VSIT and other tasks in quasi-random order (i.e., tests of similar constructs were never presented consecutively). For the VSIT, participants were seated at a laptop computer and were asked to respond using a key press. Stimuli appeared in the center of the visual field on the computer display, approximately 20 inches from the participant, with video images presented in a 7-inch wide by 5.5-inch high frame. The first item was a training item, followed by the 16 pairs of videos for the main task. Each response was scored as correct or incorrect.

2.4 Data Analysis

We compared groups on the three VSIT scores using a repeated-measures ANOVA, with percent correct on the VSIT as the dependent variable, TBI and sex as between-groups variables, and VSIT score type (First vs. Immediate vs. Delayed) as the repeated measure. Follow-up comparisons were completed using t-tests. Effect sizes were calculated using Cohen's *d*. The WM manipulation was validated in the previous VSIT study (Turkstra, 2008); however, as we had first-trial scores for the CVLT (Delis, et al., 2000), which required participants to keep supra-span items in mind for a short time, we completed an exploratory Pearson correlation of VSIT First, Immediate, and Delayed Item scores with scaled scores for the first trial of the CVLT. We expected no significant correlation between CVLT and First- or Immediate-Item scores, and a significant correlation between CVLT and Delayed-Item scores. As this was an exploratory analysis, we did not correct for alpha slippage.

3.0 Results

Average VSIT scores by condition, group, and sex are shown in Figure 2. Consistent with our previous work, there was a significant main effect of group, with higher scores in the HC group, $F(1, 360) = 21.03$, $p < .001$. As WM demands increased, accuracy on the ToM questions decreased for both groups. There was a significant main effect of VSIT item type, $F(2, 360) = 265.88$, $p < .001$, with significant differences between VSIT First and Immediate items, $t(245) = 2.91$, $p < .005$, ES = .36; First and Delayed items, $t(244) = 20.95$, $p < .001$, ES = 1.60; and Immediate and Delayed items, $t(245) = 15.99$, $p < .0001$, ES = 1.43. There was a marginally significant group-by-VSIT score interaction, $F(2, 360) = 2.37$, $p = .095$; effect sizes for the group difference were .26 for VSIT First items, .54 for Immediate items, and .58 for Delayed items. There was no significant main effect of sex, $F(1, 360) = 2.63$, $p = .11$.

CVLT first-trial scores had no significant correlation with First Item scores, $r = -.04$, $p = 71$; a marginally significant correlation with Immediate Item scores, $r = .17$, $p = .07$; and a significant correlation with Delayed Item scores, $r = .25$, $p < .01$.

4.0 Discussion

Adults with TBI and healthy comparison peers completed a video-based test of ToM in which WM load was manipulated, to replicate earlier findings and test hypotheses about sex-based differences in performance. Adults with TBI had lower scores overall than healthy comparison peers across all item types, replicating previous findings and extending these to a novel and larger group. All participants – regardless of TBI status – had low scores when WM load was high. These results suggest that when a distracting task competes with information held in WM (i.e., in everyday life), adults with or without TBI may make ToM errors.

Our results are consistent with previous studies linking WM to ToM task performance, particularly the study by Bibby and McDonald (2005). In that study, adding WM as a covariate on ToM tasks reduced but did not eliminate group differences. To more directly compare results of our study with Bibby and McDonald (2005), we replicated the authors' analysis and entered CVLT first-trial scores as a covariate in an ANOVA testing group effects on First Item scores. As in Bibby and McDonald (2005), the group difference was still significant, $F(1, 114) = 5.83$, $p < .005$; but was smaller than without the CVLT, $F(1, 123) = 9.66$, $p < .005$. Thus, while WM may be a measurement factor – and in real life may contribute to performance in situations requiring ToM – it does not explain all of the errors of adults with TBI, at least to the extent that we can capture both WM and ToM using current metrics.

The results just discussed are relevant to the ongoing debate about domain-specificity of ToM impairments in TBI (see Honan et al., 2015). In the TBI literature, there are two main accounts of low scores on ToM tasks. The *domain-specific account* claims that low scores reflect true, domain-specific ToM impairments that result from damage to brain structures thought to be critical for ToM (e.g., temporoparietal junction) (Apperly, Samson, Chiavarino, & Humphreys, 2004). This account predicts that ToM impairments can be dissociated from impairments in other cognitive functions. By contrast, the *domain-general account* claims that ToM is dependent on non-ToM cognitive functions (e.g., keeping two perspectives in mind requires WM, and shifting from one's own perspective to that of another requires cognitive flexibility). According to this account, ToM impairments are inextricably linked to impairments in cognitive functions on which ToM depends, particularly executive functions. Evidence for the domain-general account would include strong correlations between scores on ToM tasks and relevant cognitive tests.

