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Cognitive Communication Disorders After Traumatic Brain Injury: Implications for Clinical Practice

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Executive Summary

Cognition and communication deficits often prevent Traumatic Brain Injury (TBI) patients, who are otherwise functioning well, from returning to work. This study is focused on the exploration of the associations between known patient characteristics and measurable communication outcomes from speech-language pathology intervention. Furthermore, the adequacy of aphasia batteries as assessment tools for communication deficits and their effect on vocational outcomes are also examined.

In summary, it is found that the age of a Traumatic Brain Injury patient together with the severity of injury and the extend of recovery provide the information necessary to predict satisfactory communication outcomes, as determined by the Western Aphasia Battery. Yet, the patient's performance on the Western Aphasia Battery, after speech-language pathology intervention, does also provide an important predictor for the patient's vocational outcome. These two results combined establish the predictability of communication and vocational outcomes as a result of speech-language pathology intervention, with important implications for clinical practice.

Test Battery Data and Demographic Information

Patients who suffered traumatic brain injury with diffuse were selected to participate in this study, only if they were also 18-55 years of age, they had completed at least 10 years of formal education, and they were released from speech-language therapy within the last year. From the pool of 393 patients who were admitted to the brain injury service, only fifty-five met these selection criteria. Yet, five of those patients declined the invitation to participate in the study. The results of the test battery for the remaining 50 patients formed the data sample for the current investigation.

The scatterplot matrix in Figure 1 shows moderate to strong pair-wise linear associations between the four test batteries, under consideration. The strongest relationship exists between WAB and SCATBI (correlation 0.71), while the relationship between SCATBI and CPS is the weakest (correlation 0.49). Beyond these test results, several patient characteristics, including both demographic and injury-related information, were also available. These include the age, sex, pre-injury educational status, pre-injury employment status, substance abuse history, the Glascow Coma Scale for the severity of injury, the length of speech-language pathology intervention, and the patient's current living situation. Finally, the post-injury employment status for each of the 50 subject is known.

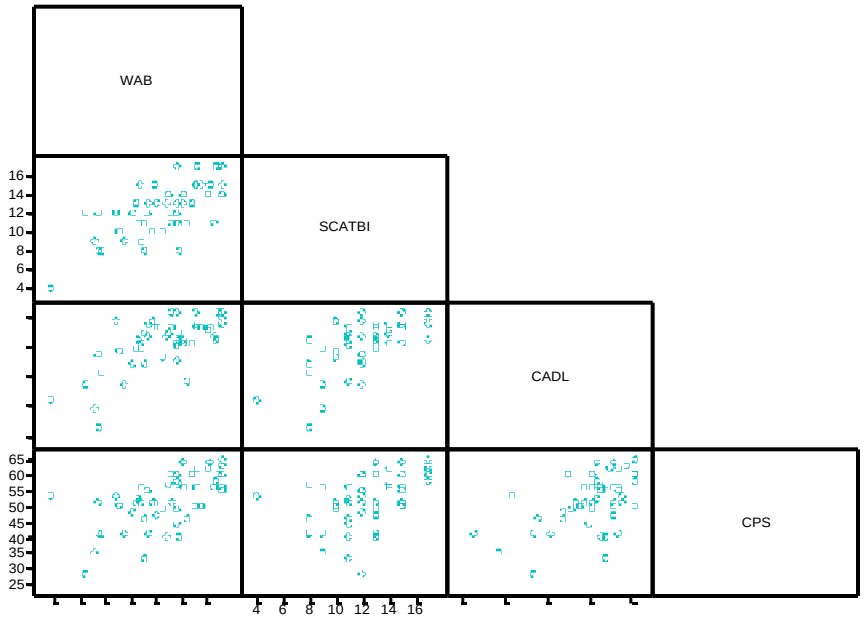

FIGURE 1.

The test battery results for the 50 subjects in the study, exhibit moderate to strong pair-wise correlations between the four cognitive/communication scales in consideration.

