Evolution of cognitive impairment after a traumatic brain injury: is there improvement after controlling the practice effect?

Genny Lubrini, Raquel Viejo-Sobera, José A. Periáñez, Marta Cicuendez, Ana M. Castaño, Javier González-Marqués, Alfonso Lagares, Marcos Ríos-Lago

Introduction. The importance of knowing the pattern of evolution of cognitive deficits in the first months after a traumatic brain injury (TBI) has encouraged the development of numerous longitudinal studies. However, the results of most of them should be taken with caution due to the lack of adequate control of practice effects that can lead to overestimating the genuine recovery of cognitive processes.

Aim. To describe the cognitive changes between the acute and subacute phases of the TBI controlling the effect of the practice.

Patients and methods. Twenty-two patients were assessed in two different time points after TBI (immediately and after six months) using the following tests: Trail Making Test (A, B, B/A, B-A), Stroop Test (W, C, CW, interference), Digit Symbol-Coding, Symbol Search, Digits Forward and Backward, Verbal Fluency and Short-term Memory. To control for the practice effects, a transformation of the scores was performed applying the procedure proposed by Calamia et al.

Results. Before controlling the practice effects, the scores of all tests improved ($p > 0.001$). However, afterward, the improvement remained only in the Trail Making Test-B, B/A and B-A, Digit Symbol-Coding, Symbol Search, Stroop CW and Digits Backward.

Conclusions. The lack of control of practice effects in longitudinal studies can generate misleading interpretations about the evolution of cognitive deficits. The pattern of recovery after a TBI varies depending on the cognitive process.

Key words. Cognitive performance. Evolution. Longitudinal design. Practice. Recovery. Traumatic brain injury.

Faculty of Education and Psychology; Universidad Francisco de Vitoria; Madrid (G. Lubrini). Cognitive NeuroLab; Faculty of Health Sciences; Universitat Oberta de Catalunya; Barcelona (R. Viejo-Sobera). Department of Experimental Psychology; Universidad Complutense de Madrid; Madrid (J.A. Periáñez, J. González-Marqués). Neurosurgery Service; Hospital Universitari Vall d'Hebron; Barcelona (M. Cicuendez). Neurosurgery Service; Hospital Universitario 12 de Octubre; Madrid (A.M. Castaño, A. Lagares, M. Ríos-Lago). Department of Basic Psychology II; Universidad Nacional de Educación a Distancia; Madrid (M. Ríos-Lago). Brain Injury Unit; Hospital Beata María Ana; Madrid, Spain (M. Ríos-Lago).

Corresponding author:
Marcos Ríos-Lago MD. Department of Basic Psychology II. UNED. Juan del Rosal, 10. E-28040 Madrid (Spain).

E-mail:
mrios@psi.uned.es

Note:
G.L. and R.V.S. equally contributed to the elaboration of the manuscript.

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Introduction

Traumatic brain injury (TBI) is the most common cause of acquired disability in young adults and the resulting impairment can be widespread, affecting both the physical, cognitive and psychosocial functioning of a person [1]. However, cognitive performance has the most direct effect on functionality, compromising the ability to return to work and significantly reducing the level of independence [2,3]. Numerous evidences indicate that the cognitive processes that are most affected after a TBI are information processing speed [3-5], memory [6], attention [5] and executive functions [3, 7]. Although it has been suggested that the severity of the injury determines the initial degree of cognitive impairment and that both, being young and having a high educational level, are associated with a greater degree of improvement over time, there seems to be considerable between-subjects variability in the pattern of improvement after a moderate to severe TBI [8]. Knowing the evolution of the deficits during the first months after the TBI is of paramount importance for the clinicians since it can contribute to establishing more accurate predictions about the time and pattern of the evolution, as well as to plan more effective intervention programs for these patients.