Attempts to resolve the ToM debate in individuals with TBI have had mixed results, with some authors reporting correlations between social cognition tasks and EF tests (e.g., Henry, Phillips, Crawford, Ietswaart, & Summers, 2006), and others finding no significant correlation (Martin & McDonald, 2005; Muller, et al., 2009; Spikman, et al., 2012). Results here and in our previous study (Turkstra, 2008), as well as those of Bibby and McDonald (2005), suggested a mixed account, with WM influencing ToM task performance to a greater or lesser extend depending on the demands on each in a given task. It may be that WM and ToM are so intertwined that we can only observe effects when one or the other is the focus of the task, and cannot truly know the independent contribution of each in everyday social interactions.

Women did not have significantly higher scores overall, which is inconsistent with the earlier-noted evidence of a female advantage on social cognition tasks (e.g., Rahman, et al., 2004; Rigon, et al., 2016; Russell, et al., 2012; Rutherford, et al., 2012), including our own previous study using the same measure (Turkstra, 2008). This finding may be a function of two factors. First, we matched carefully on education, which was not the case in our previous study of the VSIT. Thus, our previous finding of disproportionately high scores in women without TBI and disproportionally low scores in men with TBI might have been confounded by education-level differences between groups. There also were no significant sex-based differences on neuropsychological tests used to characterize our sample, and sex-based differences in those cognitive functions might have contributed to social cognition differences not only in our previous work but perhaps in studies by others. Second, it may be that the VSIT is not difficult enough to reveal sex-based differences, which tend to emerge on more challenging social cognition tasks such as recognition of emotions in partial affect displays (Kessels, Montagne, Hendriks, Perrett, & de Haan, 2014; Montagne, Kessels, De Haan, & Perrett, 2007; Rigon, et al., 2016) or identifying others' thoughts in multi-person social interactions (Taylor, Barker, Heavey, & McHale, 2013). A third possibility is that biological sex does not confer advantages across all aspects of social cognition. Our results may help identify contexts in which women (with or without TBI) do or do not outperform men in various aspects of social cognition, which is an important topic for future study.

5.0 Limitations and Future Directions

The VSIT is a third-person "spectator" test. In third-person tests, participants judge actors who are talking to each other, rather than people with whom participants are communicating (second-person tests) (Schilbach, et al., 2013). The context of third-person tests typically is new to the observer, which can increase cognitive demands, but the spectator role also can minimize emotional factors that might interfere with performance, such as anxiety about interacting with others. Also, partners are theoretical rather than actual, which changes the nature of both social perspective taking (Bradford, Jentzsch, & Gomez, 2015; Duran, Dale, & Kreuz, 2011) and also brain networks involved in performance (Dennis, et al., 2013). Thus, it is not clear how well third-person tests capture ToM as it occurs in everyday life (Byom & Mutlu, 2013; Duff, Mutlu, Byom, & Turkstra, 2012). The choice of a ToM task depends on the research question. Use of third-person tests and other controlled laboratory tasks may be informative if the goal is to test hypotheses about basic mechanisms underlying ToM, as was our focus here. Second-person tasks are more appropriate, however, if the goal is to understand how ToM functions in everyday interactions, which require constant updating of mental representations, integration of cues across modalities and people and over time, comprehension and expression of abstract and complex language, and other cognitive and affective functions. A second limitation of our main outcome measure, the VSIT is the fixed order of the items. Although items with and without distractors were randomized, the items were presented in the same order to all participants, therefore, it is unclear if the item order could have influenced our results.

A third limitation of the VSIT is that, as noted earlier, the ToM judgements are relatively simple, e.g., judging if two people know each other well or are getting along. Although item content was derived from focus groups and observations of adolescents and young adults (Turkstra, 2000), to maximize ecological validity, and is consistent with constructs tested in the adult literature (e.g., sarcasm comprehension), the targets may have been too overt. Most ToM tasks originated in the developmental literature (e.g., Baron-Cohen, Leslie, & Frith, 1985; Flavell, 1968) and were "aged up" to be used with adults, primarily by increasing demands on cognitive functions other than social cognition. We explicitly aimed to avoid increasing non-social cognitive demands, which we viewed as confounding, but it may be that "development" of social cognition in adolescence and early adulthood is mostly due to improvements in domain-general cognitive abilities such as executive functions (Taylor, et al., 2013). Further work is needed to clarify the true nature of social cognition changes after childhood, and develop more sensitive tests.

