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Letter to the editor

Validation of the simplified evaluation of consciousness disorders (SECONDs) scale in Mandarin

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Dear editor—The pathogenesis of severe brain injury is complex, and in the past 50 years advances in medical technology have increased the number of people who have survived severe brain injury. After the acute stage of cerebral injury, some people fully recover from coma, while others develop a disorder of consciousness (DoC), such as unresponsive wakefulness syndrome (UWS) or a minimally conscious state (MCS). People with UWS are awake, but unaware; without any reproducible sign of consciousness, they only exhibit reflex behaviors [1]. People in a MCS are both awake and aware; they present reproducible and purposeful behaviors [2]. MCS can be further divided, based on the presence of language-related behaviors: MCS+ and MCS-. People in a MCS+ do have language-related signs of consciousness: they can follow commands, make intelligible verbalizations and/or non-functional communication. Those in a MCS- only have language-unrelated signs of consciousness, such as visual pursuit, localization of noxious stimuli or contingent behavior like smiling or crying at appropriate stimuli [3]. When people recover functional communication and/or use of objects, they are said to have emerged from the minimally conscious state (EMCS) [2].

An accurate DoC diagnosis is crucial because it can influence treatment and, potentially, end-of-life decisions [4]. Several scales exist to evaluate a person's level of consciousness, including the Coma Recovery Scale-Revised (CRS-R) [5], the Sensory Modality Assessment and Rehabilitation Technique (SMART) [6], and the Wessex Head Injury Matrix (WHIM) [7]. Although the CRS-R is highly recommended and is the most sensitive scale for diagnosing patients compared to other scales [8], it is time-demanding (median time of 17 min) and assessors require a longer training as there are 23 items to administer [9]. In addition, due to high fluctuations in the levels of consciousness of individuals with DoC, recent guidelines emphasize the importance of repeated evaluations [10,11] which, consequently, further increases the time clinicians need to perform accurate assessments of individuals with DoC.

Recently, the Simplified Evaluation of CONsciousness Disorders (SECONDs) [12,13] was proposed as a new scale based on the most frequent items of the CRS-R that denote MCS [14]. The SECONDs is faster to administer (median time of 7 min) and easy-to-use. It could thus greatly benefit the care of people with DoC in clinical settings, such as intensive care units, and reduce the risk of misdiagnosis. It includes 8 items (6 mandatory and 2 conditional), inspired by the most frequently observed signs of consciousness among those with DoC when using the CRS-R.

The SECONDs has been validated in French [13] and we here present validation of the SECONDs in Mandarin [15]. This study assessed the concurrent validity, intra-rater reliability, and inter-rater reliability of the Mandarin version of the SECONDs [15]. The aim is to promote accurate assessment of those with DoC, and the development of clinical research on this subject in China.

We first translated the French version of the SECONDs with the permission and assistance of the original authors [13]. Then we recruited individuals at the Department of Consciousness Disorders in Shanghai Yongci Rehabilitation Hospital (Shanghai, China) from December 2021 to November 2022. The inclusion criteria were: 1) prolonged DoC (>28 days) following severe acquired brain injury; 2) aged 18–85 years old; 3) no history of other neurological or psychiatric deficits; 4) able to speak Mandarin fluently; and 5) medically stable (eg, an absence of mechanical ventilation, sedation or infection).

The ethics committee of the Shanghai Yongci Rehabilitation Hospital and the Hangzhou Normal University both approved this investigation. Written, informed consent was signed by a legal representative for each participant. The study was registered with the ClinicalTrials.gov (NCT05496985).

Three assessors (A, B and C) who were trained to use the CRS-R and experienced in its use assessed participants. Assessments were completed within 2 weeks: 5 CRS-R to obtain a reliable diagnosis [16] and 7 SECONDs, all performed by the 3 different assessors. There were 5 sessions in total: Session 1 included 1 CRS-R performed by only 1 assessor (to measure concurrent validity) and 3 SECONDs evaluations performed by both assessors A and C (to measure intra-rater reliability and inter-rater reliability). The other sessions, from 2 to 5, each included 1 SECONDs evaluation and 1 CRS-R evaluation (to measure concurrent validity) and were performed by assessors A and B.

