Cognitive Task Workflow Overview: TestMyBrain Forward and TestMyBrain Backward Digit Span

Contact: Info@ManyBrains.net
ManyBrains.net
TestMyBrain.org

TMB Test Name: TestMyBrain Forward and TestMyBrain Backward Digit Span
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The Many Brains Project & TestMyBrain

The Many Brains Project is a US-based 501(c)3 non-profit focused on the development of digital cognitive testing tools. We currently support many different types of research studies through our infrastructure for cognitive assessment - these range in size from small lab-based pilot studies to large longitudinal, multisite clinical research studies with tens of thousands of participants. As TestMyBrain.org has been continuously in operation since 2008, we provide a stable and secure platform for hosting and delivering mobile and web-based cognitive assessment protocols. Through TestMyBrain.org, data have been collected from over 2.5 million participants in a *citizen science* framework that includes structured return of research results toward the development, validation, and normative characterization of cognitive measures. We currently support research and education at over 400 sites worldwide as well as support for over 1200 clinicians or clinical sites engaged in remote digital neuropsychological assessment. For more information contact info@manybrains.net.

CITATION
Please credit The Many Brains Project and TestMyBrain in any papers, posters, or publications related to the TMB tests or data collected by TMB tests.
- Example:
  - All tasks were selected from and hosted on The Many Brains Project's web-based cognitive testing platform, TestMyBrain (Germine et al., 2012; The Many Brains Project).
    - Germine, L., Nakayama, K., Duchaine, B. C., Chabris, C. F., Chatterjee, G., & Wilmer, J. B. (2012). Is the Web as good as the lab? Comparable performance from Web and lab in cognitive/perceptual experiments. *Psychonomic Bulletin & Review*, *19*(5), 847-857.
    - The Many Brains Project. *TestMyBrain Cognitive Tests*. URL: www.manybrains.net

Document Contents

General Test Overview

Background:
TestMyBrain Forward Digit Span and TestMyBrain Backward Digit Span (Chaytor et al., 2021; Hartshorne & Germine, 2015; Germine et al., 2012; Singh et al., 2021; Treviño et al., 2021) are digital versions of in-person digit span tasks (e.g., Richardson, 2007) adapted for remote administration (The Many Brains Project & McLean Hospital, GNU LGPLv3 2023).

Task Parameters:
After being presented with a set of numbers (e.g., 246), participants are asked to recall those numbers either in their original order (246) for TestMyBrain Forward Digit Span, or in reverse order (642) for TestMyBrain Backward Digit Span. Individual numbers within each set are presented on the screen sequentially for 1000 ms each. Initially, number sets contain only two numbers, but increase up to a maximum length of 11 numbers. Participants are presented with two trials at each set length; if at least one of those two number sets is successfully recalled, the set length is increased by one number, and two trials are completed at the new set length, up to a maximum of 11 numbers. For each trial, all participants see the same sequence of numbers (e.g., the first test trial of TestMyBrain Forward Digit Span is "21" for all participants). Participants complete two unscored practice trials before beginning test trials.

Primary Outcome:
The suggested primary outcome, computed separately for TMB Forward Digit Span and TMB Backward Digit Span, is the longest number set length where at least one trial is answered correctly, a measure of working memory.

Input Device:
Participants with keyboard access enter their responses using a keyboard, whereas participants on touch devices enter their responses using a number pad presented on the screen.
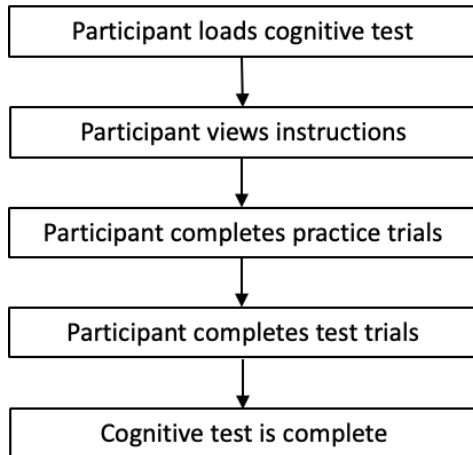
References:
Chaytor, N. S., Barbosa-Leiker, C., Germine, L. T., Fonseca, L. M., McPherson, S. M., & Tuttle, K. R. (2021). Construct validity, ecological validity and acceptance of self-administered online neuropsychological assessment in adults. *The Clinical Neuropsychologist*, *35*(1), 148-164.

