ANALYSIS OF A MEASURE OF FUNCTIONAL COGNITION FOR PERSONS WITH STROKE

By

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To my mom and dad

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LIST OF ABBREVIATIONS

ACS	Applied Cognition Scale
CTT	Classical Test Theory
CVA	Cerebral Vascular Accident
FIM	Functional Independence Measure
ICC	Item Characteristic Curve
IRT	Item Response Theory
LSAT	Law School Achievement test
MFC-S	A Measure of Functional Cognition for Persons with Stroke
MTT	Modern Test Theory
RBMT	Rivermead Behavioral Memory Test

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Stroke researchers increasingly recognize the affect of cognitive impairment on functional outcome for persons with stroke. Yet, there is no measure that evaluates applied cognition in persons with stroke that incorporates both the secondary domains of cognition and the unique cognitive impairment observed in persons with stroke. Through an extensive qualitative process, our research team developed an item bank for a measure of functional cognition in persons with stroke (MFC-S).

The overall purpose of this dissertation was to assess the measurement properties of the MFC-S. An item-level perspective was adopted in examining the: (1) dimensionality, (2) item level psychometrics and (3) the concurrent and predictive validity. One hundred twenty-eight persons with stroke, stratified for chronicity and laterality of stroke, took a paper and pencil measure for the MFC-S. A randomly selected subsample also took a battery of neuropsychological comparison measures.

In the three studies of this dissertation it was ascertained that: (1) with an exploratory factor analysis, a ten-factor solution was defendable for the dimensionality of the MFC-S, and a principle components analysis of residuals supported essential unidimensionality for each of the ten domains, (2) acceptable to good psychometrics

with nine out of ten domains separating persons into at least two distinct groups, and (3) concurrent validity was supported by moderate to strong correlations with existing comparable measures but weak associations with more fundamental performance based measures. Predictive validity was somewhat supported by predicting side of stroke in a profile analysis, but the language domain prediction was contrary to what we might have expected. That is, persons with *higher* language ability were more likely to have had a left cerebral vascular accident.

CHAPTER 1
ANALSYIS OF A MEASURE OF FUNCTIONAL COGNITION FOR PERSONS WITH STROKE

In order to move rehabilitation science forward and evaluate therapeutic interventions, investigators need to be able to compare outcomes between studies, facilities and therapists. Yet, although rehabilitation clinicians are encouraged,,[48, 76] even required, to use standardized outcome measures when evaluating clients, the number of clinicians who use standardized measures are limited.[41] In addition to lack of time, clinicians have reported a lack of familiarity or 'know how' with outcomes assessment. Further, while clinicians agree that standardized assessments are important to administrative and payor decisions, they rarely inform immediate treatment decisions.[84] For example, the Functional Independence Measure (FIMTM)[44] is an assessment currently used on admission and discharge at many rehabilitation settings to evaluate functional independence. Yet, obtaining a score on the motor portion of the FIM will not inform the clinician beyond the qualitative judgment that she requires minimal assistance for grooming. Assessments that are informative and efficient would facilitate use by clinicians. In fact, some health outcomes investigators cite advantages in efficiently informing therapeutic treatment plans as an asset of measures created using modern test theory (MTT) procedures.[84]

Measure development procedures currently fall into two categories - classical test theory (CTT), and modern test theory (MTT). While many currently available assessments have been developed using CTT, many health outcomes researchers have turned to modern test theory (MTT) procedures to optimize scale development.[83] Two primary advantages to using MTT developed assessments include: optimized ability to compare scores across studies, facilities and therapists; and improved ability to inform theory development. For example, many assessments available to clinicians and researchers were created using CTT,[21] which use standardization to compare persons. However, scores from standardized assessments cannot be easily compared across studies, as standardized scores are sample and test dependent. Scales developed with MTT address concerns of study comparison and are considered sample and test independent.

This paper reviews key concepts of classical and modern test theory, emphasizing the value added benefit of MTT. More specifically, MTT investigators cite improved efficiency, equal interval measurement and theory development as key advantages of MTT developed measures.[92]

1.1 Classical Test Theory

CTT encompasses a set of concepts and statistical procedures that are the foundation for numerous assessment tools. Classical test theory proposes that a person's score on an assessment result from the combination of their 'true score' on the measured construct, and measurement error, represented in the equation:

$$X_1 = T_X + E_1, \tag{1-1}$$

Where X_1 is the observed score on an assessment, which is the sum of the true score and the error associated with the measure. Error may include things such as noise in the environment, misunderstanding a question or variance in the manner a person administers a test. Assessments developed using CTT focus on reducing the measurement error, so that the observed score approximates the true score as close as possible.

The primary challenge in CTT is that the true score is unobservable. DeVellis (2006) summarizes CTT assumptions that address this: 1) the set of items comprising an assessment should represent one construct; 2) items should equivalently represent the construct; and 3) items that highly correlate with each other are thought discriminate better on the given construct. Though this suggests that CTT focuses on item properties, in practice CTT focuses on scale properties. That is, how well does a set of items represent a true score?

To resolve this, CTT assumes items are strictly parallel. That is, that the set of items are unidimensional; they represent one underlying construct. Additionally, each item covaries equivalently with the construct. Put differently, each item is an equally good indicator of the construct. Then, if the error associated with an item is independent of the construct, items' covariation with each other represents their common association with the underlying construct. This association is called reliability. Though these assumptions are strict, and thus unrealistic, other models exist that relax these assumptions but support estimation of scale reliability with item correlation.[6]

The statistic Cronbach's alpha[5] indicates a scale's reliability, and increases as intercorrelations between items increase. Thus, Cronbach's alpha evaluates how a scale of items represents the construct it intends to measure. Cronbach's alpha includes the number of items in a scale as well as the correlations of these items. But, because it is often easier to increase the number of items than increase the correlation of items, the easiest way to increase scale reliability is to increase the items, increasing test length.

Advantages of using CTT include: 1) familiarity to investigators, 2) easy access to statistical packages needed to perform the procedures such as calculating Cronbach's alpha, and 3) using a sum score from an assessment, which includes a variety of items that represent a construct, can attenuate errors associated with one particular item. However, disadvantages include: 1) difficulty with comparison across different assessments of a similar construct; 2) long tests that may contain redundant items; 3) assessments that are sample and item dependent; and 4) assessments that do not achieve the objective measurement principle of equal interval scaling. These challenges and how MTT addresses them are detailed below.

1.2 Modern Test Theory

Rehabilitation outcomes researchers increasingly use modern test theory methods to create measurement scales.[14, 83] Item response theory (IRT), the statistical analysis procedures used in MTT, focuses on item level statistics, in contrast with CTT focus on scale level psychometrics. IRT scales, similar to CTT scales, assume unidimensionality. MTT developers suggest the inclusion of easy items and hard items,[61] representing the breadth of a construct. For example, in a test for fear of falling in the elderly, Velozo and Peterson (2001)[82] hypothesized that “Getting out of bed” would be an easy item and “Walking outside on icy surfaces” would be a difficult item. In this manner, items used represent a range of a trait. Person ability is measured based on how a person responds to an item. On a fear of falling scale, a person who has high fear would be more likely to report feeling fearful when getting out of bed, as compared to someone with little fear of falling.

Further, while all IRT models estimate item difficulty, two-parameter models also estimate item discrimination and three-parameter models add an estimate of guessing. Person ability for the construct is measured according to the response on an item and how difficult that item is or how well the item discriminates on the latent trait. For example, a person who has a higher level of ability would be more likely to pass a more difficult item. Figure 1-1, below, presents two items with differing discrimination parameters. The slope at the level of item difficulty represents the item discrimination parameter. Items with steeper slopes discriminate persons better on the measured trait.

Many rehabilitation research investigators use the one-parameter model, also called the Rasch model to create scales. The Rasch model assumes that a person's response to an item is a function of person ability and item difficulty. Scale measures are log transformed and converted to logits (log odds units), which is an interval scale.[8] Rasch model proponents propose that equal interval measures are a key advantage of the Rasch model. The equal interval property of the one parameter IRT model is lost with further parameter estimation.[91]

Equal intervals allow for arithmetic functions such as addition and subtraction. Thus, as shown in figure 1-2, a '3' is exactly 2 more than a 1 on the interval scale. Alternatively, ordinal scale steps are not equivalent which makes it more difficult to interpret if an investigator seeks to determine health care intervention efficacy. For example, looking at the ordinal scale below, a person improving from 1 to a 2 would improve more than a person improving from 2 to 3. Yet, measuring on the ordinal scale, each person would improve one unit. Alternatively, using the interval scale, a person improving from 1 to a 2 would improve equivalently to a person improving from 2 to 3. Also, a person improving two units demonstrates 2 times the improvement of a person improving 1 unit.

The item characteristic curve (ICC), shown in figure 1-3 below, illustrates the core concept of IRT – that person ability is a function of an item's difficulty, and discrimination. The probability that a person passes an item increases as they have a higher amount of ability.

Though CTT and MTT both assume that created outcomes assessment measure one primary construct, the procedures used in MTT address measurement challenges seen in CTT measures. Below, we discuss how IRT analyses address four challenges of CTT. Lastly, we describe how IRT measures have informed theory and practice in upper extremity stroke rehabilitation.

1.3 Value added benefit of MTT

1.3.1 1) Difficulty with comparison across different assessments of a similar construct

CTT measures typically produce a score. For example, the FIM[44] produces a score of 18 to 126 based on ratings of assistance needed to perform eighteen functional motor and cognitive tasks, (bathing, grooming or memory, e.g.). Similar to the cognitive portion of the FIM, the Rivermead Behavioral Memory Test (RBMT)[89] contains items to assess functional memory. However, though these tests provide norms and standardized scores for comparison, these scores are sample dependent, which makes it challenging to compare across groups and studies. Standardization is dependent on sample heterogeneity and thus can change between samples.

Though procedures do exist that could allow for comparison between scores obtained on instruments developed using CTT such as effect size,[43] MTT procedures make these comparisons in a more straightforward manner. Specifically, IRT linking procedures put different measurement scales on a common metric,[17, 34, 81] and MTT measures possess sample and item free properties. A more detailed explanation of the property of sample and item independence is addressed in the sample and test free property of MTT below.

1.3.2 2) Long tests that may contain redundant items

One way CTT increases the precision of measures is by adding items.[21] In CTT errors associated with items are assumed random, errors can affect a score in either direction and thus cancel each other out, with a mean of zero. The law of large numbers theorem demonstrates that, for a random distribution, as the number of variables or items increases, the sample mean approaches the true mean. Increased items then decreases the error associated with a score, as the sample error approaches the true population mean of zero. However, adding items also increase the time needed to complete the test, and redundant items may create superficial precision.

Alternatively, instruments developed with MTT do not need all items to determine a person score. Each item has a difficulty 'level'. A person with higher ability has a higher probability of passing a more difficult item. If a person passes an item at the middle of the scale, presenting items at the lower end of the scale is unnecessary. Further, many measures assess a need, or a diagnosis and have a cutoff score. For those persons extreme on the scale, only a few items might be needed to ascertain that a person's ability is at the extreme low or high part of a scale. They either do or do not meet a certain cutoff. For example, the Berg Balance Scale[5] measures functional balance ability. Persons scoring less than a 45 have been found to be at risk for falling. Using MTT, a person passing the higher items of standing on one foot or standing with one foot out in front, would not need to pass the easier items, such as standing unsupported.

For persons extreme on the scale, acceptable measurement error could be greater than the case where a person falls in the middle ability level, closer to a cutoff score. To evaluate a middle level person, one may want more items and a greater precision, less measurement error. The ideal item is one where the odds are even that a person passes or fails it. Velozo and colleagues proposed an item hierarchy order for fear of falling.[81] For someone who is afraid of falling getting in and out of bed, or on or off the toilet, further items are unnecessary to obtain a measure. We can use just that part of the scale. On the other hand, for someone falling closer to the middle of the scale, more items will help refine exactly where that person falls on the scale. Summarizing, because MTT relies on item level psychometrics and the ICC, instruments developed using MTT can vary in test length. All of the items are not needed to obtain a person score. However, the more items used will decrease measurement error, if needed.

1.3.3 3) Assessments that are sample and item dependent

MTT proposes that instruments developed using these procedures are sample and test free. When measures remain stable with different instruments that evaluate a similar construct, *objective measurement* is attained.[91] Objective measurement requires two components: 1) the calibrations used in an instrument need to be independent of the items or objects used to calibrate it, and 2) the measurement of the items or objects needs to be independent of the instrument that is used to measure them. To illustrate how a measure should be item and sample free, Wright (1968) uses the example of measuring height. One would not expect a person's height to change, beyond measurement error, depending on using a yardstick or a tape measure. In turn, the tape measure or yardstick does not change based on which person is being measured.

Alternatively, measures created using CTT are dependent on the sample and items. For example, standardized test scores are dependent on the sample that takes the test. For example, an IQ assessment would score a person at a different percentile rank depending on the comparison group. If compared to high school seniors, the score might be in the 90th percentile. If compared to college seniors, the same score might fall in the 85th percentile. A person's measure would change according to the comparison group.

To illustrate how MTT procedures develop instruments that are independent of the sample used, Wright (1968) compares instrument development using CTT and MTT. First, he splits a sample of law student scores on the verbal portion of the LSAT into two groups. One group performed best on a test while the second group performed worst. The range of scores in the lowest performing group is 10-23; the range of scores in the higher performing group is 33-46. In a graph, Wright (1968) demonstrates that person calibrations for each group using CTT instrument development form two distinct lines. One can see that an instrument developed using either sample does not allow for measuring a person who falls outside of either range. That is, using the 'dumb' person group sample, there is no way to measure any person who scores in the 'smart' group range.

Though this example is certainly exaggerated, it also provides for a clear test of the sample-free property proposed by MTT procedures. Because the calibration methods are based on how a person would fair when presented with any given item, abilities can be estimated using either range of scores, and for persons at any point in the range of possible test scores. This can be done because the estimation of ability is based on what the probability is that a person with a certain amount of ability would ‘pass’ an item, given its difficulty level. That is, a person with a high ability level would be more likely to pass a more difficult item. Moreover, comparing calibrations based on the two groups, the person ability calibrations are almost identical when MTT calibration procedures are used. So, the using MTT calibrations, it doesn’t matter which sample is used. In other words, a measure created using MTT calibration procedures is sample free.

While the above discussion addresses how MTT calibrations create measures that are independent of the sample, MTT also proposes that the instruments are test free. That is, they are not dependent on the specific items used to create the measure. Using the same law student sample, to illustrate test independence, in MTT, Wright (1968) splits the test questions into two groups: one made up of the easier items and one made up of the harder items.

If person ability measures developed using MTT procedures are statistically equivalent, the mean of the standardized difference should be 0, with a standard deviation of 1. Examining the second part of Table 1-1, where the log ability transformations are noted, we can see that the difference in ability measures for a person on the two different tests are essentially 0 (.003), with a standard deviation of 1 (1.014).

1.3.4 4) Assessments that do not achieve the objective measurement principle of equal interval scaling.

The Rasch, or one-parameter IRT model, produces measures with equal intervals. To illustrate this, I use the Berg Balance Scale,[5] a scale used by physical therapists to assess balance. On the Berg Balance Scale, persons scoring below a 45 are at risks for falls. Yet, what we cannot tell from this scale is whether the difference between 35 and 40 is the same as the difference between 40 and 45. This is an ordinal scale, as shown in Figure 1-2. Thus, we cannot easily compare if two persons showing an improvement of 5 points exhibited equivalent improvement. Alternatively, a 5-unit comparison on a Rasch interval scale would be equivalent.

1.4 IRT informing theory and practice:

Beyond measurement benefits, rehabilitation scientists have proposed that IRT analysis can inform rehabilitation theory and practice. For example Woodbury et al. 2007, found that persons with stroke did not recover in a proximal to distal pattern as had long been theorized. Rather, they recovered in a simple to complex movement pattern. Also, it should be noted that this was done using IRT procedures with a measure that was created using CTT.

Occupational and physical therapy intervention in persons with stroke have assumed that recovery following stroke follows a proximal to distal direction, similar to typical development. But, when persons with stroke were evaluated using the FMA for the upper extremity, with the items evaluated using IRT procedures, Woodbury et al. 2007 showed using Rasch-generated item difficulty hierarchies that recovery proceeding from simple to complex movements better explained upper extremity stroke recovery, rather than a proximal to distal pattern.[90]

Further, Woodbury and colleagues suggest that clinicians can better identify the ‘just right challenge’ for their clients by evaluating where a person falls on a ‘keyform’. A Rasch generated form, the keyform displays items in a difficulty hierarchy format. Identifying where a person falls on the keyform allows the clinician to quickly ascertain which items fall near the client ability level. Thus, allowing for efficient goal setting for short and long term goals.

1.5 Conclusion

This paper details the value added benefit of using MTT procedures when creating health outcome measures. As health outcomes research moves forward, MTT procedures aid in comparing outcomes between studies, facilities and therapists. Additionally, MTT provides a framework for evaluating theory and practice. This should not be seen as pitting CTT against MTT, rather, that MTT allows for new means to further rehabilitation research. As illustrated by Woodbury & Velozo (2007),[90] using MTT procedures on a sound CTT measure furthered understanding of recovery in upper extremity function following stroke.