Although recent reviews have indicated that there seems to be an evident pattern of continuous recovery in the first 12 months after the TBI [9], the performance of repeated measures in the neuropsychological assessment is a procedure that should be taken with caution [10]. In particular, although it is assumed that the changes reflect a genuine improvement in the construct evaluated by a specific test, part of these differences may be due to the effect of the practice, i.e. items recall, learning of specific strategies, or gaining general experience and comfort with the assessment situations [10]. In this sense, the improvement in the score due to practice effects would occur independently of the genuine changes in patients' performance in the evaluated construct. Despite its relevance, the practice effects have not been considered in most of the studies aimed at evaluating the evolution of cognitive deficits in patients with TBI. On the one hand, some investigations do not include a control group [11-13], which could lead to an overestimation of patient recovery. On the other, in some studies the control group performs only the first evaluation [3, 14], so when comparing the patients' retest results with controls' baseline scores, patients' improvement due to practice effects is not being considered either. Some authors have tried to avoid the influence of practice using tests with high test-retest reliability or parallel forms, but this solution is not always possible. Many of the tasks commonly used for neuropsychological assessment do not have parallel forms or the forms that are assumed to be equivalent do not have adequate reliability [15] and are not always exempt from the practice effect of having performed a similar task before [16]. There are also some studies in which both patients and controls are evaluated at the same time points [4,5, 7,17]. This option, which seems ideal, also has drawbacks, since the effects of practice due to retest are not the same in a healthy sample than in a TBI sample or other clinical conditions [10,18,19]. Since practice effects are often lower in TBI patients compared to healthy people, the use of a healthy comparison group can overcorrect the effects of practice and the actual improvement of the clinical group can be attributed wrongly to practice effects [10]. Moreover, a clinical group with a lower baseline has a greater range of improvement, while a healthy comparison group may already have reached its maximum at baseline [5,10]. To control for practice effects more accurately, statistical methods have been used to correct the scores [5]. The problem to determine the reliability of the test-retest changes is frequent in studies with clinical populations, for that reason various statistical methods have been designed to determine the significance of the changes observed. Sometimes the Reliable Change Index, is calculated, which provides a more accurate measure of the change than the usual calculation of the standard deviation. However, this method does not consider the variability of practice effects depending on factors such as age, time since the first evaluation, etc. [20]. Finally, methods based on multiple regression have been developed that allow variables such as age or education to be included as predictors of the retest scores [10,20]. The latter have been shown to be the most accurate, together with the Reliable Change Index, for estimating the expected change in the retest in different populations [21]. In recent years, scales based on regression analysis have been developed to calculate the effect of practice for neuropsychological tests commonly used in the clinical setting [10,22]. This type of measurement provides the expected rate of change in a given test due to the practice effects. It also offers corrections of the different indices based on variables such as age, the interval between the first and second evaluation and even depending on the type of clinical population. However, to date, methods based on regression, although widely used in studies with other clinical populations such as epilepsy or Parkinson's, are very little used in studies of TBI recovery [20].

The objective of the present study was to examine the changes in cognitive performance between the acute and subacute phase of the TBI controlling the effect of the practice. To this end, we hypothesized that, if the observed changes in performance between the first and the second evaluation were a consequence of practice, then the differences in the neuropsychological scores observed between the acute and subacute phase will disappear when controlling for this effect. Alternatively, if the observed changes were due to a genuine spontaneous recovery in the subacute phase of the TBI, then the differences between the two phases will remain even after controlling practice effects.

Patients and methods

Participants

The sample was composed of 22 patients with TBI. All of them underwent a neuropsychological evaluation at two different times. The first evaluation took place during the acute phase of the TBI (24.4 ± 16.3 days after the TBI) and the second during the subacute phase approximately six months after the TBI (180.8 ± 41 days) and an average of 142.7 ± 50.1 days after the first evaluation (Table I). The following exclusion criteria were applied for both acute and subacute evaluations:

- Attentional (hemineglect or severe problems of sustained attention and alertness), motor, sensory and/or communication impairments that prevented the understanding or execution of the tasks.
- Emotional state that interfered with the completion of the tasks,
- In the first assessment: not being in the acute phase of the TBI (more than two months from the time of the injury, without taking into account the days that the patient could not be evaluated due to intubation or respiratory compromise).