Germine, L., Nakayama, K., Duchaine, B. C., Chabris, C. F., Chatterjee, G., & Wilmer, J. B. (2012). Is the Web as good as the lab? Comparable performance from Web and lab in cognitive/perceptual experiments. *Psychonomic Bulletin & Review*, *19*, 847-857.

Hartshorne, J., & Germine, L. (2015) When does cognitive functioning peak? The asynchronous rise and fall of different cognitive abilities across the lifespan. *Psychological Science,* 26(4), 433-443.

Richardson, J. T. (2007). Measures of short-term memory: a historical review. *Cortex 43*(5), 635–650.

Singh, S., Strong, R. W., Jung, L., Li, F. H., Grinspoon, L., Scheuer, L. S., Passell, E. J., Martini, P.,

Chaytor, N., Soble, J. R., & Germine, L. (2021). The TestMyBrain Digital Neuropsychology Toolkit: Development and Psychometric Characteristics. *Journal of Clinical and Experimental Neuropsychology*, *43*(8), 786-795.

Treviño, M., Zhu, X., Lu, Y. Y., Scheuer, L. S., Passell, E., Huang, G. C., ... & Horowitz, T. S. (2021). How do we measure attention? Using factor analysis to establish construct validity of neuropsychological tests. *Cognitive Research: Principles and Implications*, *6*(1), 1-26.
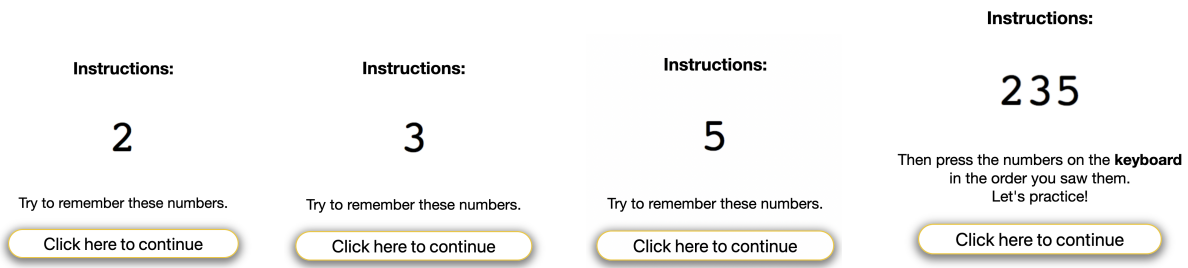
Detailed Test Activities

Flow Diagram

1) Instructions

Description

The participant views brief instructions for the test and clicks a button when ready to start the practice trials. No data is generated during the instructions phase.
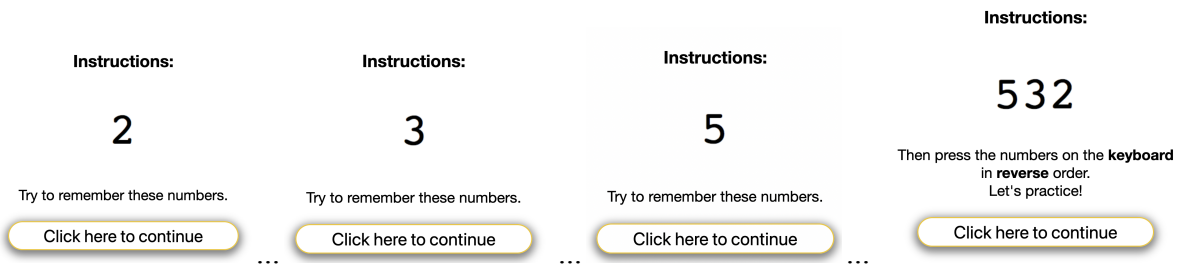
Screenshots

- TMB Forward Digit Span Instructions:

- TMB Backward Digit Span Instructions:

Instructions:

2

Try to remember these numbers.

