

Introduction

Purpose

This battery comprises a set of assessments that have been localized and adapted to test executive function (EF) skills among school-aged children in Malawi government primary schools. EFs refer to a set of skills that allow individuals to manage their attention, memory, and behavior to achieve goals. EFs encompass three core skills that include: (1) inhibitory control (i.e., the ability to resist distractions and control impulses; (2) working memory (i.e., the ability to hold and manipulate information in the mind over short periods of time); and (3) cognitive flexibility (i.e., the ability to shift attention flexibly between competing sets of rules).

During 2023 - 2024, the Imagine research team conducted iterative, small-scale pilots to develop a battery of EF assessments for the purpose of (1) extending prior research showing the relevance of EFs for children’s progress in a tablet-based program (Bardack et al., 2023) and; (2) collecting EF data at scale during the nationwide roll-out of the Building Education Foundations through Innovations & Technology (BEFIT) tablet-based curriculum program in Malawi.

Overview and status of EF assessments

All assessments are administered one-on-one to children by a trained enumerator using an Android tablet. Once connectivity is available, performance data are uploaded wirelessly to RTI International’s secure Tangerine server. The table below summarizes the target EF skill/s and development status of each assessment for administration among Standards 1-4 in Malawi. Detailed information on each assessment is presented on pages 2-4.

Assessment	EF skill/s	Status (validity & reliability)
Spatial span	Visual short-term and working memory	Validity* established for Standards 1-4.
Pick the picture	Working memory	Reliability and validity established for Standards 1-4.
Hearts and flowers	Inhibitory control and cognitive flexibility	Reliability and validity in progress for Standards 1-4.

*We are still exploring appropriate reliability measures for this assessment. Since the number of items in the spatial span assessment is not fixed across children (see pg. 2), Cronbach’s alpha is not appropriate for this measure.

Spatial Span

Description

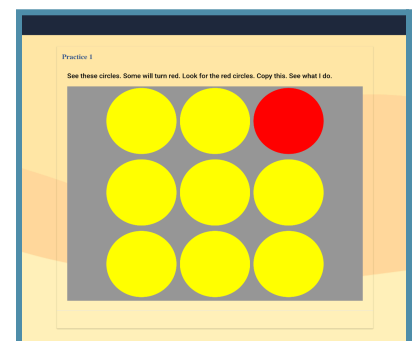
- Developed based on a version previously used by Pitchford and colleagues (2016) in Malawi, the Spatial Span assessment is designed to measure spatial (visual) short-term memory and spatial (visual) working memory.
 - Spatial short-term memory is the cognitive system allowing for the temporary storage of spatial information.
 - Spatial working memory entails the ability to keep spatial information active over a short period of time.
- Spatial Span challenges the student's ability to remember the relationships between objects in space, as opposed to verbally rehearsing items in a specific order, which relies on verbal working memory.

Procedures

- Students are asked to recall a sequence of circles in exact order for the forward span and in reverse order for the backward span.
- There are 2 sets of training trials. Students are allowed 2 attempts to pass each training trial and students must pass at least 1 of the 4 possible attempts to proceed.
- Following, there are 9 experimental trials in which stimuli are grouped into 3 sets of 2-9 circle sequences each. Beginning with 3 sets of 2 circle sequences, the assessment delivers sets of increasing length until the student fails three successive sets in a given trial. Thus, the number of items presented is not fixed across students.

Rules

- Students must remember the sequence of red circles presented and recall the exact order for the forward span and the reverse order for the backward span by touching the yellow circles in the display that correspond to the red circles previously presented.
- The student should complete as many trials in the game as accurately as possible.
- The game will stop automatically when the student reaches the performance limit (i.e., failing 3 trials consecutively).



Pick the Picture

Description

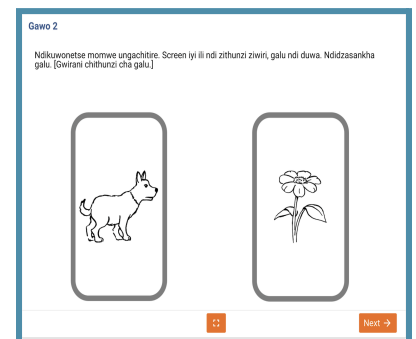
- The Pick-the-Picture Assessment is a 46-item task that measures working memory (i.e., the ability to hold and manipulate information in the mind over short periods of time).
- The game makes use of images that are easily recognizable to students, such as pictures of animals (dog, cat, pig), images (sun, star), and everyday objects (flower, car, boat).
- The mean accuracy of responses in each picture set (except for the first picture, which does not require working memory) is used to represent task performance.
- This assessment is part of the *Executive Function (EF) Touch* battery (Willoughby, Piper, et. al, 2018)