– In the second assessment: not being in the subacute phase of the TBI (to reduce the variability in the time elapsed since the TBI and prevent the patient from being classified as acute or chronic, it was established that more than 3 and less than 9 months should have elapsed from the TBI).

Table I shows the demographic and clinical characteristics of the group.

More than half of the TBIs were due to traffic accidents (59%), 18% were due to accidents in the workplace and the rest were due to other causes (23%). Regarding the severity of the TBI, 54% were mild (GCS scores between 13 and 15), 14% moderate (GCS 9-12) and 32% severe (GCS 3-8). The GCS reported is the one obtained before the hospital admission since the score measured at the time of admission may be artificially reduced due to the treatments received by the patient during the transfer to the hospital [23]. Finally, the lesions presented by the patients varied according to their location, extension and injury mechanism. The information regarding the location of the lesions was extracted from the report corresponding to the MRI and/or CAT scan performed at the time of admission or during the hospitalization period. Diffuse axonal injury was the most frequent lesion (29%) followed by frontal (27%) and temporal injuries (18%), which agrees with the most frequent pathophysiological characteristics of TBIs [24]. All participants and/or relatives were informed of the details of the evaluation and expressed their writing consent to participate in the study following the Declaration of Helsinki.

Table I. Demographic and clinical characteristics of TBI patients (n = 22).

Demographic characteristics	Women		3 (14%)
	Age (years)	Mean ± SD	34.1 ± 10.3
		Range	19-56
	Education (years) [a]	Mean ± SD	13 ± 4.2
		Range	6-22
	Laterality	Right-handed	20 (91%)
Clinical characteristics	GCS (median)	Prehospitalization [b]	13 (IR: 8)
		At hospitalization	6 (IR: 10)
	Days from injury to acute assessment [c]	Mean ± SD	24.4 ± 16.3
		Range	8-69
	Non-evaluable days [d]	Mean ± SD	7 ± 7.6
		Range	0-25
	Days from acute to subacute assessment	Mean ± SD	146 ± 47.2
		Range	46-218

GCS: Glasgow Coma Scale; IR: interquartile range; SD: standard deviation. [a] Years of schooling completed; [b] GCS score before hospitalization; [c] GCS score at hospitalization; [d] Days during which the evaluation of the patient could not be carried out during the acute phase.

Materials and procedure

After three to six months from the completion of the first assessment, the neurosurgeon contacted each patient to perform the second assessment. The evaluations lasted approximately 1.5 hours and all of them were carried out by an expert neuropsychologist. The neuropsychological tests administered were: the Trail Making Test (TMT), Stroop Color and Word test, four subtests of the Wechsler intelligence scale [25] –Digit Symbol-Coding (DS), Symbol Search (SS), Digits Forward (DF) and Backward (DB)–, a Verbal Fluency test –phonological fluency as the number of words starting with F (VFF) and A (VFA) in a minute, and semantic fluency: number of animals, VF animals)–, and an episodic memory test –logical memory: immediate recall and recognition–. Some of the scores were considered invalid, so the sample included in each set of analyses varied. Despite this, and given the independent nature of the statistical comparisons of the tests' scores, none of these participants was eliminated from the analyses of the rest of the tests. Table II shows the demographic and clinical characteristics of the samples included in each set of analyses.

