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1 **Title:**

2 Hebrew version of the Jansari assessment of Executive Functions for Children (JEF-
3 C[©]): translation, adaptation and validation

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1 **Abstract**

2 The Jansari assessment of Executive Functions for Children (JEF-C[®]) is a non-
3 immersive computerized assessment of executive functions (EFs). This study aimed
4 to create a cross-culturally adapted Hebrew version, JEF-C(H)[®] and to assess
5 reliability and validity in the Israeli context. Forty typically developing Israeli children
6 and adolescents, aged 11-18 years, were assessed with JEF-C(H)[®]. In addition,
7 participants and their parents filled in the Behavior Rating Inventory of Executive
8 Function (BRIEF). JEF-C(H)[®] was found to be feasible in Israeli children and
9 adolescents. The internal consistency was acceptable (Cronbach's alpha = 0.79).
10 Most of the JEF-C(H)[®] subtests and the Average score showed significant positive
11 moderate to high correlations with age, ranging from 0.40 to 0.78 demonstrating
12 construct validity. Multiple significant correlations were also found between the JEF-
13 C(H)[®] Average score and the BRIEF indices as well as total score in the Parent and
14 Self-report questionnaires. These preliminary findings support the reliability and
15 validity of this version. Current findings demonstrate the potential clinical utility of JEF-
16 C(H)[®] as an ecologically valid tool for Israeli children and adolescents in the
17 assessment of EFs.

18 **Key words:** Virtual reality, Hebrew, Adolescents, Ecological validity, Cultural
19 adaptation, Executive functions

20 **Disclosure statement.** No potential conflict of interest was reported by the authors

21 **Data availability statement:** The data that support the findings of this study are
22 available on request from the corresponding author, [YG].

1 INTRODUCTION

2 Executive functions (EFs), also called cognitive control, refers to the deliberate, top-
3 down neurocognitive processes involved in the conscious, goal-directed control of
4 thought, action, and emotion, as well as including cognitive flexibility, inhibitory
5 control, and working memory (Zelazo & Carlson, 2012). EFs are complex and
6 interrelated skills that include forming, maintaining, and shifting a mental set. On a
7 functional level, this refers to generating goals and plans, maintaining focus and
8 motivation to follow through, as well as **to flexibly** alter goals and plans in response
9 to changes in circumstances (Josman et al., 2014). EF deficits can interfere with the
10 ability to complete instrumental activities of daily living and are closely associated
11 with academic achievement, vocational success, and quality of life throughout the
12 lifespan, often more so than intellectual level or socioeconomic status (Vaughan &
13 Giovanello, 2010).

14 Developments in EFs co-occur with substantial structural and functional
15 changes in neural systems involving prefrontal cortex (Zelazo & Carlson, 2012).
16 During childhood, considerable cognitive progression in the realm of EFs is made
17 within a relatively short time (Spiess, Meier, & Roebbers, 2016). Cognitive flexibility,
18 goal setting and information processing undergo a critical period of development
19 between seven and nine years of age, and are relatively mature by 12 years of age.
20 At the beginning of adolescence, 'executive control' is likely to emerge and further
21 improve into late adolescence (Best, Miller, & Naglieri, 2011). Executive dysfunction
22 in adolescents has been connected to long-term psychosocial limitations, including
23 poor community integration with social isolation (Chevignard, Câmara-Costa, Doz, &
24 Dellatolas, 2016), risky driving habits and motor vehicle accidents, substance abuse,

1 making and keeping friends, academic success as well as getting and keeping a job
2 (Bailey, 2007).

3 Given the importance of EFs in most daily activities and interactions, accurate
4 assessment of its various components is essential. However, it has been recognized
5 that the measurement of executive skills is inherently challenging. EFs have been
6 considered to be one of the most difficult domains to measure using traditional
7 laboratory tests and because of the structured nature of the tests and the non-
8 distracting environment usually found in a quiet clinical setting, as well as one-on-
9 one instructions, the tests elicit cognitive activity that is too constrained to reflect the
10 type of EF difficulties associated with everyday activities (Chevignard, Soo, Galvin,
11 Catroppa, & Eren, 2012); as a result, core deficits may go unnoticed (Lyons Usher,
12 Leon, Stanford, Holmbeck, & Bryant, 2016). It is therefore questionable what the
13 correlation is between traditional paper–pencil EF tests, (which are often
14 administered in a laboratory type settings), and actual functioning in everyday life
15 (Lalonde, Henry, Drouin-Germain, Nolin, & Beauchamp, 2013).

