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Job stability in skilled work and communication ability after moderate-severe traumatic brain injury

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Abstract

Purpose—Communication deficits may play a critical role in maintaining employment after traumatic brain injury (TBI), but links between specific communication deficits and employment outcomes have not been determined. This study identified communication measures that distinguished stably employed versus unstably employed adults with TBI.

Methods—Participants were 31 adults with moderate-severe TBI who were employed full-time for at least 12 consecutive months before injury in skilled jobs and had attempted return to skilled jobs after injury. Sixteen had achieved stable employment (SE) post-injury, defined as full-time employment for 12 consecutive months; and 15 had unstable (UE) employment. Participants completed a battery of communication tests identified in a prior qualitative study of communication skills required for skilled work.

Results—Measures of spoken language comprehension, verbal reasoning, social inference, reading, and politeness in spoken discourse significantly discriminated between SE and UE groups. Two nested models were completed and compared. The first model excluded discourse data because of missing data for two UE and one SE participant. This model revealed that measures of verbal reasoning speed ($\beta = -0.18$, $p = 0.05$) and social inference ($\beta = 0.19$, $p = 0.05$) were predictive independent of the overall model. The second model included discourse data and was a better overall predictor of group membership (Likelihood ratio test, Model 1: 3.824, Model 2: 2.865).

Conclusion—Communication measures were positively associated with stable employment in skilled jobs after TBI. Clinicians should include assessment of communication for adults attempting return to work after TBI, paying specific attention to social inference and speed of verbal reasoning skills.

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Keywords

Employment; Traumatic brain injury; Vocational Rehabilitation; Communication; Language; Work

INTRODUCTION

Interpersonal skills are commonly impaired after traumatic brain injury (TBI) and have been associated with poor long-term outcomes.¹ Central to interpersonal skills is spoken communication, which allows us to influence others and manage relationships.² Spoken communication skills are increasingly important in the modern workplace,³ as the economic base of the United States has shifted in ways that create a greater demand on interpersonal interaction.⁴⁻⁶ Eighty percent of US jobs are in the service sector,⁷ where communication skills are essential, and even the manufacturing sector has integrated technologies that have increased on-the-job communication demands.^{8,9}

People with TBI who were employed pre-injury as skilled workers, such as those in the job sectors mentioned above, are more likely to attempt to return to the same job post-injury than are less skilled workers after TBI.¹⁰⁻¹⁷ For those who attempt to return to work, interpersonal problems are a common reason for post-injury job loss.^{10,18-20} Job instability after TBI is a problem for both the individual, significantly affecting quality of life,²¹ and for society at large. Most of the substantial societal cost related to the 1.7 million TBIs every year is related to long-term underemployment,²² and only 40% of persons with TBI maintain stable employment after injury.^{23,24} Although interpersonal problems have been linked to job loss for adults with TBI, the specific role of communication skills in work outcomes has been understudied.^{25,26} This makes it difficult for vocational rehabilitation specialists and speech-language pathologists to identify communication skills needed for work.¹⁹

The literature on work and productivity outcomes after brain injury is extensive.^{24,27-31} However, rehabilitation research has focused almost exclusively on neuropsychological measures and functional rating scales as predictors of work return.^{10,11,17,20,32-51} Reviews of the return-to-work literature show that neuropsychological measures are inconsistent in predicting employment outcomes.^{27,28} The same studies, however, mention communication skills as potentially important predictors. Ryan, et al.³² found that reading comprehension, verbal memory, and language were significant correlates of work reentry. Rassovsky, et al.⁴⁶ found that work return was significantly related to information processing speed, which can affect response times and topic maintenance in face-to-face communication.⁵² Reasons for work termination after supported employment for persons with TBI were reported by Sale, et al.¹⁹ who stated in their discussion, “interpersonal relationship issues are at once the most common and the most difficult catalyst to predict in [workplace] separation” (p. 7). The interpersonal relationship issues described by the authors included “inappropriate responses to social cues” and “socially inappropriate comments,” both of which relate to social communication competency.¹

This study addressed the gap in knowledge about communication skills needed for stable re-employment after TBI. We focused on jobs that required moderate training because people

employed in skilled jobs before TBI typically attempt to return to work in the same job or a similar job sector.¹⁰⁻¹⁷ Jobs were classified using the US Department of Labor's five-tiered categorization system that segments jobs into “zones” according to level of training required.⁵³ Job Zone 3 jobs require a “moderate” degree of training, defined as 1-2 years, and are described as requiring communication skills for training and managing others. Job Zones 4 and 5 also are communication-intensive but we excluded these because they require advanced education and training, and have high cognitive demands so return to work might be affected by even mild cognitive deficits after TBI.