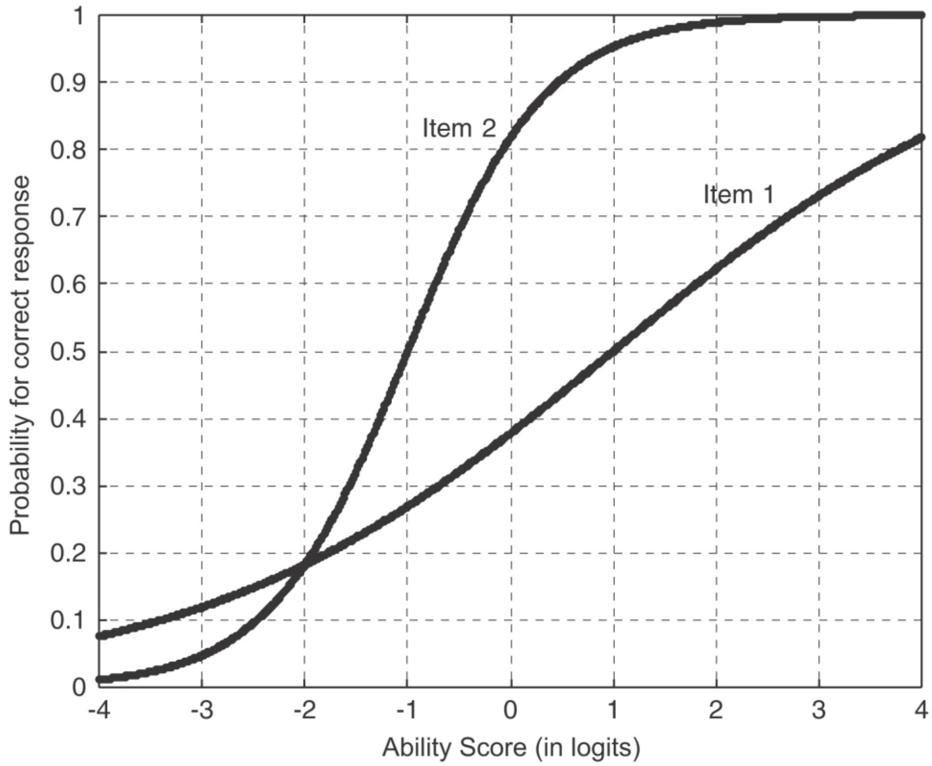

Figure 1-1. Two item characteristic curves with differing item discrimination

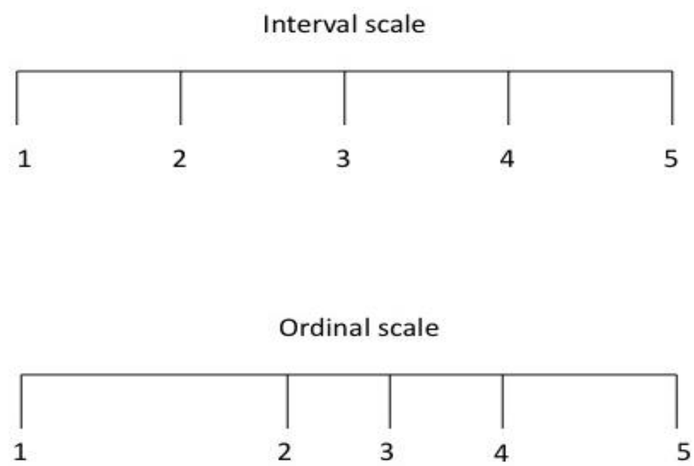

Figure 1-2. Interval and ordinal scale examples

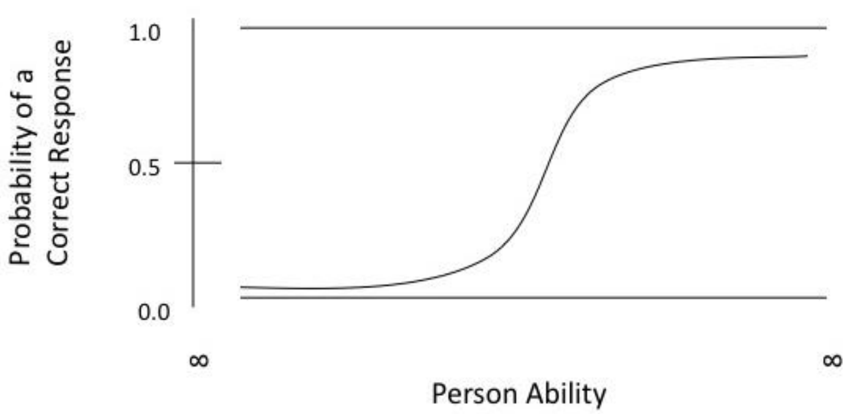

Figure 1-3. Item characteristic curve

CHAPTER 2
A MEASURE OF FUNCTIONAL COGNITION OF STROKE: ASSESSING DIMENSIONALITY

In order to better understand the functional impact of cognitive change due to aging, disease and rehabilitation, researchers have focused on measures of everyday ability. [2, 17, 44, 46, 74, 89] Two examples of applied cognition measures used or developed with persons with stroke include the Functional Independence Measure (FIM)[44] and a more recently developed measure, the Applied Cognition Scale (ACS).[17] Though the FIM has been used extensively in rehab settings, the range is limited. The FIM includes five general cognitive items: Cognitive comprehension, Expression, Social interaction, Problem solving and Memory. These items are rated on a seven point ordinal scale that ranges from complete dependence to complete independence. In an effort to improve measurement of applied cognition, Coster and colleagues[17] developed an applied cognition scale. Though the 46-item ACS improves the measurement breadth of functional cognition, included items do not distinguish between separate cognitive constructs. ACS developers included functional cognition items from seven existing measures. Examinees rated items for degree of difficulty. Example items include: (1) carrying a conversation with a friend in a noisy place, and (2) asking someone to do something for you. The items were generic in that they did not include items specific to a particular disease, and did not differentiate between cognitive domains. Persons affected by stroke present with a unique cognitive profile.[9] Further, while cognitive research evidences a strong general factor of cognition, decades of cognitive research evidences that the general factor encompasses many subdomains. [10-12, 39, 62] As such, our research team developed a measure of functional cognition in persons with stroke (MFC-S). More specifically, the aim in developing the MFC-S was to provide clinicians with a measure of applied cognition that included cognitive subdomains most pertinent to persons with stroke. We defined functional cognition as the ability to perform everyday activities that rely heavily on cognition, and separated functional cognition items into 10 cognitive domains: Language, Reading & Writing, Numerical Calculation, Visuospatial, Limb Praxis, Social Language, Emotional Function, Attention, Executive Function and Learning & Memory.[23] The qualitative process that developed these domains is described in detail in Donovan et al, 2008[23].

MTT methods, as well as most psychometrics, require that a measure is unidimensional.[56] That is, a person's score on a measure is assumed to primarily reflect the person's ability level on the measured construct, and not other factors. While perfect unidimensionality is ideal, what a test developer investigates is if the measure is essentially unidimensional. Linacre (2009)[53] suggests that when evaluating dimensionality, the measurement developer considers the purpose of the measure. Many constructs we may want to measure may contain more than one dimension. For example, a test for arithmetic may include addition and subtraction items. We would not want to separate these into two separate measures if the intent is to measure general math ability. When evaluating unidimensionality for the ten domains of the MFC-S, we expect that there will be some evidence of secondary dimensions.

Each of the MFC-S domains included items from different constructs that fall under a broader construct, the intended measurement construct. For example, the language domain contains some items that represent expressive speech and some items that represent receptive speech. However, the intent is to measure functional language ability. In cases where there is evidence of secondary dimensions, Linacre suggests inclusion of an equivalent amount of items on the secondary dimensions when developing the final measure.[53]

A variety of statistical methods, discussed further below and in the methods section, allow investigators to examine underlying dimensions of a measure and evaluate evidence of multidimensionality.[32, 56] In this study, we first explore the underlying factor structure of the entire MFC-S to evaluate quantitatively whether it is justifiable to include these 10 domains under the broader umbrella of functional cognition. Next, we investigated whether it is justifiable that each of the 10 domains of the MFC-S measure their intended construct. Alternatively, we investigated whether there was evidence that items in a given domain should be split into two separate measures.

Relevant to investigation of the entire measure factor structure, though extensive qualitative work went into the development of the MFC-S, we are unaware of prior factor analysis work supporting a strong apriori factor structure hypothesis specific to functional cognition in persons with stroke. However, there is a large body of work that has examined the factor structure of cognition more broadly. For example, Spearman[78] originally proposed the presence of a 'g' factor to explain the high correlation between individual performance on different tests of mental ability. Since that time, investigators have developed and expanded on this theory. As cognition is thought to include a higher order general factor, encompassing several subdomains,[10, 62] we expect evidence for a higher order general factor of functional cognition.

Several methods exist to establish unidimensionality.[32, 56, 73] Historically, methods used to evaluate dimensionality include factor analysis,[32, 73] principal components analysis (PCA),[56] and item response theory fit statistics[1]. There are strong arguments supporting each of these approaches. In order to evaluate dimensionality, but restricted by sample size, we chose to perform an exploratory factor analysis followed by a PCA of the standardized residuals.

Specifically, this study attempted to answer two questions: (1) Is there evidence to support a ten factor solution as an adequate fit for the MFC-S? and (2) For each of the ten proposed domains within the MFC-S, does the evidence support unidimensionality?

2.1 Methods

2.1.1 Instrumentation

The instrument development process[23] proceeded in four phases: (1) a literature review, (2) input from an expert advisory panel, (3) item development and (4) a field test. Donovan et al. 2008, detail the approach in conceptualizing functional cognition in stroke. Initially, the literature review produced seventeen constructs. An additional construct, apraxia was added after feedback from the advisory panel, resulting in ten final domains for the MFC-S.

Initial item development within each of ten domains was guided by Rasch measurement principles, neuropsychological theory and literature review. A hierarchy of easier and harder items was theorized to measure a person’s ability in each domain. The initial item pool contained 266 items. These 266 items were then presented to focus groups of persons with stroke, acute (N=20) and chronic (N=20), their significant others/caregivers and healthcare professionals. Detailed methods and results of the focus group are currently in a manuscript under preparation. Based on the focus groups items were removed, modified and added resulting in a final item bank of 244 items. The finalized 244 items crossed ten subdomains (language – 12 items, reading/writing – 14 items, numeric calculation – 9 items, limb praxis – 10 items, visuospatial function – 31 items, social use of language – 32 items, emotional function – 40 items, attention – 25 items, executive function – 41 items, memory – 29 items).

2.1.2 Participants

Approval for this study was obtained through the IRB-01 at the University of Florida. Each participant signed an informed consent approved by the IRB. Participants were recruited at local rehabilitation hospitals, outpatient clinics, area hospitals, and doctors’ offices. The final sample included 128 persons with stroke (acute = 49: right CVA = 28; left CVA = 19; other = 2; chronic = 70: right CVA = 39; left CVA = 35; other = 5). Detailed participant characteristics are presented in Appendix A. Participants with stroke were included in this study according to the following criteria: Inclusion criteria: (1) 20 to 89 years of age, (2) confirmed diagnosis of stroke (ischemic or intracerebral hemorrhage) based on medical records, (3) acute (7-21 days post onset) or chronic stroke (three months to one year) (4) English speaker. Exclusion criteria: (1) subarachnoid hemorrhage, brainstem stroke, intracranial hemorrhage due to rupture aneurysm or arteriovenous malformation, (2) previous stroke on the same side of the brain, (3) preexisting neurological disease (such as Parkinson's disease, amyotrophic lateral sclerosis, multiple sclerosis, dementia), (4) history of head trauma that resulted in residual neurological deficits, (5) legal blindness or severe visual impairment, (6) history of significant psychiatric illness (such as bipolar affective disorder, psychosis, schizophrenia, or medication refractory depression) that affects their cognitive function, (7) unresponsive to stimulation, (8) unintelligible to others, or unable to speak, (9) global aphasia (unable to understand or express).

2.2 Data Analysis

2.2.1 Unidimensionality

Unidimensionality: Historically, methods used to evaluate dimensionality include factor analysis,[32] principal components analysis (PCA),[56] and item response theory fit statistics.[1] Examining item banks for unidimensionality, some modern test theory investigators propose performing a confirmatory factor analysis (CFA) followed up with an exploratory factor analysis (EFA) if the model shows poor fit.[73] Other researchers suggest performing a PCA of standardized residuals, after removing the primary Rasch dimension, as a PCA will optimize the likelihood of uncovering a secondary dimension. Each approach has merits. Primarily due to a low subject to item ratio, we chose to conduct an EFA followed by a PCA of the standardized residuals. This allowed us to explore factor structure for the entire measure, as well as examine possible second dimensions at the item level for each domain.[56]

2.2.2 Subject to item ratio and item parceling

Though guidelines for necessary sample size and subject to item ratio to perform a factor analysis vary,[33, 60] Guadagnoli & Velicer[33] found stability of factor solutions produced with subject to item ratio as small as 3 to 1. The subject to item ratio in our dataset was small, .52. One solution investigators have used to handle small sample size is to parcel the items into a smaller number of groups. Thus, prior to EFA, items within each hypothesized domain were randomly assigned to one of three parcels, and the mean of each parcel was calculated. Further, as evaluation of normality indicated high skewness and kurtosis statistics, and a non normal distribution, the data was normalized using a Blom transformation.[6] The transformed dataset had acceptable distribution statistics.

2.2.3 Dimensionality Analysis

Exploratory factor analyses were computed in SPSS v 21[40] using principle axis factoring with promax rotation. Initial evaluation of number of factors to maintain, using Kaiser's rule of more than one eigenvalue[42] and examination of the scree plot,[13] suggested retaining four or five factors. Thus, the initial proposed ten-factor solution was assessed as well as the four and five factor solutions. Factor loadings greater than .35 were interpreted.[28] Root Mean Square Residual (RMSR) was calculated to evaluate model fit. RMSR, one of the few statistics available in EFA, compares the residuals from the reproduced to the observed correlations. RMSR $< .05$ suggests adequate model fit.[28]

Additionally, when performing an EFA, beyond examining the strength of factor loadings, investigators evaluate interpretability of solutions. Interpretability evaluates if the solution is compatible with what we know from theory and qualitative work. The ideal factor solution has high loadings on interpretable factors. Alternatively, split loadings, when items fall on two or more factors, with smaller loadings, the solution interpretation may lack clarity.

Finally, a PCA of standardized residuals was computed in WINSTEPS software.[58] If a secondary dimension is detected, indicated by an eigenvalue greater than 2 (the strength of at least two items), contrasting items are evaluated for content. In this manner, contrasting items that load on a secondary dimension can be evaluated on a theoretical basis. It is important to note that a given domain may include subdomains. For example, the reading and writing domain in the MFC-S includes reading and writing items that may load differently on a second dimension. In this instance, in order to assure an unbiased measure, an equivalent amount of reading and writing items would need to be included in an abbreviated form of the measure.

2.3 Results

2.3.1 Exploratory Factor Analysis

All factor solutions, four, five and ten, contained item parcels that split loadings on factors. Specifically, the attention and executive function domains consistently split loadings on factors, with split loadings also observed within the emotional function domain (four factor solution) and within the social language and limb praxis domain (five factor solution). As the purpose of this study was to investigate dimensionality of the ten domains of the MFC-S, and how they relate, we report the interpretation of the ten-factor solution, including the correlation of factors. Appendix B and C present the pattern matrix loadings for the four (Appendix B) and five (Appendix C) factor solution, for the interested reader.

Table 2-1 displays the pattern matrix for the conceptualized ten domains. Heywood cases indicate multicollinearity in the data, and examination of the factor correlation matrix revealed many high correlations ranging from .19 between limb praxis and language to .79 between memory and attention. Eighty seven percent of the correlations were above .4. In fact, a second order EFA, shown in Table 2-2, demonstrated evidence for a higher order general cognition factor. Factor loadings for all 10 functional cognition domains were above .4.

The ten-factor solution explained 74% of the variance prior to rotation. RMSR < .02, suggest adequate model fit. Examining the items that load on factors suggest the following interpretation of components: (1) numerical calculation, (2) limb praxis, (3) visuospatial ability, (4) reading and writing, (5)memory/verbal memory, (6) emotional function/inhibition and shifting, (7) social language, (8) executive function/updating, (9) language, and (10) attention. The first three factors in Table 2-1 had strong clear loadings on the numerical calculation domain, the limb praxis domain and the visuospatial domain. The remaining factors were interpreted as follows:

- Reading and writing items strongly load on factor three with a small loading of one attention parcel. Some of the attention items included reading and writing attention items. Interpretation of this factor is that it represents reading and writing.
- Memory items strongly load on factor five with moderately strong loading of one verbal item parcel and a negative small to moderate loading of emotional function. The interpretation of this factor is that it represents memory and verbal memory.
- Emotional function items strongly load on factor six, with moderate loadings from executive function and small loadings from social language. This factor appears to contain emotional function and the inhibition and shifting pieces of executive function associated with social emotional function.

- All social language item parcels had moderate to strong loadings on factor seven. Factor seven was interpreted as social language.
- Factor eight had moderate to strong positive loadings from two executive function item parcels and one moderate negative loading from the second language item parcel. We interpreted this factor as executive function/updating. Updating is a form
- Factor nine consisted of strong positive loadings from two of the language item parcels. This factor was interpreted as language.
- Lastly, factor ten consisted of two strong positive loadings from two of the attention domains. We interpreted this factor as attention.

2.3.2 Principle Components Analysis on Residuals

Table 2-3 summarizes PCA of standardized residuals results for the ten domains. The primary Rasch dimension for each domain explained a substantially higher amount of variance, ranging from 38% of the variance for the emotional function domain to 76% of the variance for the memory domain. Additional unexplained variance accounted for by secondary dimensions ranged from 2.7% for the memory domain to 9.7% for the limb praxis domain.

Further, secondary dimensions represented conceptualized subdomains of the construct. Appendix D details contrasting items on a second dimension, for each domain, using PCA of the standardized residuals, following removal of the primary Rasch component. Secondary domain dimensions interpretations: (1) language – receptive and expressive language items contrasted on a second dimension, (2) reading & writing – secondary dimension items contrasted on reading and writing items, (3) limb praxis -secondary dimension items separated along a movement/receptive dimension, (4) visuospatial - a secondary dimension contained items specific to hemispatial neglect, (5) social language – items that fell on a second dimension included receptive and expressive language items,

(6) emotional function – secondary dimension items fell on an emotional lability/empathy continuum, (7) attention – items loading on a second dimension fell along an action (writing or copying)/ passive (watching TV) continuum, (8) executive function – secondary dimension items fell on a mental fatigue continuum, and (9) memory - secondary dimension items fell on an episodic or semantic memory continuum or possibly a receptive/expressive continuum. The only domain that did not reveal a second dimension with an eigenvalue greater than 2 was numerical calculation.

2.4 Discussion

This study examined the dimensionality of a measure of functional cognition for persons with stroke. The findings generally support the use of ten domains in the MFC-S. However, these ten domains are highly correlated and many of the domains had split loadings between factors.

Exploratory factor analysis suggested adequate fit for a ten factor structure of the MFC-S, with a RMSR < .02, and reasonable interpretability of factors. Four conceptualized factors had split loadings: social language, executive function, attention, and language. A consideration of prior work may aid interpretation of these split loadings. For example, there is evidence that the executive function and attention constructs may contain other lower order factors. Prior factor analysis of executive function indicates this construct encompasses three interrelated factors: updating, inhibition and shifting.[52, 64] Similarly, the attention domain is thought to include several subdomains, such as sustained or divided attention.[77] Additionally, verbal ability has predicted everyday memory ability.[88] In this study, one language item parcel loaded positively on the ‘memory’ factor. Lastly, one social language item parcel split loadings between the social language and emotional function. Given that social ability is at least in part reliant on understanding emotions, this is not surprising.

It should also be noted that during qualitative item development, some theorized cognitive stroke domains were combined into a single domain. For example, expressive and receptive aphasia were combined into one language domain. Further, items in some domains crossed other domains, as might be expected when developing everyday items. For example, the attention domain contained items related to attention that included tasks or reading and writing: “Writes a message down.” and “Reads for 30 minutes without taking a break.” Thus, it is not surprising that some item parcel domains split loadings across factors.