Data analysis

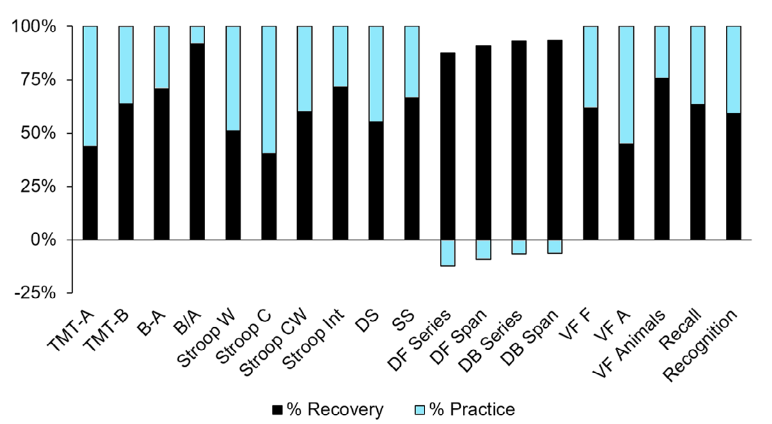
To evaluate whether variables were normally distributed, the Kolmogorov-Smirnov test was used. To compare participants' performance in the neuropsychological tests between the acute and subacute phases, repeated measures Student's t-tests were used. To control the possible practice effects on the second evaluation scores and separate them from the change due to recovery, the scores obtained by the patients in the retest were transformed. For this, in the first place, the gain due to the practice effect was calculated in terms of standard deviations based on the indices provided by Calamia et al [10]. These authors provide a measure of the change in retest scores due to practice effects depending

Table II. Demographic and clinical characteristics of the different patient subsamples included in each analysis. Mean ± standard deviation scores are presented (median in GCS).

	TMT (n = 17)	Stroop (n = 20)	DS, SS, DF, DB, Memory (n = 22)	Verbal Fluency (n = 20)
Women	3	3	3	3
Mean age (years)	33.3 ± 10	32.3 ± 8.8	34.1 ± 10.3	33.4 ± 9.4
Years of education (mean)	13.4 ± 3.7	12.9 ± 3.7	13.1 ± 4.2	12.8 ± 3.8
Right-handed/left-handed	16 / 1	18 / 2	20 / 2	18 / 2
Prehospitalization GCS (median)	13 (IR: 8)	13 (IR: 8)	13 (IR: 8)	14 (IR: 8)
Days from acute to subacute assessment (mean)	163.5 ± 41.2	165.8 ± 40.7	170.6 ± 41.9	169.3 ± 40.9

DB: Digits Backward; DF: Digits Forward; DS: Digits Symbol-Coding; GCS: Glasgow Coma Scale; IR: interquartile range; SS: Symbol Search; TMT: Trail Making Test.

Figure. Percentage of total change attributed to practice and spontaneous recovery of patients. B-A: derived score resulting from subtracting TMT A from TMT B; B/A: derived score resulting from dividing *n* TMT B by TMT A; Stroop Int: Stroop Interference score; DS: Digit Symbol-Coding; SS: Symbol Search; DF: Digits Forward; DB: Digits Backward; VF: Verbal Fluency.



on the type of test used, the age of the participant, the time elapsed since the first evaluation and the type of population (clinical or non-clinical). For each variable, the gain rate due to practice (Practice gain) was calculated in terms of standard deviations (SD); and also the retest scores of each patient removing the practice gain were estimated. The score of each patient after extracting the practice effect (Retest Score') was calculated as follows: *Retest Score'* = *Test Score* + [(*Retest gain* – *Practice gain*) × *Test SD*], where *Retest Gain (SD)* = [(*Retest Score* – *Test Score*) / *Test SD*]. For a detailed description see supplementary material.

Finally, performance in acute and subacute stages (corrected) was compared using repeated measures Student's *t*-tests. The effect size and power of the different comparisons were also calculated. In the significance level was set at $\alpha < 0.05$. The analyses were carried out using SPSS v. 21.0 and G*Power v. 3.1 software packages.