Each SECONDs was performed alternatively either before or after the CRS-R assessment. To avoid fatigue, participants had a break of 30–80 mins between each assessment. During the protocol, all 3 assessors were blinded to the result scores of the other assessors. See Fig. 1.

Initially, 49 people with a DoC were enrolled, but 2 dropped out due to complications that required their transfer to another hospital. Thus, 47 participants with a prolonged DoC completed the study: the mean (SD) age was 52 (15) years and 10 were female. The DoC etiology was traumatic brain injury for 13 participants, hemorrhagic stroke for 18, and an anoxic brain injury for 16. The median time

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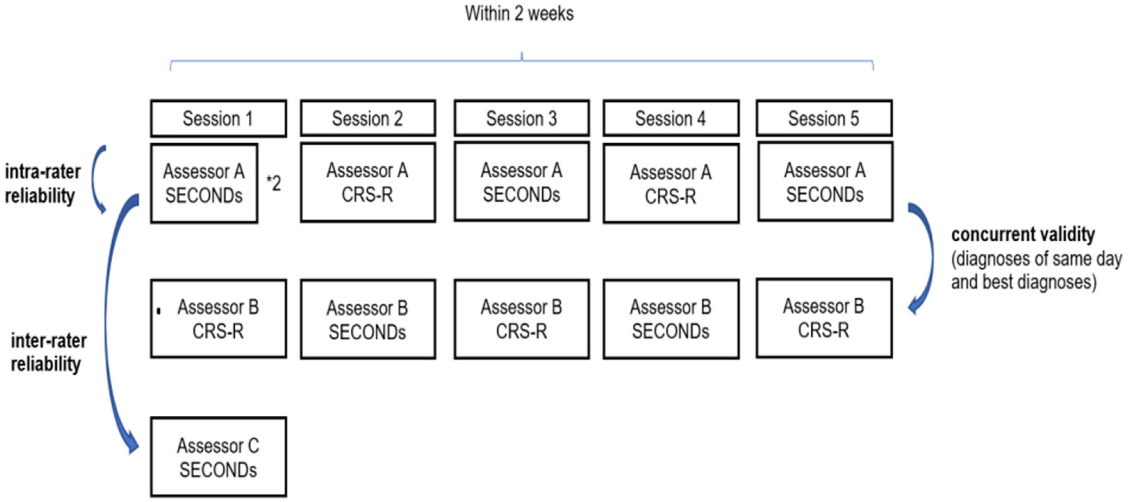

Fig. 1. Procedure for validation of the Simplified Evaluation of CONsciousness Disorders (SECONDs) scale in Mandarin. For each participant, a SECONDs was performed either before or after a Coma Recovery Scale-Revised (CRS-R) assessment and this order was randomized in 5 sessions, 1-day sessions performed over 2 weeks. There were 3 assessors (A, B and C) who evaluated participants during the trials.

since brain injury was 8 months (IQR 3–13). All participant data and descriptive statistics are shown in Table 1.

Weighted Cohen's Kappa was used to calculate the degree of diagnostic agreement, using a predefined table of weights that measured the degree of disagreement between two assessors or raters, with a higher weight indicating greater disagreement [17]. Weighted Cohen's Kappa was also used for 3 measures: 1) concurrent validity between same-day CRS-R and SECONDs diagnoses, and between the best SECONDs (best of all 7) and best CRS-R diagnoses; 2) intra-rater reliability between the 2 assessments made by assessor A during Session 1; and 3) inter-rater reliability between the assessments of assessors A and C during Session 1. We also investigated concurrent validity using Spearman correlations.

The concurrent validity between diagnoses made with the CRS-R and the SECONDs on the same day was substantial, both for MCS- and MCS+ together (mean K = 0.62; r_s =0.74; p< 0.001), and when considering a single MCS category alone (K = 0.61; r_s =0.67; p<0.001). The concurrent validity between the best CRS-R and the best SECONDs diagnosis (from all 7 iterations) was also substantial for both MCS- and MCS+ together (K = 0.69; r_s =0.86; p<0.001) and for a single MCS category (K = 0.72; r_s =0.84; p<0.001). See Fig. 2.