Further, there is extensive work examining the factor structure of cognition that indicates cognitive domains are highly correlated. Especially pertinent to this sample, these findings can be viewed within the framework of dedifferentiation in aging. That is, as persons age, mental abilities become increasingly related.[4, 19] It is not surprising then that we found strong loadings on a higher order general cognition factor in this study, with aging, neurologically impaired persons.

Though the EFA evidenced strong relatedness and split loadings, the PCA of standardized residuals supports using each of the ten domains of the MFC-S as essentially unidimensional. In spite of the fact that secondary dimensions were found, the primary measurement construct was inclusive of these smaller dimensions. Further, the primary Rasch construct explained a substantial amount of the variance over additional variance explained by possible second dimensions. Finally, all domain's residual variance found in this study is less than that found in a comparable measure, the applied cognition scale (ACS).[17] Coster and colleagues found 10.4% residual variance in the ACS. The residual variance in our domains ranged from 2.7% for the memory domain to 9.7% for the limb praxis domain. This may be partially due to the ACS containing one general domain whereas the MFC-S detailed ten cognitive domains. As cognition is thought to encompass subdomains, it is logical that a measure that did not distinguish separate domains would have higher residual variance.

Before concluding, we note four limitations of this study. First, our sample size was relatively small and included both acute and chronic, as well as right and left hemisphere persons with stroke. Thus, sample size and heterogeneity may have affected the power of this study. Second, while item parceling improves the distributional properties of our data, the item level information is lost, hindering interpretation of the EFA. Third, our sample excluded persons more severely affected with stroke, which may limit the generalization of these findings to the larger stroke population. Lastly, the ten-factor solution had eight loadings greater than one, indicating redundancy between the ten factors. Future dimensionality work might find other factor solutions to be a more parsimonious, better fit.

2.5 Conclusion

The ideal Rasch model is perfectly unidimensional, but empirically, we can never expect pure unidimensionality. This may be particularly relevant when a measure evaluates every day function through self-report. Instead, we rely on theory and prior knowledge to evaluate secondary dimensions through item content. Due to evidence of secondary dimensions, as the measure is further developed, it will be important to include equivalent numbers of items reflecting secondary domains.

Table 2-1. Pattern matrix for 10-factor solution

	Factor									
Domain	1	2	3	4	5	6	7	8	9	10
Numerical Calculation Parcel 1	.766	—	—	—	—	—	—	—	—	—
Numerical Calculation Parcel 2	.413	—	—	—	—	—	—	—	—	—
Numerical Calculation Parcel 3	1.081	—	—	—	—	—	—	—	—	—
Limb Praxis Parcel 1	—	.520	—	—	—	—	—	—	—	—
Limb Praxis Parcel 2	—	.784	—	—	—	—	—	—	—	—
Limb Praxis Parcel 3	—	.920	—	—	—	—	—	—	—	—
Visuospatial Parcel 1	—	—	.548	—	—	—	—	—	—	—
Visuospatial Parcel 2	—	—	1.010	—	—	—	—	—	—	—
Visuospatial Parcel 3	—	—	.961	—	—	—	—	—	—	—
Reading & Writing Parcel 1	—	—	—	1.051	—	—	—	—	—	—
Reading & Writing Parcel 2	—	—	—	1.241	—	—	—	—	—	—
Reading & Writing Parcel 3	—	—	—	.699	—	—	—	—	—	—
Memory Parcel 1	—	—	—	—	.896	—	—	—	—	—
Memory Parcel 2	—	—	—	—	.973	—	—	—	—	—
Memory Parcel 3	—	—	—	—	1.169	—	—	—	—	—
Emotional Function Parcel 1	—	—	—	—	—	.771	—	—	—	—
Emotional Function Parcel 2	—	—	—	—	—	.781	—	—	—	—
Emotional Function Parcel 3	—	—	—	—	-.463	1.219	—	—	—	—
Social Language Parcel 1	—	—	—	—	—	.395	.467	—	—	—
Social Language Parcel 2	—	—	—	—	—	—	.858	—	—	—
Social Language Parcel 3	—	—	—	—	—	—	.444	—	—	—
Executive Function Parcel 1	—	—	—	—	—	.392	—	.458	—	—
Executive Function Parcel 2	—	—	—	—	—	—	—	.757	—	—
Executive Function Parcel 3	—	—	—	—	—	.523	—	—	—	—
Language Parcel 1	—	—	—	—	—	—	—	—	.652	—
Language Parcel 2	—	—	—	—	.665	—	—	-.447	—	—
Language Parcel 3	—	—	—	—	—	—	—	—	1.003	—
Attention Parcel 1	—	—	—	—	—	—	—	—	—	.855
Attention Parcel 2	—	—	—	—	—	—	—	—	—	—
Attention Parcel 3	—	—	—	.374	—	—	—	—	—	1.014

Note: Factor interpretation is as follows: (1) Emotional Function; Inhibition and Shifting, (2)Memory; Crystallized Intelligence, (3) Reading and writing; Sensory Processing. (4) Numerical calculation, (5) Visuospatial, (6) Limb Praxis, (7) Language; Expressive Speech, (8) Attention, (9) Social Language, (10) Executive Function; Updating.

Table 2-2. Higher order 'G' factor

Factor Matrix	
	Factor 1
Emotional Function	.806
Memory	.879
Read & Write	.860
Numerical Calculation	.799
Visuospatial	.764
Limb Praxis	.547
Language	.658
Attention	.887
Social Language	.496
Executive Function	.782

Table 2-3. Summary of PCA of standardized residuals

CONSTRUCTS	Language (13 Items)	Reading & Writing (14 Items)	Numerical Calculation (9 Items)	Limb Praxis (10 Items)	Visuo-spatial (31 Items)	Social Use of Language (32 Items)	Emotional Function (40 Items)	Attention (25 Items)	Executive Function (41 Items)	Memory (29 Items)
Variance explained by measure	59.6%	72.5%	66.4%	57.7%	64.4%	48%	37.5%	55.9%	40.7%	75.9%
Percent of unexplained variance explained by second factor	6.5%	5.7%	—	9.7%	3.6%	6.9%	7.7%	4.6%	8.3%	3.6%
Eigenvalue of 1st residual PCA	2.1	2.9	1.8	2.3	3.2	4.2	4.9	2.6	5.7	3.2

CHAPTER 3
MEASURE OF FUNCTIONAL COGNITION IN STROKE: RASCH ANALYSIS

Recent research indicates that cognitive impairment has a significant impact on post stroke recovery.[85] Additionally, though cognitive impairment can predict functional outcome in persons with stroke,[24, 25, 67, 85] and as much as 70% of persons with stroke experience cognitive impairment, existing measures of everyday functional cognition for persons with stroke are limited in the breadth and depth of items,[18] or do not include tasks and domains specific to cognitive stroke impairment.[9] For example, the Functional Independence Measure (FIM) contains ratings of ability level for only three general cognitive items: memory, orientation and problem solving.[24, 47]

Many health outcomes researchers are increasingly turning to item response theory methods (described below) to develop and evaluate new and existing scales. Coster and colleagues[17] recently used Rasch analysis, also called the one parameter item response theory model, to develop an applied cognition scale (ACS). Their study used a convenience sample that included persons with neurological impairment, including persons with stroke, yet items did not conceptually integrate unique symptoms associated with stroke. Further, though the 46-item ACS improves the measurement breadth of functional cognition, included items did not distinguish between separate cognitive constructs.

Cognitive researchers have shown a general dimension of cognition that encompasses many subdomains.[2, 12, 62, 78] In an effort to include conceptualized cognitive subdomains for persons with stroke, our research team developed a measure of functional cognition for persons with stroke (MFC-S). The development process, described in detail in Donovan, 2008,[23] included a literature review, input from an expert advisory panel, focus groups and cognitive interviews. The final 244 item bank crossed 10 domains: Language, Reading & Writing, Numerical Calculation, Visuospatial, Limb Praxis, Social Language, Emotional Function, Attention, Executive Function and Learning & Memory.

We chose Rasch analysis[8] to evaluate each of the domains. Rasch measures allows for equal interval level measurement by converting scores to a logit scale.[8] That is, a score of 1 logit is exactly one more than a score of 2 logits. To illustrate, the Rasch model presents items on an item difficulty hierarchy, and calculates a person score based on a person's response to items. Persons with a higher ability level will be more likely to pass more difficult items, and persons with less ability will be less likely to pass more difficult items.

Through examination of the item hierarchy, and fit statistics, Rasch methods allow for examination of a measure at the item level rather than the test level. Further, Rasch modelers propose that it is better to fit the data to the model than to fit the model to the data.[54] By fitting the data to the model, misfitting items or persons can be identified, with fit statistics, and "diagnosed".

This paper evaluates and presents the Rasch psychometrics of the MFC-S. Specifically, item and person misfit, scale analysis and item hierarchy are evaluated.

3.1 Methods

3.1.1 Participants

Approval for this study was obtained through the IRB-01 at the University of Florida. Each participant signed an informed consent approved by the IRB. Participants were recruited at local rehabilitation hospitals, outpatient clinics, area hospitals, and doctors' offices. The final sample included 128 persons with stroke (acute = 49: right CVA = 28; left CVA = 19; other = 2; chronic = 70: right CVA = 39; left CVA = 35; other = 5). Detailed participant characteristics are presented in Appendix A. Participants with stroke were included in this study according to the following criteria: Inclusion criteria: (1) 20 to 89 years of age, (2) confirmed diagnosis of stroke (ischemic or intracerebral hemorrhage) based on medical records, (3) acute (7-21 days post onset) or chronic stroke (three months to one year) (4) English speaker. Exclusion criteria: (1) subarachnoid hemorrhage, brainstem stroke, intracranial hemorrhage due to rupture aneurysm or arteriovenous malformation, (2) previous stroke on the same side of the brain, (3) preexisting neurological disease (such as Parkinson's disease, amyotrophic lateral sclerosis, multiple sclerosis, dementia), (4) history of head trauma that resulted in residual neurological deficits, (5) legal blindness or severe visual impairment, (6) history of significant psychiatric illness (such as bipolar affective disorder, psychosis, schizophrenia, or medication refractory depression) that affects their cognitive function, (7) unresponsive to stimulation, (8) unintelligible to others, or unable to speak, (9) global aphasia (unable to understand or express).

3.1.2 Instrumentation

The MFC-S, presented in Appendix E, contains 244 items that cross 10 domains: language – 12 items, reading/writing – 14 items, numeric calculation – 9 items, limb praxis – 10 items, visuospatial function – 31 items, social use of language – 32 items, emotional function – 40 items, attention – 25 items, executive function – 41 items, memory – 29 items. Construct development is described in detail in Donovan et al. 2008[9] and focus group methods in a manuscript in preparation.

3.2 Administration procedures

The MFC-S was administered to patients along with several other screening instruments and assessments. Research assistants, trained by neuropsychologists, administered all assessments within the hospital room (acute patients) or within the patient's home (chronic patients). Patient assessments were administered in the following order: 1) demographics, 2) MFC-S (Appendix E), 3) NIH Stroke Scale, 4) Center for Epidemiology Studies Depression Scale (CESD), 5) anosognosia screen, 6) Modified Rankin Scale, 7) Stroke Impact Scale (participation section), 8) global cognitive functioning scale pre-stroke, 9) global cognitive functioning scale current, and 10) selected neuropsychological assessments for a random set of 50 percent of participants. The order of the administration of the MFC-S domains was counterbalanced. The MFC-S was administered in a self-report format (versus interview format) for 43 percent of the patients.

3.3 Data analysis

3.3.1 Unidimensionality

Rasch models require that an instrument is unidimensional. Unidimensionality, and assumption under item response theory (IRT), assumes that a person's score on a test is the result of their ability level on the construct measured, rather than other unmeasured constructs. Unidimensionality was evaluated, detailed in a manuscript under preparation, using exploratory factor analysis and a principal components analysis of standardized residuals for each of the ten domains. Results generally supported unidimensionality of the domains, with each domain loading on a second order, functional cognition factor.

3.3.2 Rasch Analysis

Rasch analysis was conducted on each functional cognition domain. Specifically, each domain was evaluated on five features: (1) Rating scale analysis, (2) Fit and reliability statistics, (3) Item difficulty hierarchy, (4) Ceiling and floor effects, and (5) Person separation. First, a rating scale analysis was performed. Linacre [57] proposes three essential criteria for optimal scale performance: (1) A minimum of ten observations should be observed in each rating scale category to provide unbiased step calibrations between categories, (2) Monotonicity: category measures were examined to assure they increase or decrease consistently as categories advance. (3) Outfit mean square (MnSq) for each rating category are below 2.0.

Under the Rasch model, a reasonable amount of randomness, or noise, is expected. The MnSq statistic of 1 indicates there is uniform variance of the data. Values greater than 2 suggest there is more unexplained variance than explained variance. Fit statistics were examined for each rating scale category, as well as persons and items.

Second, person fit, item fit and point-measure reliability statistics were estimated. Rasch analysis calculates two fit statistics.[7] The infit statistic is sensitive to unexpected patterns of responses on items matched to a person's ability level. The outfit statistc is sensitive to departure from model expectations when item difficulty is far from a person's ability level.

Wright and colleagues[1] suggest acceptable fit guidelines of $.6 < MnSq < 1.4$, with a corresponding standardized Z score of less than 2.0 for questionnaire type measures. Less than .6 may produce misleadingly good reliability and separation estimates, but are not degrading to the measure. High fit statistics indicate that there is more observed variance than expected by the model. Thus, items and persons that had high fit statistics were flagged and evaluated for theoretical misfit.   While the Rasch model does not include discrimination in item and persons calibrations, Winsteps [55] does provide item discrimination statistics. Low (<.2) item discrimination indices were flagged. [45] Misfitting persons were further evaluated for data entry errors or misunderstanding of items.

Third, item hierarchy was evaluated for logical order of item difficulties, and ceiling and floor effects. For a given domain, items that conceptually are more difficult should fall on the higher part of the scale. For example, for the language domain, carrying on a conversation in a distracting environment should be more difficult than responding to yes or no questions. Ceiling and floor effects are also reflected on the map. For example, in Figure 3-1, the # symbol to the left of the line represents persons. Persons reaching maximum or minimum scores fall at the top or bottom of the map, respectively.

Finally, the precision of this measure, with this particular sample, was evaluated using person separation and strata statistics. The person separation index indicates how much persons can be reliably separated into groups. Reliability above .6 allows for separation of persons into at least two statistically different groups.[1, 27] The strata index is computed from the person separation index and indicates the number of statistically distinct ability levels the sample can be divided.

3.4 Results

MFC-S Psychometrics are presented in Table 3-1.

3.4.1 Language

Linacre's three essential criteria for rating scales were met. All items met infit and outfit criteria. Three percent (4) of persons indicated high infit and outfit statistics. Two percent (2) of persons had high infit statistics. Further evaluation of the misfitting persons indicated that one person may have misunderstood simple language items such as: "Uses single words or everyday phrases (for example, "Hi," "Bye," or "How are you?" or, "Uses more than one word to express needs (for example, "drink coffee," "eat lunch," or "tired sleep")". That is, these questions were reported as "never" whereas the "always" was reported for several more difficult items such as carrying on a conversation without mistakes.

3.4.2 Item Person Map

Figure 3-1 presents the language item person map. The #s to the left of the vertical line represent two persons. Persons with higher ability are at the top, and those with lower ability at the bottom. Items are shown on the right. Items with higher difficulty are at the top, and those with lower difficulty at the bottom. Evaluating the item difficulty logic, conceptually more difficult items, such as "Carries on a conversation without mistakes," fell at the higher end of the scale. Alternatively, "Follows simple directions," was the easiest item. A ceiling effect was evident with 11% (14) of persons demonstrating maximum extreme scores. On the average people performed better than the item difficulties with the person mean at 1.68 logits +/- 1.4, and the item mean at 0 +/- .55. The person separation index was 1.56 indicating persons were separated into 2.4 statistically distinct strata.

3.4.3 Reading & Writing

Linacre's three essential criteria for rating scales were met. All items fit the Rasch model. Eight percent (10) of persons indicated high fit statistics: 5% (6) with high infit and outfit statistics, 2% (3) with high infit only, 1% (1) with high outfit only.

3.4.4 Item Person Map

Figure 3-2 presents the reading and writing item person map. Evaluating the item difficulty logic, conceptually more difficult items, such as "Completes a business form." fell at the higher end of the scale. Alternatively, "Reads familiar words." was the easiest item. A ceiling effect was evident with 17% (21) of persons demonstrating maximum extreme scores. One person had the minimum extreme score. On the average, people performed better than the item difficulties with the person mean at 1.01 logits +/- 1.78, and the item mean at 0 +/- .56. The person separation index was 1.84 indicating persons were separated into 2.79 statistically distinct strata.

3.4.5 Numerical Calculation

Linacre's three essential criteria for rating scales were met. All items fit the Rasch model. Five percent (7) of persons indicated high fit statistics: 4% (5) with high infit and outfit statistics, two with high infit only.

3.4.6 Item Person Map

Figure 3-3 presents the numerical calculation item person map. Evaluating the item difficulty logic, conceptually more difficult items, such as "Correctly divides restaurant bill for separate payments among diners." fell at the higher end of the scale. Alternatively, "Understands what numbers mean." was the easiest item. A ceiling effect was evident with 18% (23) of persons demonstrating maximum extreme scores. On the average, people performed better than the item difficulties with the person mean at

1.16 logits +/- 1.49, and the item mean at 0 +/- .69. The person separation index was 1.34 indicating persons were separated into 2.12 statistically distinct strata.

3.4.7 Limb Praxis

Linacre's three essential criteria for rating scales were not met. Though all rating scale categories had counts of 10 or greater and observed measures increased with higher ratings, the outfit MnSq = 2.24 for rating category one, exceeding the criteria of 2.0. Thus, the rating scale was collapsed to three categories. After collapsing categories, all three essential ratings scale criteria were met.

Twenty percent (2) of limb praxis items had high misfit. Specifically, "Waving goodbye" and "Is clumsy when using tools" had high infit and outfit statistics. Seven percent (9) persons indicated high fit statistics: 5% (6) with high infit and outfit statistics, and 2% (3) with high infit only.

3.4.8 Item Person Map

Figure 3-4 presents the limb praxis item person map. Evaluating the item difficulty logic, conceptually more difficult items, such as "Is clumsy when using tools" fell at the higher end of the scale. Alternatively, "Uses incorrect grooming tool" was the easiest item. A ceiling effect was present with 19% (24) of persons demonstrating maximum extreme scores. People performed much better than item difficulties with the person mean at 3.33 +/- 1.76 logits higher than item difficulty at 0 +/- 1.02. The person separation index was 1.01 indicating persons were separated into 1.68 statistically distinct strata.

