# Ecologically Relevant Outcome Measure for Post-Inpatient Rehabilitation

Introduction

The estimated annual incidence of brain injury in the United States is almost 1.9 million cases. The two most common causes of brain injury are traumatic brain injury (TBI) with 1.7 million cases, (Faul, Xu, Wald, & Coronado, 2010) and stroke with 800,000 cases (Go et al., 2013). Many of these individuals survive their injuries, but experience significant functional decline as a result (Ma, Chan, & Carruthers, 2014; Terrio et al., 2009). Rehabilitation of functional abilities after an acquired brain injury is a goal for many of these individuals, and this process often involves multidisciplinary treatment in acute and post-acute rehabilitation facilities. To achieve greater rehabilitation outcomes functional therapies aim to maximize transfer of skills from the treatment facility to the patients' home/work environments. Assessment of outcome following acquired brain injury (ABI) has been identified as an area in need of major focus, as the commonly used measures lack sensitivity in post-acute settings and/or have limited ecological validity (Leblanc & Hayden, 2000; Nichol, Higgins, Gabbe, Murray, Cooper, & Cameron, 2011; Spooner & Pachana, 2006).

Current neuropsychological and functional measures used to assess brain injury outcomes are typically administered in a controlled testing environment. Specifically, they exclude extrinsic factors that may cause distraction in order to elicit the best test performance. This artificially constructed environment is likely very different when compared to the environment a person will encounter upon discharging from treatment (Kim, Whyte, Hart, Vaccaro, Polansky,& Coslett, 2005; Levine et al., 2000, Whyte, Schuster, Polansky, Adams, & Coslett, 2000). These measures are necessary to quantify level of functional impairment, particularly in a post-acute clinical setting, but are less predictive of functional outcomes in the chronic phase of acquired brain injury (ABI) after patients discharge from post-inpatient brain injury rehabilitation (PBIR)

suggesting limited ecological validity (Spordone, 2014). The limitations in outcome measures (Bogdanova, & Verfaellie, 2012), underscore the need for developing functional outcome measures that can be used in both acute, post-acute, and community settings.

Other outcome measures, like the Disability Rating Scale (Wright, 2000), allow for measurement across the continuum of recovery, but do not address specific environmental features that may affect outcome (Rappaport, Hall, Hopkins, Belleza, & Cope, 1982). The Disability Rating scale, a measure commonly used to track functional recovery in basic ADLs such as grooming, toileting, feeding, and overall functioning after brain injury, does not consider the environment in which functional behaviors take place. The Functional Independence Measure (FIM) is a well-established measure for addressing the burden of care and level of disability in the TBI population, but focuses on basic abilities and activities that are addressed primarily during inpatient rehabilitation (Stineman, Jette, Fiedler, & Granger, 1997). Like the DRS, the FIM shows a marked ceiling effect when administered post-acutely (Hall, Mann, High, Wright, Kreutzer, & Wood, 1996). Although these outcome measures are reliable and valid (Bowers, & Kofroth, 1989; Gouvier, Blanton, LaPorte & Nepomuceno, 1987; Malec & Thompson, 1994), they do not assess the influence of environmental factors on performance both during rehabilitation and after discharge. The Mayo-Portland Adaptability Inventory (MPAI-4) is an effective measure of outcome following acquired brain injury in a post-acute setting. The MPAI-4 consists of three indices based on 30 items measured by consensus of professional staff (Malec, 2005), and has demonstrated sensitivity to the effects of post-acute rehabilitation interventions (Malec, Kragness, Evans, Finlay, Kent, & Lezak, 2003; Malec, Moessner, Kragness, & Lezak, 2000); however, it assesses degree of impairment in functional skills without consideration of

how much environmental modification is required for the person to perform these behaviors optimally.

The absence of a system for adequately addressing environmental factors during treatment following ABI has been noted for over a decade (Leblanc & Hayden, 2000; Nichol, et al., 2011; Spooner & Pachana, 2006). From a behavioral perspective, identifying a reliable system to assess functional abilities while accounting for key environmental variables present when a patient performs optimally would be very beneficial for improving the generalizability of functional gains made in rehabilitation.