When considering MCS- and MCS+ as separate categories, Assessor A's first assessment results in session 1 were: 2 Coma; 25 UWS; 9 MCS-; 10 MCS+; and 1 EMCS. The results of Assessor A's second assessment in session 1 were: 2 Coma; 22 UWS; 13 MCS-; 9 MCS+; and 1 EMCS. The weighted kappa of 2 SECONDs assessments by this same assessor was 0.91 (p<0.001). When considering a single MCS category, the weighted kappa of 2 SECONDs assessments by the same assessor was 0.90 (p<0.001). This demonstrates an almost perfect intra-rater reliability when the same evaluator rated the same participant at different times of the same day.

Inter-rater reliability for the SECONDs was also substantial when considering MCS- and MCS+ separately (K = 0.76, p<0.001) or considering a single MCS category (K = 0.76, p<0.001). This indicates that the SECONDs could reliably assess the same participant when performed by multiple assessors. See the Supplementary Material for more information.

The concurrent validity was substantial too; the CRS-R is an internationally recognized bedside behavior assessment scale for DoC, while the SECONDs is a recently developed assessment. The 2 scales were compared and evaluated over 2 weeks and differences were observed in resultant diagnoses. Mismatches observed between same-day assessments were probably linked to the 'slower' ability of the CRS-R to identify the correct diagnosis on the first assessment, since subsequent CRS-R diagnoses did match the first SECONDs outcomes, indicating that the SECONDs provides an accurate diagnosis after fewer assessments in comparison to the CRS-R.

Intra-rater reliability was almost perfect, suggesting that the results from the same evaluator were reliable. We found a reduced number of UWS diagnoses and an increased number of MCS- diagnoses in the second assessments of assessor A in session 1, which indicates that repeating SECONDs assessments enhanced the rate of MCS- detection. This finding is in line with earlier research that also recommends repeating assessments [16].

Furthermore, inter-rater reliability was also substantial, indicating that the accuracy of the diagnosis could be detected even when the person was assessed by multiple evaluators. When we considered the 5 categories, due to the fluctuation in participants' state of consciousness, degree of cooperation between participants and assessors, and the difference in choice of available commands by different evaluators, we found variations in participants' diagnoses between MCS- and MCS+.

The SECONDs features only 1 of the 2 items that diagnoses EMCS in the CRS-R: "functional communication". Significantly, some authors have highlighted that the criteria of EMCS constitutes an upper boundary to DoC that must be set arbitrarily. Since "functional use of objects" depends highly on motor function and potentially requires lower attentional resources than communication, its relevance as an emergence criterion was previously questioned [18]. Future research on the SECONDs may include this item if there is sufficient evidence.

Overall, the changes in participants' diagnoses following repeated evaluations with SECONDs and CRS-R over 5 days showed that the SECONDs had an excellent detection rate for diagnosing MCS, particularly MCS+. We believe that this is mostly due to the inclusion of the item "pain anticipation", which exploits the human body's capacity for self-protection [19].

Future studies should replicate these results on larger sample sizes, which would allow subgroup analyses and better understanding of the SECONDs scale properties. In particular, all participants had a prolonged DoC (>28 days), so subsequent studies should validate this scale among participants in the acute phase.

Table 1
Individual demographic and diagnosis data for 47 people with a disorder of consciousness (DoC).