3.4.9 Visuospatial

Linacre's three essential rating scale criteria were met. Thirteen percent (4) of items had high misfit. Specifically, "Bumps into doorways on left side", "Paralyzed limb hangs over wheelchair arm"; "Uses a map or directory to find a new location" and "Builds or constructs things" had high outfit statistics. Further, "Paralyzed limb hangs over wheelchair arm" also had high infit statistics and a low (.10) item discrimination index. Seven percent (9) persons indicated high fit statistics: 5% (7) with high infit and outfit statistics, 2% (2) with high outfit only.

3.4.10 Item Person Map

Figure 3-5 presents the visuospatial item person map. Evaluating the item difficulty logic, conceptually more difficult items, such as "Copies a chart from a book." fell at the higher end of the scale. Alternatively, "Recognizes faces of close family members." was the easiest item. Two persons had maximum extreme scores. Person ability was fairly well-matched to item difficulty with the person mean was .81 logits higher than item difficulty (anchored at 0). The person separation index was 2.0 indicating persons were separated into 3.0 statistically distinct strata.

3.4.11 Social Use of Language

Linacre's three essential rating scale criteria were not met. Though all rating scale categories had counts of 10 or greater and all MnSq were < 2, observed measures did not increase monotonically as rating scale categories increased. Specifically, the observed average measure was lower (.30) in category two than in category 1 (.42). Examination of the rating scale indicated that the probability of choosing category 2 and 3 did not reach high levels for a given ability level, so these categories were collapsed. All three essential criteria were met after collapsing scales.

One item had high outfit statistics: "Goes on and on without giving another person a chance to talk". Eleven percent (14) persons indicated high fit statistics: 9%

(12) with high infit and outfit statistics, 1% (1) with high infit only and 1% (1) with high outfit only.

3.4.12 Item Person Map

Figure 3-6 presents the social use of language item person map. Evaluating the item difficulty logic, the most difficult item was “Walks away from a conversation” The easiest item was “Understands why people are crying at a tragic event.” No persons had extreme scores. Person ability and item difficulty were well matched with the person mean at .24 +/- .59 logits, the item mean at 0 +/- 1.25. The person separation index was 1.37 indicating persons were separated into 2.16 statistically distinct strata.

3.4.13 Emotional Function

Linacre’s three essential rating scale criteria were met. Four items had high misfit: “Recognizes that he/she needs assistance for problems caused by a stroke”, “Attempts tasks that involve thinking skills beyond his/her ability”, and “Attempts to do something that would result in harm to themselves or others” had high outfit statistics. Further, “Does not know why things are difficult since having a stroke” had high infit and outfit statistics. Twenty-two percent (28) of persons indicated high fit statistics: 16% (20) with high infit and outfit statistics, 2%(3) with high outfit only and 4% (5) with high infit only.

3.4.14 Item Person Map

Figure 3-7 presents the emotional function item person map. Conceptually more difficult items, such as “Gets as much done during the day as planned” fell at the higher end of the scale. Alternatively, “Blames others for problems or mistakes” was the easiest item. No persons had extreme scores. Person ability was fairly well matched with item difficulty with the person mean at .81 logits +/- .6, the item mean at 0 +/- .42.

The person separation index was 2.31 indicating persons were separated into 3.4 statistically distinct strata.

3.4.15 Attention

Linacre's three essential rating scale criteria were met. Eight percent (2) of items had high fit statistics. Specifically, "Stops in the middle of a task when distracted" had high infit and outfit statistics. "Pays attention to the wrong conversation" had high outfit statistics. Further, these items had negative discrimination indices. Nine percent (11) of persons indicated high fit statistics: 6% (8) with high infit and outfit statistics and 2% (3) with high infit only.

3.4.16 Item Person Map

Figure 3-8 presents the attention item person map. Conceptually more difficult items, such as "Has a conversation in a noisy environment" fell at the higher end of the scale. Alternatively, "Correctly answers yes or no questions about themselves" was the easiest item. One percent (1) of persons had extreme high scores. Person ability was fairly well matched with item difficulty with the person mean at .78 logits +/- .86, the item mean anchored at 0 +/- .46. The person separation index was 2.26 indicating persons were separated into 3.35 statistically distinct strata.

3.4.17 Executive Function

Linacre's three essential rating scale criteria were met. Twenty-four percent (5) of items had high fit statistics. "Tries to do an activity before having the ability to do it" had high infit and outfit statistics. "Starts an activity automatically", "Organizes an activity several days in advance", "Takes things literally" and "Seeks help when needed" had high outfit statistics. Further, "Tries to do an activity before having the ability to do it" had negative discrimination indices. Thirteen percent (16) persons indicated high fit statistics: 11% (14) with high infit and outfit, 2% (2) with high infit only.

3.4.18 Item Person Map

Figure 3-9 presents the executive function item person map. Evaluating the item difficulty logic, conceptually more difficult items, such as "Plans a big project" fell at the higher end of the scale.   Alternatively, "Reacts appropriately in a dangerous situation" was the easiest item. No persons had extreme scores.   The person mean was .78 logits +/- .7, with the item mean at 0 +/- .38. The person separation index was 2.74 indicating persons were separated into 3.99 statistically distinct strata.

3.4.19 Memory

Linacre's three essential rating scale criteria were met. Ten percent (3) of items had high fit statistics. Specifically, "Recalls birthdays, holidays and anniversaries" had high infit and outfit statistics. "Recalls childhood events." and "Recalls where the car is parked in the mall or grocery store." had high outfit statistics. Item discrimination indices revealed adequate discrimination in these items. Eleven percent (14) of persons indicated high fit statistics: 7% (9) with high infit and 1% (2) with high outfit only.

3.4.20 Item Person Map

Figure 3-10 presents the memory item person map. Evaluating the item difficulty logic, conceptually more difficult items, such as "Recalls activities or events from several months ago." fell at the higher end of the scale.   Alternatively, "Says own name correctly when asked." was the easiest item. A ceiling effect was evident with 7% (8) of persons demonstrating maximum extreme scores. On average, people performed better than the item difficulties with the person mean at 1.76 logits +/- 1.51, and the item mean at 0 +/- .72. The person separation index was 2.29 indicating persons were separated into 3.39 statistically distinct strata.

3.4.21 Person misfit

The demographics comparing misfitting persons to the overall group are presented in Table 3-2. Misfitting persons, on average,: (1) were .5 years older, (2) scored .83 higher on the NIH stroke scale, (3) tended to be classified as moderate to severe on the Modified Rankin Scale (misfit: 74%, entire sample: 68%), (4) tended to be acute (misfit: 45.8%, entire sample: 38.3%), (5) tended to have high school education or less (misfit: 69.5%, entire sample: 58.6%), (6) tended to need assist to complete the measure (misfit: 66%, entire sample: 57%), and (7) tended to be of non-white race (misfit: 42.4%, entire sample: 31.3%),

3.5 Discussion

This study presents the psychometrics and item hierarchy of the 10 domains that comprise the MFC-S. Results from this analysis generally support the use of the MFC-S domains, except limb praxis, to evaluate functional cognition in stroke rehabilitation and research settings. . Nine of the ten domains were able to separate persons into at least two statistically significant strata. Four domains – emotional function (3.4), attention (3.4), executive function (4.03) and memory (3.39) – separated persons into three or more statistically significant strata. However, the limb praxis domain did not separate people into at least two distinct groups and showed a strong ceiling effect with 19% (24) people reaching the maximum score. The language – 11% (14), reading and writing – 16% (21) and numerical calculation 18% (23) domains also exhibited a ceiling effect. This indicates that these domains may have been too easy for this sample. One solution in future work might be to add more difficult items. While sample ability may have affected these results, Coster and colleagues[17]found comparable Rasch person separation and reliability statistics in their more general applied cognition scale. Specifically, person separation for this scale was 1.8 and person reliability was .77 in sample of 477 persons with neurologic, orthopedic and complex medical diagnoses. Twenty-five percent of their sample had extreme maximum scores. The present study, excluding the limb praxis domain, had person separation statistics ranging from 1.34 to 2.29; and person reliability from .64 to .88.

3.5.1 Item Misfit

Examining the misfitting items, possible rationale for misfit includes reverse scored items, item sensitivity to a secondary dimension and item sensitivity to individual differences. Reverse coding items are items that were rescored to reflect higher scores representing greater ability. For example, in the MFC-S the attention item: “Stops in the middle of a task when distracted” was reverse scored so that a higher rating selection indicated more attention. Reverse coding items have been used by researchers to prevent response bias [37] but more recent investigations suggest that reverse scored items may have lower loadings on the primary measurement dimension and even group together loading on a second, unintended dimension.[15] Twenty-six percent of all MFC-S items were reverse code items and 62% of these items misfit the Rasch model. Table 3-3 presents these misfitting items. It is possible some persons misunderstood these items. That said, in the conceptual development of the MFC-S, some reverse scored items were removed or reworded if possible. The items that remained were thought to include critical logical pieces of the concept, and could not be reworded without losing the nature of the questions. Future work should keep this in mind when evaluating these items in replication samples.

Beyond, reverse coding; some misfitting items may have picked up on secondary dimensions. Three domains revealed misfitting items that might be inclusive of a second dimension. First, “Waving goodbye” in the limb praxis domain was the only item that included a motor, gesture component. Second, the misfitting items in the emotional function domain all related to the ability to recognize one’s limitations. Last, the misfitting memory items all included the wording “Recalls…”

3.5.2 Person Misfit

Person misfit ranged from 2% (language) to 28% (emotional function). Coster and colleagues found 8% of their sample misfit the model.[17] The demographics comparing misfitting persons to the overall group are presented in Table 3-3. A higher percentage of misfitting persons were less educated, had more severe stroke symptoms and were from non-Caucasian racial groups. It is possible these factors influenced understanding or interpretation of the items.

Two limitations should be considered in future research: (1) person ability and (2) self-report challenges in persons with cognitive impairment. Despite the fact that this sample was of adequate size,[59, 86] ceiling effects and mismatch for difficulty of test were evident in some domains. Though including persons with more severe impairment in future study might match the person ability to item difficulty better; this leads to the challenge of acquiring accurate self-reports from persons with communicative impairment. Two possible solutions are to use proxy reports by clinicians or family members, or create performance-based measures. However, investigators have found varying levels of agreement with self-report. For example, McPhail and colleagues [63] found lower levels of agreement between self and proxy report in persons more cognitively impaired.

3.5.3 Conclusion

These results support the use of the MFC-S in research and rehabilitation settings. Though future work will further inform these results, this measure is a basis measuring functional cognition in persons with stroke. Future work should focus on evaluating: (1) how the MFC-S relates to other measures of cognition (2) new items that might extend the difficulty of ceiling domains, (3) re-conceptualizing and developing new items for the limb praxis domain and (4) evaluate the item statistics of reverse coded items.

Table 3-1. Summary of Rasch psychometrics for MFC-S

CONSTRUCTS	Language (13 Items)	Reading & Writing (14 Items)	Numerical Calculation (9 Items)	Limb Praxis (10 Items)*	Visuospatial (31 Items)	Social Use of Language (32 Items)*	Emotional Function (40 Iems)	Attention (25 Items)	Executive Function (40 Items)	Memory (29 Items)
# Items Misfitting	0	0	0	2	3	0	4	0	3	2
# Persons Misfitting	3	10	7	12	12	13	17	15	20	14
Rating Scale Categories with 10 counts or greater	4	4	4	3	4	3	4	4	4	4
Rating Scale Categories Increase (Y/N)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
MnSQ Outfit less than 2 (Y/N)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Person Separation (Extreme and Not Extreme)	1.56	1.84	1.34	1.34	1.92	1.53	2.31	2.09	2.77	2.29
Person Strata	2.4	2.79	2.12	2.12	2.89	2.37	3.4	3.12	4.03	3.39
Person Separation Reliability	.71	.77	.64	.64	.79	.70	.84	.81	.88	.84
Cronbach's Alpha	.91	.97	.96	.86	.94	.75	.89	.91	.95	.95

Table 3-1. Continued

CONSTRUCTS	Language (13 Items)	Reading & Writing (14 Items)	Numerical Calculation (9 Items)	Limb Praxis (10 Items)*	Visuospatial (31 Items)	Social Use of Language (32 Items)*	Emotional Function (40 Items)	Attention (25 Items)	Executive Function (41 Items)	Memory (29 Items)
Person to measure correlation	.84	.79	.77	.79	.58	.91	.86	.82	.85	.87
Person Mean (logits)	1.68	1.01	1.16	-2.83	.84	.31	.81	.91	.8	1.76
SD	1.4	1.78	1.49	1.83	.87	.65	.6	1.08	.73	1.51
Ceiling	14	21	23	0	3	0	0	4	0	8
Floor	0	1	0	2	0	0	0	0	0	0
Measured	111	104	103	123	124	127	127	121	124	117
Missing	3	2	2	3	1	1	1	3	4	3

Collapsed to three categories because four-category ratings scale did not meet Linacre's three essential criterion.

Table 3-2. Misfitting person demographics

	Misfitting Person group	Entire Sample
Gender	Male: 26 (44.1%) Female: 33 (55.9%)	Male: 58 (45.3%) Female: 70 (54.7%)
Age	66.34 (12.45)	65.84 (13)
NIH Stroke Scale	5.23 (4.17)	4.4 (3.84)
Acute or Chronic	Acute: 27 (45.8%) Chronic: 32 (54.2%)	Acute: 49 (38.3%) Chronic: 79 (61.7%)
Modified Rankin Scale (moderate/severe)	Mild: 15 (25.4%) Moderate/Severe: 44 (74.4%)	Mild: 41 (32%) Moderate/Severe: 87 (68%)
Stroke Location	Right: 30 (50.8%) Left: 24 (40.7%) Right and Cerebellar: 1 (1.7%) Right and Subcortical: 1 (1.7%) Uncertain: 2 (3.4%) Bilateral: 1 (1.7%)	Right: 69 (53.9%) Left: 52 (40.6%) Right and Cerebellar: 1 (.8%) Right and Subcortical: 1 (.8%) Uncertain: 2 (2.3%) Bilateral: 3 (2.3%)
Education	< High School: 16 (27.1) High School/GED 25 (42.4) Some College or more: 18 (30.5)	< High School: 27 (21.1) High School/GED 48 (37.5) Some College or more: 53 (41.4)
Global Assessment of Cognitive Function	1.33 (1.6)	1.41 (1.46)
Assist with MFC-S	Assist: 39 (66%)	Assist: 73 (57%)
Race	Black or African American: 23 (39%) White: 33 (55.9%) Asian: 2 (3.4%) Unknown: 1 (1.7%)	Black or African American: 38 (29.7%) White: 87 (68%) Asian: 2 (1.6%) Unknown: 1 (.8%)

Table 3-3. Reverse coding items

Domain	Item (s)
Limb Praxis	Is clumsy when using tools.
Visuospatial	Paralyzed limb hangs over wheelchair Bumps into doorway on left side. Gets lost in new setting.
Social Language	Goes on and on without giving another persons a chance to talk.
Emotional Function	Does not know why things are difficult. Attempts to do harmful things. Attempts tasks that require thinking skills beyond ability. Does not know why things are difficult since having a stroke.
Attention	Stops in the middle of a task when distracted. Pays attention to the wrong conversation.
Executive Function	Tries to do an activity before having the ability to do it. Takes things literally.

```
--------------------------------------------------------------------------------
        PERSONS             ITEMS
                      |
   4        #######   +
                      |
                      |
                 .#   |
                      |
                      |
                     T|
                      |
   3            ###   +
                  #   |
                      |
                      |
                  .   |
                .##   |
                  .  S|
                 ##   |
   2                  +
             .####    |
              ####    |
              ####    |
                 .#   |
                ###   |
              .### M|
                ###   |T
   1             ##   +  Carries on a conversation without mistakes
                 .#   |
                  #   |
                .##   |
                 .#   |S Speaks in short sentences   Finds the right words to get ideas across   Follows a conversation in a distracting environment by gesturing or commenting
                 .# S|  Follows multiple step directions when asked Answers questions correctly about complex information
                ###   |
                .##   |
   0            .##   +M Uses more than one word to express needs
                  .   |
                      | Follows 2-step directions when asked
                  .   |
                      |S Responds to simple yes or no questions either by nodding, gesturing, or speaking  Follows a simple conversation by gesturing or commenting
                 .# T| Uses single words or everyday phrases
                      | Turns head in direction of speaker when name is called   Follows simple directions when asked
                  .   |
  -1                  +
                      |
EACH '#' IS 2.
```

Figure 3-1. Language person item map

```
          PERSONS         ITEMS
    4   .##########  +
                     |
                     |
                     |
                  .  |
    3                +
                    T|
                 .#  |
                     |
                 .#  |
                  .  |
    2             #  +
                  #  |
                ### S|
                 .#  |
                  #  |
                 ##  |
                .##  |T
    1             #  +
               ####  |
                .##  |  Completes a business form   Writes a brief letter  Writes more than one paragraph
              .####  |S Reads complex information
                 .# M|  Reads a book
              #####  |
                  #  |  Reads a complete article in the daily newspaper or magazine   Writes a short list   Writes a short note
    0           .##  +M
                 .#  |
                  #  |  Reads titles of articles in the daily newspaper
                  .  |  Reads a personal letter that is from a relative or friend
                 ##  |S
                 ## S|  Reads the menu in a restaurant   Reads signs in a store or hospital   Writes name and address
                 .#  |  Reads familiar words
   -1             .  +
                 .#  |T
                  .  |
                  #  |
                     |
                    T|
   -2             .  +
                     |
                  .  |
                     |
                     |
   -3             .  +
                  .  |
                     |
                     ||
                     |
   -4             .  +
                     |
 EACH '#' IS 2.
```

Figure 3-2. Reading and writing person item map

```
        PERSONS              ITEMS
                         |
  3   .############     +
                    .    |
                         |
                        T|
                    .    |
                         |
                         |
                  ###    ||
                         |
                    .    |
  2                ##    +
                         |
                    .    |
                   ##   S|
                    .    |
                  .##    |
                    .    |T
                  ###    |
                    .    |
                   ##    |   Correctly divides restaurant bill for separate payments among diners
  1               .##    +
                    #    |
                 ####    |
                   ##    |S
                    .   M|   Correctly calculates amount of tip for the waitress or waiter
                   .#    |   Correctly pays for an item with exact change
               .#####    |
                         |
                    .    |
                   ##    |   Correctly measures an amount
  0                 #    +M  Adds and subtracts small numbers
                    #    |   Correctly makes change
                    #    |   Copies numbers
                    .    |
                    .   S|
                    #    |
                  .##    |
                    #    |S  Recognizes numbers
                    #    |
                         |
 -1                 #    +
                    #    |
                    .    |
                    .    |
                        T|T  Understands what numbers mean
                    .    |
                    .    |
                         |
                    .    |
 -2                      +
                         |
EACH '#' IS 2.
```