The Pate Environmentally Relevant Program Outcome System (PERPOS), was developed and has been used to guide rehabilitation treatment since the mid-1990 in response to unsatisfactory employment-related outcomes (i.e., job placement and maintenance) after brain injury rehabilitation in the 1980's. Interestingly, at that time, patients demonstrated improvements in functioning within the clinic setting, but were unable to transfer their gains in the workplace resulting in poor job maintenance outcomes (Hart & Hayden, 1989; Mysiw, Corrigan, Hunt, Cavin, & Fish, 1989). These observations created awareness and greater understanding of how day-to-day functioning is influenced by environmental characteristics for ABI individuals, and the importance of generalization of skill acquisition to the TBI rehabilitation process (Kowalske, Plenger, Lusby, & Hayden, 2000). Subsequently, environmental characteristics (i.e., behavioral antecedents) including the extent of *distractions* present in an environment and degree of *structure present in the environment* were examined as potentially useful variables to manipulate during rehabilitation (Hayden, Moreault, LeBlanc, & Plenger, 2000). The PERPOS was developed as a tool for quantifying both of these environmental characteristics in order to create

the most ecologically valid measure of day-to-day functioning that could be used to guide rehabilitation efforts.

Over the past 15 years, the PERPOS has been used to guide multidisciplinary PBIR treatment at Pate Rehabilitation in Dallas, Texas. Data from the PERPOS were collected for over 4000 patients and used to inform the treatment team under which environmental conditions patients perform best. Additionally, the PERPOS was used to inform patients, families, and third party payers of treatment progress. The aim of this study is to explore the validity and reliability of the PERPOS as a tool to guide PBIR and measure outcome.

## Method

### *Subjects*

2501 patients who had sustained a traumatic brain injury or CVA and were participating in a post-acute treatment program admitted after January 2006 and discharged by the end of December 2014 were selected for this study. Injury severity ranged from complicated mild to severe, with a majority of patients (58%) in the moderate to severe range of functional limitation as measure by the MPAI-4 (Dickson, 2012; Malec, 2005)

(Table 1 Goes Here)

### *Measures*

PERPOS

This outcome measure was developed by an interdisciplinary team as a working tool that focuses on the complex interactions of the environment and functional ability, rather than relying on ability ratings without environmental context. Determining a patient's maximum functional capacity within the context of (a) how much structure in the environment is necessary for the patient to organize and execute a functional behavior, and (b) how much potentially distracting stimuli is in the environment allows the treatment team to better understand and adjust the treatment environment for optimal recovery.

Numeric values are given for a patient's overall level of functioning (1-7) with higher numbers suggesting a greater degree of independent functioning. Level of distraction within an environment is rated with a four-point scale (1-4), with higher numbers suggesting the environment has a greater degree of frequently changing stimuli and has more frequent interruptions that could distract a person from effectively performing a task. Structure is also rated on a four point scale (1-4), and higher numbers suggest a lower degree of external structure is required to achieve the patient's highest level of overall functioning. The overall functioning score is derived using a seven-point scale (1-7), with higher scores suggesting greater functional ability across several functional domains (i.e., mobility, basic ADL's, higher-level ADL's, communication, insight, and medical insight) (Hayden et al., 2013). Functional ability in these domains are used as a guide for deriving an overall functioning score. The greatest functional ability scores are rated with consideration to the environmental characteristics in which they occur.

A PERPOS score is computed by adding the Structure and Distraction scores, which are weighted by a factor of two, with the overall level of functioning [PERPOS score = (2 x (Structure + Distraction)) + Overall Function]. PERPOS scores range from a low of 5 (totally

dependent) to a high of 23 (independent in a low structured environment with a high level of distractions). Differences in PERPOS ratings are expected among team members since they work with the patient in different environments and at different times of day.

Treatment team members are trained on PERPOS within one month of hire. Each treatment team member is assigned a mentor who has met criteria as an expert in rating the PERPOS. The clinician is expected to generate his or her own rating prior to staff meetings in collaboration with the mentor for a minimum of 3 months after beginning employment. Ongoing training continues via the treatment team discussion format and in collaboration with the mentor.

MPAI-4

The Mayo-Portland Adaptability Inventory (MPAI-4) (Malec, 2005) is a commonly used valid measure of outcome after PBIR. The MPAI-4 has been used to evaluate functional abilities following acquired brain injury in the domains of Ability, Adjustment, and Participation. The MPAI-4 has demonstrated good psychometric properties including internal consistency, construct validity, concurrent validity, and predictive validity when used with patients with acquired brain injuries (Malec et al., 2000; Malec et al., 2003)

*Procedures*

Patients' admitted to PBIR were rated with PERPOS and MPAI-4 during a treatment team meeting at admission to rehabilitation and at discharge. These ratings were made by speech therapists, occupational therapists, physical therapists, and a neuropsychologist after a three day observation and evaluation period. The treatment team's ratings were determined after a discussion of the patients' functional abilities in the aforementioned functional domains. Score

discrepancies were discussed in more detail until a team consensus was reached. Additionally, PERPOS ratings were made during team meetings every other week until their discharge.