16 In response to this, three ecologically valid approaches to assess EFs in
17 children have been summarized (Chevignard et al., 2012). They include: 1.
18 Performance in naturalistic contexts such as direct observation of the child in various
19 situations; examples include activities at school, the home or in standardized open-
20 ended settings, providing an ‘ecological’ task such as the ‘Children’s Cooking Task’
21 (CCT) (Chevignard et al., 2009); 2. Paper-and-pencil assessments developed with
22 ecological validity in mind, for example, the Behavioural Assessment of
23 Dysexecutive Syndrome Test Battery for Children (BADS-C) (Emslie, Wilson, Burden,
24 Nimmo-Smith, & Wilson, 2003) which provide opportunities for problem solving,
25 planning, time management etc. in different settings; and 3. Questionnaires asking

1 parents, teachers, or caregivers to rate the child's everyday behavior in various
2 contexts, for example the Behavior Rating Inventory of Executive Function (BRIEF)
3 (Gioia, Isquith, Guy, & Kenworthy, 2000), which assesses the child's strengths and
4 weaknesses in EFs.

5 In addition to the above new formats, concerns regarding the limitations of the
6 traditional tests has also encouraged the development of new forms of assessment
7 (Silver, 2014). Recently, researchers have been promoting a new generation of
8 'function-led' assessments that are developed from directly observable everyday
9 behaviors (Parsons, Carlew, Magtoto, & Stonecipher, 2017), which are more
10 sensitive and ecologically valid (Jansari, Sosson, & Samson, 2014). Virtual reality
11 (VR) is a technology that allows the immersion of participants into near-realistic
12 situations whilst still retaining control over the rigorous demands of direct
13 assessment. The ability to make participants feel that they are actively present in the
14 environment makes it a potentially powerful tool for the assessment of cognitive
15 functioning (Lalonde et al., 2013). Virtually enriched environments have been used
16 as a novel and effective way to ecologically test cognitive functions in children,
17 adolescents, adults and various clinical populations (Adams, Finn, Moes, Flannery, &
18 Rizzo, 2009; Gilboa et al., 2015). More recently, Parsons et al., (2017) stated that
19 the degree to which a VR based cognitive function-led approach accurately predicts
20 relevant real-world behavior may be better than traditional construct-driven paper-
21 and-pencil tests. Furthermore, there has been an increased interest in the use of
22 mixed-reality tests that involve a merging of real and digital worlds. It is an important
23 development, allowing for progressively more natural interaction with both real
24 physical and digital content (Coolen, Beek, Geerse, & Roerdink, 2020).

1 Using this blended methodology maximizes the advantages of both
2 approaches while minimizing their weaknesses. Integrating familiar objects into
3 virtual worlds reduces cognitive stress and risk of behavioral and psychological
4 symptoms (Clay et al., 2020). Amongst others, a successful VR example of a task
5 using this mixed reality approach is the Jansari assessment of Executive Functions
6 (JEF[®]). While the majority of JEF[®] occurs in a simulated virtual environment, where it
7 would seem inappropriate to perform a task by typing into a computer document, the
8 participant completes the task in the real world. For example, one of the planning
9 tasks involves rearranging a set of to-be-performed tasks that are presented in
10 random order and rather than having doing this on the computer, the participant
11 given a pen and paper to create their 'to-do' list which they can refer to during the
12 task. JEF[®] has been shown to be sensitive enough to detect significant EF
13 impairments in adult patients with circumscribed frontal lobe lesions or other forms of
14 acquired brain injury when standard clinical tests fail to do so (Denmark et al., 2017;
15 Jansari et al., 2014). In addition, a Danish translation of JEF[®] has proven to be
16 useful in highlighting the executive difficulties experienced by individuals diagnosed
17 with Bipolar Disorder (Hørlyck, Obenhausen, Jansari, Ullum & Miskowiak *in press*).
18 Additionally, the sensitivity of JEF[®] has been demonstrated in its ability to detect the
19 impact of recreational ecstasy/MDMA, alcohol (Montgomery, Ashmore, & Jansari,
20 2011), cannabis (Montgomery, Seddon, Fisk, Murphy, & Jansari, 2012), nicotine
21 (Jansari, Froggatt, Edginton, & Dawkins, 2013) and caffeine (Soar, Chapman,
22 Lavan, Jansari, & Turner, 2016).

