DEVELOPMENT AND VALIDATION OF THE TRANSCRANIAL MAGNETIC STIMULATION REPORTING ASSESSMENT TOOL (TMS-RAT )

TMSMultiLab meeting 26 Sept 25'

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WHY DO WE NEED A REPORTING ASSESSMENT TOOL?

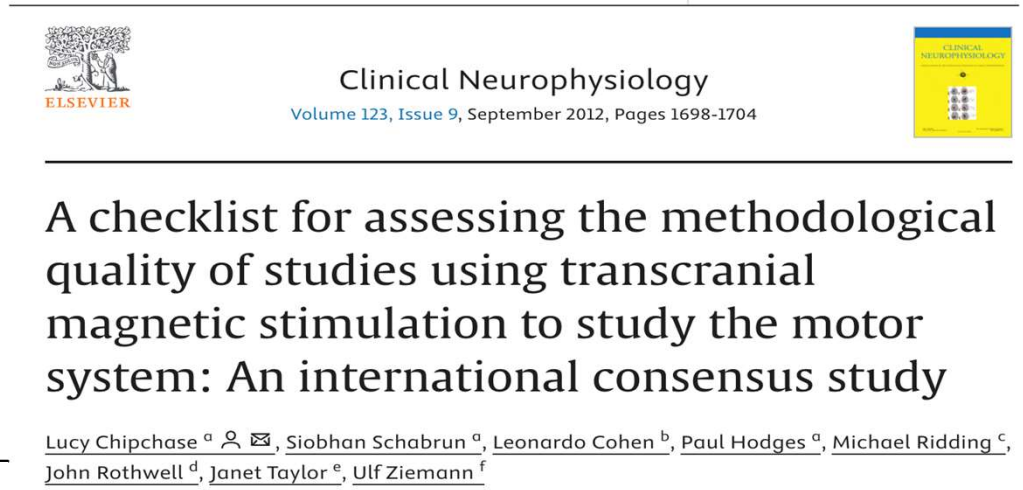
- Consistent methodologies but inconsistent reporting
- For TMS studies to be reproducible and and to be contributing to scientific progress, methods must be reported clearly
- Despite 40 years of TMS research, no standard, well-used reporting guidelines
- Existing reporting checklists for other methods/fields such as PRISMA, CONSORT, GRASS

OBJECTIVES

- Scoping review to assess current reporting standards
- Find and combine the already available checklists/item descriptions to develop and validate a new reporting tool
    - To be used both prospectively and retrospectively

CHIPCHASE ET AL. 2012

- Developed via Delphi consensus process
- Cited by 280 times and systematic reviews meta-analysis only used it 32 times
- Provided initial structure but has key limitations.



CHIPCHASE ET AL. 2012

- Motor-system-only focus
- No operational definitions

Age

'Over the age of 18'

'18-40'

'Mean age of 25 years'

List of exact age of each individual participants

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'Subject attention and arousal during testing'

AC1=0.29 , p = 0.08 (Rohel et al., 2021)

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- Controlled vs. reported

Table 4
Final checklist (N/A = Not applicable).

Were the following participant factors	Reported?	Controlled?
Age of subjects	☐	☐
Gender of subjects	☐	N/A
Handedness of subjects	☐	☐
Subjects prescribed medication	☐	☐
Use of CNS active drugs (e.g. anti-convulsants)	☐	☐
Presence of neurological/ psychiatric disorders when studying healthy subjects	☐	☐
Any medical conditions	☐	☐
History of specific repetitive motor activity	☐	☐
Were the following methodological factors		
Position and contact of EMG electrodes	☐	☐
Amount of relaxation/contraction of target muscles	☐	☐
Prior motor activity of the muscle to be tested	☐	☐
Coil type (size and geometry)	☐	☐
Coil orientation	☐	☐
Direction of induced current in the brain	☐	☐
Coil location and stability (with or without a neuronavigation system)	☐	☐
Type of stimulator used (e.g. brand)	☐	☐
Stimulation intensity	☐	☐
Pulse shape (monophasic or biphasic)	☐	☐
Determination of optimal hotspot	☐	☐
The time between MEP trials	☐	☐

Only 31% (10/32) use this

CHIPCHASE ET AL 2012

- Motor-system-only focus
- No operational definitions
- No empirical validation (usability, inter-rater reliability)
- Controlled vs reported

AIMs:

