Impact of Motor, Cognitive, and Perceptual Disorders on Ability to Perform Activities of Daily Living After Stroke

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Background and Purpose—Using confirmatory factor analysis, this study evaluates the relative impact of motor, cognitive, and perceptual deficits on functional autonomy with 100 elderly (aged 55 to 79 years) victims of stroke.

Methods—Two different approaches were used for measuring functional autonomy: the Functional Autonomy Measurement System (Système de Mesure de l’Autonomie Fonctionnelle [SMAF]) and the Assessment of Motor and Process Skills (AMPS).

Results—The results of the confirmatory factor analysis show that motor, cognitive, and perceptual factors all make a significant contribution to the variation in functional autonomy and confirm the accuracy of the model (93% of the variance is explained when the SMAF is used to measure functional autonomy, and 64% of the variance is explained when the AMPS is used).

Conclusions—The factors that make the greatest contribution in explaining the variance in functional autonomy are, in order of importance, the motor factor, the perceptual factor, and the cognitive factor. (Stroke. 2001;32:2602-2608.)

Key Words: activities of daily living • cognition • perception • rehabilitation • stroke

Despite improvements in health since the 1950s, strokes remain a major source of functional disabilities in the elderly because of their frequency and consequences.1,2 Although the incidence of stroke has declined since the 1950s, with the aging of the population and the increase in the poststroke survival rate, there are actually a larger number of stroke victims than in the past.3 The sequela after a stroke may be motor, sensory, perceptual, or cognitive deficits, and these impairments can have various impacts on individual functioning by generating disabilities and affecting rehabilitation potential.

Many studies confirm the impact of motor, cognitive, and perceptual sequela on functional autonomy. Among these sequela, motor deficits are one of the most important in terms of their impact on the ability to carry out the activities of daily living (ADL).4-7 Studies by Sea et al8 and by Bechinger and Tallis9 also report a significant link between sensory deficits and performance of the ADL. Lincoln et al,6 Carter et al,10 and Tatemichiet al11 reported a significant correlation between various components of the ADL and one or many particular cognitive components. Hajek et al12 attributed 23% of the variance in performance on various functional evaluations to cognitive deficits. There also appears to be a relationship between perceptual deficits and performance of the ADL.13-20

However, most of the above studies did not make any attempt to evaluate the relative and simultaneous impact of each of these sequela (motor, cognitive, and perceptual) on functional autonomy. Studies that tried to do so obtained mixed results concerning the importance of each of these deficits in regard to their impact on the ADL.6,14-21 These studies show that it is difficult to obtain a clear picture of the relative and simultaneous impact of motor, cognitive, and perceptual sequela on functional autonomy.

The objective of the present study was to quantify the relative contributions of motor, cognitive, and perceptual deficits in explaining variations in the functional level of stroke victims. More knowledge of these measures will help health workers to target their rehabilitation interventions.

Subjects and Methods

Subjects

The sample for the present study was a convenience sample, ie, one guided by reasoned selection criteria (age, language, and etiology of the lesion). The main justification for the age group chosen, 55 to 79 years, was the increased frequency of stroke with age and the availability of norms for certain tests. The exclusion criteria were, briefly, the presence of major deficits that made it impossible to take the tests, especially the presence of another neurological pathology or significant comorbidity (eg, amputation, severe rheumatoid arthritis, and psychiatric disorders), major comprehension or attention deficits, or insufficient visual acuity (<20/100 on the Jaeger Test). Because of the possibility of spontaneous recovery after a stroke, the time elapsed after the stroke for all the subjects was at least 3 weeks. The subjects were recruited at 3 institutions: an acute care hospital,
a long-term care facility, and a geriatric center. The present study was approved by the institutional ethics committee, and the subjects gave informed consent.

**Measuring Instruments**

**Functional Aspect**

**Functional Autonomy Measurement System**

The Functional Autonomy Measurement System (Système de Mesure de l’Autonomie Fonctionnelle [SMAF]) is an instrument for evaluating autonomy that was developed on the basis of the theoretical framework of the World Health Organization’s international classification of impairments, disabilities, and handicaps. It evaluates 29 functions covering activities of daily living (7 items), mobility (6 items), communication (3 items), mental functions (5 items), and instrumental activities of daily living (8 items). Each function is scored on a 5-point scale (0, −0.5, −1, −2, and −3). Interrater and test-retest reliability and validity of the SMAF have been demonstrated.23–24 This instrument has been translated into 7 languages and is used in many epidemiological studies and assessments.25–29 A high score on this scale indicates a low level of functional autonomy.