23 A children's version of this task, JEF-C[®] (the Jansari assessment of Executive
24 Functions for Children) has been developed (Jansari, Edmonds, Gordon, Nwosu, &
25 Leadbetter, 2012) and a French translation used successfully with children and

1 adolescents (Gilboa et al., 2017). The Gilboa et al (2017) was able to demonstrate
2 the sensitivity of the task in detecting deficits in EFs following paediatric brain injury.
3 Run on a standard laptop, whereby the participant organizes a birthday party and
4 overcomes certain problems which arise during the party, this test assesses eight
5 constructs portraying the different aspects of EFs, such as planning, adaptive
6 thinking and prospective memory (see Method for further details).

7 An increase in the number of multinational and multicultural research projects
8 and the growing need to adapt health status measures for use in multiple languages,
9 suggests a great need for cross-culturally validated research instruments.
10 Translating or rather trans-adapting outcome measures is an important process by
11 which treatment efficacy can be proven and comparability can be established across
12 cultures. The process is divided into three steps, namely, language translation,
13 cultural adaptation, and replacement of items unsuitable for translation and/or
14 adaptation (Hoegh & Hoegh, 2009). Views on the effect of culture on EFs are
15 inconsistent. While some evidence from the West has suggested that executive skills
16 are underpinned by key cultural processes (Campbell et al., 2014), there are also
17 thoughts that children in a diversity of societies develop EFs at similar speeds. In
18 addition, the relationships between different EF components have also been
19 demonstrated to be similar across cultures thereby reinforcing the suggestion that
20 the executive system is relatively culture-free (Lan, Legare, Ponitz, Li, & Morrison,
21 2011).

22 In conclusion, the Jansari assessment of Executive Functions for Children
23 (JEF-C[®]) is a non-immersive VR assessment of executive functions, originally
24 standardized in English (Jansari et al., 2012); further it has been adapted and
25 translated to be suitable for French children and adolescents (Gilboa et al., 2017).

1 The objective of the current study was to translate JEF-C[®] into Hebrew as well as
2 creating a cultural adaptation, and evaluating its psychometric properties in an Israeli
3 sample of children and adolescents. In doing so, we are facilitating the appropriate
4 assessment of EFs in children and adolescents in Israel. Specifically, our aim was to
5 establish the psychometric properties of this new assessment, in particular, the
6 internal consistency and the construct and concurrent validity.

7

8 **METHODS**

9 **Participants**

10 For this cross-sectional study, a convenience sample of 40 typically developing
11 children aged 11-18 years (42.5% male), and their primary caregivers were recruited.
12 Inclusion criteria comprised the following: Hebrew speaking children who (a) live in
13 Israel; (b) attend mainstream education schools; (c) received parental consent.
14 Exclusion criteria included: (a) children who were eligible for special education
15 services, and (b) children diagnosed with and/or significant motor, comprehension,
16 memory, hearing, visual, or reading deficits according to parents' reports.

17 **Materials**

18 **Jansari assessment of Executive Functions for Children (JEF-C[®]: Jansari,**
19 **Edmonds, Gordon, Nwosu, & Leadbetter, 2012).** JEF-C[®] has been developed to
20 assess EFs for children and adolescents between 8 and 18 years old. JEF-C[®] is a
21 **mixed-reality** neuropsychological test using non-immersive VR in combination with
22 'paper and pencil' (Gilboa et al., 2017). There are sixteen subtasks to be completed
23 during the assessment, which are grouped under 8 proposed executive
24 behaviors/constructs thought to be central to executive function namely: Planning

1 (PL), Prioritization (PR), Selective Thinking (ST), Creative Thinking (CT), Adaptive
2 Thinking (AT), Action Based Prospective Memory (APM), Event-Based Prospective
3 Memory (EPM), and Time-Based Prospective Memory (TPM). The assessment is
4 based around a birthday party, whereby, the participant is responsible for organizing
5 their own party. For each of the eight constructs, realistic tasks that could happen in
6 a child's birthday party have been developed, whereby the participant is asked to
7 plan, set up and run this party through the completion of tasks by moving freely
8 through the virtual home (Gilboa et al., 2017). Please see Table 1 for an operational
9 definition and example of a subtask for each construct.

