Annals of Physical and Rehabilitation Medicine 58 (2015) 78–85

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Original article

The Cognitive Assessment scale for Stroke Patients (CASP) vs. MMSE and MoCA in non-aphasic hemispheric stroke patients

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ARTICLE INFO

Article history:
Received 4 August 2014
Accepted 18 December 2014

Keywords:
Comparison
Feasibility
CASP
MMSE
MoCA

ABSTRACT

Introduction: CASP specifically assesses post-stroke cognitive impairments. Its items are visual and as such can be administered to patients with severe expressive aphasia. We have previously shown that the CASP was more suitable than the Mini Mental State Examination (MMSE) and Montreal Cognitive Assessment (MoCA) in aphasic patients. Our objective was to compare the above scales in non-aphasic stroke patients, and assess to what extent the solely visual items of the CASP were problematic in cases of neurovisual impairments.

Methods: Fifty non-aphasic patients admitted to Physical Medicine and Rehabilitation (PM&R) units after a recent left- or right-hemisphere stroke were evaluated with the CASP, MMSE and MoCA. We compared these three scales in terms of feasibility, concordance, and influence of neurovisual impairments on the total score.

Results: Twenty-nine men and 21 women were included (mean age 63 ± 14). For three patients, the MoCa was impossible to administer. It took significantly less time to administer the CASP (10 ± 5 min) than the MoCA (11 ± 5 min, $P = 0.02$), yet it still took more time than MMSE administration (7 ± 3 min, $P < 10^{-6}$). Neurovisual impairments affected equally the total scores of the three tests. Concordance between these scores was poor and only the CASP could specifically assess unilateral spatial neglect.

Conclusion: The sole visual format of the CASP scale seems suitable for administration in post-stroke patients.

1. Introduction

The relevance of assessing cognitive impairments early on after stroke has been largely validated. Several batteries of tests are used in clinical practice today, regardless of having been previously validated for that specific use. In a recent work [3,4], we reported the main assessments scales for cognitive disorders and demonstrated the superiority of the Cognitive Assessment scale for Stroke

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http://dx.doi.org/10.1016/j.rehab.2014.12.001
1877-0657/

Patients (CASP) over the Mini Mental State Examination (MMSE) [5,6] and MoCA (Montréal Cognitive Assessment) [11] in terms of feasibility in a population of post-stroke aphasic patients. As a matter of fact, the CASP was specifically designed, both in terms of content and format, for a quick evaluation of post-stroke cognitive disorders at "the patient's bedside". Its main characteristics consist in (see details in the primary publication by Barnay et al., [4]):

- six cognitive functions being evaluated: language, praxis, short-term memory, temporal orientation, spatial neglect/visual construction, executive functions (Appendix 1);
- each of the six functions is scored on a scale of 6 (equal weight attributed to each function). The score is expressed either as a profile (i.e. "5-6-4-2-3-4"), or as a total score out of 36;
- patients can answer the tests without using language (solely visual tests or designating the right answer among distractors). The CASP can be administered to patients with mutism as long as they retained some oral comprehension for simple orders (BDAE aphasia severity score ≥ 3 for the comprehension dimension [7,10]);
- elements from the test that the patient must look at are systematically ordered in a column and/or placed on the right side of the test sheet to minimize the influence of left unilateral spatial neglect;
- it is the only short cognitive evaluation battery containing a test validated specifically for spatial neglect, issued from the French unilateral neglect battery BEN (Batterie d'Evaluation de la Négligence) (20-cm horizontal line bisection test) [2];
- shorter administration time in aphasic patients (13 ± 4 min).

In our first study we were able to note that when MMSE and MoCA could not be administered to several aphasic patients, it was however possible to administer the CASP in these patients. For other patients, results to the MMSE and MoCA tests evaluating non-language functions were highly influenced by the severity of aphasia, significantly more than for the CASP. Therefore, with the CASP we observed (in this work and in our daily clinical practice) that a significant portion of aphasic patients retained a pretty good orientation to time, an element impossible to verify with the MMSE and MoCA. However, in this study, we experienced great difficulties in administering the CASP in at least one patient presenting major neurovisual impairments (cortical blindness). This observation was expected since CASP items are solely visual-related.