Figure 3-3. Numerical calculation person item map

```
       PERSONS          ITEMS
                   |
  5     #########  +
                   |
                   |
                   |
                   |
      .########## S|
                .  |
  4             #  +
                   |
                   |
                .  |
                   |
          .######  |
                   |
  3             .  +
                .  |
              .## M|   Is clumsy when using tools
                #  |
                   |
                .  |
                .  |
  2             .  +T
                   |
               .#  |
                .  |
               ##  |
                  S|
                .  |
  1            .#  +S
                .  |
                .  |   Waves hello or goodbye
                   |
                   |
               .#  |
                   |   Uses incorrect cooking tools
  0             #  +M  Chooses the right kitchen tool but uses it in the wrong way
                  T|
                   |   Chooses the right grooming  tool but uses in the wrong way  Chooses the right utensil but uses it in the wrong way
                .  |   Uses wrong eating utensil
                   |   Chooses the right tool for the job but uses  in the wrong way
                   |   Chooses the incorrect tool for the job
                   |
 -1                +S
                .  |
                   |   Uses incorrect grooming tool
                   |
                   |
                   |
                   |
 -2                +T
                   ||
EACH '#' IS 3.
```

Figure 3-4. Limb praxis person item map

```
     PERSONS            ITEMS
                |
 3          XX  +
                |
                |
            XX  |
                |
             X  |
           XXX  |
            XX T|
             X  |
 2          XX  +
            XX  |
                |
            XX  |
          XXXX  |
               S|
        XXXXXX  |
             X  |T
    XXXXXXXXXX  |
            XX  |   Copies a chart from a book
 1          XX  +   Draws a simple sketch   Draws a simple map
   XXXXXXXXXXX  |   Builds or constructs things
          XXXX M|
          XXXX  |
    XXXXXXXXXX  |S  Writes or draws on left side of paper
        XXXXXX  |   Uses a map or directory to find a new location
     XXXXXXXXX  |   Folds a piece of paper in thirds to put in an envelope
       XXXXXXX  |   Uses a mouse to click on a computer screen
    XXXXXXXXXX  |   Looks at left side of clock   Gets lost in a new setting  Points to specific text text on a page Points to a location on a map
           XXX S|   Reads words on left side of a menu or book   Locates a particular item on the first try Gets specific book off bookshelf
                     Stacks items according to shape and size
 0 XXXXXXXXXXX  +M  Eats food on left side of plate or tray  Dresses or grooms left side of body Reaches out and grasps an object
                    Makes an entry on the correct line of a form
         XXXXX  |   Recognizes the face of a person they met recently
             X  |   Moves eyes or turns head to left side in response to person entering room or the phone ringing
                    Paralyzed limb hangs over wheelchair arm (R)
                    Finds way around grocery store to locate items
             X  |   Bumps into doorways on left side (R)
             X  |
             X  |
                |S  Finds way around family or friend's house
             X T|
                |   Gets lost when driving or walking around own neighborhood (R)
                |
-1              +   Recognizes faces of neighbors, co-workers, hairdresser, or pastor/minister
                |   Finds way around own house
                |
                |T  Recognizes own faces in the mirror
                |   Recognizes faces of close family members
                |
                |
                |
                |
                |
-2              +
                |
```

Figure 3-5. Visuospatial person item map

```
        PERSONS            ITEMS
   5                +
                    |
                 .  |
                    |
                    |
                    |
   4                +
                    |
                    |
                    |
                    |
   3                +
                 .  |
                    |
                    |T
                    |
                    |
   2                +  Walks away from a conversation (R)
                 .  |
                   T|  Facial expression does not match the conversation (R)
                       Blurts out something off topic during a conversation (R)
                    |  Jumps to a topic unrelated to the conversation (R)
                 #  |  Talks at the wrong time (R)   Sounds rude or demanding when making a request (R)   Gets stuck on a topic during a conversation (R)
                .#  |S Interrupts other people's conversations (R)  Tone of voice does not indicate that a question is being asked (R)
                       Uses flat tone of voice when should be expressing anger or happiness (R)
   1          .### S+  Misunderstands the intent of the person who is speaking (R)  Tone of voice does not indicate an emotion (R)
                       Leaves out an important piece of information during a conversation (R)
                ##  |  Tone of voice does not indicate that a minor problem has occurred (R)
           #######  |
              ####  |
        ########### M|
      #############  |
   0       #######  +M  Smoothly changes to a new topic during a conversation
          .#######  |
          .### S|   Has a conversation with more than one person   Makes a relevant comment during a conversation
                 .  |
                .#  |   Begins to answer open-ended questions within 2 seconds   Stays on topic while participating in a short conversation
                    |   Understands subtle jokes   Stays on topic when telling a story or explaining something   Tells life events or story in the correct order
  -1             . T+   Uses appropriate eye contact when having a conversation
                    |S 103. Allows others to take a turn in a conversation
                    |  108.  Turns toward a person when speaking to him/her
                       79. Understands that they are being teased
                       82. Understands obvious humor
                 .  |  104. Shows interest in what other people are saying
                       81. Recognizes when spouse or loved one is upset
                    |
                    |  80. Recognizes when someone is asking a question
  -2                +
                    |  83. Understands why people are crying at a tragic event
                    |
                    |T
                    |
                    |
  -3                +
                    |
 EACH '#' IS 2.
```

Figure 3-6. Social language person item map

```
      PERSONS              ITEMS
 3              .  +
                   |
                   |
                #  |
                .  |
                .  |
               .#  |
 2              . T+
                .  |
                #  |
               ##  |
                   |
               ## S|
               ##  |
             ####  |
 1        #######  +
          #######  |T  Gets as much done during the day as they planned
              .## M|
             ####  |
          #######  |   Feels or shows a different emotion intensity after stroke (R)  Shows an emotional response to sad movie
                       Stops an activity without getting upset   Listens to another's perspective without arguing
          .######  |S  Shows interest in trying new things   Picks up on subtle displays of emotion   Becomes tearful easily (R)
                       Accepts constructive criticism without losing temper   Emotions swing among happy, sad, and angry (R)
          .###### S|   Attempts tasks that involve thinking skills beyond his/her ability (R)   Attempts to do physical things that he/she cannot do (R)
                       Sees a job through to the end   Gets started on things that are important to them  Accepts help without losing temper
             .###  |   Does not know why things are difficult since having a stroke (R)  Has trouble making plans for the future (R)  Shows emotion when something very exciting or bad happens
                       Shows interest in doing things   Reacts when people are visibly upset   Overreacts to frustrating situations (R)
                       Gets upset with a change of routine (R)
 0            .##  +M  Shows concern about impairments or challenges   Shows interest in getting together with friends or extended family
                       Shows concern when someone is talking  Recognizes another person's point of view
                .  |   Demonstrates an understanding of own abilities  Acknowledges when someone is crying or shouting Gets upset with new situations (R)
                .  |   Is aware of a problem in functioning, but believes it is due to something other than the strok
                  T|S  Recognizes that he/she has problems resulting from a stroke   Recognizes that he/she needs assistance for problems caused by a stroke
                       Shows an emotional response that does not match the situation (R)
                   |   Makes demands without considering the other person's feelings (R)   Has angry or tearful outbursts for no apparent reason (R)
                   |   Asks embarrassing questions or makes hurtful or inappropriate comments (R)   Blurts out things that are offensive to others (R)
                   |
                   |T  Recognizes that he/she had a stroke   Attempts to do something that would result in harm to themselves or others (R)
-1                 +   Blames others for problems or mistakes (R)
                   ||
EACH '#' IS 2.
```

Figure 3-7. Emotional function person item map

```
       PERSONS        ITEMS
  4          X  +
                |
                |
             X  |
                |
                |
                |
  3             +
             X  |
                |
                |
            XX T|
             X  |
             X  |
  2       XXXX  +
             X  |
        XXXXXX  |
           XXX  |
           XXX S|
           XXX  |
          XXXX  |
       XXXXXXX  |
  1    XXXXXXX  +
     XXXXXXXXX  |T  Has a conversation in a noisy environment
    XXXXXXXXXX M|   Stops in the middle of a task when distracted (R)
     XXXXXXXXX  |   Reads 30 minutes without taking a break
      XXXXXXXX  |S  Talks with a person while the TV is on
      XXXXXXXX  |   Correctly writes down a message   Watches TV without being distracted by people talking
   XXXXXXXXXXX  |   Participates in therapy session 30 min without rest  Does an activity in a busy or distracting environment without stopping
                    Completes a meal while talking with someone   Locates a phone numberin telephone book
         XXXXX  |   Copies information correctly   Returns to an activity without a reminder after a short interruption
  0          X S+M  Pays attention to an hour-long TV program   Listens to a 15-30 minutes speech with focus
                    Participates in therapy session for 30 minutes with rest  Pays attention to the wrong conversation (R)
        XXXXXX  |   Selects meal items from a menu
          XXXX  |   Uses short sentences that make sense   Waves or nods to someone who enters the room
           XXX  |   Goes directly from his/her room to another room without wandering  Completes self care activities without getting distracted
            XX  |S  Answers the ringing phone
             X  |   Turns eyes in the direction of someone entering the room
            XX  |   Greets someone who enters the room
               T|T
 -1             +   Correctly answers yes or no questions about themselves
             X  |
                |
                |
                |
                |
                |
                |
 -2             +
                |
```

Figure 3-8. Attention person item map

```
      PERSONS        ITEMS
 3              +
                |
                |
                |
             X  |
             X  |
            XX  |
            XX  |
               T|
           XXX  |
 2          XX  +
             X  |
                |
            XX  |
            XX  |
         XXXXX S|
           XXX  |
          XXXX  |
         XXXXX  |
          XXXX  |
 1 XXXXXXXXXXX  +
       XXXXXXX  |
        XXXXXX M|T  Plans a big project
          XXXX  |
          XXXX  |   Readily changes behaviors when an error is pointed
      XXXXXXXX  |   Catches own mistakes while working on a task
     XXXXXXXXX  |S  Starts an activity without being told  Stops and starts an activity without being told
                    Breaks a job down into smaller parts  Feels tired or exhausted after working on a short thinking task (R)
      XXXXXXXX  |   Provides at least one solution to a problem   Plans a common daily activity
                    Tries to do an activity before having the ability to do it (R)  Gets slower and slower during a long thinking task (R)
       XXXXXXX  |   Fills free time without being told  Readily switches between activities
                    Organizes an activity days in advance  Keeps personal area organized  Follows an automated phone menu
                    Easy thinking tasks seem difficult (R)  Makes more mistakes during a long thinking task (R)
           XXX S|   Tries a different approach to a problem when the first does not work
                    Takes a long time to come up with an answer(R)  Completes a new routine in the allowed time
                    Has trouble getting up the energy to start a project(R)  Has trouble maintaining energy to complete thinking task (R)
 0         XXX  +M
       XXXXXXX  |   Makes careless errors during a new activity (R) Responds to simple requests without being asked several times
                    Avoids things that involve mental energy (R)  Has mental energy to do basic activities
                    Avoids a leisure activity because it takes too much mental energy (R)
         XXXXX  |   Starts an activity automatically   Responds to a question without being asked several times
                    Keeps up the pace required of therapy, school, or work
            XX  |   Takes things literally (R)
           XXX  |S  Responds to simple requests in a timely manner   Makes careless errors in daily tasks (R)
                    Seeks help when needed
                |   Says the same thing over and over (R)  Starts a task early enough to finish  Falls asleep in a thinking task (R)
               T|
                |   Plans ahead in order to get to an appointment on time   Follows safety rules
                |T
                |
-1              +   Responds appropriately to dangerous situations
                ||
```

Figure 3-9. Executive function person item map

```
        PERSONS           ITEMS
                   |
 5           ####  +
                   |
                   |
                   |
                #  |
                .  |
 4                 T+
                   |
             ####  |
                   |
                .  |
                   |
 3            ###  +
                .  |
               .# S|
              .##  |
              .##  |
                #  |
 2            .##  +
             .###  |
          #######  |
               ## M|T
                #  |   Recalls activities or events from several months ago
               .#  |
 1           ####  +   Recalls activities or events from one month ago  Recalls the story line in a book  Recalls where to find something
               .#  |   Recalls the information given at a previous appointment
              .##  |S  Recalls specific activities from last birthday or vacation Recalls activities from one week ago  Recalls childhood memories
            .####  |   Completes steps of a simple activity   Recalls where the car is parked in the mall or grocery store
             .### S|   Recalls more than one appointment in a single day
               .#  |   Recalls birthdays, holidays, and anniversaries   Describes the steps of a simple activity Recalls a simple therapy routine
 0             ##  +M  Recalls what he/she did before the stroke  Recalls activities done earlier in the day Recalls whether or not took medicine
               .#  |   Recalls simple routines
                .  |   Recalls how to use simple equipment  Recalls a visit by a familiar person from the previous day Says home phone number correctly
                .  |   Answers correctly when asked for current location
                #  |S  Correctly reports why they are/were in hospital
                  T|   Says home address correctly
-1              .  +   Says age correctly  Says the current year correctly  Names the current President
                   |   Says relative's name correctly when asked
                   |   Says own name correctly when asked
                .  |T
                   |
                   |
-2                 +
                   |
EACH '#' IS 2.
```

Figure 3-10. Memory person item map

CHAPTER 4
A VALIDITY STUDY OF A MEASURE OF FUNCTIONAL COGNITION FOR PERSONS WITH STROKE

Our research team recently developed the MFC -S to encompass everyday tasks that rely heavily on cognition. [23] Cognition is thought to include multiple secondary dimensions.[10-12] Following qualitative work including a literature review and expert panel recommendation, the MFC-S included items specific to the cognitive impairment observed in persons with stroke, covering ten cognitive domains: (1) Language (2) Reading and writing (3) Numerical calculation (4) Limb praxis (5) Visuospatial ability (6) Social language (7) Emotional function (8) Attention (9) Executive function and (10) Memory.

A critical component to instrument development is evaluation of validity. That is, does the used measure provide a meaningful outcome score given the intended goal?[16] Determining the validity of a newly developed applied cognitive measure is important, especially since this instrument intends to capture the implications of cognitive deficits on everyday life. Two types of evidence used to evaluate validity include: (1) comparing an instrument to other instruments thought to measure a similar construct, and (2) evaluating how an instrument predicts group membership.[16] Cognitive researchers have used more fundamental measures of cognition, as well as existing every day measures thought to measure a similar construct to examine concurrent validity.[2]

Additionally, the ten domains of the MFC-S were developed based on cognitive impairments observed in persons with stroke. For example, persons with a left sided cerebrovascular accident (CVA) are more likely to have impairments with expressive or receptive speech. Alternatively, persons with a right hemisphere CVA are more likely to experience visuospatial impairments. If the MFC-S measures the functional cognition of stroke, we should be able to predict whether a person has a left or right hemisphere CVA.

This study examines the validity of the MFC-S, answering two questions. First, what is the relationship between person scores measures on the MFC-S and traditional neuropsychological measures of cognition from similar domains? Second, can the MFC-S predict group membership? That is, does the profile of person scores, and for which domains, predict whether a person has had a right or left hemisphere stroke?

4.1 Methods

4.1.1 Participants

Approval for this study was obtained through the IRB-01 at the University of Florida. Each participant signed an informed consent approved by the IRB. Participants were recruited at local rehabilitation hospitals, outpatient clinics, area hospitals, and doctors' offices. Participants in this study represent a stratified random sample, based on acute/chronic and mild (Modified Rankin score 0-2) or moderate (Modified Rankin Score (3-5), from the larger sample (n=128) who took the MFC-S. This sample included 62 persons with stroke (acute = 22: right CVA = 17; left CVA = 3; other = 2; chronic = 40: right CVA = 19; left CVA = 16; other = 5). Detailed participant characteristics are presented in Table 4-1. Participants with stroke were included in this study according to the following criteria: Inclusion criteria: (1) 20 to 89 years of age, (2) confirmed diagnosis of stroke (ischemic or intracerebral hemorrhage) based on medical records, (3) acute (7-21 days post onset) or chronic stroke (three months to one year) (4) english speaker. Exclusion criteria: (1) subarachnoid hemorrhage, brainstem stroke, intracranial hemorrhage due to rupture aneurysm or arteriovenous malformation, (2) previous stroke on the same side of the brain, (3) preexisting neurological disease (such as Parkinson's disease, amyotrophic lateral sclerosis, multiple sclerosis, dementia), (4) history of head trauma that resulted in residual neurological deficits, (5) legal blindness or severe visual impairment, (6) history of significant psychiatric illness (such as bipolar affective disorder, psychosis, schizophrenia, or medication refractory depression) that affects their cognitive function, (7) unresponsive to stimulation, (8) unintelligible to others, or unable to speak, (9) global aphasia (unable to understand or express).

4.1.2 Instrumentation

4.1.2.1 The MFC-S

The MFC-S is a questionnaire type measure that includes 244 items over 10 domains: language – 12 items, reading/writing – 14 items, numeric calculation – 9 items, limb praxis – 10 items, visuospatial function – 31 items, social use of language – 32 items, emotional function – 40 items, attention – 25 items, executive function – 41 items, memory – 29 items. Respondents rated their ability of performing a task in the past week on a 4-point likert scale. Example items include: (1) Responds to simple yes or no questions either by nodding, gesturing, or speaking, and (2) Has trouble making plans for the future. Traditional Neuropsychologicall Measures: Table 4-2 presents MFC-S domains and corresponding neuropsychological measures, described further below.

4.1.2.2 Repeatable Battery for the Assessment of Neuropsychological Status (RBANS)[72]

The RBANS has been used to screen general cognitive function in a variety of diagnoses[31, 38, 50, 51, 65, 69, 72], including persons with stroke . The RBANS contains 12 subtests that constitute 5 index scores: (1) The immediate memory index comprises the subtests of list learning and story memory; (2) Figure copy and line orientation yield the visuospatial/constructional index; (3) Picture naming and semantic fluency yield the language index; (4) the attention index contains the digit span and coding subtests; (5) the delayed memory index includes list recall, list recognition, story recall, and figure recall subtests. We used: (1) the language index score to examine relationship with the MFC-S language domain; (2) index score of visuospatial construction to examine relationship with the MFC-S visuospatial domain; (3) the index score of immediate memory and the index score of delayed memory to examine relationship with the MFC-S learning and memory domain; and (4) the index score of attention to examine relationship with the MFC-S attention domain.

4.1.2.3 Digit Symbol-Coding

The Digit Symbol Coding, a subtest of the Wechsler Adult Intelligence Scale third edition (WAIS III)[87] was used to assess processing speed. A list of matched numbers and symbols is presented to the participant who is then asked to copy the symbols under the boxes of the numbers as fast as they can within 120 seconds. The number of correct responses is recorded. The WAIS-III coding scale was seleted to compare to MFC-S scores on the attention domain.