Click here to continue

...

Instructions:

3

Try to remember these numbers.

Click here to continue

...

Instructions:

5

Try to remember these numbers.

Click here to continue

...

Instructions:

5 3 2

Then press the numbers on the **keyboard** in **reverse** order.
Let's practice!

Click here to continue

2) Practice Trials

Description

The participant completes two practice trials. In TMB Forward Digit Span (pictured below), the participant must enter each number set in the same order in which they viewed it (12), whereas in TMB Backward Digit Span, the participant must enter each number set in reverse order (21). The first practice trial has a span length of two numbers, while the second practice trial has a span length of three numbers. If the participant answers either practice trial incorrectly, they are informed they have made a mistake, told the correct answer, and required to repeat the practice trial until they get it correct. Participants have unlimited time to make their response. Incorrectly entered numbers can be cleared by pressing backspace, except for the final number of the digit set. Practice trials are recorded in the trial level data for the test, but do not contribute to full test outcomes.

Screenshots

- Practice Trial Structure:

| Digit 1
1000 ms each | Digits 2-N
1000 ms each | Response Prompt 1
3000 ms | Response Prompt 2
Until response | Feedback
1000 ms |
|---|---|---|---|---|
| Memorize the numbers!

1 | Memorize the numbers!

2 | Now press the numbers... | Press 2 numbers. | Correct!

12 |

3) Test Trials

Description

Test trials begin with a number span length of two numbers, and increase up to a maximum span length of 11 numbers. In TMB Forward Digit Span, the participant must enter each number set in the same order in which they viewed it (12), whereas in TMB Backward Digit Span, the participant must enter each number set in reverse order (21). The participant is presented with two trials at each number span length; if at least one of those two number spans is successfully recalled, the set length is increased by one number, up to a maximum of 11 numbers. The test ends when either (1) both trials at a number span length are answered incorrectly or (2) the participant completes two trials at a span length of 11 numbers. No response feedback is given for test trials, but otherwise the individual test trials are structured the same as the practice trials described in the previous section. Test trials are recorded in the trial level data for the test, and also contribute to full test outcomes.

Screenshots

- Instructions:

Excellent!
You have completed the practice.
Now let's do more.

To correct mistakes
you can press backspace/delete.

Click here to continue

- Test trial structure:

Digit 1 1000 ms each	Digits 2-N 1000 ms each	Response Prompt 1 3000 ms	Response Prompt 2 Until response
Memorize the numbers! 1	Memorize the numbers! 2	Now press the numbers...	Press 2 numbers.

Trial Level Data

Variable	Description
type	Trial type ['practice', 'test']
digits	The digits displayed (int)
response	The digits reported (int)
correct	Response correctness, boolean [0,1]
rt	Reaction time (ms)
state	Event triggered by the response: timeout => no response until timeout keyup => keyboard keypress touchend, pointerup.touch => touchscreen touch

Full Test Outcome Data

Variable	Description
num_correct	Number of correct responses for 'test' trials [0-20] (int)
span	The highest number of digits with 0 or 1 errors (int). Recommended primary test outcome. [0, 2-11]
reportOrder	Whether the digits were required to be reported in the forward (as displayed; TMB Forward Digit Span) or reversed order (TMB Backward Digit Span) ['forward','backward']
score	Score = span [0, 2-11]
responseDevice	User's response device: keyboard touch
testVersion	Test's script version