Of course, CASP relevance would be quite limited if it was restricted to aphasic patients (this is why we took into account a possible left spatial neglect in designing the test). The objectives of the present study were to validate the applicability of CASP in non-aphasic stroke patients, assess the influence of neurovisual disorders on CASP administration, and compare CASP scores to those of the MMSE and MoCA.

2. Patients and methods

During 2013, we recruited fifty patients consecutively admitted in seven PM&R units for recent primary hemispheric stroke without aphasia. They all benefited from the systematic administration of the CASP, MMSE and MoCA. The study consisted in:

- estimating the percentage of patients for whom the administration of one or several items of these three scales was impossible;
- comparing the mean administration time of the tests;
- evaluating in each battery of tests the influence of neurovisual impairments on the total score (outside of neurovisual items);
- comparing the scores of the three batteries.

2.1. Inclusion criteria

Patients hospitalized in a rehabilitation unit during the first 100 days following a primary stroke affecting the left and/or right hemisphere, not presenting with aphasia, without any restriction in terms of age or severity of cognitive disorders.

2.2. Exclusion criteria

Consciousness disorders, patients not speaking French, cognitive, psychotic or visual disorders, not compatible with reading, which were known prior to the stroke, stroke-induced language impairments (BDAE aphasia severity score between 0 and 5).

2.3. Administration of the three tests

According to the local context, the tests could be administered by a physician, a resident, a speech therapist, or a neuropsychologist. The order in which the three tests were administered was decided in advance by random drawing. For each patient, one unique examiner had to administer the three tests.

2.4. Collected data

Scores and administration times of the three scales were noted. Scores for items exploring neurovisual functions were calculated separately for each scale: sum of item 3 (copy of a cube) and item 6 (line bisection), on 6 points for the CASP; item 6 (reproduction of a drawing), on 1 point for the MMSE; item 1 (drawing letters/numbers to connect + reproducing a cube + watch test), on 5 points for the MoCA. General demographic data and stroke characteristics were collected.

2.5. Data treatment

The comparison of mean administration times between the three batteries was evaluated by the non-parametric Wilcoxon signed-rank test (assumptions and conditions for the paired two-sample t-test were not satisfied). The influence of the neurovisual items on the total scores (outside of neurovisual items) was assessed with the Pearson product-moment correlation coefficient (for correlation) and the intraclass correlation coefficient (ICC) (for concordance). In order to evaluate how the line bisection test (CASP6) yielded specific information, a Principal component analysis (PCA) was conducted using all neurovisual tests from the three batteries. All statistics computations were conducted with the Number Cruncher Statistical System 9 software [8].

3. Results

The fifty patients planned for the protocol were included over a 4-month period (29 men/21 women). Mean age 63 ± 14 years (Ranges: 30–88), 44 were right-handed (88%), 4 were left-handed (8%), and 2 were ambidextrous (4%). Brain damage concerned the right hemisphere for 37 patients (74%), there was never bilateral damage, the stroke was ischemic for 38 patients (76%), hemorrhagic for 11 patients (22%), ischemic and hemorrhagic in 1 case (2%). Time since stroke was 40 ± 17 days (Ranges: 13–99).

3.1. Administration of the three batteries

The results of the administration of the three batteries are listed in Table 1. Three patients were unable to pass the first item of the MoCA ("visuospatial/executive" item). Among these three patients, none obtained the maximum scores on the neurovisual tests of the other two batteries. One of them was among the

Table 1
For the three batteries, number of complete and incomplete test administrations, score and administration time.

Battery	Incomplete test administrations	Complete test administrations	
	Number (%)	Scores	Times (min)
CASP (/36)	0 (0)	29 ± 5 (15.5–36)	10 ± 5 (3–40)
MMSE (/30)	0 (0)	25 ± 4 (13–30)	7 ± 3 (3–20)
MoCA (/30)	3 (6)	21 ± 5 (8–28)	11 ± 5 (5–32)

CASP: Cognitive Assessment scale for Stroke Patients; MMSE: Mini Mental State Examination; MoCA: Montreal Cognitive Assessment.