→Wider range of studies

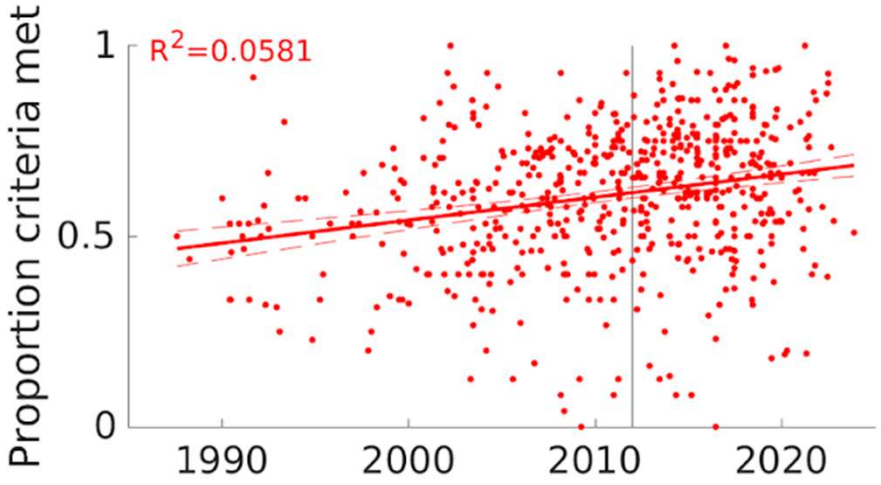
→ Examples and guidance doc with operational definitions

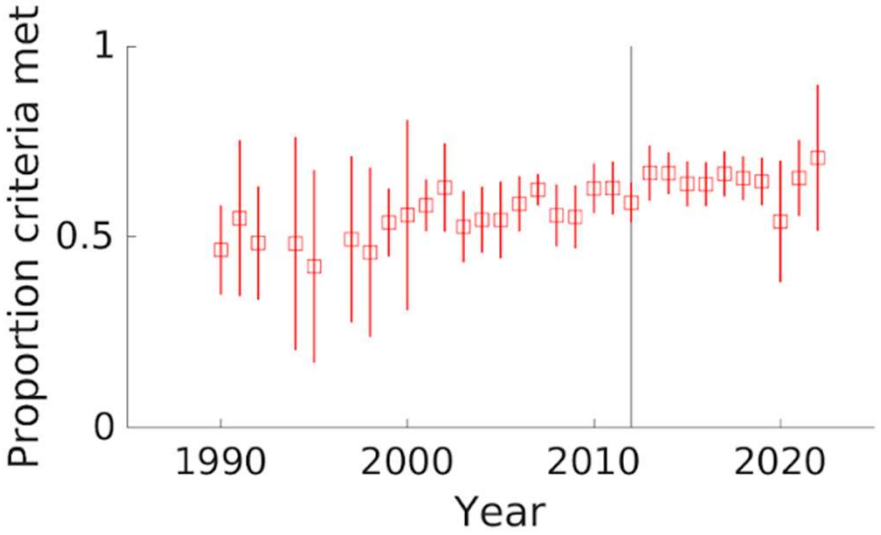
→Empirical validation, usability, inter-rater reliability, test-retest reliability

→Removal of controlled vs. reported distinction

+ introduced missing/part/full reporting

REPORTED ITEMS ACCORDING TO THE CHIPCHASE CHECKLIST





TMS-RAT V0.1

- 85 (67) items
- 30 items from the Chipchase et al. (2012) checklist (some of them broken down into separate items)
- Rest of the items: newly added, from (considered in) other studies (Rohel et al., 2021; Pellegrini et al., 2020, Gefferie et al., 2023)