In order to identify communication measures of interest to Job Zone 3 jobs, in a prior study we conducted semi-structured interviews of persons *without* injury employed in Job Zone 3 jobs, then analyzed interview transcripts using thematic content analysis.⁵⁴ This information was used to identify communication measures associated with both the identified communication themes as well as common communication impairments encountered after TBI.⁵⁴ That study identified seven measurable communication constructs associated with Job Zone 3: 1) spoken language comprehension, 2) verbal memory; 3) reading and writing; 4) verbal reasoning; 5) expressive pragmatics; 6) verbal multi-tasking; and 7) social inference.

The purpose of the current study was to test whether the communication constructs identified by our qualitative research were associated with stable employment outcomes after TBI. Specifically, we hypothesized that communication measures would be positively associated with stable employment in skilled jobs after moderate-severe TBI.

METHODS

We used a case-control design⁵⁵ to establish if degree of communication impairment was associated with employment outcomes in persons who attempted to return to skilled jobs after TBI. We used logistic regression with employment as the binary outcome variable (stable versus unstable). The case condition was people with TBI with stable work status before and after injury. The control condition was people with TBI who had stable work status before injury, but unstable work status after injury.

Participants

Between June 2012 and January 2013, we recruited 31 adults with moderate-severe TBI from local TBI support groups, statewide brain injury associations, nonprofit advocacy programs, vocational rehabilitation agencies, internet resources, and through outreach to service providers. Participants were recruited from seven states spanning the Midwest to north Atlantic regions of the US.

All participants were employed in Job Zone 3 jobs full-time (>30 hours a week) before their TBI, were cleared to return to work by a medical professional, and returned to full-time employment after injury. Participants in the stable employment (SE) group had returned to their pre-injury job, or another Job Zone 3 job, and were employed full-time for 12 months or more after injury. Participants in the unstably employed (UE) group also returned to their

pre-injury job, or another Job Zone 3 job, but were unable to maintain employment for 12 consecutive months and either were released by their employer or left voluntarily.

Additional inclusion criteria for participants in both groups were: 1) age 22-65 years; 2) Glasgow Coma Scale (GCS) score of 3-13 and/or post-traumatic amnesia (PTA) >24 hours; 3) English as primary language, by self-report; 4) intelligible in connected conversation, determined by the first author in a screening interview; and 5) hearing sufficient for study measures. TBI diagnosis and severity were verified by medical records for 12 participants. Medical records were not available for 19 participants, so injury severity was estimated by PTA duration and length of unconsciousness by report of the participant or family members. PTA duration was estimated by asking the participant or family member how long it took to return full memory of daily events after the TBI.

Exclusion criteria included: 1) positive history of neurological disease affecting language or learning, per self-report; 2) diagnosis of additional TBI after return to work; and 3) return to part-time employment only (<30 hours/week). We also excluded students, adults working as homemakers, and persons unemployed at the time of injury in order to focus on paid, competitive employment after injury.

Our focus on Job Zone 3 jobs for competitive employment after injury was deliberate because after TBI people attempt to return to skilled jobs more frequently than less skilled jobs.¹⁰⁻¹⁷ This criterion for Job Zone 3 jobs was incorporated in an attempt to examine a population that most closely represents persons with TBI who are likely to return to work after injury, as this population would be the most clinically relevant.⁵⁶

All participants completed a pure-tone, air-conduction screening. For participants with a threshold of 30 dB HL or better in each ear (averaged across 500, 1000, and 2000 Hz) auditory processing measures were used. For participants who did not meet this threshold, or were wearing hearing aids, spoken language processing measures were not administered.

Tests and Tasks

Communication measures were identified by our previous qualitative research to evaluate skills identified in the previous qualitative study, and are listed in Table 1.

Spoken Language Processing—We measured spoken language processing with the SCAN-3A. The SCAN-3A has four subtests that require the participant to attend to a spoken signal in the presence of background noise (auditory figure-ground), recognize speech when the signal is distorted (filtered words), and listen for single words (competing words) and sentences (competing sentences) when competing stimuli are presented binaurally. Higher scores on these subtests indicate a higher number of correct responses.

The SCAN-3A was not administered to UE04, SE15, and SE16, see Table 2, who failed the hearing screening. None of these participants complained of difficulty hearing or demonstrated behaviors characteristic of hearing problems, such as requests for repetition or for the examiner to speak more loudly. All stimuli were presented at suprathreshold levels, during test administration the administrator's face was always in full view to provide speech

cues, and participants were allowed to control the loudness of auditory stimuli for all tasks. Therefore, hearing loss in these participants was unlikely to have affected their performance on tasks that included auditory stimuli.