16 patients (32%) who failed the line bisection test (CASP6). Mean scores were 29 ± 5/36 for the CASP, 25 ± 4/30 for the MMSE and 21 ± 5/30 for the MoCA. The scores were not significantly influenced by time since stroke ("*r*" values between 0.02 and 0.19, $P > 0.20$). Mean administration time for the CASP (10 ± 5 min) was significantly shorter than for the MoCA (11 ± 5 min, $P < 0.02$) and significantly longer than for the MMSE (7 ± 3 min, $P < 10^{-6}$). These mean administration times were not significantly influenced by time since stroke ("*r*" values between −0.17 and −0.01, $P > 0.20$).

3.2. Influence of neurovisual disorders on total scores' performance (outside of neurovisual items)

In each battery, the score for the item (or items) testing neurovisual functions was: (1) positively correlated to other items of the battery. The three "*r*" values were similar: $r = 0.41$, $P = 0.003$; $r = 0.34$, $P = 0.015$; $r = 0.39$, $P = 0.007$, respectively for the CASP, MMSE and MoCA; and (2) negatively correlated to the administration time of the complete battery for the CASP ($r = -0.32$, $P < 0.03$) and for the MMSE ($r = -0.32$, $P < 0.03$), but not for the MoCA ($r = -0.15$, $P > 0.32$). Four patients did not obtain the maximum score at the CASP1 item for image naming. The patient TOU5 obtained a score of 2/3 for this item, yet he had obtained the maximum score to the "language" items of the other two batteries. Since he obtained poor scores to the purely neurovisual items of the three batteries, one can imagine that the purely visual aspect of the CASP image naming test might have disrupted his comprehension; patients GRE6 and GRE12 (2/3 and 2.5/3 to CASP1) also failed to answer most items of the three batteries; and finally patient CCR5 (2/3 to CASP1) obtained good scores otherwise.

3.3. Relationship between the scores of the three batteries

The three scores were significantly correlated with one another ($r > 0.69$, $P < 10^{-6}$ for the three paired comparisons), but their concordance was moderate: ICC at 0.734 [0.579–0.837] between CASP and MMSE, 0.590 [0.404–0.728] between CASP and MoCA, and 0.579 [0.423–0.701] between MMSE and MoCA.

3.4. Information yielded by the line bisection test (CASP6)

The PCA was conducted with the neurovisual items of the three batteries. Two main factors represented more than 79% of the information. The first factor (57% of the information) was mainly correlated with the CASP3 ($r = 0.82$), MMSE6 ($r = 0.79$) and MoCA1 ($r = 0.87$). The second factor (22% of the information) was mostly correlated to the CASP6 ($r = 0.84$). The circle of correlations can appreciate the statistical distance between these four items (Fig. 1). The PCA correlation table yielded values between 0.51 and 0.60 for correlations between the CASP3, MMSE6 and MoCA1. Correlation coefficients between these three items and the CASP6 were lower, ranging between 0.15 and 0.38.

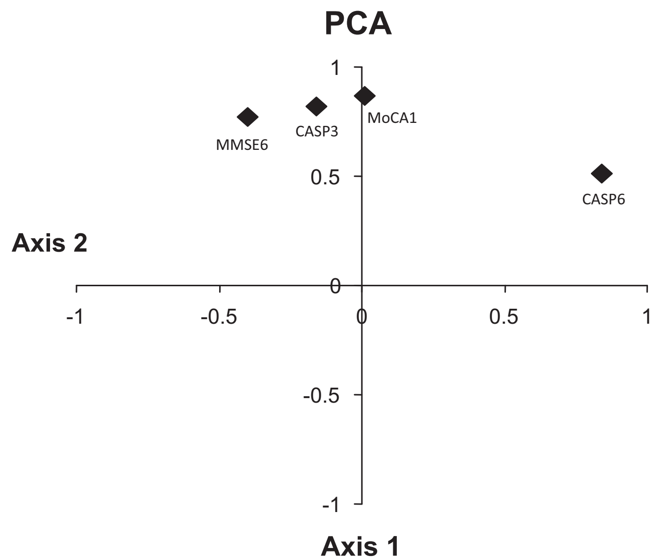


Fig. 1. Principal component analysis (PCA) run with neurovisual items of the three batteries. The first principal component (Axis 1) is strongly correlated with items CASP3, MMSE6 and MoCA1. The second component (Axis 2) is strongly correlated with item CASP6 (line bisection test).

