Ecological assessment of numerical skills in adults with left stroke

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Letter to the editor

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Dear Editor,

The capacity to process numbers and perform simple calculations in activities of daily living might be disturbed after a stroke [1]; these include difficulties in reading time, making use of money currency or paying bills, estimating quantity or entering a door code. Analytical tests have been developed to diagnose acalculia and to assess numerical skills in patients (*batterie d'évaluation du traitement des nombres et du calcul chez l'adulte, Test Lillois de Calcul 2, évaluation clinique des aptitudes numériques* [ECAN]), but ecological tests assessing these specific disorders are lacking. In 2015, we standardized and published the Ecological Assessment Battery of Numbers (EABN) [2] that assesses impairments to perform calculations and to deal with numbers through (semi-)naturalistic daily life scenarios. In the present study, patients with a history of left stroke were included to: (1) assess their functional impairment regarding calculation and number processing as assessed by the EABN and; (2) analyze correlations of the EABN score with formal scores of calculation, language, cognitive disorders, global disability and quality of life.

1. Material and Methods

Home-dwelling adults with a history of single left-hemisphere stroke (and no prior neurologic or psychiatric disease) were consecutively included by speech therapists in 3 departments of Physical Medicine and Rehabilitation between September 2011 and May 2015. Numerical skills were assessed with the EABN, which includes 8 timed tasks corresponding to common everyday life situations involving number processing (total score ranging from 0, most severe, to 40, least severe, and Z-scores adjusted on age and socio-cultural level to depict pathological scores). Formal capacity to process numbers was evaluated with an analytical battery, the ECAN [3], consisting of 35 sub-tests (total score ranging from 0, most severe, to 535, least severe).

The language and communication assessments entailed a global assessment of speech (Assessment Severity Rating Scale [ASRS] of the Boston Diagnostic Aphasia Examination). Cognitive functioning was assessed with the Mini-Mental State Examination. Global disability in daily living was assessed with the generic Functional Independence Measure (FIM) and the Barthel index. The patient's self-awareness of difficulties to deal with numbers was assessed with a visual analog scale ranging from 0, feeling most impaired, to 10, feeling least impaired. Initial severity of stroke was assessed with National Institute of Health Stroke Score.

Simple linear regression was used to assess the association between the ecological EABN score and all other scores including the analytical ECAN calculation score. Statistical analyses involved using SPSS 20.0. Missing data were treated with pairwise deletion, which resulted in analysing cases in which all the variables of interest were present.

In accordance with French legislation, patients were informed about the purpose of the study, protocol, data collection and possibility to decline participation. Participants received oral information, a written note, and gave their informed consent. Approval from the local ethical committee (*comité de protection des personnes*, CPP Île-de-France VI) was obtained, and the study followed the STROBE statement.

2. Results

We included 36 left stroke participants (n = 18 men, 50%) with mean (SD) age 61.6 (SD 18.7; range 21 to 93). The mean duration since stroke was 9.2 months (13; range 3 to 85).

The mean (SD) EABN total score was 22.4 (12.2; range 0 to 38), and 25 (69%) patients had a pathological score. The mean duration of EABN was 22 min (8.6; range 9 to 44). Fig. 1 shows patterns of impairment as assessed by the EABN. Patients had impaired scores more in the following 4 daily life activity tasks related to transcoding capacities: reading numerical data, entering a door code, paying by cheque and cash payment.

Most common difficulties included the recipe sub-test, in which patients are asked to estimate quantities on a scale (measuring cup): most patients were wrong about the centiliters-to-liters conversion. The choice of a movie, taking into account day timeline due to mental calculation, was difficult for many patients. Entering a door code (transcoding sub-test) was also discriminant with patients who were given the code orally (''A2801'') and would type something entirely different on the keyboard (e.g., in one patient, ''B9518''). The number of patients with impaired scores for each sub-test of EABN is in Table 1.

The mean ECAN score was 366 (128.6; range 61 to 516), and 10 (43%) patients had a pathological score on the ECAN. The ECAN mean duration was 1 h12 min. EABN scores were strongly

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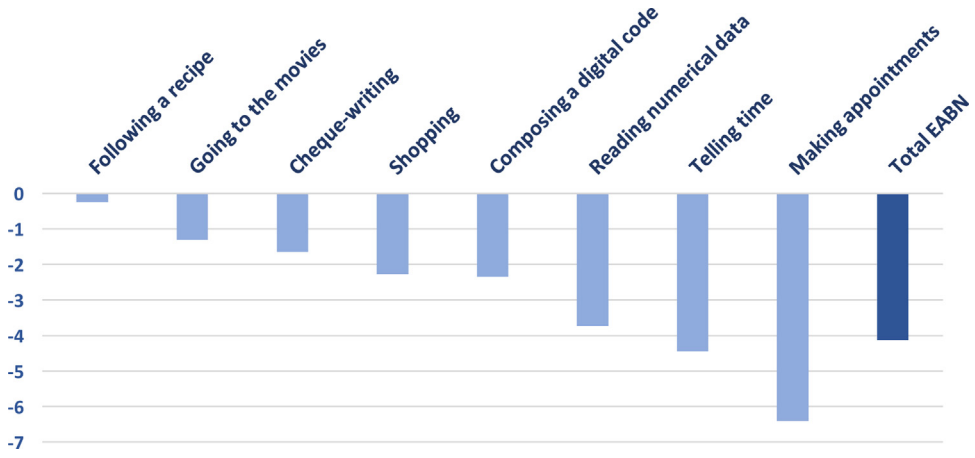

Fig. 1. Ecological Assessment Battery of Numbers (EABN) Z-scores by sub-tasks in left stroke individuals.