Procedures

- At the beginning of the assessment, enumerators read instructions to the students.¹ The student then plays the game on the tablet, independently.
- During the assessment, students are presented with a first set of training items:
 - If students fail the first training items, they are presented with a second set of training items. The task automatically terminates if students fail both sets of training items.
- For students who proceed to the test trials, they are presented with arrays of pictures that vary in length (i.e., 2,3,4,6 or 8 pictures per set).

Rules

- The game presents students with 8 trials that include picture sets of increasing length, beginning with 2 sets of 2 pictures and ending with 8 sets of 8 pictures.
 - After the first array shown in a set, the same set of pictures are presented, but each picture is in a different location. Students are then instructed to pick a picture that has not yet been touched in 1 of the previous sets.
 - As the number of pictures within each trial increases, the assessment increasingly challenges children’s working memory skill as they have to keep track of which picture has not yet been touched across an increasing number of picture sets.



¹ Imagine is exploring developing a version of this assessment that is fully “self-administered” by embedding instructions in the software

Hearts and Flowers

Description

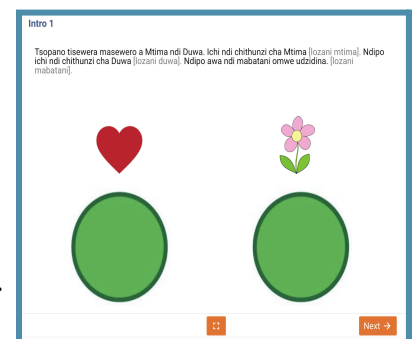
- The Hearts and Flowers (H&F) task was developed by Adele Diamond as a modification of her ‘Dots’ task (Davidson et al., 2006; Diamond, 2013). The task comprises 3 types of test trial blocks:
 - In the first block (congruent condition), a heart is displayed either on the left or right side of the monitor. Students are instructed to press the virtual button on the same side as the heart.
 - In the second block (incongruent), students see a flower instead of a heart and must respond by pressing the virtual button opposite to the location where the flower is displayed. These two blocks together measure baseline performance for classic choice reaction to location, and Stroop-like conditions where stimuli characteristics (in this case location, not color) interfere with the choice reaction task of pressing the left or right key.
 - The third block introduces task switching. Students must remember to apply rules for the congruent or incongruent trials depending on which stimulus (heart vs. flower) is displayed, thus leveraging their cognitive flexibility skills.

Procedures

- At the beginning of the assessment, enumerators read instructions to the student². The student then plays the game on the tablet, independently.
- During the assessment, students are presented with a 9-item training set and must answer 6 items correctly in order to pass. If students fail the first training set, they are presented with a second set of training items. The task automatically terminates if students fail both sets of training items.
- Students who proceed to the test trials are presented with 4 blocks, each comprising 24 items: a block of hearts trials, a block of flowers trials, and 2 blocks of mixed trials.

Rules

- For the hearts and flowers trials, the stimuli appear on the screen for 2500 milliseconds. The stimulus for the mixed trials appears on the screen for 2500 milliseconds for the first “slow” trial and for 2000 milliseconds for the second “fast” trial. Correct answers involve pressing the button that corresponds to the rules of the given stimuli (i.e., same side for hearts, opposite side for flowers).



² Imagine is exploring developing a version of this assessment that is fully “self-administered” by embedding instructions in the software

References

- Bardack, S., Lopez, C., Levesque, K., Antonie Chigeda, & Symon Winiko. (2023). An exploratory analysis of divergent patterns in reading progression during a tablet-based literacy program. *Frontiers in Education*, 8. <https://doi.org/10.3389/feduc.2023.983349>
- Davidson, M. C., Amso, D., Anderson, L. C., & Diamond, A. (2006). Development of cognitive control and executive functions from 4 to 13 years: Evidence from manipulations of memory, inhibition, and task switching. *Neuropsychologia*, 44(11), 2037–2078. <https://doi.org/10.1016/j.neuropsychologia.2006.02.006>
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- Willoughby, M. T., Piper, B., Kwayumba, D., & McCune, M. (2018). Measuring executive function skills in young children in Kenya. *Child Neuropsychology*, 25(4), 425–444. <https://doi.org/10.1080/09297049.2018.1486395>