4.1.2.4 Behavior Rating Inventory of Executive Functions –Adult (BRIEF)

The Behavior Rating Inventory of Executive Function Adult Version (BRIEF-A) contains eight subscales.[74] The BRIEF is a questionnaire consisting of 75 items assessing executive behaviors. Three-point rating scale of the BRIEF ranges from 1 to 3, with 1 representing “never”, 2 representing “sometimes”, and 3 representing “often”. The Emotional Control subscale scores were compared to the MFC-S emotional function scores. The inhibit, shift, metacognition, and self-monitor scores were compared to the MFC-S executive function scores.

4.1.2.5 Functional Assessment of Communication Skills for Adults (ASHA-FACS)[30]

The ASHA-FACS contains a social communication subscale of 21 items. On a seven point rating scale, persons rate their ability on items such as: “Understands tone of voice” or “Initiates communication with other people.” The score of the social communication subscale was compared to the MFC-S social language score.

4.1.2.6 Center for Epidemiologic Studies – Depression Scale (CES-D)

The CES-Dis a 20 item self-report scale designed to assess a person’s level of 6 depression domains: depressed mood, feeling of worthlessness, feeling of helplessness, psychomotor retardation, loss of appetite and sleep disturbance. The questionnaire is rated on the frequency of experiencing depression-related symptoms in the past week. The four point scale ranges from 0 – rarely or none of the time to 3 – most or all of the time. CES-D scores range from 0-60 with higher scores indicative of higher depression symptoms. CES-D scores were compared to MFC-S emotional function scores.

4.1.2.7 Wechsler Individual Achievement Tests (WIAT-II)[79]

The WIAT-II is a standardized test for measuring achievement. The full-length assessment contains 9 subscales to assess academic achievement. We used the Word Reading, Spelling and Numerical Calculation subtests to examine the relationship with: (1) the MFC-S reading & writing domain (WIAT- II word reading and spelling); and (2) the MFC-S numerical calculation domain (WIAT - II numerical calculation).

4.1.2.8 Trails A & B

The Trail Making Test (TMT) is a timed test and includes parts A and B, which are both visual scanning tasks.[80] The TMT integrates recognition of numbers and letters and perception of spatial distribution. The Trails A requires connecting dots in sequential order of numbers whereas the Trails B requires connecting dots alternating sequential letters and numbers. We used the Trails A index score to examine the relationship with the MFC-S attention domain. The Trails B index score, and the Trails B/A raw score to examine the relationship with the executive function domain.[3] Some investigators have used the difference score between Trails A and B or the ratio of the Trails B to A to differentiate the processing speed component of Trails A from the switching component of Trails B.[49]

4.1.2.9 Delis Kaplan Executive Functions Scale (D-KEFS) Sorting Test[20]

The D-KEFS Sorting Test has two parts: a sort recognition condition and a free sort condition. In the free sorting condition the participant sorts cards into groups according to stimulus words or patterns on the cards. In the sort recognition condition the examinee attempts to describe the grouping rule the examiner uses to sort the cards. The D-KEFS Sorting allows for evaluation of several components of executive function such as problem solving, initiation and inhibition. The scores of the sorting test were compared to the MFC-S executive function score.

4.1.2.10 Mini - Florida Apraxia Battery (Mini-FAB)

The Florida Apraxia Battery (FAB) was chosen to assess praxis ability and has been used in studies with persons with stroke[29, 35, 68, 70, 75]. Subtest 5, gesture to command, was used in this study. Example items include “Show me how you wave goodbye”, or “Show me how you hammer a nail”. Participants were given verbal instruction to gesture or pretend to use a tool as if they were actually holding the tool in the hand. Persons were scored pass/fail if they could perform the gesture on 30 praxis items. FAB scores were compared to MFC-S limb praxis domain scores.

4.1.3 Administration Procedure

Research assistants, trained by a neuropsychologist, administered all the assessments. Assessment sessions occurred within the hospital room (acute patients), or within the patient's home (chronic patients). The MFC-S was administered in a self-report format (versus interview format) 43 percent of the time for patients. As with the MFC-S domains, the ordering of the neuropsychological/ functional assessment battery was counterbalanced.

4.1.4 Data Analysis

Correlation, profile analysis and logistic regression were used to evaluate the validity of the MFC-S. Pearson correlations were computed in SPSS vs 21 [40]between the neuropsychological measures and the corresponding domains of the MFC-S to examine the relationship between the traditional neuropsychological measures and the MFC-S domains. In order to control for family wise error rate, for each domain that had more than one comparison, we report the p value from the statistical output, then use the Bonferroni correction[26] (α / number of comparisons) to evaluate significance at the $p = .05$ level. So, if there are three comparisons for a domain, we would need the reported p value to be $.05/3 = .017$ to reach statistical significance, controlling for multiple comparisons. . We predicted to find significant correlations between comparable constructs.

Next, a profile analysis was done comparing right hemisphere CVA and left hemisphere CVA groups. As persons with stroke often present with cognitive impairment based on the side of their CVA, we predicted that persons with left and right hemisphere stroke would present with a different pattern of scores. Lastly, we performed a logistic regression; following the profile analysis to assess which domains significantly predicted group membership (i.e. left or right hemisphere CVA).

4.2 Results

4.2.1 Correlation with concurrent measures

Table 4-3 presents the correlation results for the MFC-S domains with comparison measures. Seven of the ten domains had statistically significant correlations with at least some of the comparison measures. Significant correlations ranged from .26 between the ASHA FACS and the social language domain to .62 between the BRIEF shift subtest and the executive function domain. P values available from the statistical output are reported. Two significant p values could be considered non significant, at the $p < .05$ level, with Bonferroni correction: (1) The RBANS immediate memory in the memory domain (Bonferroni correction p value = .025) and (2) the D-KEFS Sort Recognition in the executive function domain (Bonferroni correction p value = .006).

4.2.2 Profile Analysis

Figure 4-1 illustrates the profile of MFC-S domain scores comparing persons with a left CVA to right CVA. From visual inspection, persons with a left CVA tended to perform worse on all domains except the language and visuospatial domains. Data screening was done and three persons had missing data so were removed from further analysis. In order to meet the commensurate scales assumption, the scores from each domain were transformed using a Blom transformation. The Box's M test was not significant at the .001 level, $F(55, 38018) = 1.342$, $p = .05$, but our sample sizes were unequal: right CVA: $n=62$, left CVA: $n=52$. However, as the Levene's test was non significant for unequal variances, assumptions were satisfied to proceed with the analysis. The test for equal levels between groups was not significant. The test for parallel profiles, tested with Pillai's trace, was significant $F(9, 104) = 2.44$, $p = .015$.

4.2.3 Logistic regression

The model including all ten domains was significant $X^2(10) = 24.79$, $p = .006$, correctly classifying persons with right CVA 74.2%, and persons with left CVA 57.7%. The regression coefficients for the language domain Wald (1) = .846, $p = .004$ and visuospatial domain Wald (1) = 7.66, $p = .005$ were statistically significant. Interpreting these regressions coefficients, displayed in Table 4-4, the odds that a person had a right CVA, rather than a left CVA, are 70% less likely for one logit increase in language, and 65% less likely with a one logit increase in visuospatial.

4.3 Discussion

Validity of the MFC-S was supported by findings of moderate to strong correlations[36] for seven of the domains: Language, reading and writing, visuospatial, social language, emotional function, executive function and memory. Further, the profile analysis predicted group membership for right or left CVA with significant predictors of language and visuospatial scores. Alternatively, two possible validity challenges are noted. First there was a lack of a relationship to comparison measures for the numerical calculation, limb praxis, and attention domains, and for the WIAT-II spelling score to the reading and writing domain. Second, though the profile of scores did predict the side of CVA, persons with left CVA score higher on the language domain. We might expect persons with left CVA to perform worse on the language domain based on neuroanatomical studies of stroke impairment.[9]

Examining the above mentioned challenges more closely, sample selection and previous findings may help to explain these findings. This study, because of the nature of self-report, necessitated that persons with severe communication impairment were not included. This may have biased the left hemisphere group to be less inclusive of the language impairment associated with left sided CVA, thus influencing our results. Also, when developing items for the MFC-S, there was not an intention to separate right from left CVA, but to include items that were more descriptive of the cognitive impairment observed in persons with stroke, inclusive of both right and left CVA symptoms. The visuospatial domain included several items that relate to left side neglect. For example: “Dresses or grooms left side of body”. Left sided neglect is observed in persons with R CVA. This may have impacted the predictiveness of the visuospatial scores for right vs left CVA.

Further, it is notable that 9/9 of the comparison measures that did not show a relationship with the MFC-S domain were comprised of performance based, measures of cognition. For example, the Trails A and Trails B measure the speed and ability to switch, respectively, between numbers and/or letters. On the other hand, the comparison measures that significantly and strongly associated with the MFC-S domain were similar self-report measures of everyday ability: (1) the BRIEF and (2) the ASHA FAC and (3) the CESD. Some cognitive researchers propose that though there is a relationship between performance based measures of cognition and everyday ability, this relationship may be moderated by other variables such as education.[22]

Limitations of this study include challenges of using a self-report measure in persons with cognitive impairment, sample size limitations, and the use of univariate analyses. The nature of a self-report measure requires that persons are able to communicate, yet persons with stroke may experience communication challenges. One solution is to use proxy or interview formats. Yet, differences have been found between self and proxy, caregiver or health provider, report. Future work should consider how the MFC-S self-report scores relate to proxy reports, and include persons more severely affected by stroke. Further, the generalizability is limited to this sample, which included persons mildly to moderately affected by stroke. The NIH stroke scale score for persons of moderate to severe impairment is 15. Our sample averaged 4.54 (4.07) for the acute group and 4.31 (3.72) for the chronic group. For domains that did not related to comparison future work might include performance based or questionnaire comparison measures to further evaluate validity in these domains. Lastly, sample size limitations may have affected the power of detecting relationships between comparison studies, a type II error. In contrast, while we attempted to decrease type II errors using Bonferroni corrections, this was still a possibility.

4.4 Conclusion

This study presents beginning evidence that the MFC-S can be used as a meaningful measure of everyday cognition for persons with stroke. Interesting next questions might be to evaluate how the MFC-S compares with proxy report, to other everyday performance measures of cognition and in a clinical setting. Lastly, future work with larger sample sizes will allow for further investigation of the impact of variables such as age, education and race moderate the effect between more fundamental cognitive performance on measures, such as the Trails A and B, and functional cognitive ability.

Table 4-1. Participant characteristics

Demographic Information of Patient (n=128)		Acute (n=49)		Chronic (n=79)	
Gender					
	Female	27	55.10%	43	54.40%
	Male	22	44.90%	36	45.6
Age					
	Mean (SD)	64.84	(12.534)	66.47	(13.335)
Highest Grade Completed					
	<High school	13	26.50%	14	17.70%
	High school, GED	22	44.90%	26	32.90%
	Some college	6	12.20%	14	17.70%
	Associate's degree	2	4.10%	5	6.30%
	Bachelor's degree	5	10.20%	9	11.40%
	Advanced degree	1	2.00%	11	13.90%
Marital Status					
	Married	24	49.00%	46	58.20%
	Divorced	8	16.30%	12	15.20%
	Widowed	12	24.50%	14	17.70%
	Single	5	10.20%	6	7.60%
	Separated	0	0.00%	1	1.30%
Racial					
	White	32	65.30%	55	69.60%
	Alone	11	22.40%	20	25.30%
	With housekeeper or aid	1	2.00%	0	0.00%
	Other	0	0.00%	1	1.30%
Stroke Severity					
	Moderate/Severe (MRS=3,4,5)	42	85.70%	45	57.00%
	Mild (MRS=0,1,2)	7	14.30%	34	43.00%
NIH Stroke Scale total score (n=77)		(n=46)		(n=75)	

Table 4-1. Continued

Demographic Information of Patient (n=128)		Acute (n=49)		Chronic (n=79)	
0= no stroke					
1-4= minor stroke					
5-15= moderate stroke	Mean (SD)	4.54	(4.07)	4.31	(3.716)
15-20= moderate/severe stroke					
21-42= severe stroke					
SIS-Participation subscale total score (n=49 chronic)					
	Mean (SD)	N/A		26.63	(7.931)
Days post stroke onset					
	Mean (SD)	14.29	(3.99)	151.92	(78.848)
Stroke Type (n=127)				(n=78)	
	Ischemic	45	91.80%	60	75.90%
	Hemorrhagic	4	8.20%	12	15.20%
	Uncertain	0	6.3%	6	7.60%
Stroke Location					
	Right Hemisphere	28	57.10%	39	49.40%
	Left Hemisphere	19	38.80%	35	44.30%
	Bilateral	0	0.00%	3	3.80%
	Right Hemisphere & Cerebellar	1	2.00%	0	0.00%
	Right Hemisphere & Subcortical	1	2.00%	0	0.00%
	Uncertain	0	0.00%	2	2.50%
Have prior stroke					
Demographic Information of Patient (n=128)		Acute (n=49)		Chronic (n=79)	
No		35	71.40%	58	73.40%
Yes		14	28.60%	21	26.60%
Prior Stroke Location (n=14)		(n=5)		(n=15)	
Same Hemisphere		3	60.00%	9	60.00%
Different Hemisphere		2	40.00%	5	33.30%
Bilateral		0	0.00%	1	6.70%
Hand used for writing prior to stroke					
Right		47	95.90%	73	92.40%
Left		2	4.10%	6	7.60%

Table 4-1. Continued

Demographic Information of Patient (n=128)	Acute (n=49)		Chronic (n=79)	
Have a history of sustained, unresolved, alcoholism or drug use				
No	48	98.00%	75	94.90%
Yes	1	2.00%	4	5.10%
Have hearing problems (n=80)	(n=47)			
No	44	89.80%	66	83.50%
Yes	4	8.20%	13	16.50%
Have vision problems				
No	43	87.80%	58	73.40%
Yes	6	12.20%	21	26.60%
Use memory aids since the stroke (for example a memory book)				
No	45	91.80%	53	67.10%
Yes	4	8.20%	26	32.90%
Have weakness or paralysis since the stroke				
No	7	14.30%	16	20.30%
Yes	42	85.70%	63	79.70%
Aware of having a stroke (n=123)	(n=47)		(n=76)	
No	0	0.00%	1	1.30%
Yes	47	100.00%	75	98.70%
Aware of problems due to stroke (n=123)	(n=47)		(n=76)	
No	7	14.90%	8	10.50%
Yes	40	85.10%	68	89.50%

Table 4-2. Neuropsychological measures and associated MFC-S domain

Domain	Neuropsychological Measure Comparison
Language	RBANS Picture Naming RBANS Semantic Fluency
Reading & Writing	WIAT-II Word Reading WIAT-II Spelling
Numerical Calculation	WIAT-II Numerical Operations
Limb Praxis	Mini-FAB
Visuospatial	RBANS Figure Copy RBANS Line Orientation
Social Language	ASHA FACS (21 items)
Emotional Function	CESD *(Day 1)* BRIEF *(Emotional Management Items)*
Attention	RBANS Digit Span (forward) WAIS-III Coding Trails A
Executive Function	Trails B Trails B-A D-KEFS Sorting *(BRIEF – inhibit, shift, metacognition, and self-monitor scales*)
Learning and Memory	Immediate: RBANS List Learning RBANS Story Memory Delayed: RBANS List Recall RBANS List Recognition RBANS Story Memory RBANS Figure Recall

Table 4-3. MFC-S Domain correlations with neuropsychological measures

Domain	Measure used for Analysis	Pearson's Correlation Coefficient	Significance
1) Language	RBANS language score n = 59	.30 *	p = .01
2) Reading & Writing	WIAT-II-A standard score of word reading n = 59	.29*	p = .01
	WIAT-II-A standard score of spelling n = 62	.16	p = .11
3) Numerical calculation	WIAT-II-A numerical operation n = 62	.12	p = .19
4) Limb praxis	Mini Florida Apraxia Battery n = 61	.15	p = .18
5) Visuospatial	RBANS viso-spatial construction n = 59	.31*	p = .008
6) Social language	ASHA FACS (21 items) n = 62	.26*	p =.02
7) Emotional function	CESD *(Day 1)* n = 62	-.5*	p < .001
	BRIEF *(Emotional Management Items)* n = 62	-.47*	p < .001
8) Attention	Trails A n = 62	-.12	p = .17
	WAIS-III coding n = 56	-.09	p = .31
	RBANS attention n = 62	.12	p = .18

Table 4-3. Continued.

Domain	Measure used for Analysis	Pearson's Correlation Coefficient	Significance
9) Executive function	BRIEF inhibit n = 62	-.47*	p < .001
	BRIEF shift n = 62	-.62*	p < .001
	BRIEF self monitor n = 62	-.51*	p < .001
	BRIEF Metacognition n = 62	-.52*	p < .001
	D-KEFS confirmed correct sorts n = 62	.08	p = .28
	D-KEFS free sorting description n = 62	.14	p = .15
	D-KEFS sort recognition n = 59	.30*	p = .011
	Trails B n = 61	.17	p = .17
	Trails B/A Ratio n = 61	-.11	p=.11
10) Learning & Memory	RBANS immediate memory n = 62	.24*	p = .03
	RBANS delayed memory n = 62	.27*	p = .02

* Significant correlations.