10 TABLE 1 ABOUT HERE

11 To start the assessment, the participant is given a letter that is from their
12 parents wishing them a Happy Birthday and letting them know that they are going to
13 trust the participant to run their own birthday party while the parents go out for the
14 afternoon; this letter effectively serves as the instructions for the task. After reading
15 the letter, the participant is allowed to explore the ground floor rooms of the family
16 house and garden, move objects and familiarize themselves with technicalities of the
17 assessment that allow successful interaction within the virtual environment. The
18 assessor then reads from a script that explains the task to the participant. After the
19 reading of the script and clarification of any unclear points, the participant is given an
20 instruction card and lists for use during the assessment. The participant is then
21 allowed to review the materials that they have been given and once they are ready,
22 the VR program is formally started.

23 To run the assessment, basic technology is required including a standard
24 laptop running a Windows operating system as well as some desk space for hard-
25 copy paperwork needed during the administration as seen **in** Figure 1. While most of

1 the tasks are completed in the virtual environment, for ease, some of the tasks (such
2 as Selective Thinking and Planning tasks) are executed in the 'real world' on hard
3 copy; this blend of traditional and computer-based items in the assessment makes it
4 a mixed-reality approach (see above). The assessment takes between 30 and 35
5 minutes to complete. As the participant completes each task, their performance is
6 recorded manually by the assessor on a scoring proforma according to each
7 cognitive construct.

8 Each individual subtask is scored on a 3-point scale for success: 0 for failure, 1
9 for a partial or non-optimal completion, and 2 for satisfactory completion. Clear
10 definitive guidelines have been provided on how to use these scores for each
11 subtask to ensure minimal bias. Thereafter, the scores for the two tasks for any
12 particular construct are summed (maximum of 4 possible) and this score is
13 converted to a percentage for this construct. In addition to the eight individual
14 construct scores, an average total percentage is computed for the whole
15 assessment.

16 The inter-rater reliability for the scoring system has been established in previous
17 research (Cracknell, 2013), with correlation coefficients ranging between $r = .96$ ($p <$
18 $.001$) and 1.0 ($p < .001$) for the eight constructs separately and $r = .999$ ($p < .001$) for
19 the overall average JEF-C[®] score. Gilboa et al., (2017) found internal reliability using
20 Cronbach's alpha was .62 as well as medium and significant inter-correlations
21 between a number of the JEF-C[®] subscales. Gilboa et al. (2017) found that JEF-C[®]
22 was able to differentiate between a group of children and adolescents with acquired
23 brain injury and a control group of age-and gender matched healthy children.

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Insert Figure 1 about here.

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Cross-Cultural Adaptation of the Israeli version

Translation and linguistic adaptation were performed for the English version. JEF-C[®] was translated and culturally adapted to the Israeli population using the simplified Guillemin criteria (Guillemin, Bombardier, & Beaton, 1993) under the supervision of the developer of the assessment and a panel of Hebrew speaking experts who ensured the maintenance of the original meaning of the items. Before using JEF-C[®] in an Israeli context, a cross-cultural adaptation process was completed and overall, the majority of the JEF-C[®] Hebrew version (JEF-C(H)[®]) was equivalent to the original version. The activities used were familiar and appropriate following a few cultural adaptations (see below).

The English version of JEF-C[®] was independently translated into the Hebrew language by two bilingual translators whose first language was Hebrew. The backward translation was carried out by two other bilingual Occupational Therapists. Thereafter, the few discrepancies were reconciled by consensus to produce a single harmonized version. Because Hebrew language grammar differs between male and female subjects, separate assessments were required. Figure 2 shows a screenshot of the entrance to the house within the JEF-C(H)[®] virtual environment, including pop-up texts of the male version whereby the participant is asked to choose between two options.

The order of individual elements and tasks in JEF-C(H)[®] were the same as that of the original English version and subtle changes were made to words or expressions perceived to be inappropriate or less culturally accepted or contextually irrelevant.

Based on ethnoreligious sentiments, a number of cultural adaptations were made to

1 JEF-C(H)[®]. The names of the guests were changed from typically English names to
2 Hebrew names and since the task involves serving food according to the guests'
3 preferences, to be congruent with a Kosher diet, sausages were replaced with a
4 pizza. Clinicians or researchers who are interested in using either the English or
5 translated versions of JEF-C[®] should visit <https://www.gold.ac.uk/artlab/>.