**Assessment of Motor and Process Skills**

The Assessment of Motor and Process Skills (AMPS) provides a measure of the quality of motor and process skills when the subject carries out an activity of daily living or a domestic activity.30 Motor skills refer to posture, mobility, coordination, strength, and effort used; the process skills evaluated are temporal and spatial organization, efficient utilization of objects, and adaptability. Metrological studies on interrater and intrarater reliability and validity studies have been conducted with various populations, including stroke victims.31–34 Over 5000 people aged ≥5 years have contributed to the process of validating this instrument.31–33 Multivariate statistical analyses were used to calibrate the degree of difficulty of the tasks and the degree of severity of each rater.30

**Motor Factor**

**Evaluation for UEFH**

Upper extremity functional hemiplegia (UEFH) is taken from a battery of tests evaluating motor function, balance, passive range of motion, and pain. Only the evaluation for UEFH35 is used in the present study. A cumulative ordinal scoring system (0, 1, 2, 1) is used, and the maximum score is 66. In metrological studies, the UEFH has shown good interrater reliability36 and good external validity.37

**Berg test**

Balance assessment relates to the activity and muscle tone of the proximal and distal muscles of the trunk and lower extremities and to the automatic organization of these voluntary motor functions. The Berg38,39 test is a reliable valid instrument that is used to assess balance quantitatively (maximum score 56) by means of 14 tasks with precise instructions.

**Cognitive Factor**

Most of the various tests chosen to evaluate cognitive functions were taken from a neuropsychology battery called Protocole d’Évaluation Neuropsychologique Optimal (PENO).40 Specific reference data for this battery are available for people aged 50 to 84 years, and various subtests were taken from existing batteries that already had well-established norms.41 Language and its subcomponents were evaluated by using 4 tests: 2 lexical recall subtests and 2 subtests measuring discursive skills.40 Memory and its subcomponents were evaluated by means of 2 subtests: logical memory (immediate and delayed recall) and visual memory (immediate and delayed recall). The test used to evaluate executive functions was 1 of the 2 suggested in the PENO battery, ie, a variation of the Tower of London42 for planning and problem-solving abilities.40

**Perceptual Factor**

**Evaluation by MVPT-V**

The Motor Free Visual Perception Test-Vertical (MVPT-V)43,44 evaluates visual discrimination, figure-ground differentiation, consistency of form, visual memory, and visual synthesis. Reliability and validity studies have demonstrated its metrological qualities and normative values.45,46

**Bells test**

A cancellation task using bells was developed by Gauthier et al47 and gives a more refined evaluation of the degree of unilateral visual neglect than previous cancellation tests (Albert test48 and Diller test49,50).

**Benton test**

Spatial relation deficits were measured with the line orientation judgment test,51 which was considered by Beaumont and Davidoff52 to be a test of visuospatial functions.

**OSOT battery**

Three subtests were taken from the Ontario Society of Occupational Therapy perceptual evaluation battery53 to measure visuoconstructual deficits/apraxia.

**Rey figure test**

Visuoconstructual deficits/apraxia were also measured with the complete detailed scoring system for the copy of Rey’s complex figure.54 Norms have been established for neurologically healthy people and for various groups of stroke patients.55

**Procedure**

The subjects who agreed to participate in the present study were tested in 3 separate sessions, within 4 to 12 days. Some of them were seen in their homes, and others were seen in the hospital or long-term care facilities. The intersession and intrasession test order was randomized to avoid a systematic bias of time effect on the variables measured and a fatigue effect during the sessions.

**Statistical Analysis**

The sociodemographic characteristics of the persons who refused to participate were compared with those of the participants by use of the r test for the continuous variables and the Fisher exact test or χ2 test for the categorical variables. Confirmatory factor analyses (CFAs) were used to determine the respective contributions of each category of factors examined (perceptual, motor, and cognitive) to the variance in functional autonomy. Two models were studied: the SMAF and the AMPS served in turn as the observed measure of functional performance for a better understanding. LISREL software (version 8.20), developed by Jöreskog and Sörbom,56 was used to conduct the CFA. The analyses were performed from the covariance matrix, and various indices of goodness of fit were calculated for both models and analyzed. These indices may vary from 0 (no fit) to 1.00 (perfect fit).