Participant ID	Age (years)	Sex	DoC Etiology	Time since injury (months)	Best CRS-R diagnosis	Best SECONDs diagnosis
1	51	F	TBI	12	MCS-[3]	MCS-[1]
2	75	F	hemorrhagic stroke	8	MCS-[2]	UWS[1]
3	47	F	anoxia	12	MCS+[2]	MCS+[1]
4	60	F	hemorrhagic stroke	2	UWS[1]	UWS[1]
5	71	M	anoxia	26	UWS[1]	UWS[1]
6	69	M	hemorrhagic stroke	4	MCS-[1]	MCS-[1]
7	25	M	TBI	13	EMCS[1]	MCS+[1]
8	39	M	anoxia	1	UWS[1]	UWS[1]
9	65	M	TBI	21	UWS[1]	UWS[1]
10	75	M	anoxia	>24	MCS-[1]	MCS-[1]
11	36	M	hemorrhagic stroke	15	UWS[1]	UWS[1]
12	41	F	anoxia	16	UWS[1]	UWS[1]
13	37	M	hemorrhagic stroke	10	UWS[1]	UWS[1]
14	81	M	anoxia	16	MCS-[4]	UWS[1]
15	44	M	anoxia	36	MCS-[1]	MCS-[1]
16	29	M	TBI	10	MCS-[2]	MCS-[1]
17	71	M	anoxia	11	MCS-[2]	MCS-[1]
18	66	M	TBI	11	MCS-[1]	MCS+[1]
19	71	M	anoxia	10	MCS-[1]	MCS+[3]
20	43	M	hemorrhagic stroke	2	Coma[1]	UWS[3]
21	71	M	TBI	10	UWS[1]	UWS[1]
22	27	F	hemorrhagic stroke	2	MCS-[3]	MCS-[1]
23	40	M	hemorrhagic stroke	25	MCS+[1]	EMCS[2]
24	43	M	hemorrhagic stroke	4	MCS-[2]	MCS-[1]
25	57	F	TBI	2	UWS[1]	UWS[1]
26	22	F	anoxia	20	MCS-[1]	MCS-[1]
27	66	M	TBI	2	MCS+[3]	MCS+[1]
28	63	F	hemorrhagic stroke	2	MCS-[1]	MCS-[1]
29	43	M	anoxia	1	UWS[1]	UWS[1]
30	66	M	anoxia	30	UWS[1]	UWS[1]
31	49	M	anoxia	8	MCS-[4]	MCS-[1]
32	52	M	hemorrhagic stroke	3	UWS[1]	UWS[1]
33	35	M	TBI	3	EMCS[2]	MCS+[1]
34	33	M	hemorrhagic stroke	4	UWS[1]	UWS[1]
35	60	M	hemorrhagic stroke	5	MCS-[1]	MCS+[1]
36	65	M	anoxia	8	MCS-[5]	UWS[1]
37	55	M	TBI	2	UWS[1]	Coma[1]
38	39	M	anoxia	11	MCS-[1]	MCS+[1]
39	51	M	hemorrhagic stroke	5	MCS-[1]	MCS+[1]
40	64	M	hemorrhagic stroke	3	MCS-[2]	MCS+[1]
41	69	F	TBI	4	MCS-[2]	MCS-[1]
42	56	M	hemorrhagic stroke	6	MCS+[5]	MCS+[1]
43	44	M	TBI	18	MCS-[1]	MCS-[1]
44	57	M	anoxia	4	UWS[1]	UWS[1]
45	63	M	TBI	1	EMCS[1]	EMCS[1]
46	51	M	hemorrhagic stroke	4	MCS-[3]	MCS-[3]
47	47	M	hemorrhagic stroke	8	MCS-[2]	MCS-[1]

Numbers in superscript indicate which assessment (of 5) provided the diagnosis.
[1] diagnosed by the first assessment.
[2] diagnosed by the second assessment.
[3] diagnosed by the third assessment.
[4] diagnosed by the fourth assessment; and.
[5] diagnosed by the fifth assessment. Eleven participants (numbers 1, 3, 16, 17, 22, 24, 27, 31, 41, 42 and 47) received their diagnosis following a SECONDs earlier than after a CRS-R assessment.MCS, minimally conscious state; EMCS: Emerged from a minimally conscious state. F, female; M, male. MCS-, Minimally Conscious State (without language-related signs of consciousness); MCS+, Minimally Conscious State (with language-related signs of consciousness); TBI, Traumatic Brain Injury; UWS, Unresponsive wakefulness syndrome; SECONDs, Simplified Evaluation of CONsciousness Disorders; CRS-R, Coma Recovery Scale-Revised.

In addition, neuroimaging and electrophysiological measures were not included in this study, so there is a risk that we included participants with covert consciousness that was not detected at the bedside [20]. Several multimodal assessments exist that could be used to examine the bedside assessment misdiagnosis rate when using the SECONDs.