Data Analysis and Results

From the clinical practice viewpoint, it is highly desirable to establish the predictability of the TBI patients' communication and vocational outcomes, on the basis of their characteristic profiles. In the remaining of this section we attempt to address this issue in two steps. First we will use the test battery results, in conjunction with other relevant patient characteristics, in an attempt to explain discrepancies between the pre and post-injury employment status of the subjects in the study. Any success in that direction will help us establish the predictability of vocational outcomes as a result of the speech-language therapy intervention, provided that the relevant test-battery results are also predictable on the basis of known patient characteristics. The latter is the question that will be undertaken in the second step, below.

Predictability of Vocational Outcomes

A statistical technique suitable to address the issue of predictability of post-injury employment of TBI patients, is given by classification tree-based models (see e.g., Clark & Pregibon, 1992). Tree-based models provide an alternative to linear logistic and additive logistic models for classification problems. They are fitted by binary recursive partitioning, whereby the data is successively split into increasingly homogeneous subsets. The classification tree in Figure 2, for example, provides a model for the variability in the post-injury employment status. It consists of a sequence of classification rules subdividing TBI patients in five homogeneous strata, thus explaining as much as possible of the discrepancies in post-injury employment.

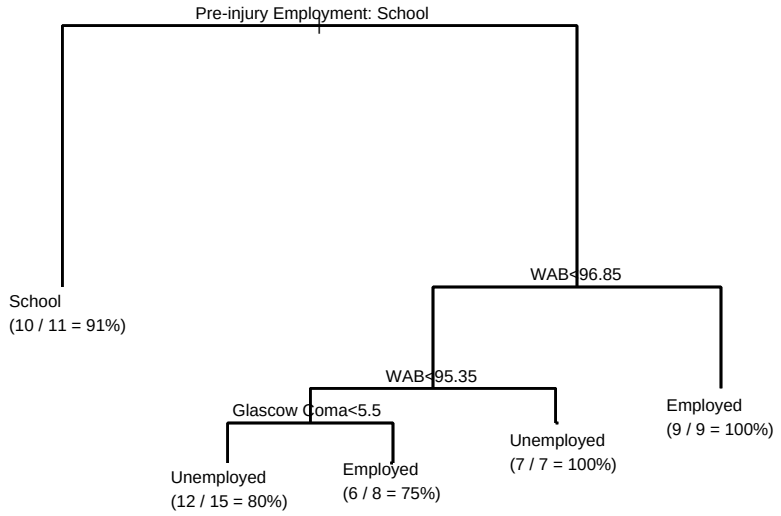

FIGURE 2.

A classification tree-based model for the variability in post-injury employment of TBI patients, consisting of rules based on the Western Aphasia Battery and the Glascow Coma Scale. Despite its simplicity, this model achieves a misclassification error rate of only 12%; thus demonstrating good predictability for post-injury employment.

After rehabilitation, ten (or 20%) of the subjects returned to school, 18 (or 36%) were employed, and the remaining 22 (or 44%) were unemployed. Using a split on pre-injury employment status, the left-most branch of the model in Figure 2 defines a stratum which consists of the 11 (or 22%) of the subjects who were attending school prior to injury. The vocational outcome for ten (or 91%) of these subjects, who returned to school, can be thus correctly predicted. The next split on WAB, which creates the right-most branch in the tree-based model does also correctly predict the vocational outcome for the nine (or 18%) of the subjects who scored more 96.85 on the WAB scale. The remaining 30 (or 60%) of the subjects are further split into three additional strata: (i) those who scored less than 95.35 on WAB and they also had very severe injuries (this group consists of 15 of the subjects, 80% of whom are correctly predicted to be unemployed); (ii) those who scored less than 95.35 on WAB but suffered less severe injuries (this group consists of 8 subjects, 75% of whom are correctly predicted to be employed); (iii) those who scored between 95.35 and 96.85 on WAB (this group consists of seven subjects, all of whom happened to be unemployed). Overall, the tree-based model in Figure 2 classifies correctly 88% of the subjects, thus establishing the predictability of post-injury employment of TBI patients on the basis of their performance on the Western Aphasia Battery and the severity of their injury. Logistic regression analysis does also confirm that a patient's satisfactory performance on WAB has a marginally (statistically) significant effect on the patient's probability to return to work.

The classification rules which define the model were selected by the model fitting algorithm over all other possible rules, including rules which involved the other test batteries and patient demographics. If we eliminate the Western Aphasia Battery from consideration, an alternative model is obtained using SCATBI and the in-patient length of stay (see Figure 3). This model, however, leads to a much higher misclassification error rate (16%).