4. Discussion

The CASP was designed for evaluating post-stroke cognitive impairments at the patient's bedside. In a previous work, we reported that: (1) its administration was better suited to patients with severe oral expression disorders and moderate comprehension disorders than the MMSE and MoCA and (2) its total score (outside of language items) was 50% less influenced by aphasia severity than those of the MMSE and MoCA [4]. The present work focused on a population of non-aphasic patients, 75% of them had a right-hemisphere stroke. The CASP could be administered in its entirety to all patients, including those with spatial neglect, screened via a line bisection test. The only administration failures concerned the MoCA item that explored both executive and neurovisual functions.

Mean administration time for CASP was 10 minutes, an intermediate time between those of the MMSE and MoCA, thus compatible with a quick assessment of cognitive disorders. It was not statistically correlated to time since stroke (even if the Pearson's "*r*" coefficients were, in all logic, negative). Furthermore, time since stroke did not influence battery scores (even if the Pearson's "*r*" coefficients were, in all logic, positive). These results do not imply that all three batteries are not responsive enough to clinical changes. They simply showed that there was a wide diversity in the severity of cognitive impairments for our patients. A study on the responsiveness to change of these three batteries is planned in the very near future on a new cohort of patients who will be examined twice during the first trimester post-stroke.

We had expected that patients with major neurovisual disorders would be disturbed by the purely visual aspect of the items of the CASP, exploring other impairments. This was probably the case for at least one of our patients, for the image naming items CASP1 (he still obtained a score of 2 points out of 3 for this item). Furthermore, we observed that the presence of neurovisual disorders had a similar impact on the total score of the three batteries. However, it had a significantly greater impact on the administration time of the CASP and MMSE than the MoCA. This last result was expected for the CASP, but not for the MMSE which only includes one visual item (MMSE6: reproduction of drawings). Finally, we can consider that the visual aspect of the CASP only had an anecdotal influence on its administration and score, as we previously demonstrated in left-hemispheric aphasic stroke patients. We did not initially expect the following element when we elaborated the CASP, but the examiner could, when relevant for certain patients, adapt some visual test of the CASP by replacing images by words ("memory" test) or interview patients verbally rather than propose multiple-choice written answers ("calendar" item).

In the present study, similarly to the previous one, the three scores were highly correlated with one another. This result was expected a priori as previously shown by Aggarwal for the MMSE and MoCA in a rehabilitation setting [1]. In his study, Aggarwal only calculated Pearson's "*r*" coefficient (null hypothesis "H0: no relationship between both scores"), even though no indication was given on the real concordance between both scores. In this study the concordance was moderate. This result was predictable because of the structural differences between the three batteries. For example, the MMSE gives more importance to the "orientation" item (10 points/30 = 1/3) than the CASP (6 points/36 = 1/6) and MoCA (6 points/30 = 1/5). Conversely, the only neurovisual item of the MMSE (reproduction of a drawing) has much less impact on the total score (1 point/30) than neurovisual items from the CASP (6 points/36) and MoCA (5 points/30). Furthermore, gestural praxis and unilateral spatial neglect are only tested in the CASP battery. Thus, it is natural for the concordance to be poor between these three batteries since they do not evaluate exactly the same impairments and do not give the same importance to the different functions.

Furthermore, like in any other clinical scale assessing different impairments, computing the sub-scores into one unique score is quite limiting by nature. For this reason, and contrarily to choices made by the authors of the MMSE and MoCA, we gave the same importance of 6 points/36 to the six functions evaluated and suggested that clinicians use the "profile" form of the score ("5/4/6/3/1/4"), in addition to the total score.

Unilateral spatial neglect is a relatively common impairment post-stroke, especially after right-hemispheric damage. Even if it can disrupt the completion of the neurovisual items of the MMSE and MoCA, it is not specifically evaluated. We included in the CASP a line bisection test, previously validated for assessing spatial neglect [2]. Our results suggest that the bisection item yields specific information, insufficiently taken into account by the other neurovisual items of the three batteries. This validates our choice of having included an item specifically evaluating spatial neglect within the CASP.