Spoken language comprehension and verbal memory—Participants completed subtest 4 from the Woodcock-Johnson III Tests of Cognitive Abilities (WJ-III), Understanding Directions.⁵⁷ We selected this as a spoken language comprehension measure because it was more representative of a common workplace communication activity than the SCAN-3A. The Understanding Directions subtest measures the ability to follow spoken directions by requesting participants to point at various objects in a series of colored pictures. This addresses both language comprehension and verbal memory demands.⁵⁷ Task complexity in this measure is related to the number of elements participants are asked to point to and the linguistic complexity per stimulus item (e.g., inclusion of use of passive voice and if-then conditional sentences). Higher scores on these subtests indicate a higher number of correct responses.

Verbal Memory—We measured verbal memory with the Wechsler Memory Scale (WMS-III) Logical Memory subtest.⁵⁸ Participants listened to two paragraph-length stories spoken twice each. In the Logical Memory I subtest participants were asked to repeat these stories immediately after stimulus presentation. The Logical Memory II subtest measures memory following a delay where participants repeat the two stories after a 25-30 minute delay with distraction. Higher scores on these tasks indicate more story elements and themes were recalled.

Reading—We measured reading comprehension and reading rate with the Nelson-Denny Reading Test (NDRT).⁵⁹ The NDRT has seven passages of varying reading levels followed by 5-8 multiple-choice questions. Participants were given 20 minutes to complete all seven passages. A reading rate measure was taken during administration of the first passage where the line of text the participant was reading at 60 seconds into the passage was recorded. Higher scores on this measure correspond with faster reading rates or a higher reading accuracy.

Verbal Reasoning—We measured verbal reasoning using the Functional Assessment of Verbal Reasoning and Executive Strategies (FAVRES).⁶⁰ The FAVRES is made up of four tasks modeled on familiar daily activities: planning an event, scheduling a work day, making a decision on a gift, and writing a letter of complaint. Each task evaluates decision-making and is designed to require weighing evidence and filtering out unimportant information. Higher scores on accuracy measures indicate better performance, while lower speed scores indicate faster performance.

Spoken Pragmatics (Politeness in Discourse)—We collected a language sample using the Voicemail Elicitation Task (VET).⁶¹ The VET is an experimental procedure that uses voicemail message scenarios to elicit language samples in different conditions. Each scenario requires participants to provide a message that 1) presents new information and 2) makes a request. Scenarios are thematically related to workplace events, with the four voicemail recipient conditions based on status and familiarity (subordinate, colleague,

friend, and superior). We measured politeness in discourse with the VET language samples using an exchange structure analysis procedure described by Togher and colleagues.^{62,63} Language samples were analyzed for mood and modality markers reflecting politeness.^{2,64,65} Linguistic markers for politeness included finite modal verbs (e.g., will, would, and could) and comment adjuncts (e.g., please, hopefully, and unfortunately). We focused on politeness markers because Togher and colleagues have reported that people with TBI produce fewer politeness markers.^{62,63} Furthermore, politeness markers have been of specific interest to linguists studying workplace communication because they facilitate working relationships with colleagues, customers, and employers.^{2,66-68} Higher scores indicate more politeness markers were produced, controlling for length of time of the voicemail recordings.

Verbal multi-tasking—We assessed verbal multi-tasking using the modified Six Elements Test (mSET) from the Behavioral Assessment of the Dysexecutive Syndrome (BADS).⁶⁹ The mSET consists of three tasks (i.e., elements): 1) arithmetic, 2) written picture naming, and 3) story dictation. Each of these three tasks has two sub-tasks, resulting in six elements. Participants were asked to attempt at least part of each of the six sub-tasks within 10 minutes. They had to follow the rule not to switch directly from a sub-task of one type to its counterpart of the same type. For example, if the participant completed a portion of the arithmetic subtest they cannot move onto the other arithmetic subtask, instead they must remember to pick from a different sub-task, either picture naming or dictation. Higher scores on this measure indicate more accurate performance overall.

Social inference—We measured social inference using the Video Social Inference Test (VSIT),⁷⁰ an experimental computer-based measure that uses short (30 seconds) videotaped vignettes relevant to adolescents and adults.^{70,71} After each vignette a question is posed on the basis of the social interaction. These questions require a mental state inference based on verbal and nonverbal communication cues (e.g. are the two actors 'getting along?'). The VSIT uses the same video stimuli to ask questions about the future behavior (e.g., will these two want to socialize in the future).⁷⁰ These questions are asked immediately after presentation of the vignette in an immediate condition (Immediate scores) and after a distraction activity in a delayed condition (Delayed scores). The delayed condition requires working memory and new learning. We collected the total score for items in which both the Immediate and Delayed responses were correct (Immediate + Delayed). Higher scores on this measure indicate a more accurate performance in identifying social relationships.