Table 4-4. Regression coefficients for binary logistic model predicting left or right CVA

Domain	B	S.E.	Wald	df	Sig.	Exp(B)
Language	-1.175	.404	8.459	1	.004	.309
Read & Write	682	.404	2.857	1	.091	1.978
Numerical Calculation	.115	.333	.119	1	.730	1.122
Limb Praxis	.152	.281	.293	1	.588	1.165
Visuospatial	1.020	.369	7.656	1	.006	.361
Social Language	.163	.250	.423	1	.515	1.176
Emotional Function	.698	.391	3.176	1	.075	2.009
Attention	.354	.389	.826	1	.363	1.424
Executive Function	.063	.435	.021	1	.884	.939
Memory	.723	.394	3.362	1	.067	2.061

Table 4-5. Model classification of right or left CVA

Observed		Predicted		
		Stroke Location		Percentage Correct
		Right	Left	
Stroke	Right	46	16	74.2
Location	Left	22	30	57.7
Overall Percentage				66.7

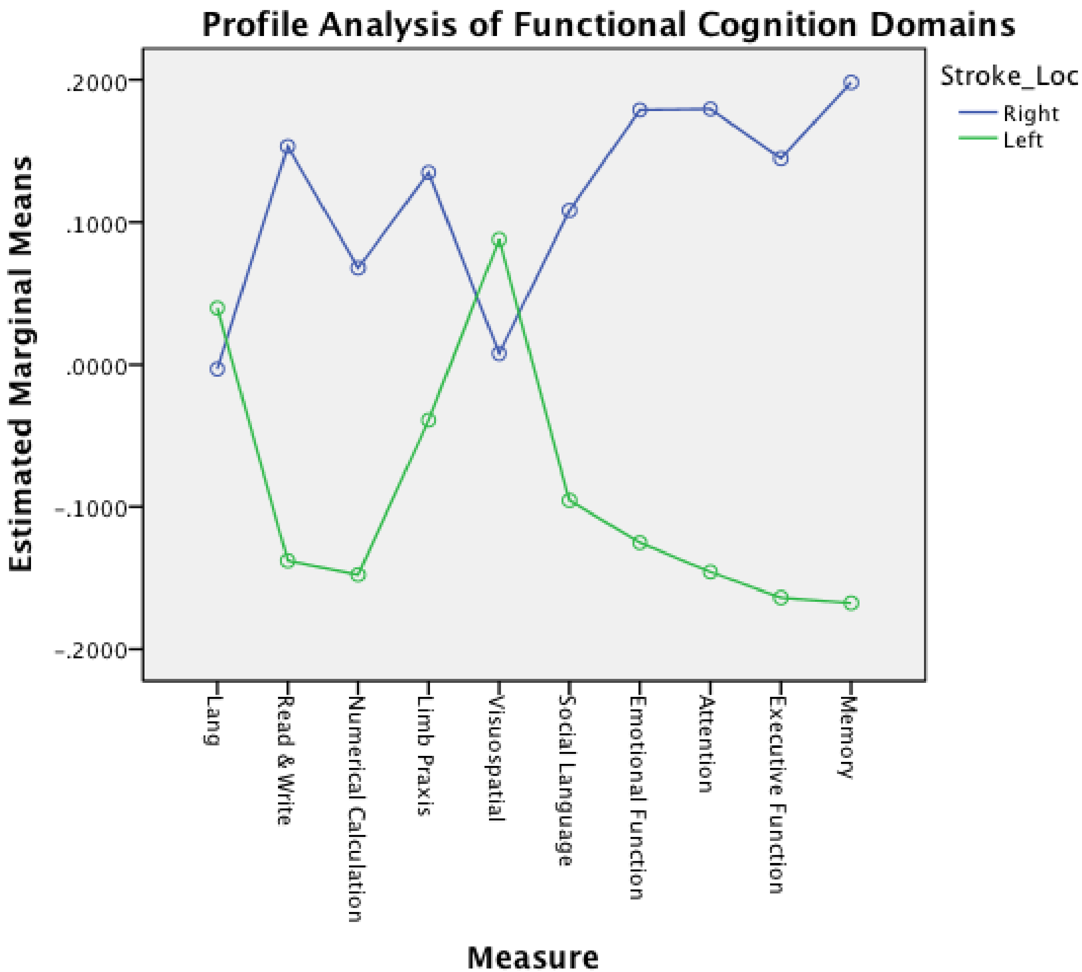

Figure 4-1. Left vs. right comparison profile

CHAPTER 5
SUMMARY AND CONCLUSION

Research indicates that cognitive impairment associated with stroke affects functional outcomes.[85] While important work remains to be done to determine optimal treatment methods, and related issues, given this information, this project was concerned with the measurement of applied cognition. Current measures to evaluate functional, or everyday, ability specifically related to cognitive impairment are limited in breadth [18] or contain neither the secondary constructs of cognition nor impairment unique to stroke.[17]

5.1 Summary

To that end, this project examines the psychometric properties of a measure of functional cognition in persons with stroke (MFC-S). Beginning with a review and comparison of classical test theory (CTT) and modern test theory (MTT), this project proceeded to three studies: (1) evaluation of dimensionality of the MFC-S through exploratory factor analysis (EFA) and principle components analysis (PCA) of the residuals, (2) evaluation of the measurement properties of the MFC-S using the Rasch measurement model, and (3) evaluation of the validity of the MFC-S using correlation analysis to comparison measures and a profile analysis to predict laterality of cerebrovascular accident (CVA).

Study one used factor analytic techniques to examine the dimensionality of the MFC-S. The EFA demonstrated support for a ten-factor solution, with second order factors loading on a higher general factor. The PCA of residuals allowed for item level examination. Every domain, except numerical calculation, revealed a possible second dimension. But, for every domain, the majority of the variance was captured by the primary Rasch component. Further, each secondary dimension was explained by constructs the primary dimension intended to capture. For example, the reading and writing domain contained both a reading and writing secondary dimension. This study was important since it supports measuring the individual dimensions of MFC in the population of individuals with stroke.

Study two used the Rasch measurement model to assess item level psychometrics of the MFC-S. Nine of the ten domains, all but limb praxis, were able to separate persons into at least two statistically different groups.   Further, evaluation of the item hierarchy for each domain indicated a gradient from less difficult to more difficult items that was conceptually sound. For example, the language domain indicated that “follows simple directions when asked” was at the easier end of the scale and “carries on a conversation without mistakes” was at the more difficult end of the scale. Though, several of the domains showed ceiling effects with persons from this sample reaching the maximum extreme score: language (11% (14)), reading & writing (17% (21)), numerical calculation (18% (23)), limb praxis (19% (24)) and memory (6% (8)), our sample selection criteria excluded those persons more severely affected by stroke. On the National Institute of Health Stroke Scale (NIHSS), the mean of our acute group was 4.54 (4.07) and the chronic group was 4.31 (3.716). The NIHSS range for moderate stroke is 5-15 and the cutoff for moderate to severe stroke is 15-20. This study demonstrated that the MFC-S domains (with the exception of apraxia) separate persons into statistically distinct levels of functional/applied cognitive ability.

Study three examined the validity of the MFC-S using correlation with comparison measures, and a profile analysis followed up by logistic regression to predict laterality of stroke. Comparison questionnaire type measures that included everyday abilities such as the Functional Assessment of Communication Skills for Adults (ASHA-FACS),[30] the Behavior Rating Inventory of Executive Functions –Adult (BRIEF)[74] and the Center for Epidemiologic Studies – Depression Scale (CES-D)[71] had statistically significant and stronger associations with the MFC-S than did the more traditional neuropsychological measures. The profile analysis indicated that profile scores associated with right or left CVA could predict group membership, i.e. in which cerebral hemisphere a person had their stroke. The language and visuospatial domains were significant predictors in a logistic regression model entering all ten domains, though language was the opposite of what we would have expected. That is, a person with left CVA, for this sample, tended to have a higher language scores. We posited that as this sample, selected on criterion that excluded persons with communication impairment may have affected this result. Alternatively, the visuopsatial domain scores did predict in the expected direction. Persons with left CVA tended to do better with visuospatial ability than persons with right CVA. This study demonstrates the concurrent validity of the MFC-S.

5.2 Conclusion

The importance of this series of studies was that it evaluated a measure of functional, or applied, cognition in persons with stroke that incorporates secondary cognitive constructs. The above findings suggest that the MFC-S can provide a profile of applied cognitive abilities and deficits that can be the target of treatment interventions. The above findings strengthens clinicians and investigators confidence using the MFC-S, specifically to measure differences in applied cognitive ability and to relate this ability on this measure with meaningful outcomes such as the ability to live on one's own, or the need for and level of support, such as a health care facility or in home support.

Future work needs to focus on replicating and expanding these findings. If the misfitting items in this study continue to misfit or not discriminate persons, removing these items should improve the measure. Additional work should focus on reexamination of the limb praxis domain. It is possible that this sample was truncated with respect to ability, i.e., too able, for this measure to discriminate well. It is also possible that the items did not fully capture the functional limb praxis domain. This needs to be further investigated. Future work with larger sample sizes will allow for further investigation of the impact of variables such as age, education and race moderate the effect between more fundamental cognitive performance on measures, such as the Trails A and B, and applied cognitive ability. Future work should also investigate the sensitivity of the MFC in monitoring meaningful clinical differences in patients across normal recovery and recovery followed by rehabilitation interventions.

The overarching purpose of this series of studies supports the rehabilitation research goals of developing meaningful measurement tools to assess treatment effects. [66] While this represents the initial psychometric findings of the MFC, it provides the basis for evaluating treatment interventions through meaningful outcome measures that evaluate everyday tasks that rely heavily on cognition.

APPENDIX A
PARTICIPANT CHARACTERISTICS

Demographic Information of Patient (n=128)		Acute (n=49)			Chronic (n=79)	
Gender						
	Female	27	55.10%		43	54.40%
	Male	22	44.90%		36	45.6
Age						
	Mean (SD)	64.84	(12.534)		66.47	(13.335)
Highest Grade Completed						
	High school, GED	22	44.90%		26	32.90%
	<High school	13	26.50%		14	17.70%
	Some college	6	12.20%		14	17.70%
	Advanced degree	1	2.00%		11	13.90%
	Bachelor’s degree	5	10.20%		9	11.40%
	Associate’s degree	2	4.10%		5	6.30%
Marital Status						
	Married	24	49.00%		46	58.20%
	Divorced	8	16.30%		12	15.20%
	Widowed	12	24.50%		14	17.70%
	Single	5	10.20%		6	7.60%
	Separated	0	0.00%		1	1.30%
Racial						
	White	32	65.30%		55	69.60%
	Alone	11	22.40%		20	25.30%
	With housekeeper or aid	1	2.00%		0	0.00%
	Other	0	0.00%		1	1.30%
Stroke Severity						
	Moderate/Severe (MRS=3,4,5)	42	85.70%		45	57.00%
	Mild (MRS=0,1,2)	7	14.30%		34	43.00%
NIH Stroke Scale total score (n=77)		**(n=46)**			**(n=75)**	
0= no stroke 1-4= minor stroke 5-15= moderate stroke 15-20= moderate/severe stroke 21-42= severe stroke	Mean (SD)	4.54	(4.07)		4.31	(3.716)
SIS-Participation subscale total score (n=49 chronic)						
	Mean (SD)	N/A			26.63	(7.931)
Days post stroke onset						
	Mean (SD)	14.29	(3.99)		151.92	(78.848)
Stroke Type (n=127)					**(n=78)**	
	Ischemic	45	91.80%		60	75.90%
	Hemorrhagic	4	8.20%		12	15.20%
	Uncertain	0	6.3%		6	7.60%
Stroke Location						
	Right Hemisphere	28	57.10%		39	49.40%
	Left Hemisphere	19	38.80%		35	44.30%
	Bilateral	0	0.00%		3	3.80%
	Right Hemisphere &	1	2.00%		0	0.00%

Demographic Information of Patient (n=128)		Acute (n=49)			Chronic (n=79)	
	Cerebellar					
	Right Hemisphere & Subcortical	1	2.00%		0	0.00%
	Uncertain	0	0.00%		2	2.50%
Have prior stroke						
	No	35	71.40%		58	73.40%
	Yes	14	28.60%		21	26.60%
Prior Stroke Location (n=14)		**(n=5)**			**(n=15)**	
	Same Hemisphere	3	60.00%		9	60.00%
	Different Hemisphere	2	40.00%		5	33.30%
	Bilateral	0	0.00%		1	6.70%
Hand used for writing prior to stroke						
	Right	47	95.90%		73	92.40%
	Left	2	4.10%		6	7.60%
Have a history of sustained, unresolved, alcoholism or drug use						
	No	48	98.00%		75	94.90%
	Yes	1	2.00%		4	5.10%
Have hearing problems (n=80)		**(n=47)**				
	No	44	89.80%		66	83.50%
	Yes	4	8.20%		13	16.50%
Have vision problems						
	No	43	87.80%		58	73.40%
	Yes	6	12.20%		21	26.60%
Use memory aids since the stroke (for example a memory book)						
	No	45	91.80%		53	67.10%
	Yes	4	8.20%		26	32.90%
Have weakness or paralysis since the stroke						
	Yes	42	85.70%		63	79.70%
	No	7	14.30%		16	20.30%
Aware of having a stroke (n=123)		**(n=47)**			**(n=76)**	
	Yes	47	100.00%		75	98.70%
	No	0	0.00%		1	1.30%
Aware of problems due to stroke (n=123)		**(n=47)**			**(n=76)**	
	Yes	40	85.10%		68	89.50%
	No	7	14.90%		8	10.50%

APPENDIX B
PATTERN MATRIX RETAINING FOUR FACTORS

	Factor			
	1	2	3	4
Language Parcel 1	—	—	.451	—
Language Parcel 2	—	—	.646	—
Language Parcel 3	—	—	.558	—
Reading & Writing Parcel 1	.891	—	—	—
Reading & Writing Parcel 2	.900	—	—	—
Reading & Writing Parcel 3	.703	—	—	—
Numerical Calculation Parcel 1	.719	—	—	—
Numerical Calculation Parcel 2	.505	—	—	—
Numerical Calculation Parcel 3	.592	—	—	—
Limb Praxis Parcel 1	—	—	—	.632
Limb Praxis Parcel 2	—	—	—	.589
Limb Praxis Parcel 3	—	—	—	.726
Visuospatial Parcel 1	.682	—	—	—
Visuospatial Parcel 2	.686	—	—	—
Visuospatial Parcel 3	.806	—	—	—
Social Language Parcel 1	—	.738	—	—
Social Language Parcel 2	—	.624	—	—
Social Language Parcel 3	—	.699	—	—
Emotional Function Parcel 1	—	.779	—	—
Emotional Function Parcel 2	—	.736	—	—
Emotional Function Parcel 3	—	1.033	-.362	—
Attention Parcel 1	.375	—	.366	—
Attention Parcel 2	.641	—	—	—
Attention Parcel 3	—	—	—	—
Executive Function Parcel 1	—	.406	—	—
Executive Function Parcel 2	—	—	—	—
Executive Function Parcel 3	—	.447	—	—
Memory Parcel 1	—	—	.851	—
Memory Parcel 2	—	—	.939	—
Memory Parcel 3	—	—	.889	—

APPENDIX C

PATTERN MATRIX RETAINING FIVE FACTORS

	Factor				
	1	2	3	4	5
Language Parcel 1	—	—	.432	—	—
Language Parcel 2	—	—	.677	—	—
Language Parcel 3	—	—	.548	—	—
Reading & Writing Parcel 1	—	.897	—	—	—
Reading & Writing Parcel 2	—	.868	—	—	—
Reading & Writing Parcel 3	—	.814	—	—	—
Numerical Calculation Parcel 1	—	—	—	—	.844
Numerical Calculation Parcel 2	—	—	—	—	.535
Numerical Calculation Parcel 3	—	—	—	—	.966
Limb Praxis Parcel 1	—	—	—	.610	—
Limb Praxis Parcel 2	—	—	—	.572	—
Limb Praxis Parcel 3	—	.366	—	.741	—
Visuospatial Parcel 1	—	.534	—	—	—
Visuospatial Parcel 2	—	.648	—	—	—
Visuospatial Parcel 3	—	.769	—	—	—
Social Language Parcel 1	.799	—	—	—	—
Social Language Parcel 2	.662	-.370	—	—	—
Social Language Parcel 3	.750	—	—	—	—
Emotional Function Parcel 1	.852	—	—	—	—
Emotional Function Parcel 2	.798	—	—	—	—
Emotional Function Parcel 3	1.129	—	—	—	—
Attention Parcel 1	—	—	—	—	—
Attention Parcel 2	—	.522	—	—	—
Attention Parcel 3	—	—	—	—	.415
Executive Function Parcel 1	.431	—	—	—	—
Executive Function Parcel 2	—	—	—	—	—
Executive Function Parcel 3	.474	—	—	—	—
Memory Parcel 1	—	—	.903	—	—
Memory Parcel 2	—	—	1.011	—	—
Memory Parcel 3	—	—	1.049	—	—

APPENDIX D
SECONDARY DIMENSION AFTER REMOVING PRIMARY RASCH DIMENSION

Domain (Eigenvalue)	Loading	Items
Language (2.1)	.69	4. Follows 2-step directions when asked.
	.61	5. Follows multiple step directions when asked.
	.41	7. Follows a conversation in a distracting environment by appropriately nodding, smiling, gesturing.
	-.57	---
	-.51	10. Uses more than one word to express needs.
	-.43	8. Answers questions correctly about complex information.
		11. Speaks in short sentences.
Reading & Writing (2.9)	.68	26. Writes a brief letter
	.58	24. Writes a short note
	.53	23. Writes a short list
	.52	27. Writes more than one paragraph
	.49	25. Completes a business form

	-.56	16. Reads signs in a store or hospital
	-.53	15. Reads the menu in a restaurant
	-.48	19. Reads a complete article in the daily newspaper or magazine
Limb Praxis (2.3)	.73	38. Is clumsy when using tools ®
	.52	37. Waves hello or goodbye

	-.71	42. Chooses the right kitchen tool but uses it in the wrong way ®
	-.60	43. Chooses the right grooming tool but uses in the wrong way ®
	-.58	41. Chooses the right utensil but uses it in the wrong way ®
Visuospatial (3.2)	.74	54. Eats food on left side of plate or tray.
	.71	55. Looks at left side of clock or uses left-side controls on radio or TV.
	.58	53. Writes or draws on left side of paper.
	.50	56. Dresses or grooms left side of body.
	.46	52. Reads words on left side of a menu, newspaper, or book.

	-.46	68. Folds a piece of paper in thirds to put in an envelope

Domain (Eigenvalue)	Loading	Items
Social Use of Language (4.2)	.58	78. Understands subtle jokes
	.57	80. Recognizes when someone is asking a question
	.55	79. Understands that they are being teased
	.47	94. Stays on topic when telling a story or explaining something
	.43	81. Recognizes when spouse or loved one is upset
	.40	82. Understands obvious humor
		--
	-.51	98. Jumps to a topic unrelated to the conversation ®
	-.50	97. Blurts out something off topic during a conversation ®
	-.45	107. Talks at the wrong time ®
	-.41	89. Uses flat tone of voice when should be expressing anger or happiness ®
	-.40	85. Tone of voice does not indicate that a minor problem has occurred ®
	-.40	90. Facial expression does not match the conversation ®
Emotional Function (4.9)	.65	143. Overreacts to frustrating situations ®.
	.59	148. Emotions swing among happy, sad, and angry
	.56	®
		149. Has angry or tearful outbursts for no apparent
	.54	reason ®
	.50	142. Blurts out things that are offensive to others ®
	.44	144. Gets upset with a change of routine ®
		138. Asks embarrassing questions or makes hurtful
	.43	or inappropriate comments ®
	.40	147. Gets upset with new situations ®
		120. Feels or shows a different intensity of emotion than before the stroke ®
	-.46	--
	-.46	136. Acknowledges when someone is crying or
	-.44	shouting
		134. Shows an emotional response to a sad movie or story
		131. Reacts when people are visibly upset.