Table 1
Number of patients with pathological scores on sub-tests of the Ecological Assessment Battery of Numbers ($n = 36$).

Telling time	14 (39)
Shopping	24 (67)
Cheque-writing	17 (47)
Making appointments	20 (56)
Going to the movies	17 (47)
Entering a door code	15 (42)
Following a recipe	11 (31)
Reading numerical data	17 (47)
Total score	25 (69)

Data are *n* (%).

correlated with ECAN scores ($R^2 = 0.82$; $P < 0.01$) (Table 2). Six patients had a pathological score on the EABN but a normal score on the ECAN.

All mean scores in other cognitive tests were pathological (Table 2). Mean (SD) visual analog scale score for self-assessment of numerical skills was 3.8 (3.1; range 0 to 9.7 cm).

In linear regressions, a worse overall EABN score was correlated with more severe aphasia on language assessment (ASRS), worse cognitive function on the Mini-Mental State Examination, and lower level of autonomy on the FIM and Barthel Index. However, the EABN score was not significantly correlated with initial severity of stroke (National Institute of Health Stroke Score).

The severity score of the ASRS was well correlated with the composite transcoding score of the EABN. However, some cases showed dissociation: 2 patients with severe aphasia (ASRS score 0–2) had normal scores on the EABN, and 12 patients with mild aphasia (ASRS score 4–5) had pathological scores.

3. Discussion

The main objective of the present study was to assess numerical skills in activities of daily living with the EABN scale in patients with left-hemisphere stroke. More than two thirds of patients (69%) were impaired in numerical skills in activities of daily living by using an ecological test (EABN), whereas less than half (43%) were impaired by using the formal analytical test (ECAN). After brain injury, numerical skills disorders ranged from 10% to 90% [4], but little has been reported in clinical practice for assessing these disorders and on how they affect activities of daily life in individuals. In agreement with our results, 57% of 127 aphasic patients had frequent complaints when using a credit card or cheque to purchase items [5].

More specifically, we showed that the transcoding process — reading numerical data, entering a door code, paying by cheque and cash payment — was the most impaired, which echoes research from Delatollas and Basso [1]. The correlation of numerical disorders with language test scores was not surprising because some numerical processes occur in the speech area, which is logically impaired in left stroke patients [6]. However, some cases showed a dissociation between aphasia and acalculia, as shown by Basso and De Luccia, with numerical skills disorders not purely and solely explained by language disorders [7,8].

The EABN score was correlated strongly with the ECAN score, which agrees with previous results from our group [2], with even higher sensitivity to depict numerical disorders. Dissociation between analytical and ecological results has been found in other cognitive functions [9]. Particularly in executive functions, ecological tests have better psychometric value than usual analytical tests [10], which do not predict cognitive functioning

Table 2
Test results and simple regression analysis of correlation between EABN score and scores for clinical variables.

	Descriptive statistics	Simple linear regression between EABN score and clinical variables	
Clinical variables	Mean (SD) (range); % pathological score	Adjusted R^2	*P*-value
NIHSS (0–40) ($n = 34$)	9 (9.6) (0–27)	0.02	0.18
ECAN (0–535) ($n = 23$)	366 (128.6) (61–516); 43%	0.82	< 0.01
MMSE (0–30) ($n = 21$)	21.3 (9.2) (3–30); 52%	0.85	< 0.01
ASRS score (0–5) ($n = 32$)	3 (1.7) (0–5); 37% severe aphasia	0.47	< 0.01
FIM (18–126) ($n = 12$)	106.3 (15.1) (64–121)	0.36	< 0.01
Barthel Index (0–100) ($n = 32$)	89.7 (22.6) (5–100)	0.23	< 0.01
VAS (cm) (0–10) ($n = 12$)	3.8 (3.1) (0–9.7)	−0.04	0.44

ECAN: *évaluation clinique des aptitudes numériques*; MMSE: Mini-Mental State Examination; ASRS score: Assessment Severity Rating Scale of the French adaptation of Boston Diagnostic Aphasia Examination; FIM: Functional Independence Measure; VAS: visual analog scale of self-assessment of difficulties with numbers.

well in the lives of patients. We suggest that both approaches bring complementary information. Also, patients with pathological scores on the EABN could greatly benefit from an evaluation with the ECAN to understand the impaired process regarding numerical abilities and thus enable personalized cognitive rehabilitation [11]. Finally, the correlation with functional scores (Barthel Index, FIM) suggests that impairment in numerical skills plays a significant role in the overall disability situation of the individuals and supports the ecological value of the EABN.

The strength of the present study is the prospective design with a sample of 36 left-stroke patients who all underwent time-consuming and detailed assessments. To our knowledge, the EABN is the first and only French standardized and validated tool that addresses the use of numbers in daily life. This test is 3 times faster to administer than the analytical test and entails concrete activities, which supports its acceptability, as is often the case in ecological evaluation and could add value to patients' rehabilitation programs. The EABN could be useful to assess financial capacities in vulnerable cognitive individuals and to support decision-making regarding legal guardianship.

Limitations of the study include a small sample size, as is often the case in neuropsychological studies. Future work could investigate patients with lesions in other brain areas (right stroke, cerebellar and subcortical lesions) to depict similarities and differences in impairment related to brain anatomical regions.

As a whole, impairment in numerical processing is frequent in stroke patients and has significant functional impact. Patients would benefit from a more systematic assessment as well as targeted and innovative rehabilitation programs in the field.

Disclosure of interest

The authors declare that they have no competing interest.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.rehab.2020.03.008.

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