Neuropsychological measures—To characterize our participant sample we selected neuropsychological measures that were included in the common data elements established by the TBI Outcomes Workgroup.⁷² We chose the processing speed Index (PSI) from the Wechsler Adult Intelligence Scale—Fourth Edition (WAIS-IV)⁷³ as a measure associated with the common data elements. The Delis-Kaplan Executive Function System (D-KEFS)⁷⁴ Trails and Color-Word Inhibition and the California Verbal Learning Test – Second Edition (CVLT-II)⁷⁵ were chosen based on their common use in the RTW literature.^{23,44,76,77} These measures are listed in Table 4.

The PSI, a measure of speed of response to visuospatial tasks, includes two subtests from the WAIS-IV; symbol search and coding. Symbol search required participants to search for two abstract designs in an array of five. Coding required participants to copy numbers paired with geometric shapes in a series of boxes. Participants were asked to complete both of these tasks as quickly as possible within 120 seconds. The color-word test (a response-inhibition measure) and trails (a 'connect-the-dots' measure of processing speed) are subtests from the D-KEFS. Both measures have been correlated with successful RTW after TBI.^{11,35,76,78-80}

In addition to tests with predictive value with regard to RTW one measure shown typically not to have predictive value is list-learning.^{44,45,81} The CVLT-II was selected as a fold to the other measures because performance on this test should not be predictive of work stability per the literature. The CVLT-II is a set of 16 list items presented orally five times. After each presentation free recall is tested. List items fall into four categories to permit semantically clustering items to facilitate recall. About 20 minutes after completion of the learning phase free recall of all 16 items is tested.

Procedure

Study procedures were approved by institutional review boards of the University of Wisconsin (Madison, WI) and Spaulding Rehabilitation Hospital (Boston, MA). Participants provided written informed consent. We gathered background information via structured intake interviews, then conducted a hearing screening. Study assessments were presented in a quasi-randomized order with the exception of the memory measures, which required a 20-30 minute delay, and thus these measures were administered in the first half of a session. Time for the full assessment and interview protocol was approximately 5-6 hours. Participants could complete testing in two sessions and were offered frequent rest breaks to minimize fatigue effects.

Scoring and Analysis

Communication measures were selected for a logistic regression model based on results of independent paired t-test results between SE and UE participants. We anticipated that inclusion of the VET would reduce the overall power of a logistic regression model because of missing data from three participants (UE06 and UE15 did not complete the task due to time constraints, and data for SE11 were lost due to software malfunction). Therefore, we constructed a two-step nested logistic regression to identify which of the two communication models was most closely associated with work stability. Model 1 excluded VET data, and Model 2 included VET data.

To compare the relative goodness-of-fit between models we calculated the chi-square difference between the two nested models. The chi-square statistic in logistic regression reflects the deviance of the model from the null. By comparing the chi-square statistic of a model to the chi-square statistic of a second model that contains all the same variables, plus one additional variable of interest, we can see the change in deviance from the null resulting from the addition of a new variable. A smaller chi-square statistic reflects a lower deviance from the null, indicating a better model fit.

Demographic data were compared between groups using t-tests for continuous variables and chi-square tests used for categorical variables, to rule out potential confounds due to group differences.

RESULTS

The demographic and injury characteristics of research participants are displayed in tables 2 and 3. Demographic data showed no significant group differences for age $t(29) = -0.494$, n.s.; education $t(29) = 0.356$, n.s. time post onset $t(28) = 1.159$, n.s.; PTA $t(23) = -0.471$, n.s. Chi-square tests showed no significant differences for region, $\chi^2(1, N = 31) = 0.536$, n.s. or mechanism of injury, $\chi^2(1, N = 30) = 0.694$, n.s.

Performance characteristics of the two groups is displayed in Table 4. Continuous demographic variables were normally distributed and there were no significant differences between groups on any demographic variable. Table 2 presents the participant job titles as listed in Job Zone 3. One SE participant and three UE participants reported that they had received vocational rehabilitation, and all participants reported receiving other forms of rehabilitation at some point during their recovery.

Scores to be entered into logistic regression were selected using independent t-tests to identify scores that differed between groups. Results are shown in Table 5. Measures from the mSET were not used because there were no significant between-group differences, so the logistic regression included the following scores: scaled scores for Subtest 4 from the WJ-III (understanding directions), scaled scores for total time to complete the FAVRES, politeness markers per minute from the VET, the SCAN-3A Competing Words subtest scaled score, WMS-III Logical Memory II scaled scores, the comprehension scaled score from the NDRT, and percent correct for the VSIT Immediate versus Delay items.