**Results**

Of the people contacted, 29 refused to participate. The final sample was composed of 100 individuals (59 men and 41 women) who had had ≥1 stroke and met the selection criteria. The location of the stroke was on the right hemisphere for 48 subjects, on the left hemisphere for 39 subjects, and on both hemispheres for 13 subjects. The mean age of the participants was 69.8 years (range 55 to 79 years). Seventy-five of the subjects lived at home, and the rest lived in a hospital or long-term care facility. Statistical analyses showed no significant differences between those who had had a right stroke and those who had had a left stroke, in regard to age, education, and sex. Also, no statistically significant differ-
TABLE 1. Results of the Participants on the Different Tests for Each Factor

<table>
<thead>
<tr>
<th>Factor</th>
<th>Mean ± SD</th>
<th>Minima</th>
<th>Maxima</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor factor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UEFH/66</td>
<td>41.60 ± 22.2</td>
<td>6</td>
<td>66</td>
</tr>
<tr>
<td>Berg/56</td>
<td>38.30 ± 17.3</td>
<td>1</td>
<td>56</td>
</tr>
<tr>
<td>Cognitive factor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visual memory/30</td>
<td>8.91 ± 6.6</td>
<td>0</td>
<td>28</td>
</tr>
<tr>
<td>Tower of London/12</td>
<td>7.70 ± 1.8</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td>Lexical recall</td>
<td>32.26 ± 7.8</td>
<td>0</td>
<td>63</td>
</tr>
<tr>
<td>Discursive skills/19</td>
<td>8.44 ± 3.3</td>
<td>0</td>
<td>16</td>
</tr>
<tr>
<td>Logical memory/46</td>
<td>10.40 ± 6.8</td>
<td>0</td>
<td>33.5</td>
</tr>
<tr>
<td>Perceptual factor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bells test*</td>
<td>1.69 ± 2.4</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>Benton/30</td>
<td>19.58 ± 6.6</td>
<td>1</td>
<td>30</td>
</tr>
<tr>
<td>OSOT/12</td>
<td>9.76 ± 2.9</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>Rey’s figure/36</td>
<td>21.92 ± 9.4</td>
<td>1</td>
<td>35</td>
</tr>
<tr>
<td>MVPT-V/36</td>
<td>27.34 ± 6.2</td>
<td>9</td>
<td>36</td>
</tr>
<tr>
<td>Functional performance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SMAF/~87*</td>
<td>19.40 ± 15.0</td>
<td>0</td>
<td>-56</td>
</tr>
<tr>
<td>AMPS motor</td>
<td>0.54 ± 1.5</td>
<td>-3</td>
<td>4</td>
</tr>
<tr>
<td>skills/~3, +4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AMPS process</td>
<td>0.85 ± 1.0</td>
<td>-3</td>
<td>3</td>
</tr>
<tr>
<td>skills/~3, +4</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

The numbers after the virgules indicate maximum scores.
*Except for the SMAF and the Bells test, the higher the score, the better the performance.

dences were found between the men and women regarding age, education, or degree of functional autonomy as evaluated by the SMAF. Ninety-two of the subjects wore corrective lenses when taking the tests, but only 11 presented any hemianopsia (right, 3 subjects; left, 8 subjects). A comparison of the sociodemographic characteristics of the subjects who refused to participate (29) with those who accepted (100) showed no statistically significant difference regarding age ($P > 0.58$), education ($P > 0.56$), or sex ($P > 0.97$). The mean and standard deviation of the performance of the subjects on the different tests used for each category of variables are presented in Table 1.

Figure 1 presents the relationship between the observed variables and the exogenous variables. It is a completely standardized solution. The perceptual factor, cognitive factor, and motor factor (upper extremities and balance, respectively) are exogenous latent variables because their causes lie outside the model. The factors related to motor function are subdivided in the CFA because performances on the Fugl-Meyer Scale (upper extremities) and the Berg test (balance) do not relate to the same deficit location and identify different functional consequences. The first number shown on the left of the observed variables is an index of variability of the error terms for each of the measures. Next, the size of the relationship between each of the measures and the 4 exogenous latent variables is shown.