The sample was predominantly comprised of Caucasian adults from the Midwestern United States. Replication in other racial, ethnic, and language groups is important, although there is evidence that basic perspective-taking does not differ across these groups and development of this skill is universal (Flavell, 2004). Further, the social and cognitive differences that do exist between Western and Non-Western cultures have been largely attributable to cultural norms and values vs. innate biological differences between groups (Greenfield, Keller, Fuligni, & Maynard, 2003), so brain damage may have similar effects regardless of culture, ethnicity, or native language. This is only a hypothesis, however, and data are needed. Rates of TBI are disproportionately high among individuals from minority populations, so data from these individuals are particularly important.

6.0 Conclusion

Results of this study echo earlier findings of impaired ToM in adults with TBI, on a test designed to manipulate WM load. Adults with TBI underperformed their uninjured peers even when WM load was low, consistent with evidence that ToM impairments are not due solely to measurement effects of tasks. When WM load was high, even adults without TBI had low scores, showing that WM can affect ToM performance in contexts like those in everyday life. There were no significant accuracy differences between men and women, inconsistent with prior evidence – including our own data using the same test. There is strong evidence of a female advantage on other social cognition tasks, and the parameters of this advantage remain to be discovered.

Future work should attempt to replicate the findings presented here as part of a broader and systematic effort to verify and replicate core empirical findings in the field. This is consistent with efforts to address the growing "replication crisis" in psychology and biomedical research. Replication is critically important in the study of traumatic brain injury, where cognitive heterogeneity is the norm and small sample sizes are common. The replication and extension here of our own previous findings, in a significantly larger sample and a sample better balanced for sex, is an attempt to separate reliable findings from the spurious. Such replications, both within and across labs, serve to improve our theoretical accounts of the neural correlates and underlying mechanisms of cognitive and social dysfunction in TBI and will inform clinical management.

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Highlights

- Low social cognition test scores are linked to negative life outcomes for adults with TBI.
- Low test scores may reflect impairments in non-social cognitive functions like working memory.
- Comparing adults with vs. without TBI, we found larger group differences when WM load was higher.
- We found no significant difference between men and women, with or without TBI.

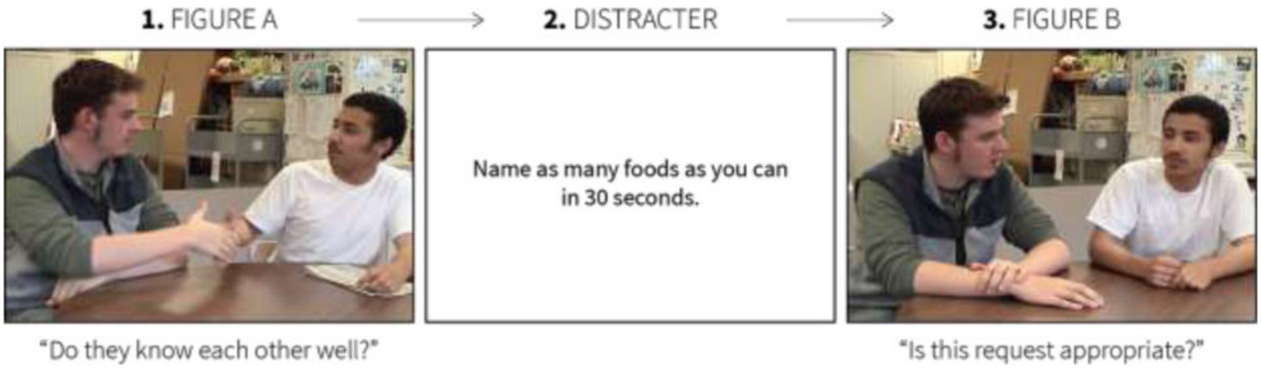

Figure 1.

Example VSIT stimulus with initial video (Figure A, First Item), distracter, and follow-up video (Figure B, Delayed Item). In the initial video, the actor on the left introduces himself to the actor on the right. In the second video, the actor on the left asks the actor on the right to water his plants when he is out of town that weekend. Note that for Immediate Items, the follow-up video follows immediately after the participant responds to the initial video, with no distracter.