Domain (Eigenvalue)	Loading	Items
Attention (2.6)	.66	167. Correctly writes down a message from an answering machine or person on the phone
	.61	159. Selects meal items from a menu
	.52	160. Copies information correctly
	.48	168. Locates a phone number or address in the telephone book
		--
	-.53	172. Watches TV without being distracted by people talking
	-.42	173. Talks with a person while the TV is on.
Executive Function (5.7)	.66	207. Easy thinking tasks seem difficult and require a lot of effort ®
	.65	213. Makes more mistakes during a long thinking
	.59	task ®
	.57	214. Gets slower and slower during a long thinking task ®
	.56	206. Feels tired or exhausted after working on a short thinking task ®
	.55	215. Avoids a leisure activity because it takes too
	.51	much mental energy ®
	.43	208. Avoids things that involve mental energy ®
	.42	192. Makes careless errors during a new activity ®
		191. Makes careless errors in daily tasks ®
	.42	201. Takes a long time to come up with an answer to a question after it is asked ®
	-.50	212. Falls asleep in the middle of a thinking task ®
	-.44	--
	-.41	178. Fills free time with activities without being told
		182. Readily switches from one activity to another
	-.41	199. Responds to simple requests without being asked several times
	-.41	184. Stops an activity and starts a new activity without being told
		185. Plans a common daily activity
Memory (3.2)	.69	243. Says home address correctly
	.66	244. Names the current President
	.52	237. Says relative's name correctly when asked
	.49	242. Says home phone number correctly
	.45	240. Says age correctly
		--
	-.52	218. Recalls specific activities from last birthday or vacation
	-.51	220. Recalls activities or events from one month ago
	-.42	221. Recalls activities or events from several months ago

APPENDIX E
MFC-STROKE PAPER AND PENCIL FIELD TEST ITEM POOL FOR PATIENT

I. LANGUAGE

1. I turn my head in direction of speaker when my name is called.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
2. I respond to simple yes or no questions either by nodding, gesturing, or speaking.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
3. I follow simple directions when asked (for example, "Hand me the cup.").	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
4. I follow 2-step directions when asked (for example, "Pick up the paper and throw it away.").	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
5. I follow multiple step directions when asked (for example, I am able to follow directions to find a location or place).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
6. I follow a simple conversation by appropriately nodding, smiling, gesturing, or commenting.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
7. I follow a conversation in a distracting environment by appropriately nodding, smiling, gesturing, or commenting.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
8. I answer questions correctly about complex information (for example, medical history or the plot of a movie).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
9. I use single words or everyday phrases (for example, "Hi," "Bye," or "How are you?").	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
10. I use more than one word to express needs (for example, "drink coffee," "eat lunch," or "tired sleep").	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
11. I speak in short sentences (for example, "It's time to go" or "I feel sick").	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
12. I find the right words to get ideas across with few mistakes.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
13. I carry on a conversation without mistakes.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**

II. READING & WRITING

1. I read familiar words (for example, my name, address, or neighborhood street signs).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
2. I read the menu in a restaurant.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
3. I read signs in a store or hospital.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**

4. I read titles of articles in the daily newspaper.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
5. I read a personal letter that is from a relative or friend.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
6. I read a complete article in the daily newspaper or magazine.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
7. I read a book.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
8. I read complex information (for example, insurance documents or papers that come with medicine).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
9. I write my name and address.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
10. I write a short list (for example, a shopping list).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
11. I write a short note (for example, a phone message or brief instruction).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
12. I complete a business form (for example, credit card application, catalog order form, or medical form).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
13. I write a brief letter (for example, a postcard, personal letter, or e-mail).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
14. I write more than one paragraph (for example, a long letter, story, or report).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**

III. NUMERICAL CALCULATION

1. I recognize numbers (for example, I point to my phone number or birthdate on a form).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
2. I understand what numbers mean (for example, I tell time using a digital clock).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
3. I copy numbers (for example, the amount from a bill to a checkbook).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
4. I add and subtract small numbers (for example, to balance a checkbook).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
5. I correctly pay for an item with exact change.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
6. I correctly make change.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
7. I correctly divide restaurant bill for separate payments among diners.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
8. I correctly calculate amount of tip for the waitress or waiter.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**

9. I correctly measure an amount (for example, 1/2 cup or 1/4 inch).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
IV. LIMB PRAXIS					
1. I wave hello or good bye.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
2. I am clumsy when using tools (for example, eating utensils, pencil, or pen).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
3. I use the wrong eating utensil (for example, I try to eat cereal with a knife or try to cut meat with a spoon).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
4. I use incorrect cooking tools (for example, I use a knife for mixing batter or use a spoon to flip an egg).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
5. I choose the right utensil but use it in the wrong way (for example, I try to eat soup with a spoon upside down or try to cut with the dull edge of a knife).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
6. I choose the right kitchen tool but use it in the wrong way (for example, I use a whisk outside the bowl).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
7. I choose the right grooming tool but use it in the wrong way (for example, I use a brush handle to brush my hair or use the wrong end of an electric razor).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
8. I use the incorrect grooming tool (for example, I use a comb to brush my teeth or toothbrush to comb my hair).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
9. I choose the incorrect tool for the job (for example, I choose a saw to pound a nail or choose a spatula to beat eggs).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
10. I choose the right tool for the job but use in the wrong way (for example, I try to hammer a nail upside down).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**

V. VISUAL SPATIAL FUNCTION

1. I recognize my own face in the mirror.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
2. I recognize faces of close family members (for example, spouse or children).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
3. I recognize faces of neighbors, co-workers, hairdresser, or pastor/minister.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
4. I recognize the face of a person I just met (for example, new therapist, grocery clerk, or delivery person).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**

5. I move my eyes or turn my head to left side in response to person entering room or the phone ringing.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
6. I read words on left side of a menu, newspaper, or book.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
7. I write or draw on left side of paper.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
8. I eat food on left side of plate or tray.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
9. I look at left side of clock or use left-side controls on radio or TV.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
10. I dress or groom the left side of my body.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
11. I bump into doorways on left side.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
12. My paralyzed limb hangs over the wheelchair arm.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
13. I find my way around my house.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
14. I find my way around family or friends' house.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
15. I find my way around grocery store to locate items.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
16. I get lost when driving or walking around my neighborhood.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
17. I get lost in a new setting (for example, new building, hospital, house, or city).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
18. I use a map or directory to find a new location.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
19. I reach out directly and grasp an object (for example, I pick up a cup without reaching around for it).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
20. I locate a particular item on the first try (for example, I go to the correct drawer to get an article of clothing or kitchen utensil).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
21. I use a mouse to click on a computer screen.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
22. I fold a piece of paper in thirds to put in an envelope.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
23. I point to a specific area of text on a page (for example, a phone number in the phone book or a section of a menu or bill).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**

24. I get a specific book off a bookshelf.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
25. I make an entry on the correct line of a form (for example, in a checkbook).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
26. I point to a location on a map or directory.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
27. I stack items according to shape and size (for example, dishes, containers, books, or tools in a case).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
28. I build or construct things (for example, I make scrapbooks, build bird houses, or assemble puzzles).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
29. I draw a simple sketch (for example, a stick figure of a person or a flower).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
30. I copy a chart from a book (for example, a chart of facts or diagram from a text book).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
31. I draw a simple map.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**

VI. SOCIAL USE OF LANGUAGE

1. I understand subtle jokes (for example, a play on words or witty remark).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
2. I understand when I am being teased.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
3. I recognize when someone is asking a question (for example, I recognize intonation).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
4. I recognize when my spouse or loved one is upset.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
5. I understand obvious humor (for example, "a pie in the face").	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
6. I understand why people are crying at a tragic event (for example, a car accident or death).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
7. I misunderstand the intent of the person who is speaking (for example, I do not recognize when someone makes a joke or uses sarcasm). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
8. My tone of voice does not indicate that a minor problem has occurred (for example, spilling a drink on some papers).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
9. My tone of voice does not indicate an emotion (for example, anger, urgency, or fear).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
10. My tone of voice does not indicate that a question is being asked.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**

11. I sound rude or demanding when making a request. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
12. I use a flat tone of voice when I should be expressing anger or happiness.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
13. My facial expression does not match the conversation (for example, I smile too much during a serious conversation or look angry when saying something nice). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
14. I stay on topic while participating in a short conversation. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
15. I make a relevant comment during a conversation.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
16. I smoothly change to a new topic during a conversation.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
17. I stay on topic when telling a story or explaining something.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
18. I leave out an important piece of information during a conversation.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
19. I get stuck on a topic during a conversation (for example, I keep talking about the same thing). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
20. I blurt out something off topic during a conversation. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
21. I jump to a topic unrelated to the conversation. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
22. I tell life events or story in the correct order (for example, describing education or work history).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
23. I use appropriate eye contact when having a conversation.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
24. I begin to answer open-ended questions within 2 seconds (for example, "What did you do today?" or " What did you do in therapy?"). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
25. I have a conversation with more than one person.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
26. I allow others to take a turn in a conversation (for example, I give another person a chance to talk). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
27. I show interest in what other people are saying (for example, by commenting or nodding). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
28. I interrupt other people's conversations. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
29. I go on and on without giving another person a chance to talk.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**

30. I talk at the wrong time (for example, I talk when I should be listening). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
31. I turn toward a person when speaking to him/her.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
32. I walk away from a conversation before it is finished. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**

VII. EMOTIONAL FUNCTION

1. I recognize that I had a stroke.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
2. I recognize that I have problems resulting from a stroke (for example, trouble talking, walking, thinking, or remembering things).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
3. I recognize that I need assistance for problems caused by a stroke.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
4. I attempt tasks that involve thinking skills beyond my ability (for example, I try to manage finances alone when I really need help).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
5. I attempt to do physical things that I cannot do (for example, I try to get dressed when needing physical help).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
6. I do not know why things are difficult since having a stroke.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
7. I blame others for problems or mistakes. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
8. I demonstrate an understanding of my own abilities (for example, I know what I can and cannot do, such as driving, returning to school/work, or cooking). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
9. I am aware of a problem in functioning, but I believe it is due to something other than the stroke (for example, I make excuses or say that's how I've always been).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
10. I attempt to do something that would result in harm to myself or others (for example, I cook alone when I need supervision or try to drive with visual problems).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
11. I feel or show a different intensity of emotion than before the stroke (for example, my emotions seem to be much stronger or to be lacking or "flat").	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
12. I get as much done during the day as I had planned.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
13. I see a job through to the end.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**

14. I show interest in trying new things (for example, starting a new hobby or learning something new).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
15. I have trouble making plans for the future.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
16. I get started on things that are important to me.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
17. I show concern about impairments or challenges (for example, I am aware of deficits).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
18. I show interest in getting together with friends or extended family.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
19. I show emotion when something very exciting or bad happens.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
20. I show interest in doing things.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
21. I pick up on subtle displays of emotion (for example, when someone rolls their eyes or shrugs).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
22. I react when people are visibly upset (for example, I ask "Are you ok?" when someone is crying). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
23. I show concern when someone is talking about their problems (for example, I offer words of support).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
24. I make demands without considering the other person's feelings (for example, I ask someone who is crying to do something).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
25. I show an emotional response to a sad movie or story (for example, I become tearful or upset).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
26. I recognize another person's point of view. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
27. I acknowledge when someone is crying or shouting.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
28. I show an emotional response that does not match the situation (for example, I show no response to bad news or laugh inappropriately). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
29. I ask embarrassing questions or make hurtful or inappropriate comments. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
30. I become tearful easily. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
31. I stop an activity and start a new activity without getting upset (for example, I stop watching TV and come to eat dinner). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
32. I accept constructive criticism without losing my temper. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**

33. I blurt out things that are offensive to others (for example, I curse or make sexual comments). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
34. I overreact to frustrating situations (for example, tool does not work or someone takes parking place). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
35. I get upset with a change of routine. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
36. I accept help without losing my temper. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
37. I listen to another's perspective without arguing. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
38. I get upset with new situations (for example, change of nurse, therapist, or room). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
39. My emotions swing among happy, sad, and angry. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
40. I have angry or tearful outbursts for no apparent reason. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
VIII. ATTENTION					
1. I correctly answer yes or no questions about myself (for example, " Is your name___?" or "Are you in a hospital?"). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
2. I use short sentences that make sense. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
3. I pay attention to an hour-long TV program. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
4. I read 30 minutes without taking a break. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
5. I listen to a 15-30 minute speech or presentation quietly and with focus (for example, religious service or class lecture). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
6. I go directly from my room to another room without wandering (for example, dining room or therapy room). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
7. I turn my eyes in the direction of someone entering the room.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
8. I wave or nod to someone who enters the room.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
9. I greet someone who enters the room. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
10. I select meal items from a menu. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**

11. I copy information correctly (for example, daily schedule or medical information). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
12. I answer the ringing phone. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
13. I participate in a therapy session for 30 minutes with a rest break. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
14. I participate in a therapy session for 30 minutes without a rest break. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
15. I complete self care activities without getting distracted (for example, brushing teeth or getting dressed). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
16. I complete an activity in a busy or distracting environment without stopping.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
17. I complete a meal while talking with someone. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
18. I correctly write down a message from an answering machine or person on the phone. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
19. I locate a phone number or address in the telephone book. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
20. I return to an activity without a reminder after a short interruption. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
21. I stop in the middle of a task when distracted (for example, by someone talking). ® ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
22. I have a conversation in a noisy environment (for example, cafeteria or therapy room). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
23. I watch TV without being distracted by people talking. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
24. I talk with a person while the TV is on. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
25. I pay attention to the wrong conversation (for example, I listen to nearby talking). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**

IX. EXECUTIVE FUNCTION

1. I start an activity automatically (for example, I start to eat when given food or wash my face when given a wash cloth). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
2. I respond to simple requests in a timely manner (for example, I sit up upon request or eat on request). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
3. I start an activity without being told (for example, exercise program, chores, or housework). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**

4. I fill free time with activities without being told. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
5. I provide at least one solution to a problem. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
6. I try a different approach to a problem when the first one does not work (for example, when a drain cleaner does not work, I call a plumber). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
7. I plan a big project (for example, I arrange a trip or home improvement). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
8. I readily switch from one activity to another (for example, I stop watching TV to begin dressing). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
9. I say the same thing over and over (for example, “I want to go home.”). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
10. I stop an activity and start a new activity without being told (for example, I stop watching TV to do a chore). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
11. I plan a common daily activity (for example, I gather items needed for dressing or grooming). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
12. I plan ahead in order to get to an appointment on time. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
13. I start a task early enough to get it done (for example, I start to get ready for school, work, or appointment in order to arrive on time). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
14. I break a job down into smaller parts (for example, steps for cooking a meal or organizing the garage). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
15. I organize an activity several days in advance (for example, I plan a trip or plan holiday activities). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
16. I keep my personal area organized (for example, I put things away or straighten things up). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
17. I make careless errors in daily tasks (for example, I miss a button or forget to put toothpaste on toothbrush). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
18. I make careless errors during a new activity (for example, cooking or craft project). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
19. I readily change behaviors when an error is pointed out. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
20. I catch my own mistakes while working on a task. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
21. I seek help when needed. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**

22. I follow safety rules (for example, looking both ways before crossing street or not opening doors to strangers). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
23. I respond appropriately to dangerous situations (for example, I call for help if injured or turn heat down if a pot is boiling over).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
24. I try to do an activity before having the ability to do it (for example, walking, cooking, or driving). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
25. I respond to simple requests without being asked several times (for example, "Close your eyes" or "Look at me"). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
26. I respond to a question without being asked several times (for example, "What do you want to drink?”).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
27. I take a long time to come up with an answer to a question after it is asked.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
28. I follow an automated phone menu that contains instructions or choices (for example, "Press 1 for an operator").©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
29. I take things literally (for example, I leave the room when someone jokingly says, "Oh, get out of here!").	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
30. I complete a new routine in the allowed time (for example, I complete a therapy activity by the end of the session). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
31. I keep up the pace required of therapy, school, or work. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
32. I feel tired or exhausted after working on a short thinking task (for example, after paying a few bills or making a grocery list).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
33. Easy thinking tasks seem difficult to me and require a lot of effort.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
34. I avoid things that involve mental energy (for example, balancing a checkbook or attending a meeting).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
35. I have trouble getting up the energy to start a project or chore.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
36. I have trouble maintaining energy to complete a thinking task (for example, reading or doing a crossword puzzle).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
37. I have the mental energy to do basic activities (for example, getting dressed or making a phone call).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
38. I fall asleep in the middle of a thinking task (for example, during reading or a meeting).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**

39. I make more mistakes during a long thinking task (for example, balancing a checkbook or writing a letter).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
40. I get slower and slower during a long thinking task (for example, balancing a checkbook or writing a letter).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
41. I avoid a leisure activity because it takes too much mental energy (for example, reading or doing crossword puzzles).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
X. MEMORY					
1. I recall what I did before the stroke (for example, job, school, or homemaking).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
2. I recall birthdays, holidays, and anniversaries. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
3. I recall specific activities from last birthday or vacation.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
4. I recall activities or events from one week ago.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
5. I recall activities or events from one month ago.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
6. I recall activities or events from several months ago.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
7. I recall childhood memories (for example, school, pets, and friends).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
8. I recall activities done earlier in the day (for example, I remember what I had for breakfast or visiting the doctor).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
9. I describe the steps of a simple activity (for example, making a sandwich).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
10. I complete steps of a simple activity (for example, washing a car).	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
11. I recall the information given at a previous appointment. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
12. I recall the story line in a book from one reading to the next. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
13. I recall how to use simple equipment (for example, using call button to call nurse or turning on TV). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
14. I recall a simple therapy routine (for example, exercise program or using memory book). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
15. I recall simple routines (for example, switching laundry from washer to dryer or locking the door when leaving the house). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**

16. I recall more than one appointment in a single day (for example, multiple health care appointments or social activities). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
17. I recall a visit by a familiar person from the previous day (for example, a friend or family member). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
18. I recall where to find something when it is not put in its usual place (for example, looking for keys). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
19. I recall where the car is parked in the mall or grocery store parking lot. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
20. I recall whether or not medicine was taken that day.	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
21. I say my name correctly when asked. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
22. I say relative's name correctly when asked (for example, wife, husband, brother, or sister). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
23. I answer correctly when asked for current location (for example, "Where are you right now?"). ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
24. I correctly report why I am/was in hospital. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
25. I say my age correctly. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
26. I say the current year correctly. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
27. I say my home phone number correctly. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
28. I say my home address correctly. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**
29. I name the current President. ©	**Never**	**Sometimes**	**Often**	**Always**	**N/A**

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BIOGRAPHICAL SKETCH

Kathleen Berger, PT graduated with her Bachelor of Science in physical therapy in 1984 from Northwestern University. Her clinical experience has been divided between the fields of geriatrics and pediatrics Her earlier work included employment in the home care setting, skilled nursing facility, and rehabilitation centers with persons with stroke. More recently, her work has focused on persons with developmental disability. After her son was diagnosed with a seizure disorder and autism in 1990, she was pushed into understanding more about autism. Then, after founding and directing a therapy intensive respite program for children with autism and their families, Kathleen returned to graduate school to become competent to do research to understand autism better, especially persons with nonverbal autism. Kathleen completed her Master of Science in psychology in 2010, and her PhD in rehabilitation science from the University of Florida in 2013.