SHORT REPORT

A diagnostic test of unawareness of bilateral motor task abilities in anosognosia for hemiplegia

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Anosognosia for hemiplegia (AHP) is conventionally defined/diagnosed by generic questions about awareness of limb plegia. However, unawareness of inability to perform tasks requiring bilateral use of limbs is more widespread and outlasts generic unawareness of plegia. Some patients consistently overestimate bilateral task ability. Our aim was to assess how well specific questions about bilateral task ability predict whether patients consistently overestimate their abilities. Six statistical indices were calculated to rank the questions for predictiveness of consistency of overestimation of bilateral task ability. Overall, bimanual questions are better predictors than bipedal questions of consistent overestimation. Three bimanual and two bipedal questions had both sensitivity and specificity above 80%. On the basis of accuracy and discriminability, one bimanual and one bipedal question that performed maximally could be used for a quick bedside heuristic index. For a more thorough diagnostic, especially for research, five bimanual and two bipedal questions were good predictors, and should be used. For both purposes, such tests should be given in combination with conventional generic questions assessing awareness of limb plegia, since the two kinds of question reflect different kinds of unawareness of motor incapacity.

The aim of this paper is to report predictiveness statistics on a test of unawareness of motor task abilities in anosognosia for hemiplegia (AHP). Anosognosia refers to unawareness or denial of a deficit following brain damage^{1,2} and is the greatest impediment to rehabilitation.³ However, despite a century of research, AHP remains poorly understood.^{4,5} One basic problem lies in the diagnostic classification itself of patients. Almost all classification, indeed the standard criterion, has been based on conversational content or responses to questions,^{6,7} or, at best, formalisation of this in a structured interview.⁸

However, we have found⁴ that many patients who on these criteria are aware of having a plegia or have recovered such awareness, remain unaware of its consequences or entailments. That is, quite apart from any tendency to attempt impossible tasks, such patients are unaware on questioning of their inability to execute tasks that are bilateral and require use of the plegic limb(s). This latter unawareness can outlast the former unawareness by a significant period. We used a set of questions involving estimation of ability to carry out unimanual, bimanual, and bipedal tasks (see Appendix B in Marcel *et al.*⁴). The purpose of the present analysis was to assess performance of the bilateral questions so that they can be used as a concise but predictive test for awareness of lack of abilities that can be adapted to either quick bedside diagnosis or as a research tool. Specifically, our aim was to

calculate how well each question predicts whether a patient consistently overestimates their bilateral task abilities.

PARTICIPANTS

The original study was carried out on 42 right brain damaged (RBD) and 22 left brain damaged (LBD) stroke patients. For exclusion criteria, including aphasia, and for discussion of this issue, see Marcel *et al.*⁴ At the time of testing all had severe weakness of the arm, 35 RBD and 16 LBD patients had severe weakness of the leg, and the rest had moderate weakness in the leg. Interview questions about their present condition ("Why are you in hospital?", "Can you move your arms/legs?", etc) were adapted from Anderson and Tranel⁹ (see Appendix A in Marcel *et al.*⁴). Only five RBD patients were unaware of why they were in hospital and that they had a hemiplegia. When specifically asked about motor function in arms and legs, 11/42 RBD and 2/22 LBD patients were unaware of a motor deficit.

BILATERAL TASK QUESTIONS AND ORIGINAL PERFORMANCE

The tasks enquired of regarding current bilateral task abilities are listed in table 1. The present analysis was conducted on questions of the form: "In your present state how well, compared with your normal ability, can you tie a knot?, If you can do it as well as usual, say 'ten'.", "If you cannot do it at all, say 'nought'.". An estimate of 5 or more was counted as overestimation on that question. Some patients consistently overestimated their abilities. Individuals were classified as consistent bimanual overestimators if they overestimated five or more of these eight tasks, and consistent bipedal overestimators if they overestimated three or more of these four tasks. Table 1 shows the numbers of LBD and RBD patients who were and were not anosognosic on conventional criteria and who overestimated no bimanual tasks, up to four, and five or more. There was a small double dissociation in that a few patients unaware on conventional questions were not consistent overestimators.

Hardly any LBD patients overestimated their task abilities, except on three tasks that they had plausibly encountered in occupational therapy (see table 5 in Marcel *et al.*⁴). Only one was a consistent overestimator on bimanual tasks and none were consistent overestimators on bipedal tasks. Of the RBD patients, the percentage overestimating each task ranged between 17% and 81%. Twenty two were consistent overestimators on bimanual tasks and five of these were consistent overestimators on bipedal tasks. What makes task ability estimates of particular interest is the fact that 22 patients consistently overestimated their ability on bimanual tasks, while only five of them were unaware of their hemiplegia and only 11 of them were unaware of a motor deficit when specifically asked about the relevant limb. The

Abbreviations: AHP, anosognosia for hemiplegia; LBD, left brain damaged; RBD, right brain damaged

Table 1 Number of bimanual tasks overestimated by LBD and RBD patients who were anosognosic or not on conventional criteria

	Unawareness of hemiplegia	Number of bimanual tasks overestimated		
		0	1–4	5–8 (consistent overestimators)
LBD	Unaware	0	2	0
	Aware	4	15	1
RBD	Unaware	1	2	10
	Aware	4	13	12

Unawareness of hemiplegia: unawareness on either (a) "Why are you in hospital?/What is wrong with you?", or (b) "Do you have any problems moving/any weakness in your arms/legs? (This one? That one?)".

responses of the RBD patients constitute the data of the present analysis. This was performed to reveal how well, on various criteria, each of the eight bimanual and four bipedal tasks enquired of predict consistent overestimation.