To determine the interrater reliability of the PERPOS, a subsample of 56 consecutive admissions between January 2014 and December 2014 were evaluated. For this subsample, PERPOS scores (i.e., structure, distraction, and overall functioning) were determined and recorded blindly by each of nine therapists on the treatment team after a discussion about the patient's functional abilities and input from each specialty was given. Therapists were required to describe testing results and/or behavioral observations from therapy sessions without the use of numeric PERPOS ratings. Each therapist then submitted their individual ratings blindly before a final consensus PERPOS score was determined and recorded.

## Statistical Analyses

### *Interrater Reliability*

An interclass correlation coefficient was used to determine degree of agreement among the therapists in the treatment team for the overall PERPOS rating (i.e., 5-23) at time of admission to PBIR. Additionally, a Pearson's correlation coefficient was used to examine the association between individual therapist PERPOS scores and the treatment team consensus PERPOS score. Kappa coefficients were used to determine rater agreement for each of the components that comprise the PERPOS score (i.e., Structure, Distraction, and Overall Function ratings) given their restricted ranges (Fleiss, 1981).

### *Concurrent Validity*

A Pearson correlation coefficient was used to determine the association between PERPOS score and MPAI-4 score at time of admission to PBIR. Bivariate Spearman rho correlations were used to examine associations among the PERPOS sub-scores and the MPAI-4 component raw scores, as these measures are ordinal.

## Results

### *Characterization of Sample*

The sample of 2501 person's with ABI was divided into 1221 people with TBI and 1280 person's with CVA. As expected, patients with TBI were significantly younger upon admission to PABIR than patients with CVA ($t_{(2168.2)}$=-27.120, p<0.001). Patients with TBI also admitted to PABIR with significantly lower MPAI-4 scores and higher PERPOS scores than patients with CVA ($t_{(2447.6)}$=-3.159, p=0.002) and ($t_{(2423.7)}$=4.357, p<0.001), respectively. Patients with CVA admitted to PABIR significantly earlier ($t_{(1266.9)}$=8.148, p<0.001) and were treated longer ($t_{(2499)}$=-3.572, p<0.001) than patients with TBI.

### *Inter-rater reliability*

For the subsample of 56 patients, the inter-class correlation of therapists' overall score at admission on the PERPOS was 0.879 ($f_{261}$=22.63, p<.001). Interrater agreement for the Structure scale demonstrated substantial agreement, as its Kappa coefficient = 0.763. Kappa for the Distraction scale was 0.664. Overall Functioning demonstrated moderate agreement as the Kappa coefficient was 0.523.

(Table 2 Goes Here)

The correlations between therapists' blinded PERPOS scores and the treatment team's consensus PERPOS scores are all very strong and are presented in Table 2.

*Concurrent validity*

For the CVA, TBI, and combined samples, bivariate Spearman rho between the PERPOS total and the MPAI-4 total were significantly associated with one another, at admission and at discharge from PBIR, respectively (see Table 3). The PERPOS total also correlated highly with the Ability, Adjustment, and Participation subscales of the MPAI-4 at admission and also at discharge from PBIR (see Table 4). The Functional score of the PERPOS also correlated highly with the MPAI-4 total score and the three MPAI-4 subscales. See Table 3.

(Table 3 Goes Here)

(Table 4 Goes Here)

## Discussion

This study examined the use of a tool (i.e., PERPOS) to rate functional abilities and quantify two environmental characteristics believed to be important for transferring acquired skills from brain injury rehabilitation to the community. Amount of structure required and amount of potentially distracting stimuli present in the environment in which a person performs functional behaviors was quantified by members of a brain injury rehabilitation team to design treatment plans for re-acquiring functional skills and transferring them to their homes and natural environments. The study examined the reliability and validity of this tool for use with patients undergoing post-inpatient brain injury rehabilitation after TBI and stroke.

