### EF Measures

#### Working Memory

A revised version of the Scrambled Boxes Working Memory Task (Diamond, Prevor, Callender, & Druin, 1997) was developed with 40 typically developing preschool children at the London Babylab, University College London (Downes, 2016) due to lack of consistent administration, design, and scoring parameters in previous studies (Schoemaker et al., 2012; Wiebe et al., 2011). The revised task shows good convergent validity. Nine boxes were chosen rather than six at pilot phase as ceiling effects were observed with the latter number of boxes. The number of consecutively correct trials is related to parent ratings of working memory on the BRIEF-P (N=27) (Downes, 2016). The examiner instructs the child to find all of the toys in the least amount of trials. Children are permitted to open only one box per trial. Nine boxes are scrambled according to a predetermined protocol during a 10-second inter-trial interval. The task continues until a maximum of 20 trials are administered or until the child finds all of the toys. The total retrieved stimuli within 20 trials are coded along with the number of consecutively correct trials and the total number of trials. Working memory for this task is considered impaired if the child does not receive all of the stimuli in the maximum number of trials.

#### Attention

The DDTP is a modified version of a cancellation task previously used to measure attention (Byrne, Bawden, DeWolfe, & Beattie, 1998). The task was revised at the London Babylab, University College London, with five typically developing preschool children in order to make it more age appropriate for this age range before validation with 26 children. Previous research found that the original version of the task was appropriate for typically developing four and five-year olds but not for three year olds or children with disorders that affect executive development, despite the fact that the objective of this task is to detect difficulties in these children (Parker, 2005). Parker (2005) concluded that further work was required to standardize the administration in order to make the task a more reliable and valid. The main modifications of the task in the current version from previous versions include updated stimuli, an in-depth script and examiner instructions, and the addition of objective instructions to administer “cues” to participants who go off-task for upwards of 20 seconds, as well as instructions for scoring incomplete attempts.

The utility of the final version wastheninvestigated with 26 typically developing children showing good convergent validity (Downes, 2016). The child undergoes a training phase (2 x 6 array of shapes) and a practice phase (two pages with targets ([30]: triangle) and distracters ([90]: circle, square, diamond, and octagon) arranged in a 10 × 6 array), to ensure that they can hold and use the bingo stamper successfully and can understand the task instructions, before the test phase (8 pages with 10 × 6 arrays of targets (N=120 standing dogs) and distracters (N=360 four identical dogs varying in position only).  The aim is to stamp the target stimuli as cued by the image on the top of the page. The test phase was modified so that the examiner can cue if a child remains off-task for greater than a 20 second block and terminate the task if a child remains off-task for greater than a 20 second block on a second occasion. Finally, the child completes the motor speed phase where they start at the top left side dog stimulus stamp all the dogs until the end, going as fast as they can.

The variables in this measure are omissions, commissions, time to completion, and motor speed. Number of omissions and commissions are combined during the test phase to obtain the mean rate of errors in typically developing children so that the number of patients and controls performing greater than 1.5 standard deviations below the average score of typically developing children can be computed. Time to completion is the time taken to complete the test phase and motor speed is the time taken to stamp every stimulus on the motor speed phase. Impairment on this task is defined as failing the practice phase or obtaining a score greater than 1.5 calculated SD above average on the combined rate of omissions and commissions.

#### Parent-reports of Executive Functioning

The BRIEF-P is a standardized rating scale that measures everyday EF with high internal reliability and validity (Sherman & Brooks, 2010). The researcher scored the BRIEF-P using a computerized scoring program which showed no rater negativity and inconsistency. Raw scores were converted to standardized T-scores (Mean=50; SD=10). T-scores over 65 (greater than 1.5 standard deviation above the mean) are considered clinically significant.

#### Cognitive Flexibility

The EF Scale for Early Childhood assesses cognitive flexibility across seven levels with increasing difficulty (Beck, Schaefer, Pang, & Carlson, 2011; Carlson & Schaefer, 2012). This graded measure of EF incorporates three tasks; categorization (Carlson, Mandell, & Williams, 2004), dimensional change card sort (Diamond, Carlson, & Beck, 2005) and integrated/advanced dimensional change card sort (Zelazo et al., 2003). It requires the participant to sort cards according to one rule for the first half of each level and then switch to a new rule for the second half of the level. The dependent variables are the number of correct trials and the highest level at which the child passes both pre-and post-switch trials. Children who did not reach the average level for their age were considered to have impaired cognitive flexibility (Fuglestad et al., 2014).

*Inhibitory Control and Processing Speed*

The NIHTB measures of inhibitory control and processing speed taps these domains using standardised computerized tasks free from experimenter bias (Zelazo et al., 2013). The inhibitory control task is administered as an age-appropriate Flanker task where flankers face the same direction for congruent trials and a different direction for incongruent trials. The processing speed task involves pressing a target button in response to on-screen pictures that are the same or different. Standardised age-adjusted scores of less than 85 for both tasks are considered atypical performance based on normative data.

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**Table S1.** Pattern of individual ‘impaired’ scores across the seven executive measures

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Patient** | **BRIEF-P** | **NIHTB-IC** | **NIHTB-PS** | **DDTP** | **WM** | **EF Scale** |
| **A** |  |  |  |  |  | x |
| **B** |  |  |  |  |  |  |
| **C** |  |  |  | x | x |  |
| **D** |  |  |  |  |  |  |
| **E** | x |  | x |  | x |  |
| **F** |  |  | x | x |  | x |
| **G** | x | x | x | x |  |  |
| **H** |  |  |  | x | x | x |
| **I** |  |  |  |  |  | x |
| **J** |  |  | x | x |  |  |
| **K** |  | x |  |  |  |  |
| **L** |  |  | x | x |  |  |
| **M** |  | x | x |  | x |  |
| **N** |  |  |  |  |  |  |
| **O** |  |  |  | x | x |  |
| **P** |  |  |  |  |  |  |
| **Q** |  |  | x |  |  | x |
| **R** |  |  |  | X |  | x |
| **S** | x |  |  | x |  |  |
| **T** |  |  |  | x | x |  |
| **U** |  |  |  |  |  |  |
| **V** |  |  |  |  |  |  |

BRIEF-P=Behavior Rating Inventory of Executive Function. NIHTB-IC=NIH Toolbox task of inhibitory control. NIHTB-PS=NIH Toolbox task of Processing Speed. DDTP= Doggie Deletion Task for Preschoolers. WM= Scrambled Boxes Working Memory Task. EF Scale=Executive Function Scale for Early Childhood.