DESIGN AND METHOD

The focus of interest is in the relationship between (a) a binary classification O (that is, is a person a consistent overestimator (O+) or not (O−) of bilateral task ability) that summarises performance across a range of questions, and (b) each question Q (for example, estimation of current ability to tie a knot) that indicates awareness of ability on one of the constituent tasks. The aim was to assess the extent to which overestimation (Q+) or non-overestimation (Q−) on Q can be used as a predictor for the presence (O+) or absence (O−) of O.

There are a variety of indices which quantify the ability of a binary question Q to indicate a binary state O. The multiplicity of these indices reflects the fact that "there is no one simple index which enables us to compare different tests in all the ways we would like".⁹ This paper uses six indices (see table 2) in combination to rank the predictive-ness of the questions. The criterion used was to select questions for which sensitivity and specificity are both

greater than 80%, and then to rank these by predictive accuracy (or equivalently by discriminability).^{9, 10}

RESULTS AND DISCUSSION

Table 2 shows the results of the analysis. They are best summarised in terms of two ways in which they can be used. First, as a bedside heuristic, one needs one or two indicative questions. Of the bimanual questions, five ("clap", "shuffle", "catch", "wash", "cut") performed with sensitivity and specificity below 80%. Of the remaining three, the best in terms of predictive accuracy and discriminability is "row a boat", followed by "tie a knot" and "unscrew a bottle". On this basis the "row" question could be used alone or in conjunction with "tie" and/or "unscrew". Of the bipedal questions, "jump" is consistently maximal for all indices, followed by "climb". On this basis the "jump" question could be used alone or with "climb".

Second, for research or to classify consistent overestimators, one needs a criterial set of questions. Three bimanual questions ("catch", "wash", "cut") are poor predictors in terms of predictive accuracy and discriminability, while the remaining five ("tie", "row", "unscrew", "clap", "shuffle") are good predictors (predictive accuracy greater than 80%). By the same criterion, two bipedal questions ("jump", "climb") are good predictors and the other two are rather poor. In our original paper our criterion for consistent overestimation was overestimation on 5/8 bimanual questions and on 3/4 bipedal questions. If in total five bimanual and two bipedal questions are used, what classifying criteria are appropriate? Since the five bimanual questions are all good predictors, they could be used in order of weighting according to their predictability with a criterion (of consistent overestimation) of 4/5. Since only two bipedal questions are relatively good predictors, we conclude that overestimation on both should be criterial for consistent bipedal overestimation.

Of the questions used, bipedal questions are worse predictors of consistent overestimation than bimanual questions. This has both diagnostic and practical importance: overestimation of bipedal ability can cause more severe

Table 2 Statistical indices of predictiveness of overestimation of current ability on a set of bimanual and bipedal tasks for consistent bimanual and bipedal overestimation

	Tasks	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)	Discriminability (d')
Consistent bimanual overestimation (prevalence 52.4%) as predicted by:	Tie a knot?	95.5	85.0	87.5	94.4	90.5	2.49
	Clap hands?	77.3	90.0	89.5	78.3	83.3	1.89
	Shuffle cards?	66.7	100	100	73.1	82.5	2.42
	Row a boat?	95.0	95.0	95.0	95.0	95.0	2.93
	Catch a ball?	100	40.0	64.7	100	71.4	1.96
	Wash hands?	100	55.0	71.0	100	78.6	2.27
	Unscrew bottle?	81.8	90.0	90.0	81.8	85.7	2.04
	Cut bread?	90.9	60.0	71.4	85.7	76.2	1.51
Consistent bipedal overestimation (prevalence 11.9%) as predicted by:	Ride a bicycle?	60.0	70.3	21.4	92.9	69.0	0.64
	Climb a ladder?	80.0	89.2	50.0	97.1	88.1	1.72
	Jump?	80.0	91.9	57.1	97.1	90.5	1.89
	Walk?	80.0	70.3	26.7	96.3	71.4	1.03

Sensitivity (of Q to O): the proportion of consistent overestimators (O+) who overestimate task Q, that is, $P(Q+|O+)$. Another name for this is the hit rate or true positive rate.

Specificity (of Q for O): the proportion of patients that are not consistent overestimators who do not overestimate on Q, $P(Q-|O-)$. It is equal to 1 minus the false alarm rate of Q, that is, $P(Q+|O-)$. Another name for specificity is the true negative rate.

PPV: the positive predictive value of Q for O. This is the proportion of patients that overestimate task Q who would be correctly identified as O+ on the basis of observing Q+, that is, $P(O+|Q+)$.

NPV: the negative predictive value of Q for O. This is the proportion of patients that do not overestimate task Q who are not consistent overestimators, that is, $P(O-|Q-)$.

Accuracy: the predictive accuracy of Q for O. This is the proportion of patients for which the outcome of Q matches the state of O, that is, the proportion that are correctly classified by Q with respect to O.

Discriminability: D-prime (d'), the classical signal detection theory index of detectability. It estimates how far the O− and O+ patients are separated on the basis of Q− and Q+.

Prevalence: the proportion of patients who are consistent overestimators, that is, $P(O+)$.

accidents. The disparity in predictability may be due partly to the fewer bipedal questions and therefore a less reliable criterion. It may also be due to the relation between plegia and unawareness of it.

In summary, a bedside test should include both (a) conventional generic questions (for example, "What is wrong with you?", "Can you move both your arms/legs normally?"; see Anderson and Tranel⁸ and our adaptation⁴), and (b) one bimanual task question ("How well could you row a boat in your present condition compared to normal?") and one bipedal task question ("How well could you jump ... ?"). For research purposes and a more thorough index, we recommend adding to the conventional generic questions the five bimanual and two bipedal questions specified above. While the generic questions do diagnose AHP, the latter kind of question reveals a further kind of unawareness of motor incapacity (as implied by the double dissociation shown in table 1) and is more relevant to management and rehabilitation.

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