Results

The repeated measures *t*-test used to compare the performance in the acute and subacute phases revealed significant differences in TMT A scores ($t_{(16)} = 2.30$; $p = 0.036$), TMT B ($t_{(16)} = 4.17$; $p = 0.001$), B-A ($t_{(16)} = 4.05$; $p = 0.001$), B/A ($t_{(16)} = 2.82$; $p = 0.012$), Stroop W ($t_{(19)} = -2.22$; $p = 0.039$), Stroop C ($t_{(19)} = -2.64$; $p = 0.016$), Stroop CW ($t_{(19)} = -4.56$; $p < 0.001$) Stroop Interference ($t_{(19)} = -2.31$; $p = 0.032$), DS ($t_{(21)} = -4.65$; $p < 0.001$), SS ($t_{(21)} = -4.43$; $p < 0.001$), DB number of series ($t_{(21)} = -4.29$; $p < 0.001$) and span ($t_{(21)} = -2.83$; $p = 0.01$), VFF ($t_{(19)} = -2.83$; $p = 0.01$), VFA ($t_{(19)} = -2.31$; $p = 0.032$), VF animals ($t_{(19)} = -3.80$; $p = 0.001$), short-term memory Recall ($t_{(21)} = -2.53$; $p = 0.02$) and Recognition ($t_{(21)} = -3.04$; $p = 0.006$). The DF task test-retest performance comparison did not reveal significant differences in the number of series repeated ($t_{(21)} = -1.50$; $p = 0.149$) or the span ($t_{(21)} = -1.62$; $p = 0.119$). The effect size was moderate to large ($d > 0.5$) in all the scores that showed significant differences. The power in these cases was also high. The effect size for DF scores (number of series and span) was lower, as expected, which, together with the small number of patients in the group, meant that the power was low.

Retest gain calculation in terms of standard deviations and the gain due to practice effects revealed that the greatest practice effect occurred in the TMT A, Stroop W, and VFA scores. The proportion of change due to practice accounted for more than 50% of the gain (Table III; Figure). For the rest of the scores, the effect of the recovery was greater than the practice effects. The scores less affected by practice were DF and DB tests (in which the practice impaired performance) and the TMT B/A score. Other scores in which the practice accounted for less than a third of the gain were VF Animals, Stroop Interference and TMT B-A (Table III).

The repeated measures *t*-test used to compare performance in the acute and subacute stages once controlled the practice effect revealed significant differences in the TMT B scores ($t_{(16)} = 2.65$; $p = 0.017$), B-A ($t_{(16)} = 2.88$; $p = 0.011$), B/A ($t_{(16)} = 2.61$; $p = 0.019$), Stroop CW ($t_{(19)} = -2.70$; $p = 0.014$), DS ($t_{(21)} =$

−2.55; p = 0.019), SS ($t_{(21)}$ = −2.92; p = 0.008), DB number of series ($t_{(21)}$ = −4.65; p <0.001, DB span ($t_{(21)}$ = −3.01; p = 0.007), and VF Animals ($t_{(19)}$ = −2.88; p = 0.01). The changes observed in the rest of the scores once the practice effect was eliminated were not significant: TMT A ($t_{(16)}$ = 1.00; p = 0.331), Stroop W ($t_{(19)}$ = −1.14; p = 0.27), Stroop C ($t_{(19)}$ = −1.07; p = 0.297), Stroop Interference ($t_{(19)}$ = −1.64; p = 0.117), DF series ($t_{(21)}$ = −1.75; p = 0.095), DF span ($t_{(21)}$ = −1.80; p = 0.086), VFF ($t_{(19)}$ = −1.76; p = 0.095), VFA ($t_{(19)}$ = −1.04; p = 0.312), short-term memory Recall ($t_{(21)}$ = −1.59; p = 0.126), and short-term memory Recognition ($t_{(21)}$ = −1.80; p = 0.087) (Table IV).

Table III. Score changes between the two assessments (gain) presented as standard deviations (SD) and percentage of change. The change attributed to practice and recovery is shown separately.