*Reliability*

The three primary PERPOS scales each demonstrated good to excellent inter-rater reliability through averaged Kappa scores (Cicchetti & Sparrow, 1981), suggesting therapists agree on the amount of structure and distractions present in patients' environments after assessing these factors independently. Furthermore, therapists were able to reliably describe patients' overall level of performance despite differences in the environment in which they observed patients through an overall functional score and a total calculated PERPOS score. These are remarkable findings, as there is a large degree of variability in the environments/settings in which the therapists observe the patient and limited time prior to their initial team meeting. For example, a patient may be able to ambulate with supervision in a long narrow hallway with few doorways and windows; however, may require contact guard assistance when walking down a grocery store aisle. The functional ability scale had the most variability in therapist rating. This is expected given a therapist's perception of functional ability can vary depending on the environment in which it is observed; however, despite this variability the reliability of the overall function scale falls within the "moderate agreement" range. The results of this study suggest therapists within a multidisciplinary team who are observing patients in varied environments can agree on the patient's level of functional independence given the degree of structure and distraction present in the environment, regardless of brain injury type or severity.

It is also noteworthy that therapist ratings of patients' best functioning prior to discussing the PERPOS ratings with other members of the therapy team is strongly associated with the consensus PERPOS rating that is created after a thorough discussion of functional performance from each of the therapists. One explanation for these findings is that the PERPOS provides therapists the framework for rating important environmental considerations in which functional

behaviors occur. Through multidisciplinary discussion of performance within varying environments, therapists form a clinically relevant and reliable opinion of patients' actual functional level. One concern was that individual therapist PERPOS total scores would be strongly associated with the team PERPOS total score simply due to the multiple ways to calculate the same PERPOS total score (Merbitz, Morris, & Grip, 1989). A therapist may rate a patient high on the functional scale due to being low on structure or distraction, giving the same or similar PERPOS total score as a therapist who rated the patient lower on function but higher on structure or distraction. Due to this concern, we looked at both the absolute agreement between each staff member, (i.e., Kappa Scores), and PERPOS total score agreement (i.e., ICC), and found this concern to be unfounded, as the PERPOS demonstrated a good to excellent level of absolute agreement in the three scales that comprise the PERPOS total score.

*Validity*

The MPAI-4, a commonly used measure of functioning before and after PBIR, was used as a gold standard to measure the concurrent validity of the PERPOS. Spearman's correlation coefficients demonstrated a strong association between the MPAI-4 total score and the PERPOS total score suggesting it has good concurrent validity at both admission and discharge as seen in Table 3. This result is held true for both patients with TBIs and those with CVAs, suggesting that PERPOS can be utilized for acquired brain injury diagnoses. The strong correlations at admission suggest that the overall scores for both the PERPOS and the MPAI-4 provide equivalent estimates of overall functional disability on assessing a patient newly admitted to PBIR. At discharge the PERPOS and MPAI-4 remain highly correlated, suggesting the PERPOS can be utilized by therapists to formulate discharge recommendation for altering their home environment with regard to Structure and Distraction to optimize their functioning. The

PERPOS constructs of Structure, Distraction, and Function correlate well with the MPAI-4 constructs of functional Abilities, Adjustment to life after a brain injury, and degree of Participation in their community following brain injury (See Table 4). The highest subscale to subscale correlation is Function at discharge to Participation at discharge. This result makes intuitive sense in that the subcomponents of the Function subscale are similar to the subcomponents of the Participation subscale, both looking at activities contributing to functional abilities in a real world environment. These results lend credibility to the use of the PERPOS to assess functional abilities for individuals with acquired brain injuries and as a tool to guide clinical practices.

*Guiding Neurorehabilitation after TBI and CVA*

In this study the PERPOS was used serially to guide treatment among patients with TBI and CVA. Given the relative brevity in assessing PERPOS scores in comparison with computing the MPAI-4, the PERPOS is well suited for repeated administration throughout the rehabilitation process. Repeated ratings of PERPOS serve to provide the treatment team with a tool to not only measure progress, but also to guide treatment and discharge planning. This is commensurate with studies demonstrating the MPAI-4 can reliably assess functional outcome in both of these clinical populations (Kean, Malec, Altman, & Swick, 2011; Malec, Kragness, Evans, Finlay, Kent, & Lezak, 2003). While there are notable similarities between the two instruments (MPAI-4 and PERPOS), there are differences that should be recognized. The MPAI-4 is best utilized as a marker of functional change from pre-PBIR to post-PBIR treatment, and provides a more detailed assessment of motor and cognitive abilities, interpersonal and adjustment issues, and aspects of participation that may be targeted for rehabilitation. While the PERPOS can also be used to estimate overall functional change over the course the rehabilitation, the strength of the

PERPOS is its ability to stimulate discussion across therapists on the treatment team about function within various environments to better guide therapists as to how to obtain a patients best performance and how to adequately challenge a patient by manipulating their environment. Environmental manipulations may include removing or introducing structure or potentially distracting stimuli during their therapy day to more adequately resemble the environment to which the patient will eventually be discharged. The numerical rating simply serves as a marker of progress which encapsulates the team discussion and as a starting point for future discussions. The high degree of interrater reliability observed in PERPOS scores suggests therapists across disciplines can be trained to use the instrument as a reliable framework to elicit discussions regarding important clinical information that guide PBIR.