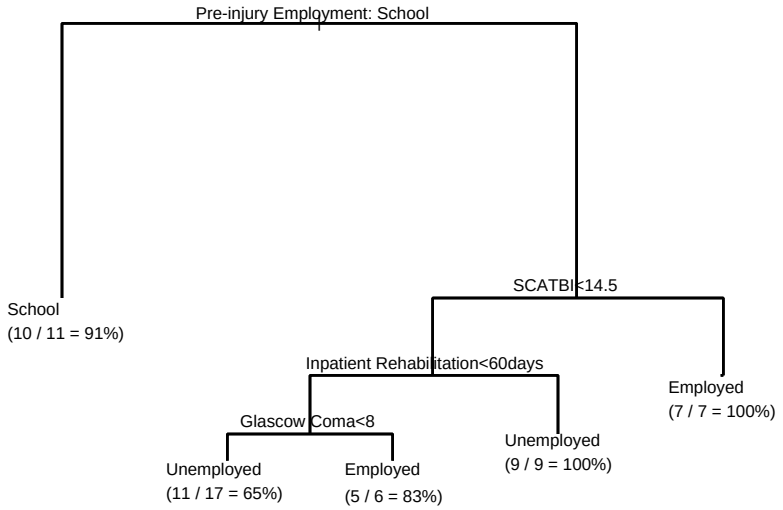

FIGURE 3.

A tree-based model for post-injury employment of TBI patients based on SCATBI yields a 16% misclassification error rate (as opposed to 12% for the model in Figure 2).

Predictability of Communication Outcomes

Out of the 50 subjects in the study, 21 (or 42%) failed to meet the cut-off for normal communication outcomes as determined by the Western Aphasia Battery. Likewise, 21 (or 42%) also failed the CADL, and 18 (or 36%) failed the SCATBI test Batteries. From the clinical intervention standpoint, it is important to identify the patient characteristic profiles that could help explain these failures; thus, allowing the predictability of communication outcomes from speech-language pathology intervention. The classification tree-based models in Figures 4-6 serve precisely that purpose.

In the case of the model for WAB (Figure 4), the majority of patients who failed to meet the cut-off for normal communication outcomes fall within two characteristic profiles: (i) those who are older than 22 years of age and they have at least some sort of dependency (11 out of 12 patients in this group showed deficiencies), and (ii) those who are older than 33 years of age and suffered severe injuries, regardless of their current living situation(5 out of 5 patients in this group showed deficiencies). Once again, the results obtained from logistic regression analysis do also confirm statistically significant effects due to both age and inability to live independently on the probability of a patient to perform satisfactorily on the Western Aphasia Battery after rehabilitation.

Finally, the tree-based models given in Figures 5 and 6 can be used, just as in the case of WAB above, to derive the characteristic profiles associated with failures on SCATBI and CADL. Nevertheless, it should be noted that the misclassification error rates associated with these last two models are fairly high.

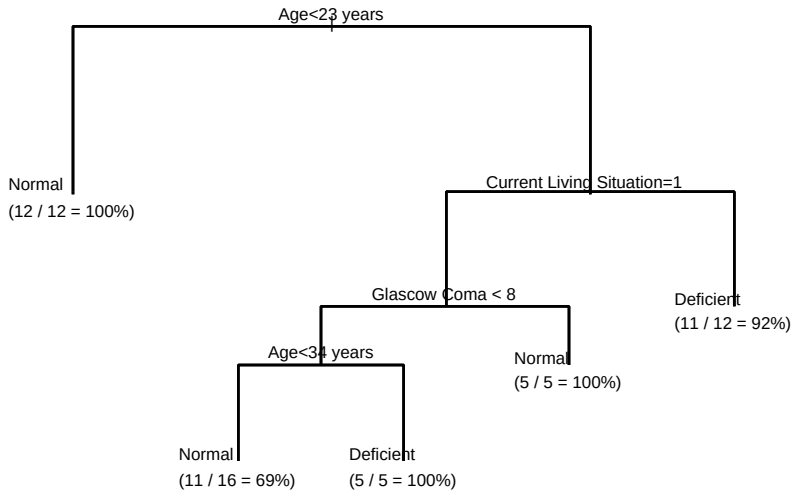

FIGURE 4.