Figure 2 presents the structural model. Functional autonomy, which is considered the endogenous latent variable to predict, is measured in turn by the SMAF and by the AMPS. The standardized weight of each exogenous latent variable in explaining the endogenous variable is indicated. The fit of the individual components of each model is supported by the fact that each of the estimated parameters has the expected sign and size. Also, several global indices of the fit of the model, as compared with those of a null model, have values approaching unity. The different goodness-of-fit indices calculated for each model show close to the perfect fit ($> 0.92$).

Analysis for the SMAF

As indicated in Figure 2, the largest direct link between the exogenous factors and functional autonomy, as evaluated by the SMAF, is associated with the balance function factor (0.64). The cognitive factor has the next largest impact on the variance in functional autonomy (0.24), followed by the motor factor related to the upper extremities (0.17) and the perceptual factor (0.16). The 4 factors explain 93% of the variance in functional autonomy (Table 2). The large correlations between the different predictive variables must be taken into account when evaluating the impact of each category of factors. Thus, when direct and indirect links are taken into account, the balance factor has the greatest impact on functional autonomy, explaining 83% of the variance, and the cognitive factor has the least impact, explaining 31.7% of the variance.

Analysis for the AMPS

The largest direct link between the exogenous factors and functional autonomy, as evaluated by the AMPS (Figure 2), is again associated with the balance factor (0.39). The perceptual factor (0.31) and the motor factor related to the upper extremities (0.26) have the next largest impact on the variance in functional autonomy. The cognitive factor does not show any significant independent effect on functional autonomy, as measured by the AMPS. In this model, the 4 factors (exogenous latent variables) explain 64% of the variance in functional performance (Table 2). The motor factor related to balance has the greatest impact on functional autonomy, with this factor category explaining 53.3% of the variance in functional performance, followed by, in decreasing order of importance, the perceptual factor (39.5%), the motor factor related to the upper extremities (38.7%), and, finally, the cognitive factor, which explains only 12.9% (Table 2).

Discussion

The aim of the present study was to determine the relative contributions of perceptual, motor, and cognitive deficits to variations in the functional capacity of stroke victims. Functional autonomy was evaluated by using 2 instruments, the SMAF and the AMPS. The point of using these 2 measures of functional autonomy was to gain more understanding of the respective contribution of each factor evaluated in relation to 2 different aspects of daily functioning. The SMAF evaluates the degree of functional autonomy regarding 29 different components of the ADL on a 5-point scale, whereas the AMPS evaluates the quality of motor and process skills when the patient performs daily or domestic activities.
In the first CFA, in which functional performance was measured with the SMAF, the 4 factors explain 93% of its variance. In the other model, with the AMPS measure of functional performance, 64% of the variance is explained. The result of the analyses indicates that the motor factor related to balance, in correlation with the other cognitive, perceptual, and motor (upper extremities) factors (direct and indirect links), explains much of the variance in the degree of functional autonomy (83%) and in the quality of performance in ADL and domestic activities (53.3%). Also, taken alone, the motor factor, independent of the other factors (direct link), contributes the most to functional autonomy as measured by both the SMAF (weight 0.64) and the AMPS (weight 0.39). This result is not surprising inasmuch as the impairment related to this pathology impacts on independence in moving around (mobility section), in domestic activities (domestic task section), and in daily living activities (ADL section), all elements present in the SMAF.

The proportion of the variance in functional autonomy related to the upper extremities, in correlation with the other perceptual, cognitive, and motor (balance) factors (direct and indirect links), is 49.5% for the SMAF and 38.7% for the AMPS. This impact is less than expected, given the importance of the upper extremities in carrying out everyday activities. However, brain damage affects the extremity opposite the lesion, and most ADL and domestic activities can usually be performed with just one extremity, which could explain why the direct contribution of the upper extremities to the variance in the SMAF, which primarily measures the final result and not how the task is carried out, is not so large. Another explanation of the smaller than expected contribution of the motor function related to the upper extremities could be the fact that the pure motor function of the upper extremities was deliberately evaluated in the present study, not their functional performance, because the latter is often evaluated by using various tasks.