In conclusion, our study demonstrates that the Mandarin version of the SECONDs has nearly perfect reliability, substantial inter-rater reliability, and substantial concurrent validity compared to the CRS-R. These results support previous research [13] which showed the SECONDs to be a reliable and valid scale to assess individuals with DoC. This Mandarin SECONDs version could be used to promote the widespread use of standardized and validated bedside diagnostic tools for people with DoC in a broad array of clinical settings throughout China, and therefore reduce misdiagnosis rates.

		Session 1 CRS-R					Best CRS-R					
		Coma	UWS	MCS-	MCS+	EMCS	Coma	UWS	MCS-	MCS+	EMCS	
Session 1 SECONDs	Coma	1	1	0	0	0	0	1	0	0	0	Best SECONDs
	UWS	0	20	2	0	0	1	14	3	0	0	
	MCS-	0	7	6	0	0	0	0	15	0	0	
	MCS+	0	0	6	2	1	0	0	6	3	2	
	EMCS	0	0	0	0	1	0	0	0	1	1	

a

		Session 1 CRS-R				Best CRS-R				
		Coma	UWS	MCS	EMCS	Coma	UWS	MCS	EMCS	
Session 1 SECONDs	Coma	1	1	0	0	0	1	0	0	Best SECONDs
	UWS	0	20	2	0	1	14	3	0	
	MCS	0	7	14	1	0	0	24	2	
	EMCS	0	0	0	1	0	0	1	1	

b

Fig. 2. Diagnostic agreement between the Simplified Evaluation of CONsciousness Disorders (SECONDs) and the Coma Recovery Scale-Revised (CRS-R) during 5, 1-day sessions performed over 2 weeks to validate the SECONDs scale in Mandarin in 47 people with disorders of consciousness (DoC). DoC diagnoses made with the SECONDs and the CRS-R during Session 1 are illustrated on the left. The best SECONDs and the best CRS-R diagnoses are illustrated on the right. Numbers in the cells indicate the number of participants with matching diagnoses following SECONDs and CRS-R. Shaded boxes indicate differential diagnoses: yellow when the SECONDs result was better than the CRS-R, and blue when the CRS-R result was better than the SECONDs. DoC diagnoses were: unresponsive wakefulness syndrome (UWS); minimally conscious state (MCS); minimally conscious state minus (MCS-); minimally conscious state plus (MCS+); and emerging from the minimally conscious state (EMCS). For more information, see the Supplementary Material.

Differences between the validation results of the Mandarin and French versions, and the limitations of this study, are in the Supplementary Material.

Data availability

The authors do not have permission to share data.

Declaration of Competing Interest

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Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.rehab.2023.101764.

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Anqi Wang[1]
Lingxiu Sun[1]
Lijuan Cheng
Nantu Hu[*]
Yan Chen
International Vegetative State and Consciousness Science Institute, Hangzhou Normal University, Hangzhou, Zhejiang 310036, China

Leandro R D Sanz
Aurore Thibaut
Olivia Gosseries
Coma Science Group, GIGA-Consciousness, GIGA Research Center, University of Liège, Liège, Belgium
Centre du Cerveau[2], University Hospital of Liège, Liège, Belgium

Steven Laureys
International Vegetative State and Consciousness Science Institute, Hangzhou Normal University, Hangzhou, Zhejiang 310036, China
Coma Science Group, GIGA-Consciousness, GIGA Research Center, University of Liège, Liège, Belgium
Centre du Cerveau[2], University Hospital of Liège, Liège, Belgium
CERVO Research Center, Laval University, Quebec, Canada

Charlotte Martial[2]
Coma Science Group, GIGA-Consciousness, GIGA Research Center, University of Liège, Liège, Belgium
Centre du Cerveau[2], University Hospital of Liège, Liège, Belgium

Haibo Di[2,*]
International Vegetative State and Consciousness Science Institute, Hangzhou Normal University, Hangzhou, Zhejiang 310036, China

*Corresponding authors.
E-mail addresses: hunt@hznu.edu.cn (N. Hu), haibodi@hznu.edu.cn (H. Di).

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[1] co-first author
[2] co-last author