A tree-based model providing the characteristic profiles of TBI patients who failed to meet the cut-off for normal communication outcomes on WAB. The misclassification error rate associated with this model is only 12%.

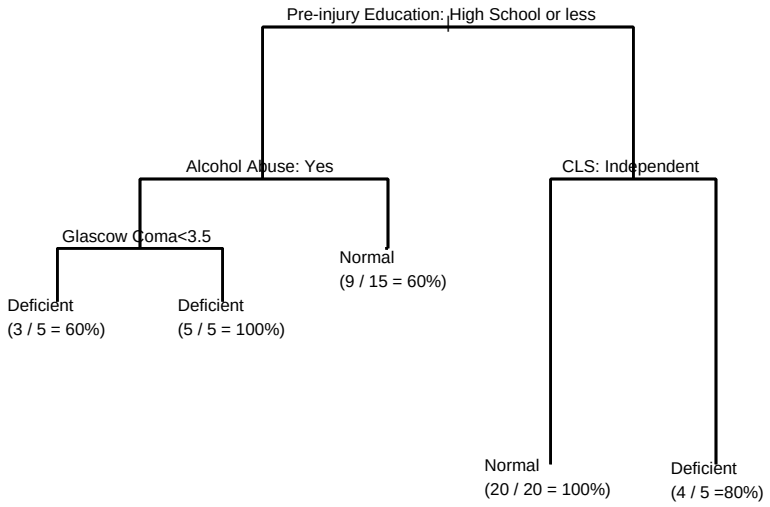

FIGURE 5.

A tree-based model providing the characteristic profiles of TBI patients who failed to meet the cut-off for normal communication outcomes on SCATBI. The misclassification error rate associated with this model is 18%.

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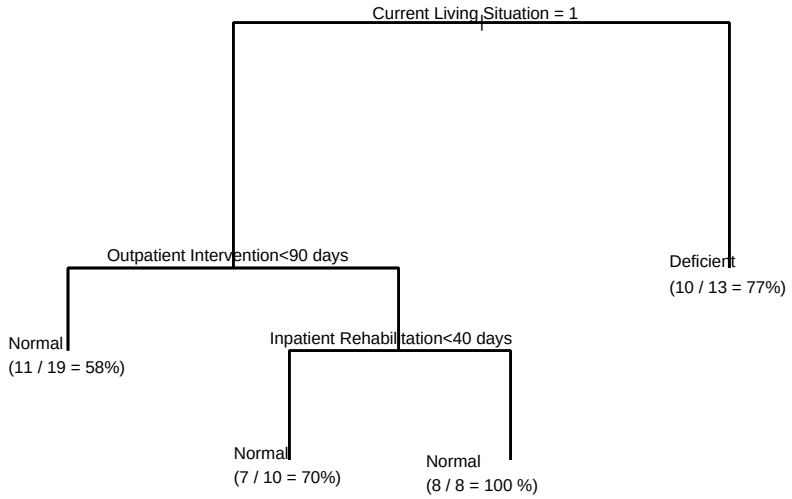

FIGURE 6.

A tree-based model providing the characteristic profiles of TBI patients who failed to meet the cut-off for normal communication outcomes on CADL. The misclassification error rate associated with this model is 28%.

Concluding Remarks

For the TBI subjects in this study, the Western Aphasia Battery outperformed all other test batteries considered, with regard to both its predictability (on the basis of patient characteristic profiles) and its value as a predictor for patients' vocational outcomes. Indeed, the classification tree-based models given in Figures 2 and 4 provide a strong evidence for the predictability of TBI patients' communication and vocational outcomes as a whole. Nevertheless, it should be noted that classification tree-based models are largely data driven; yet the sample of 50 patients used in this study is fairly small. Consequently, despite that the results obtained in this study are quite promising, they must be treated with some caution until they are replicated using another sample of TBI patients.

References

Clark, L. A., Pregibon, D. (1991), "Tree-Based Models," Statistical Models in S, eds Chambers J.M. & Hastie T. J., Chapman & Hall, London