The VET measure for politeness markers per minute contained an outlier that skewed the data; skewness = 0.043, kurtosis = 0.085. Skew was corrected using a log transformation and transformed data were used for all subsequent analyses.

As shown in Table 6, a pair-wise Pearson correlation with Bonferroni correction for multiple comparisons identified significant correlations between SCAN-3 scores and scores from both Understanding Directions from WJ-III and also the VET. The SCAN-3 was deleted from the model because of this overlap, and because there were missing data for this measure and the WJ-III measure had more face validity for spoken language comprehension in the workplace.

Table 7 shows that both communication models revealed significant differences between SE and UE groups. Model 1 significantly predicted group membership, $\chi^2(4, N = 31) = 17.21$, $p < 0.002$. The Nagelkerke R^2 calculation indicated that this model explained 64.7% of the variance in employment. FAVRES and VSIT measures made a unique and statistically significant contribution to Model 1. The odds ratio for the time to complete the FAVRES was 0.838 and was negatively associated with stable outcomes (i.e., the UE group took 1.2 times longer than the SE group to complete the FAVRES). The odds ratio for the VSIT

Immediate + Delay score was 1.2 (i.e., the SE group performed 1.2 times better than the UE group on the VSIT).

Model 2 included all five variables selected for analysis (WJ-III, FAVRES, VET, VSIT, and NDRT) and significantly predicted group placement, $\chi^2(5, N = 31) = 22.92, p < 0.001$. The Nagelkerke R^2 calculation indicated this model explained 78.3% of the variance in employment stability. No variables were independently statistically predictive in this model.

The relative predictive value of Model 1 vs. Model 2 was calculated using a likelihood ratio test. The addition of the VET significantly improved the fit of Model 2, $\chi^2(1, N = 31) = 5.69, p < 0.017$. Table 6 shows that both models were able to classify the UE and SE groups. Model 2 provided greater sensitivity at classifying UE participants (92%). Model 1 correctly classified 83% of UE participants (sensitivity) and 86% of the SE participants (specificity).

DISCUSSION

This study advanced previous research examining the relationship between clinical measures and employment outcomes, with the methodological innovation of using job characteristics to focus subject selection criteria, and qualitative research to guide measure selection. Findings indicated that performance on communication tasks was associated with work stability in skilled jobs after moderate-severe TBI, which helps clinicians to fill the gaps in understanding how communication disorders can affect work outcomes after TBI. While communication has been identified anecdotally as a factor in job loss after TBI, to our knowledge this is the first empirical study to associate communication disorders with work stability. By recruiting participants employed in skilled jobs and who had and good outcomes after injury this research attempted to focus on a population with TBI who have high probability for successful work outcomes.^{13,56,82} Despite this approach to participant selection, we were able to recruit many people with unstable work histories after TBI. This might indicate that catalysts for job loss after TBI are not consistently addressed clinically and further research is necessary to guide clinical practice.

Our successful identification of measures associated with employment after TBI is likely due to the use of qualitative techniques to select communication measures relevant for skilled work.⁵⁴ This mixed-method approach had several advantages. First, instead of making *a priori* assumptions about work skills that were important, we identified skills via interviews with employees and supervisors. Second, test selection was empirically driven by work skills, rather than dictated by previous findings in the literature. Third, the qualitative study yielded a rich database of employment-related communication skills that can direct future research and clinical intervention.⁵⁴ Last, the mixed-methods approach addressed methodological concerns that have been highlighted in recent reviews of return-to-work research,^{24,27} particularly concerns about variability in participant age, injury severity, pre-injury employment, length of post-injury employment, and job types.

Our findings are also consistent with three studies that examined communication and return to work after TBI and contributes to a growing consensus of significant relationships between social communication skills and employment outcomes.^{40,41,76} Isaki and

Turkstra⁴⁰ found accuracy measures from FAVRES and verbal reasoning accuracy measures from the SCAN were correlated with work outcomes in a sample of 20 persons with mild-severe TBI (10 employed and 10 unemployed).³⁰ In a study of 121 persons with mild-moderate TBI, Struchen et al.³⁹ reported a significant correlation between social communication and employment outcomes in persons with TBI. The authors measured social communication using self-report on the La Trobe Communication Questionnaire (LCQ)⁸³ as well as performance on the Florida Affect Battery. Rietdijk, et al.⁴¹ examined performance on the FAVRES and self-report on the LCQ in 14 adults with severe TBI and likewise found a correlation between scores on these measures and work status after TBI. Rietdijk, et al.⁴¹ provided detailed descriptions of participant characteristics, including job titles before and after TBI, but the sample was relatively acute (7 months after onset) and very small. LCQ self-report data also should be interpreted with caution, as impaired insight is common after TBI, particularly in the sub-acute stage, and would affect self-report measures such as the LCQ.⁸⁴ There were differences across these studies – e.g., Rietdijk, et al.⁴¹ found reported group differences on three of the FAVRES subtests, whereas Isaki and Turkstra found differences on two – highlighting the problem of variability in outcomes using when sample sizes are small and have broad eligibility criteria.