6 Insert Figure 2 about here.

7

8 **The Behavior Rating Scale Inventory (BRIEF) - Parents Form (Gioia et al., 2000)**

9 **Hebrew version (Linder, Kroyzer, Maeir, Wertman-Elad, & Pollak, 2010)**

10 The BRIEF is commonly used to measure parents' perceptions of their children's EF
11 performance in research and clinical settings across countries and is considered to
12 be a valid and reliable measure of EFs in children aged 5–18 years (Yung et al.,
13 2019). The BRIEF assesses an individual's EF difficulties through rating everyday
14 behaviors at home, at school, and in the community (Gioia & Isquith, 2004). The
15 Parent Form comprises 86 questions, assessing eight domains of EFs in the real
16 world: Three behavioral domains (inhibit, shift, and emotional control), which lead to
17 a Behavioral Regulation Index (BRI), and five cognitive domains (initiate, working
18 memory, plan/organize, organization of materials, and monitor), which lead to a
19 Metacognitive Index (MI).

20 These two composite scores lead to a Global Executive Composite (GEC) as
21 well as two validity scales (Inconsistency and Negativity). Parents rate their child's
22 behavior for each question on a 3-point Likert scale (never, sometimes, and often).
23 T-scores are calculated with a mean score of 50 (SD = 10) and the level of clinical
24 significance is defined at 1.5 SD (i.e., a T-score \geq 65). A higher score indicates

1 poorer EFs. Mean internal consistency ratings reported for clinical populations using
2 the BRIEF Parent Form range from 0.82 to 0.98. Three-week test–retest correlations
3 for clinical populations on the Parent Form range from 0.72 to 0.84 (Gioia et al.,
4 2000).

5 **The Behavior Rating Inventory of Executive Function - Self Report (BRIEF-SR:**
6 **Guy, Gioia, & Isquith, 2004) Hebrew version (Roth, Isquith, & Gioia, 2014)**

7 The BRIEF-SR is a standardized self-report EF measure for individuals aged 11
8 through to 18 years old who have a fifth-grade or better reading level. The Self
9 Report comprises 80 questions and like the Parent's form, it also assesses eight
10 domains of EFs, which include the three behavioral domains and five cognitive
11 domains from the participants' perspective. Like the Parent's form, scoring is based
12 on a 3-point Likert scale (never, sometimes, and often). T-scores are calculated with
13 a mean score of 50 (SD = 10) and the level of clinical significance is defined at 1.5
14 SD (i.e., a T-score ≥ 65). A higher score indicates poorer EFs. Because the items
15 are related to potential problems in organization, planning, and attention, the results
16 provide valuable ecological insight that can facilitate understanding issues occurring
17 at home and at school. Internal consistency for the self-report form yields alpha
18 coefficients ranging from 0.80 to 0.94 for the clinical scales and 0.96 to 0.98 for the
19 index scores (Reid, McKittrick, Davtian, & Fong, 2012). The self-report takes about
20 15 minutes to complete (Guy et al., 2004).

21 **Procedure**

22 The study took place between April 2018 and November 2019. Approval for this
23 study was obtained from the ethics committee of the Faculty of Medicine, Hebrew
24 University of Jerusalem and written informed consent was obtained from all

1 participants and their parent. With permission of the author, Dr. Ashok Jansari, JEF-
2 C[©] was translated and culturally adapted to the Israeli population. Thereafter,
3 children and adolescents were recruited via convenience sampling, and were
4 assessed either in their homes or in a clinic located in the vicinity of their homes. The
5 participant underwent JEF-C(H)[©] and BRIEF SR assessment, which was performed
6 in a session of approximately an hour. The parents filled in the BRIEF parent form
7 and the demographic questionnaires, which took approximately 15 minutes.

8 **Data analysis**

9 All analyses were performed with SPSS version 21. Descriptive statistics were
10 computed for demographic and test parameters, using means and SDs for
11 continuous data and percentages for categorical data. Cronbach's alpha was used
12 for evaluating internal consistency. Since the data was normally distributed (Shapiro-
13 Wilk test $W=.96$; $P = .22$), parametric statistics were used. Pearson correlations was
14 calculated to check for associations between JEF-C(H)[©] and both BRIEF scores and
15 age. In addition, t-tests were used to investigate gender differences and to compare
16 BRIEF total scores to the normative sample. Given the exploratory nature of the
17 study, multiple testing corrections were not performed in the statistical analyses.