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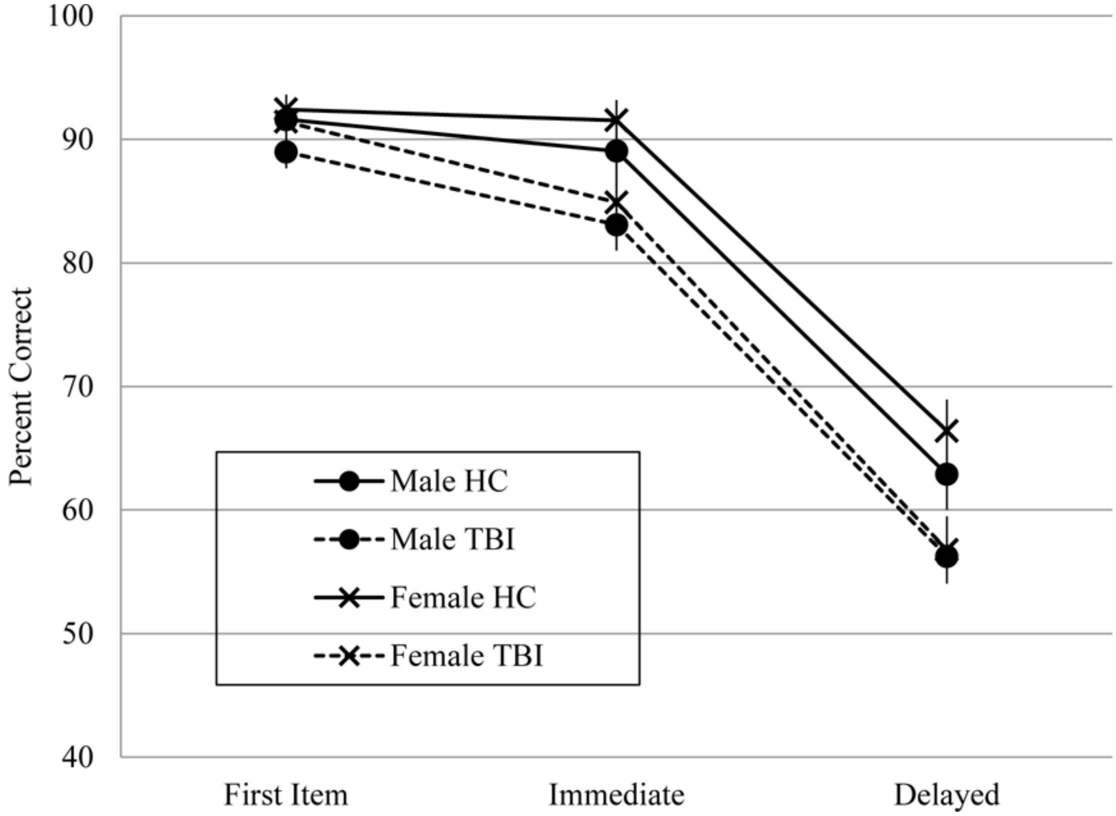

Figure 2.

Mean percent correct for First Items, Immediate Items, and Delayed Items on the VSIT. HC = Healthy Comparison group, TBI = Traumatic Brain Injury group. Error bars are SEMs.

Table 1

Participant characteristics. HC = Healthy Comparison group; TBI = Traumatic Brain Injury group. CVLT = California Verbal Learning Test (Delis, et al., 2000), Trails A: Trailmaking Test Part A Trails B = Trailmaking Test Part B (Tombaugh, 2004), WAIS PSI = Wechsler Adult Intelligence Scale (Wechsler, 2008) Processing Speed Index. Age and time post-injury are years; months. Trails B scores are z-scores; CVLT and WAIS PSI scores are scaled scores.

	HC Group (n=66)	TBI Group (n=58)	Between-Groups Comparison
Mean Age	41;2 (14.05)	42;3 (14.41)	$F(1,36) = .03$, $p = .99$
Age Range	18;0–65;0	22;5–65;4	N/A
Time post-injury	N/A	9;0 (10;3)	N/A
Years of Education	15.25 (1.72)	14.97 (2.16)	$F(1, 122) = .62$, $p = .43$
Trails A	.63 (.92)	−.38 (1.48)	$F(1, 131) = 19.54$, $p < .001$
Trails B	.61 (1.45)	−1.46 (3.84)	$F(1, 126) = 23.23$, $p < .001$
WAIS-PSI	108.00 (18.42)	92.07 (16.78)	$F(1, 129) = 15.58$, $p < .01$
CVLT First Trial	7.41 (1.89)	5.89 (1.77)	$F(1, 131) = 18.57$, $p < .001$
CVLT Immediate	58.62 (9.19)	46.30 (11.48)	$F(1, 126) = 17.77$, $p < 001$

Table 2

Mean percent correct in First Item, Immediate Item, and Delayed Item conditions on the VSIT. SDs are in parentheses. HC = healthy comparison group.

	HC		TBI	
	Men (n = 32)	**Women (n = 34)**	**Men (n = 34)**	**Women (n = 24)**
First Items	91.60 (7.88)	92.42 (7.12)	88.97 (7.70)	91.41 (8.80)
Immediate Items	89.06 (10.88)	91.54 (9.59)	83.09 (12.26)	84.90 (14.27)
Delayed Items	62.89 (13.65)	66.39 (14.82)	56.25 (12.02)	56.77 (13.28)