Limitations

Generalizability of our findings is limited by a few factors. First, the sample size was small and as a result there was a low participant-predictor ratio. Our sample also was relatively older and had higher levels of education than most previous studies examining return to work reviewed for this paper,^{11,17,32,33,36,38,41-45,47,49,76,85} which is a limitation when comparing results to the existing literature. However, our findings are relevant to the clinical population most likely to attempt to return to work (i.e., higher education levels, with longer exposure to the workforce, and stable work histories). Adults like those in our sample also may be more likely to receive rehabilitation services in the clinic as people employed in skilled jobs are more likely to have health insurance coverage.

A second limitation of the study was the use of employment stability as a surrogate for occupational competence. Many reasons for termination of employment are unrelated to performance, including economic considerations, business policy decisions, and retirement. This study was completed during an economic downturn, which might have increased the likelihood that job separation, or difficulties finding new work, had occurred for reasons other than occupational competence. Ten of 15 UE participants reported that reasons for not returning to open-ended questioning providing reasons that were equally distributed between physical, cognitive, interpersonal, and transportation issues.

A third limitation was the wide array of different work settings listed under Job Zone 3, including registered nurses, hairdressers, electricians, sales representatives, and machinists. Job characteristics in our sample included different communication partners and settings, deadlines and time pressures, and consequences of poor performance. The concern is that selecting jobs on the basis of training might not be an effective means of limiting variability of job skills. Efforts to sample Zone 3 jobs were an attempt to improve methodological rigor,

however, and our results demonstrate significant findings, indicating this might not be a significant limitation.

A fourth limitation was that the study was done retrospectively and relied on community resources for recruitment, as opposed to medical referrals. As a result, we were unable to collect medical records in many cases and had to rely on participant reports for some essential information, such as PTA and duration of coma. There are many weaknesses to self-reported data collection, including participants' forgetfulness, limited ability to self-diagnose TBI, and gaps between known information and what one is willing to articulate to an interviewer.^{86,87} These factors were expected to affect both groups equally, however, and so were unlikely to have accounted for the study findings.

Future Directions

If the present findings are replicated, then links between employment outcomes and communication skills have important clinical implications. First, clinicians should evaluate not only cognitive skills required to competently complete workplace tasks, but also communication skills. Communication skills can be critical for what are referred to as "soft skills" in employment, such as the ability to forge working relationships with co-workers, which are becoming increasingly important in our service-focused economy. Speech-language pathology services can therefore serve as a helpful resource when preparing an adult with TBI to return to work after injury. Although speech-language pathology services are currently incorporated in milieu-based vocational rehabilitation programs⁸⁸⁻⁹⁰ there is a paucity of research and there are no practice standards for the role of speech-language pathology in vocational rehabilitation. Speech-language pathologists working with patients on return to work as a goal require an evidence base from which to operate. Furthermore, most return-to-work programs do not follow a milieu-based approach,⁹¹ so speech-language pathology may not be consulted.

The present study was a first step in quantifying communication demands for skilled employment, and there is a critical need for further research. Future studies on workplace communication should be systematic and avoid the pitfalls common in the literature to date by using consistent measures, selection criteria, and work classification methods. Prospective studies are needed to examine the predictive power of workplace communication measures, with larger samples to improve statistical power and generalizability, as well as employment outcomes in different rehabilitation settings and service delivery models. Further research is also necessary to establish the role of communication in jobs beyond the skilled category examined here, as physical environment and job responsibilities may affect workplace communication patterns.²

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Declaration of Interest Statement

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Implications for rehabilitation

- Traumatic brain injury (TBI) often results communication impairments associated with the cognitive skills underlying interpersonal skills.
- Communication impairment after TBI has been anecdotally associated with job instability. This research directly assessed communication functioning in two cases of TBI, those with stable employment after injury and those with unstable employment after injury.
- These findings indicate that communication impairment should be assessed in persons with TBI returning to skilled employment after injury.

Table 1

Communication measures administered because of their associated with both Zone 3 jobs and TBI pathology.