One limitation of this study is that the degree of familiarity with the PERPOS was not quantified and is likely to vary. The results of this study may have been influenced by variability in how long the therapists have used the PERPOS; however, variance in how much experience one has with the instrument would likely increase the variability in PERPOS inter-rater agreement (i.e., lower reliability) which was not observed. Another limitation for this study is that the tool was examined within a facility that utilizes a treatment model that emphasizes assessment and manipulation of environmental structure and distraction, as the instrument may not be as valid, reliable, or clinically useful in other facilities; however, skill transfer (i.e., generalization) is a priority in rehabilitation for ABI and assessment and manipulation of the environment should be common among rehabilitation facilities.

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Table 1. Sample Demographics

| | TBI N=1221 $\bar{x}$ (SD) | CVA N=1280 $\bar{x}$ (SD) | TBI & CVA N=2501 $\bar{x}$ (SD) |
|---|---|---|---|
| Age (years) | 39 (15.5) | 53 (10.8)* | 46(15.2) |
| Gender (% male) | 75.8% | 60.0% | 67.7% |
| Days in Treatment | 66(59.5) | 74(57.4) | 70(58.6) |
| Time Since Injury $\bar{x}$ [median] | 408[79] | 93[41] | 247[53] |
| PERPOS AD | 11.4(3.5) | 10.9(3.1) | 11.1(3.3) |
| PERPOS DC | 15.5(4.7) | 15.0(3.1) | 15.2(4.6) |
| MPAI-4 AD | 54.2(18.1) | 56.4(16.4) | 55.4(17.3) |
| MPAI-4 DC | 39.6(21.5) | 42.3(20.5) | 41.0(21.0) |

Note. MPAI-4 = Mayo-Portland Adaptability Inventory-4, AD = Admission, DC = Discharge.
* Denote significant differences between the TBI and CVA groups ($p<0.05$)

Table 2. Inter-rater Agreement & Correlational Analyses

| | | TBI & CVA N=56 | TBI N=28 | CVA N=28 |
|---|---|---|---|---|
| PERPOS ICC | | 0.879* | 0.660* | 0.755* |
| Therapist to Team PERPOS | Pearson r | 0.939* | 0.949* | 0.928* |

Note. ICC = Intra Class Correlation.
*p<0.001

Table 3. PERPOS/MPAI-4 Correlations

| | | CVA | TBI | CVA & TBI |
|---|---|---|---|---|
| Correlation | | | | |
| | PERPOS AD-MPAI-4 AD | -0.772* | -0.813* | -0.797* |
| | PERPOS DC-MPAI-4 DC | -0.856* | -0.849* | -0.855* |
| | PERPOS AD-PERPOS DC | 0.680* | 0.749* | 0.721* |
| | MPAI-4 AD-MPAI-4 DC | 0.743* | 0.745* | 0.746* |

Note. AD = Admission, DC = Discharge, MPAI-4 = Mayo-Portland Adaptability Inventory-4.
*Spearman's rho, $p<0.001$

Table 4. PERPOS/MPAI-4 Subscale Correlations

| | PERPOS at Admission | | | |
|---|---|---|---|---|
| MPAI-4 Admit | Function | Structure | Distraction | Total |
| Ability | -0.739* | -0.688* | -0.593* | -0.762* |
| Adjustment | -0.557* | -0.524* | -0.479* | -0.588* |
| Participation | -0.718* | -0.759* | -0.609* | -0.813* |
| Total | -0.766* | -0.716* | -0.615* | -0.797* |

| | PERPOS at Discharge | | | |
|---|---|---|---|---|
| MPAI-4 Discharge | Function | Structure | Distraction | Total |
| Ability | -0.799* | -0.790* | -0.715* | -0.836* |
| Adjustment | -0.698* | -0.695* | -0.637* | -0.737* |
| Participation | -0.806* | -0.801* | -0.711* | -0.841* |
| Total | -0.816* | -0.809* | -0.729* | -0.855* |

Note. MPAI-4 = Mayo-Portland Adaptability Inventory-4.
*Spearman's rho, $p < 0.0001$