Even if the structure of the CASP seems better suited than those of the MMSE and MoCA in post-stroke patients (especially in aphasic patients), it is not possible today to confirm its superiority in terms of screening for cognitive disorders. In order to do so we would have to complete our study by the concomitant administration of these three tests along with a gold standard test in a new group of patients.

5. Conclusion

In daily clinical practice, just like in clinical research, evaluating cognitive disorders post-stroke is quite complex. The CASP was designed for non-expert examiners to evaluate at "the patient's bedside", six cognitive functions commonly impaired post-stroke. We reported in a previous study that its aspect, almost essentially consisting of visual items, was well adapted to aphasic patients (predominant motor aphasia). Elaborating a battery of cognitive evaluation tests to be used in these patients was in fact our first motivation, knowing that aphasia is a very common impairment post-stroke [9]. The present study shows that the administration of the test is rarely impossible in patients with severe neurovisual disorders. Thus, the format of the CASP seems globally better suited than the MMSE or MoCA in stroke patients. Its psychometric properties remain to be studied, a national PHRC (Hospital Project of Clinical Research) is ongoing. This PHRC includes an analysis of the validity, reliability and responsiveness to change for the CASP, the setting of standards by age range and the comparison to the MMSE and MoCa in terms of screening for cognitive disorders. Furthermore, systematic data collection on the location of brain damage will enable histoclinical correlation studies.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

Funding: The CASP validation protocol was financed by the French national 2012 PHRC.

Appendix 1

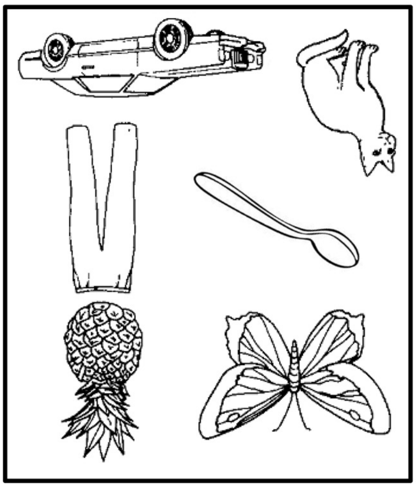
Cognitive Assessment for Stroke Patients (CASP)

Last name :

First name :

Date :

1) NAMING-- / 3



"I will show you images. You must name what you see". Show the image *"what is it?"* Add *"you must remember what you see".*

Note the answers:

Score: ½ point by correct answer

2) COMPREHENSION-- / 3

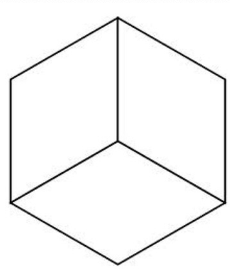
Place a pen, phone and sheet of paper in front of the patient on a table and arranged them in a vertical column. Ask the patient:

a. *Touch the pen*
b. *Show me your nose*
c. *Place the pen next to the phone*
d. *Show me your knees*
e. *Put the phone on the sheet of paper, don't touch the pen*
f. *Show me your stomach*

OK

Score: ½ point for each correctly performed task

3) REPRODUCING A COPY OF A CUBE-- / 4



"Here is a drawing" (show the cube). *"You must draw an identical cube next to it"*

Score: 4 points if the three sides are reproduced and the angles are kept. 1 point only per reproduced side if the angles are not respected. 0 points if not.

4) GRAPHIC SERIES-- / 2

∇ X ∇ X ∇ X

O X O X O X

"Here is the beginning of a suite". Show the suites. *"You must continue this suite until the end of the page".*

Score 1 point per correctly executed suite (10 correct alternations), if not score 0.