Communication Construct	Tests and Measures	Measures Selected for analysis
Spoken Language Comprehension and Verbal Working Memory	1. WJ-III - Subtest 4: Understanding Directions	Accuracy (raw score)
Spoken Language Processing	2. SCAN – 3A - Filtered Words - Auditory Figure Ground - Competing Words - Competing Sentences	Not selected because correlated with WJ-III and VET.
Verbal Memory	3. WMS-III - Logical Memory I - Logical Memory II	Not selected because not statistically significant.
Reading	4. NDRT - Comprehension - Reading Rate	Comprehension (raw score)
Verbal Reasoning	5. FAVRES - Timing - Accuracy - Rationale - Reasoning	Timing (minutes)
Expressive Pragmatics	6. VET - Politeness Markers	Politeness Markers per minute (raw score)
Verbal multi-tasking	7. mSET	Not selected because not statistically significant.
Social Inference	8. VSIT - Immediate Predict - Immediate + Delay Predict	Immediate + Delay (raw score)

WJ-III: Woodcock Johnson – III, SCAN – 3A: Tests for Auditory Processing Disorders in Adolescents and Adults, WMS-III: Wechsler Memory Scales – III, NDRT: Nelson-Denney Reading Test, FAVRES: Functional Assessment of Verbal Reasoning and Executive Strategies, VET: Voicemail Elicitation Task, mSET: Modified Six Elements Test, VSIT: Video Social Inference Test

Table 2

Participant job titles before and after TBI injury.

UE Group	Job Title		SE Group	Job Title	
	Before injury	After injury		Before injury	After injury
UE01	Computer Support	Computer Support	SE01	Sales Representative	Sales Representative
UE02	Operations Manager	Operations Manager	SE02	Machinist	Machinist
UE03	Steamfitter	Steamfitter	SE03	Desktop Publishing	Desktop Publishing
UE04	Building Manager	Building Manager	SE04	Operations Manager	Operations Manager
UE05	Vocational Teacher	Vocational Teacher	SE05	Registered Nurse	Registered Nurse
UE06	Pharmacy Technician	Preschool Aid	SE06	Police Patrol Officer	Police Patrol Officer
UE07	Office Machine Repairer	Office Machine Repairer	SE07	Police Sergeant	Police Sergeant
UE08	Registered Nurse	Registered Nurse	SE08	Registered Nurse	Registered Nurse
UE09	Food Service Manager	Food Service Manager	SE09	Computer Operator	Computer Operator
UE10	Police Patrol Officer	Head Cook	SE10	Bookkeeper	Bookkeeper
UE11	Machinist	Machinist	SE11	Operations Manager	Operations Manager
UE12	Restoration Technician	Restoration Technician	SE12	Loan Officer	Loan Officer
UE13	File Clerk	File Clerk	SE13	Operations Manager	Operations Manager
UE14	Sales Representative	Sales Representative	SE14	Operations Manager	Emergency Medical Technician
UE15	Sales Representative	Sales Representative	SE15	Machinist	Machinist
			SE16	Computer Support	Computer Support

UE, unstably employed, not employed for 12 consecutive months post-injury; SE, stably employed, employed for greater than 12 consecutive months post-injury; all jobs in this chart are listed as Job Zone 3 occupations according to the Department of Labor; All jobs were held as full-time employment before injury and after injury.

Table 3

Participant demographics and injury characteristics.

			Employment		Total (N=31)
			Unstable (n=15)	Stable (n=16)	
Demographic Characteristics	Sex	Male	9	11	20
		Female	6	5	11
	Age at Testing (years)	Mean	46.4	48.8	47.7
		SD	11.6	11.5	10.9
		Range	24-60	25-63	24-63
	Education (years)	Mean	15.3	15.0	15.1
		SD	2.2	2.0	2.1
		Range	12-20	12-18	12-20
	Region	Urban	4	2	6
		Suburban	8	9	17
		Rural	4	4	8
	Time Post Onset (months)	Mean	119.3	168.7	144.0
		SD	107.5	125.6	117.6
		Range	15-320	18-362	15-362
		Missing	1		1
Injury Characteristics	PTA (days)	Mean	30.8	37.7	34.4
		SD	27.4	43.7	36.2
		Range	1-84	3-168	1-168
		Missing	3	3	6
	Cause	MVC	8	8	16
		MCC	3	3	6
		Sport	2	4	6
		Fall	1	1	2
		Missing	1		1

SD, standard deviation; PTA, post-traumatic amnesia; MVC, motor vehicle crash; MCC, motorcycle crash

Note: All between groups tests were non-significant ($p>0.05$).

Table 4

Descriptive statistics for neuropsychological tests.