The cognitive factor showed the smallest contribution to the variance in the measures of functional autonomy. Even taking into account the correlations with the perceptual and motor factors (direct and indirect links), the cognitive factor explained only 31.7% of the variance in the SMAF and only 12.9% of the variance in the AMPS. Its direct link, independent of the other factors, is not significant in the analysis performed with the AMPS but is still present in the analysis performed with the SMAF (weight 0.24). However, not finding that the cognitive factor contributes to the variance in the AMPS score is very surprising because the process aspects of carrying out daily and domestic activities involve planning and self-control skills, 2 ingredients of the executive functions included in the cognitive factor. In the SMAF, there are 5 items related to the evaluation of mental functions, which may explain why the cognitive factor had a significant impact on the variance in the SMAF.

The results of the present study partly confirm those obtained by the few studies that took into account the impact of perceptual, cognitive, sensory, and motor factors on functional autonomy. For example, Lincoln et al\(^6\) concluded that motor deficits had a larger impact than did perceptual deficits on the ADL. However, they admitted that their measure of motor capacities was much more refined than was their measure of perceptual deficits, which might explain why they did not find a strong relationship between perceptual
1) Measured with the SMAF

- Perceptual factor
- Cognitive factor
- Motor factor (Upper extrem.)
- Motor factor (Balance)

2) Measured with the AMPS

- Perceptual factor
- Cognitive factor
- Motor factor (Upper extrem.)
- Motor factor (Balance)

**Figure 2.** Structural models relating 4 factors to the degree of functional performance: (1) measured with the SMAF and (2) measured with the AMPS.

Deficits and the ADL. On the other hand, Fullerton et al. who used refined measures of perceptual deficits and gross instruments for motor deficits, obtained a very clear link between difficulties in the ADL and perceptual deficits. For their part, Bernspang et al. found a comparable impact of motor and perceptual deficits on self-care ability 4 to 6 years after a stroke. These 2 sequel combined explained 71% of the variance related to self-care ability. Regression studies conducted by Lincoln et al. took into account perceptual, motor, and cognitive deficits simultaneously in predicting the score on the ADL, and they came to the conclusion that perceptual deficits had little impact on the ADL. These studies show that it is difficult to obtain a clear picture of the relative and simultaneous impact of motor, cognitive, and perceptual sequelae on functional autonomy. Like theirs, the present study showed the importance of the motor function (especially the balance aspect) in functional autonomy. Unlike their study, however, the present study showed a significant contribution of the perceptual factor in the variance in functional autonomy. Therefore, perceptual deficits after a stroke, just like motor deficits, should be considered in the rehabilitation phase, given their impact on the degree of functional autonomy and their even greater impact on the quality of performance in carrying out the ADL and domestic activities.

The results show different weights associated with the SMAF and the AMPS, globally and for each of the factors discussed previously. These results with the confirmatory factor analysis appear to be directly dependent on the various components measured respectively by the SMAF and the AMPS. Although the degree of variance explained by the models tested in the present study is still high and very significant, they did not explain all the variances in the

**TABLE 2. Percentage of Variance in Functional Autonomy Explained by Exogenous Latent Variables**

<table>
<thead>
<tr>
<th>Factors</th>
<th>SMAF</th>
<th>AMPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceptual factor</td>
<td>47.0%</td>
<td>39.5%</td>
</tr>
<tr>
<td>Cognitive factor</td>
<td>31.7%</td>
<td>12.9%</td>
</tr>
<tr>
<td>Motor factor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper extremities</td>
<td>49.5%</td>
<td>38.7%</td>
</tr>
<tr>
<td>Balance</td>
<td>83.0%</td>
<td>53.3%</td>
</tr>
<tr>
<td>Total</td>
<td>93.0%</td>
<td>64.0%</td>
</tr>
</tbody>
</table>
measure of functional performance. Some variables, not included in the basic model tested, such as certain psychological (eg, degree of motivation or presence of depression) or environmental (appropriate or inappropriate physical environment) factors could have increased the predictive value of the model. However, the high proportion of the variance in the SMAF explained by the model tested in the present study implies that these other variables had limited additional impact in this instance, but the same inference cannot be applied to the AMPS.

The present study showed the very large contribution of the motor, perceptual, and (to a lesser extent) cognitive factors to the degree of functional autonomy of the victims of a stroke. This contribution varies depending on whether we measure only the degree of functional autonomy (SMAF) or whether we also take into account the quality of performance when carrying out ADL or domestic activities (AMPS). In the current context of rationalization in the health care system, the results of the present study could improve the choice of rehabilitation interventions for stroke patients.

Acknowledgments

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