		Change (SD)			% of change	
		Total	Practice	Recovery	Practice	Recovery
TMT	A	0.47	0.26	0.21	56.1%	43.9%
	B	0.88	0.32	0.56	36.3%	63.7%
	B-A	0.88	0.26	0.62	29.2%	70.8%
	B/A	0.66	0.05	0.60	8.2%	91.8%
Stroop	Stroop W	0.46	0.23	0.24	48.9%	51.1%
	Stroop C	0.38	0.23	0.15	59.7%	40.3%
	Stroop CW	0.53	0.21	0.32	40%	60%
	Stroop Int	0.44	0.12	0.31	28.5%	71.5%
IPS	DS	0.71	0.32	0.39	44.6%	55.4%
	SS	0.65	0.22	0.43	33.5%	66.5%
Digits Forward	Series	0.31	−0.05	0.36	−16.4%	116.4%
	Span	0.45	−0.05	0.50	−11.1%	111.1%
Digits Backward	Series	0.64	−0.05	0.69	−7.8%	107.8%
	Span	0.67	−0.05	0.72	−7.4%	107.4%
Verbal Fluency	F	0.61	0.23	0.38	38.3%	61.7%
	A	0.42	0.23	0.19	55.2%	44.8%
	Animals	0.96	0.23	0.72	24.3%	75.7%
Memory	Recall	0.56	0.20	0.35	36.6%	63.4%
	Recognition	0.50	0.20	0.29	41%	59%

DS: Digits Symbol-Coding; IPS: information process speed; SS: Symbol Search; Stroop Int: Stroop Interference; TMT: Trail Making Test.

Discussion

The goal of the present longitudinal study was to examine changes in cognitive performance between the acute and subacute phase of TBI controlling the possible practice effect due to successive assessments. The literature has shown the need to develop longitudinal studies to advance the knowledge and management of cognitive and functional deficits that usually appear after a TBI [9,26]. For this, a group of patients was evaluated twice, immediately and approximately 6 months after TBI. Moreover, a statistical control of the practice effects was carried out on the neuropsychological tests in order to disentangle the practice from the true spontaneous recovery effects.

Next, we will try to clarify the two hypotheses of this study based on our results. The first hypothesis stood that, if the changes observed are due to the practice effects, then the differences in the neuropsychological scores observed between the acute and subacute stages would disappear when controlling these effects. The results showed that the changes in some neuropsychological scores were due to practice effects. Specifically, it was the case of TMT A, Stroop W, Stroop C, Stroop Interference, VFF, VFA, and episodic memory Recall and Recognition. Therefore, the practice effects were responsible for the changes observed in simple information processing speed, episodic memory, and phonological fluency. Previous work shows that, according to the results of the present study, practice effects occur significantly in phonological fluency tasks and also memory tasks [19]. Regarding phonological fluency, it has been seen that, in chronic TBI, this capacity is affected while semantic fluency is not [27]. Therefore, the absence of change in phonological fluency could be related to a more permanent alteration.

Alternatively, the second hypothesis suggested that, if the observed changes were due to a genuine spontaneous recovery in the subacute phase of the TBI, then the differences between the two phases would remain even after controlling practice effects. Considering the results obtained, we can assume a spontaneous recovery in processing speed (DS and SS), alternating attention (TMT B, B/A, and B-A), selective attention (Stroop CW) and working memory (DB). According to these results, some works that controlled the practice effect found

Table IV. Mean scores (standard deviation), significance, effect size and contrast power obtained in *t*-tests comparing the performance of patients in the acute and subacute stage of TBI in each of the neuropsychological tests. Results calculated before and after correcting practice effects are shown.