Appendix 1 (*Continued*)

5) INHIBITION / FLEXIBILITY-- / 4

"When I pound once on the table with my fist, you answer by pounding twice. When I pound twice, you pound once". Ensure that the patient has understood by giving him/her an example of each condition. Then complete the series: 1-1-2-1-2-2-1-1-1-2. **Take out 1 point per mistake, on the basis of 2 points**

"Now when I pound once, you will answer by pounding once as well. When I pound twice, you will not do anything". Again, make sure the patient has understood by making an example. Then complete the series: 1-1-2-1-2-2-1-1-1-2. **Take out 1 point per mistake, on the basis of 2 points**

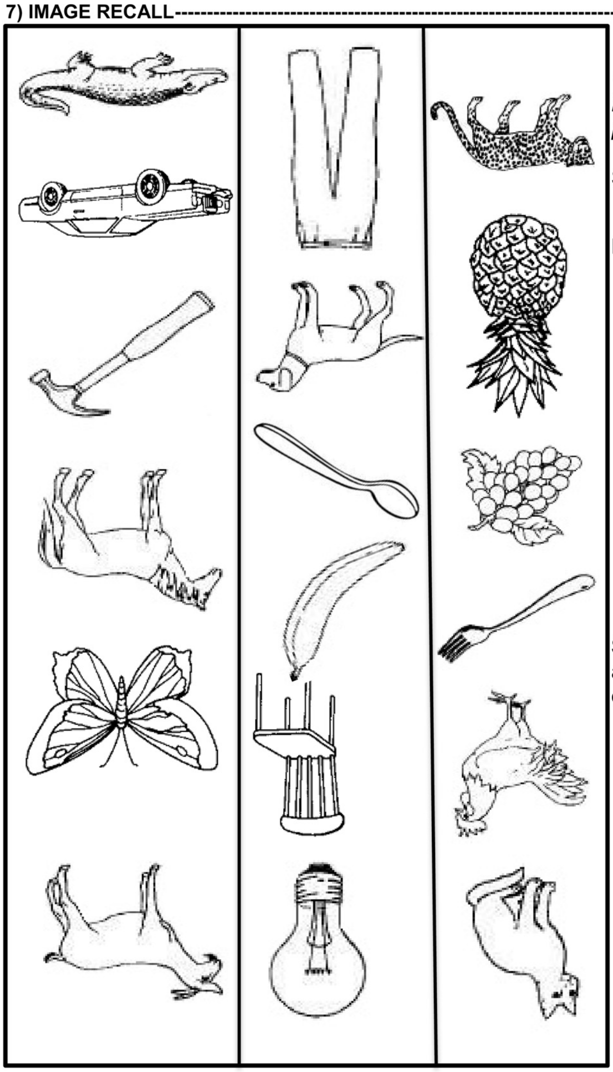
6) BISSECTION OF A HORIZONTAL LINE-- / 2

The line on the right side of this page: we hide the rest of the page with a white sheet *"Please indicate by a mark the middle of the line".*

Le center of the line and the deviation by ±6.5mm are indicated on the right side of page 1

Score: 2 points if the task is completed (norms on page 1)

7) IMAGE RECALL-- / 6



"Earlier on, I showed you 6 images, can you find them and point them to me?"

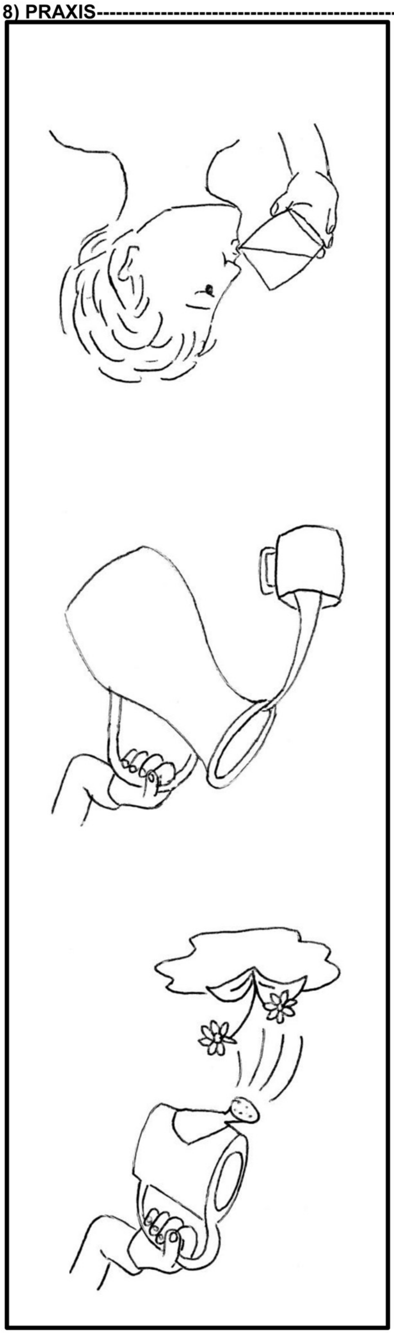
Show the 3 columns of 6 images.