Measures	UE		SE	
	$\bar{x}$ (SD)	Range	$\bar{x}$ (SD)	Range
Wechsler Adult Intelligence Scale—Fourth Edition (WAIS – IV)				
Symbol Search ¹	7.5 (2.6)	3-13	9.3 (3.1)	3-14
Coding ¹	7.9 (2.5)	4-12	9.8 (2.3)	6-14
PSI	87.6 (12.3)	68-114	97.4 (13.0)	79-122
Delis-Kaplan Executive Function System (D-KEFS)				
Trail Making Test ²	7.7 (3.0)	1-12	11.3 (1.7)	9-14
Color-word interference test ³	7.6 (3.7)	1-13	10.9 (2.1)	7-14
California Verbal Learning Test – Second Edition (CVLT – II)				
Trials 1-5 Free Recall ⁴	50.1 (9.4)	33-63	51.9 (10.1)	26-62
Long Delay Free Recall ¹	10.5 (3.5)	4-15	10.3 (2.9)	4-16

SE, stably employed group; UE, unstably employed group

¹ Presented with standard scores;² Number-letter switching subtest, presented with standard scores³ Inhibition subtest, presented with standard scores⁴ Presented with T scores.

Table 5

T-test outcomes as a rationale for variable selection.

	SE Group		UE Group		t-score	p
	$\bar{x}$	SD	$\bar{x}$	SD		
WJ-III	39.7	3.6	35.1	4.5	3.15	0.002
NDRT	33.6	28.2	18.2	20.1	1.76	0.044
SCAN-3A	44.7	7.5	37.4	7.2	2.65	0.007
VSIT	91.8	8.5	84.8	9.1	2.17	0.020
FAVRES	39.6	10.5	54.6	13.5	3.45	0.001
VET	9.6	3.8	5.6	2.6	2.17	0.002
mSET	3.6	0.9	3.2	0.8	1.21	0.118
WMS	16.8	5.4	17.5	7.6	0.30	0.766

WJ-III, Woodcock-Johnson Scales of Achievement III; NDRT, Nelson-Denny Reading Test; SCAN-3A, Tests for Auditory Processing Disorders in Adolescents and Adults; VSIT, Virtual Social Inference Test; FAVRES, Functional Assessment of Verbal Reasoning and Executive Strategies; VET, Voicemail Language Elicitation Task; mSET, modified Six Elements Test; WMS, Wechsler Memory Scale

Table 6

Matrix of Pearson correlation with Bonferroni correction

	WJ-III	NDRT	SCAN-3A	VST	FAVRES	VET
WJ-III	1.000					
NDRT	0.216	1.000				
SCAN-3A	0.558 [*]	−0.125	1.000			
VSIT	0.191	0.142	0.339	1.000		
FAVRES	−0.273	−0.427	−0.050	0.057	1.000	
VET	0.196	0.185	0.593 [*]	0.483	−0.113	1.000

WJ-III, Woodcock-Johnson Scales of Achievement III; FAVRES, Functional Assessment of Verbal Reasoning and Executive Strategies; VET, Voicemail Language Elicitation Task; VSIT, Virtual Social Inference Test; NDRT, Nelson-Denny Reading Test; SCAN-3A, Tests for Auditory Processing Disorders in Adolescents and Adults;

Note:

^{*} indicates correlation is significant at the 0.05 level (2-tailed)

Table 7

Comparison of nested logistic regression models for communication measures.

Variables included in models	Model 1			Model 2		
	β	p	OR (95% CI)	β	p	OR (95% CI)
Constant	-14.61	0.06		-19.95	0.14	
WJ-III UD	0.23	0.10	1.26 (0.98-1.61)	0.17	0.21	1.19 (0.91-1.54)
FAVRES	-0.18	0.05	0.84 (0.71-0.99)	-0.30	0.09	0.74 (0.53-1.05)
VSIT	0.19	0.05	1.21 (1.00-1.45)	0.21	0.16	1.24 (0.92-1.67)
NDRT	-0.03	0.43	0.97 (0.90-1.04)	-0.02	0.73	0.99 (0.91-1.07)
VET				4.94	0.15	139.600.16 (0.16-120187.05)
Nagelkerke R^2		0.647				0.783
-2 Log likelihood		18.67				12.97
χ^2		17.23				22.92
p		0.002				0.0001
Likelihood ratio test						5.69, $p=0.02$

WJ-III UD, Woodcock-Johnson Scales of Achievement subtest four Understanding Directions; FAVRES, Functional Assessment of Verbal Reasoning and Executive Strategies; VET, Voicemail Language Elicitation Task; NDRT, Nelson-Denny Reading Test, χ^2 , chi-square β , estimated coefficient; CI, confidence interval; OR, odds ratio

Table 8

Classification table for the nested logistic regression model's prediction of employment stability.

		Model 1 (Excluding VET)			Model 2 (Including VET)		
		Employment Status		% Correct	Employment Status		% Correct
		Unstable	Stable		Unstable	Stable	
Employment Status	Unstable	10	2	83.3	11	1	91.7
	Stable	2	12	85.7	2	12	85.7
Overall Percentage				84.6			88.5