		Without practice effects correction					With practice effects corrected			
		Acute stage	Subacute stage	Significance	*d*	Power	Subacute stage	Significance	*d*	Power
TMT	A	52.6 ± 34.3	36.5 ± 9.4	0.036 [c]	0.56	0.58	45.5 ± 9.2	0.331 [d]	0.24	0.16
	B	136.9 ± 69.3	76.3 ± 22	0.001 [a]	1.01	0.97	98.3 ± 22.8	0.017 [c]	0.64	0.70
	B-A	84.4 ± 50.8	39.8 ± 18	0.001 [a]	0.98	0.98	52.8 ± 19.3	0.011 [c]	0.70	0.77
	B/A	2.9 ± 1.2	2.1 ± 0.5	0.012 [c]	0.69	0.76	2.2 ± 0.4	0.019 [c]	0.64	0.69
Stroop	Stroop W	85.9 ± 19	94.7 ± 18.7	0.039 [c]	0.50	0.56	90.3 ± 18.7	0.270 [d]	0.25	0.19
	Stroop C	60.7 ± 15.4	66.5 ± 14.8	0.016 [c]	0.59	0.71	63 ± 14.7	0.297 [d]	0.24	0.17
	Stroop CW	33.9 ± 15.6	42.1 ± 12.7	< 0.001 [a]	1.02	0.99	38.8 ± 12.7	0.014 [c]	0.60	0.72
	Stroop Int	–1.6 ± 10.8	3.1 ± 9.5	0.032 [c]	0.52	0.59	1.8 ± 9.6	0.117 [d]	0.37	0.35
IPS	DS	44.7 ± 22.2	60.4 ± 18.5	< 0.001 [a]	0.99	0.99	53.4 ± 18.3	0.019 [c]	0.54	0.68
	SS	24.7 ± 11.1	32 ± 9.6	< 0.001 [a]	0.94	0.99	29.5 ± 9.6	0.008 [b]	0.62	0.80
Digits Forward	Series	7.3 ± 1.6	7.8 ± 1.5	0.149 [d]	0.32	0.30	7.9 ± 1.6	0.095 [d]	0.37	0.39
	Span	5.2 ± 0.9	5.6 ± 0.9	0.119 [d]	0.35	0.34	5.6 ± 0.9	0.086 [d]	0.38	0.41
Digits Backward	Series	4.4 ± 1.8	5.5 ± 1.6	< 0.001 [a]	0.91	0.98	5.6 ± 1.6	< 0.001 [a]	0.99	0.99
	Span	3.5 ± 1	4.2 ± 1.3	0.010 [c]	0.6	0.77	4.3 ± 1.3	0.007 [b]	0.64	0.81
Verbal Fluency	F	7.3 ± 4	9.8 ± 2.7	0.010 [c]	0.64	0.77	8.8 ± 2.7	0.095 [d]	0.39	0.39
	A	7.9 ± 4	9.6 ± 2.8	0.032 [c]	0.52	0.60	8.6 ± 2.8	0.312 [d]	0.23	0.17
	Animals	13.7 ± 6.1	19.5 ± 5.1	0.001 [b]	0.85	0.95	18 ± 5.1	0.010 [b]	0.64	0.78
Memory	Recall	7.7 ± 3.1	11.5 ± 3.1	0.020 [c]	0.54	0.67	8.8 ± 3.3	0.126 [d]	0.34	0.33
	Recognition	9.5 ± 2.1	10.9 ± 1.1	0.006 [b]	0.64	0.82	10 ± 1.4	0.087 [d]	0.38	0.40

d: effect size; DS: Digits Symbol-Coding; IPS: information process speed; SS: Symbol Search; Stroop Int: Stroop Interference; TMT: Trail Making Test. [a] $p < 0.001$; [b] $p < 0.01$; [c] $p < 0.05$; [d] Non-significant difference ($p > 0.05$).