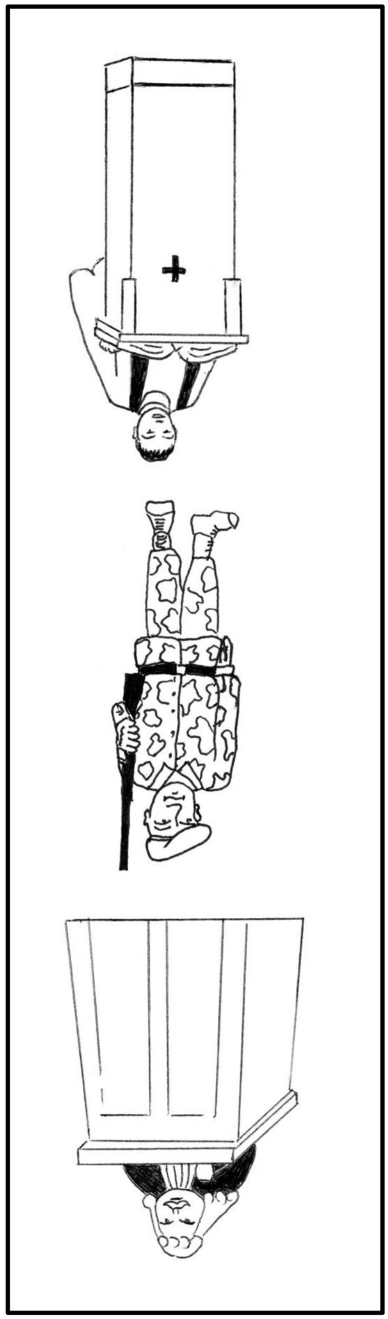
Note down the answers:

Score 1 point for each good answer. Take out 1 point for each false recall recognition.

Appendix 1 (*Continued*)

8) PRAXIS -- / 6





a. *"Do like me".* Hand on the table, make a horn with the 2nd (index) and 5th (little) fingers extended, the others flex.
b. *"Do like me".* Make a pinch with the thumb and middle finger.
c. *"Make the gesture of blowing a kiss".*
d. *"Make the gesture to say "shhh"".*
e. The examiner makes a military salute and asks the patient to associate this gesture to one of the three drawings (1st column).
f. The examiner makes the gesture of drinking a glass of water (without a glass) and asks the patient to associate this gesture to one of the three drawings on the 2nd column.

Score: 1 point for each successfully completed test

Appendix 1 (*Continued*)

9) CALENDRIER-- / 6

SUNDAY	31		2017
	30		2016
SATURDAY	29		2015
	28		2014
FRIDAY	27		2013
	26		2012
THURSDAY	25		2011
	24	DECEMBER	2010
WEDNESDAY	23		2009
	22	NOVEMBER	2008
TUESDAY	21		2007
	20	OCTOBER	2006
MONDAY	19		2005
	18	SEPTEMBER	2004
	17		2003
	16	AUGUST	2002
	15		2001
	14	JULY	2000
	13		1999
	12	JUNE	1998
	11		1997
	10	MAY	1996
	9		1995
	8	APRIL	1994
	7		1993
	6	MARCH	1992
	5		1990
	4	FEBRUARY	1917
	3		1916
	2	JANUARY	1915
	1		1914

"Can you tell me what day it is today, complete with month and year? You can use this calendar."

Score 1 point for the day of the week (e.g. Wednesday), 1 point for today's date (the 9^{th}), 2 points for the month, 2 points for the year.

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