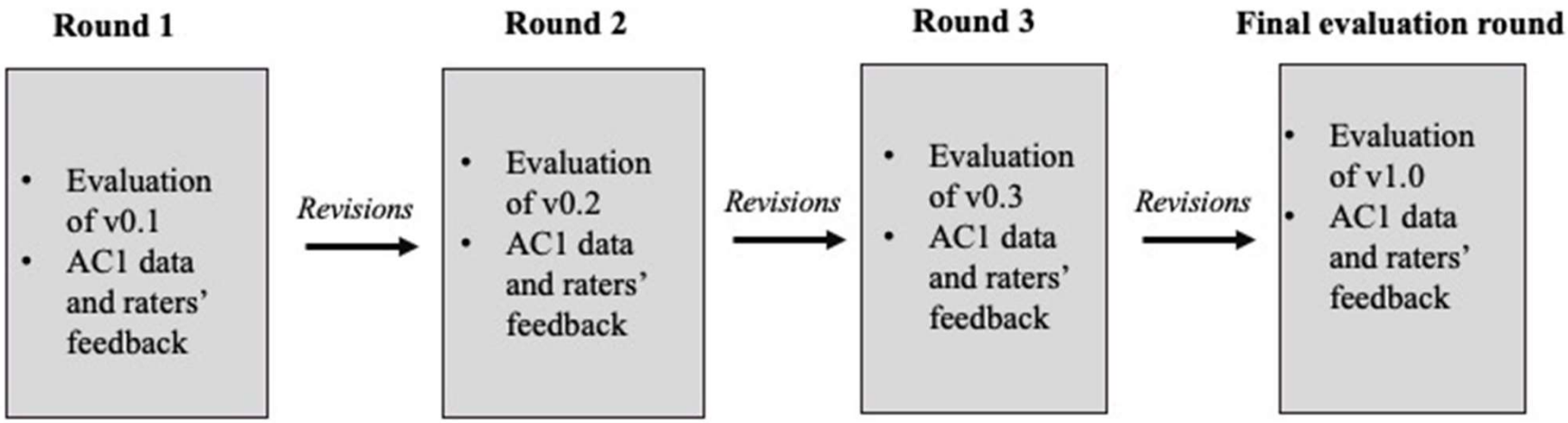
TMS-RAT

		PROTOCOL RELEVANCE						
SECTION	TOPIC	Single pulse TMS	Motor-evoked potentials	Motor	Afferent conditioning	Paired-associate conditioning	Paired-pulse TMS	Repetitive TMS
A	Participant bio	✔	✔	✔	✔	✔	✔	✔
B	Participant state	✔	✔	✔	✔	✔	✔	✔
C	Design	✔	✔	✔	✔	✔	✔	✔
D	Hardware	✔	✔	✔	✔	✔	✔	✔
E	Locations	✔	✔	✔	✔	✔	✔	✔
F	Intensity	✔	✔	✔	✔	✔	✔	✔
G	Single pulse	✔	✔	?	✔	✔	✔	✘
H	Motor threshold	?	✔	?	✔	✔	✔	?
I	Motor variables	?	✔	✔	✔	✔	?	✘
J	EMG and muscles	?	✔	?	✔	✔	?	✘
K	Afferent stimulation	✘	✘	✘	✔	✔	✘	✘
L	Conditioning	✘	✘	✘	✔	✔	✔	✘
M	SEP	✘	✘	✘	?	?	✘	✘
N	Repetitive	✘	✘	✘	✘	✘	✘	✔

REPORTING CATEGORY	LABEL	RATING	ATER COMMENT	Description	Full = SUFFICIENT	Part = PARTIAL	Missing = INSUFFICIENT	n/a = NOT APPLICABLE
G. SINGLE PULSE	G1. Trial-to-trial interval			What was the duration between each successive test (unconditioned) pulse of TMS? Alternatively, what was the TMS frequency?	"Every 5 seconds" "TMS was presentedat between every 5-10 seconds" "At 0.2Hz" "A mean (SD) of 6.5 (1.5) s"	Some detail "A random interval" "Approximately 5 seconds"	No report	Always applicable
	G2. Number of pulses			How many single pulses of test (unconditioned) TMS were presented?	"40 repeats per block, 4 blocks per condition, total 160 MEPs" "20 repeats per condition, total 80 MEPs" "30 single pulses of TMS (test pulses) were presented" "20 unconditioned TMS pulses were randomly intermixed with the conditioned TMS pulses"	Details ambiguous, eg if >1 condition "Ten pulses per condition" "A total of 200 pulses across all conditions" "40 MEPs per block of conditioned and unconditioned TMS pulses" "90 MEPs"	No detail	Always applicable
	G3. Evoked response raw QUANTITATIVE			What are the values of responses evoked by test (unconditioned) pulses of TMS, in raw units? Most commonly: MEP amplitudes in mV or μV; could also be EMG area under curve or silent period duration; EEG responses; in conditioning protocols, the 'unconditioned' response	List all evoked responses in mV or mV.ms (e.g., Table, Figure, Suppl, OSF), or mean/median and a measure of dispersion (e.g., SD, SE, IQR, range): "Unconditioned MEP amplitudes were a mean of 1.2 (SD=0.2) mV" "Single pulse MEPs varied from 500 to 1800 μV (median=1250 μV)" "Silent periods were a mean of 140 (SD=23) ms long"	Only mean/median or only a measure of dispersion "Mean 1.1 mV" "100 to 350 μV" "20-35 mV.ms" "a mean of 140 ms long"	No report	No MEPs, silent periods, or other EMG features measured: n/a

G. SINGLE PULSE					
Applies to all studies which present single pulses of TMS separate from other stimuli (i.e., unconditioned), including during conditioning protocols or recruitment curves					
	Description	**Full reporting**	**Partial reporting**	**Missing**	**Notes**
G2. Number of pulses	How many single pulses of test (unconditioned) TMS were presented?	The report clearly specifies the total number of unconditioned TMS pulses delivered to each participant and the number of repetitions per condition. The information is detailed enough to calculate the total pulses per participant and how they were distributed across conditions. Examples: "40 repeats per block, 4 blocks per condition, total 160 MEPs" "20 repeats per condition, total 80 MEPs" "30 single pulses of TMS (test pulses) were presented" "20 unconditioned TMS pulses were randomly intermixed with the conditioned TMS pulses"	The report provides some information about the number of unconditioned TMS pulses but lacks clarity or precision. It may report only the total number of pulses or only the repetitions per condition. Examples: "Ten pulses per condition" “A total of 200 pulses across all conditions” "40 MEPs per condition" "90 MEPs"	The report does not provide any information about the number of unconditioned TMS pulses or how they were distributed across conditions.	The reporting should be sufficient to calculate the total numbers of TMS pulses that each person received, as well as how many for each condition of the study design.