improvement in complex skills such as executive functions and working memory but not in processing speed [5,7,17]. On the other hand, most of the studies that found an improvement in processing speed [12] or improvement in other capacities as well as processing speed [11,14], did not use a control group or any other control of practice effects, which could explain the differences regarding the results of the present study. In fact, the results of the present study before correcting the effect of practice also showed improvement in processing speed (and in all the cognitive processes evaluated). Precisely, this is what is observed when comparing the group of patients with TBI with a group of patients with non-cranial trauma [28]. According to these authors, there is an improvement in all the evaluated capacities (including processing speed) in both groups. On the other hand, the results agree only partially with those found by Felmingham et al [4]. These authors evaluate a group of healthy controls and two groups of patients, one with diffuse lesions and the other one with mixed lesions. These authors found that patients with diffuse lesions improved in basic processing speed (TMT A, Stroop W, and Simple Reaction Time) unlike what occurred with TBI with mixed lesions and controls. The differences with the present study could be due to the fact that patients with specific characteristics (diffuse axonal injury), might show a differential pattern of change compared to the one observed in patients with both mixed and diffuse lesions.

Finally, regarding the findings on the DF test, it should be noted that, both before and after controlling for the practice effects, there were no differences between the acute and subacute stages. The absence of change in this test is consistent with previous results that show that DF test is not affected by practice effects neither in healthy controls [17] nor in patients [19], and with the results found by Wilson et al [19] who also indicate that DF test scores cannot tell apart patients and controls.

In summary, the results of the present study show that, once practice effects due to repeated assessments have been controlled, the differences between test and retest scores are not the same as before performing said control. While before the correction there was an improvement in all cognitive processes evaluated, afterward, that improvement disappeared in some of them. This finding allows us to draw two main conclusions. On the one hand, as has been shown in previous studies [11,29], there is an improvement during the first months after the TBI but, on the other, the pattern of evolution is not uniform and varies depending on the cognitive process. Therefore, the lack of control of practice effects in retest situations in some previous longitudinal studies could have generated erroneous interpretations of their results. This aspect acquires special relevance in research on the effectiveness interventions. Because practice effects generally improve scores in the retest, the lack of control could lead, for example, to erroneously interpret the effect of a neutral intervention as positive.

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Evolución de las alteraciones cognitivas tras un traumatismo craneoencefálico: ¿hay mejoría tras controlar el efecto de la práctica?

Introducción. La importancia de conocer el patrón de evolución de los déficits cognitivos en los primeros meses tras un traumatismo craneoencefálico (TCE) ha fomentado el desarrollo de numerosos estudios longitudinales. Sin embargo, los resultados de la mayoría de ellos deberían tomarse con cautela debido a la falta de un control adecuado del efecto de la práctica, que puede llevar a sobreestimar la recuperación genuina de los procesos cognitivos.

Objetivo. Describir los cambios cognitivos entre las fases aguda y subaguda del TCE controlando el efecto de la práctica.

Pacientes y métodos. Veintidós pacientes realizaron dos evaluaciones neuropsicológicas tras el TCE (inmediata y tras seis meses) mediante los siguientes tests: *Trail Making Test* (A, B, B/A y B-A), test de Stroop (P, C, PC e interferencia), clave de números, búsqueda de símbolos, dígitos directos e inversos, fluidez verbal y memoria inmediata. Para controlar el efecto de la práctica se realizó una transformación de las puntuaciones aplicando el procedimiento propuesto por Calamia et al.

Resultados. Antes de controlar el efecto de la práctica, se evidenció una mejoría en las puntuaciones de todos los tests ($p > 0,001$). Sin embargo, tras él, la mejoría permaneció sólo en el *Trail Making Test* B, B/A y B-A, la clave de números, la búsqueda de símbolos, el test de Stroop PC y los dígitos inversos.

Conclusiones. La falta de control del efecto de la práctica en estudios longitudinales puede generar interpretaciones erróneas sobre el perfil de evolución de los déficits cognitivos. El patrón de recuperación tras un TCE varía en función del proceso cognitivo.

Palabras clave. Diseño longitudinal. Evolución. Práctica. Recuperación. Rendimiento cognitivo. Traumatismo craneoencefálico.