TOOL DEVELOPMENT PROCESS



RATING

- 333 studies double-rated by the 17 authors
- Total of over 53, 000 ratings
- Naïve raters added each round
- Pairing strategy (naïve vs experienced)

Round	Raters	Naïve raters	Articles Rated	Cumulative Articles Rated
Development 1 (0.1)	4	2	28	28
Development 2 (0.2)	8	4	40	68
Development 3 (0.3)	11	3	72	140
Final validation (1.0)	17	6	293	333

RATERS

- PhD students (n = 4), postdoctoral researchers (n = 8), senior technical specialists (n=1) and more senior academics (n = 4).
- Affiliated with 21 different institutions
- Individual experience with TMS ranged from 1 to 24 years (mean=6.5, SD=5.5)
- Estimated proportion of current research involving TMS ranged from 15% to 100% (mean=60.3, SD=30.4)

WIDER CONSULTATION

- Active TMS researchers based on the PubMed and Google Scholar from 32 countries
- Feedback from 12

RESULTS

Tool version	N of sections	N of Items	M reporting score across all articles	Overall AC1 (min-max)
0.1	9	67	46%	0.57 (-0.20-1.0)
0.2	11	65	51%	0.50 (-0.20-1.0)
0.3	12	70	49%	0.63 (0.16-0.99)
1.0	13	71	53%	0.67 (0.60-0.99)

PRE-REGISTERED EXCLUSION CRITERIA

- Gwet's AC1 ≥ 0.60
- P-value < 0.05
- Lower bound of 95% confidence interval ≥ 0.50

Exclude 22 out of 71 items

IMPORTANT ITEMS EXCLUDED

- *Were participants screened for prescribed or unprescribed medications?*
- *For experimental sessions, what was the session duration?*
- *What was the intensity of the TMS used, in % of the maximum stimulator output (%MSO) or dI/dT?*
- *What was the level of activity in the targeted muscles or body parts during TMS?*

SECTION	TOPIC
A	Participant bio
B	Participant state
C	Design
D	Hardware
E	Locations
F	Intensity
G	Single pulse
H	Motor threshold
I	Motor variables
J	EMG and muscles
K	Afferent stimulation
L	Conditioning
M	SEP
N	Repetitive

V1.1

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1.0	13	71	53%	0.67 (0.16-0.99)
1.1	12	49	52%	0.80 (0.60-0.99)

V1.0

- 12 sections, 71 items
- Prospective guideline for reporting completeness
- For authors and reviewers
- For comprehensive and transparent documentation of methods and procedures in original research

V1.1

- 11 sections, 49 items
- For retrospective assessments
- For evaluation of reporting in meta-analyses and systematic reviews
- Overall reporting =overall proportion of reported items within the study.
- Metrics can be used as covariates in meta-regression or subgroup analyses

CONCEPTUAL CHALLENGES IN REPORTING

- Disagreements
  - inconsistencies in literature
  - lack of shared conceptual standards
  - Just very difficult, hard, laborious work

Right now it is not possible to have a single tool both as a prospective guideline and as a retrospective reporting assessment tool

ADOPTION AND FUTURE REVISIONS

- We hope adoption of the TMS-RAT will help close current conceptual gaps in the field
- Wider use may support the development of more consistent reporting and shared standards
- It is intended as a living resource, evolving with community feedback and research practice
- Future plans include validating and expanding the tool to cover rTMS and testing it on paired associative stimulation protocols

TEST-RETEST [IN PROGRESS]

- After a 2-month break following the final validation round (v1.0)
- [Results currently being processed]

HOW **YOU** CAN CONTRIBUTE

- Give feedback
- Consider using the tool when writing up your future TMS studies (v1.0)
- or when assessing the reporting quality of studies in systematic reviews/meta-analyses (v1.1)
- When reviewing manuscripts suggest to others to do the same
- When you have used it, share your completed spreadsheets with us so we can use them in future updates

QUESTIONS? QUESTIONS!

- Would you use the TMS-RAT?
- What would you use it for?
- If you wouldn't use it, why not?