18

19 **RESULTS**

20 *Participant characteristics*

21 Characteristics of the sample are shown in Table 2. Socio-Economic Status (SES),
22 which included the highest maximal education level achieved by either of the two
23 parents and family income indicated a very high percentage of the parents (95%)
24 achieved superior studies after graduation from high school and the majority of the

1 participants' parents had a high (37.5%) or average (55%) family income, indicating
2 participants from a medium to high socio-demographic population.

3

4 Insert Table 2 about here.

5

6 JEF-C(H)[©] was found to be feasible in an Israeli-speaking group of children and
7 adolescents. All participants were able to complete the task. Based on informal
8 feedback, the participants found the assessment fun, motivating and participated
9 fully. JEF-C(H)[©] Average score ranged between 46.88- 93. 75 (M= 73.98; SD=
10 12.16). The results of JEF-C(H)[©] did not demonstrate ceiling or floor effects (Terwee
11 et al., 2007). Moreover, none of the participants achieved either the minimal or the
12 maximal score. The performance in all JEF-C(H)[©] subscales is presented in Table 3.

13 *Internal consistency*

14 Overall, the internal consistency was found to be acceptable (Cronbach's $\alpha = .79$).
15 Some significant inter-correlations were found between a number of the JEF-C(H)[©]
16 subscales (see Table 4).

17 Insert Table 4 about here

18

19 *Construct validity*

20 As expected, significant positive high to moderate correlations were found between
21 age and JEF-C(H)[©] average score ($r = .778$, $p < .01$) as well as most of the subtests
22 (see Table 5). In addition, a t-test comparing the performance of boys and girls on
23 JEF-C(H)[©] average score revealed no significant difference ($t(38) = .85$; $p > 0.05$).

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25 Insert Table 5 about here

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Concurrent validity: correlational analysis between JEF-C(H)[®] and the BRIEF (Parent and Self Report)

The BRIEF subscale and index scores are presented in Table 3. Using one sample t-tests, no significant differences were found between the norms and our sample GEC scores of the parents and the self-reports ($p>0.05$). As seen in Table 6, significant negative medium correlations were found between the JEF-C(H)[®] average score and the BRIEF scores of parents and self-report total scores and most of the subscales; please note that high scores on BRIEF denote executive difficulties while high scores on JEF-C(H)[®] denote stronger abilities and therefore the negative correlations are in the expected direction. More specifically, for both parent and self-reports the MI and the GEC scores showed significant correlations with JEF-C(H)[®] ($p< 0.01$), whereas the BRI scores, were not significantly correlated.

Insert Table 6 about here

DISCUSSION

This exploratory study described the process of translation, cross-cultural adaptation and validation of JEF-C(H)[®], a VR assessment tool designed for the evaluation of EFs for Israeli children and adolescents. Overall, in this preliminary study, JEF-C(H)[®] was feasible in a Hebrew speaking group of healthy children and adolescents across a wide age range, whereby all participants were able to complete the task, participated fully and enjoyed the assessment. The results indicated that JEF-C(H)[®] showed acceptable psychometric properties for measuring EF performance of Israeli children and adolescents. This validation study was essential to provide a standardized, validated tool available for therapists to identify EF

1 problems, to plan specific intervention programs and conduct research in the Israeli
2 population. The acceptable internal consistency (Cronbach's alpha = 0.79), as well
3 as the strong Pearson correlation with age and the strong correlation between JEF-
4 C(H)[®] and the BRIEF, further supports this reliability and validity.

5 Application of the simplified Guillemin criteria (Guillemin et al., 1993) which
6 represents a more thorough adaptation process than a mere literary translation
7 proved to be straightforward. No difficulties were encountered in translating the test
8 and the additional materials (e.g., letter from the parents, instruction card and lists)
9 and the back-translations corresponded very well to the original English versions.
10 The Hebrew version of JEF-C[®] appeared to be culturally appropriate and clearly
11 understood tool (e.g. no questions were asked or objections were raised regarding
12 the changes made) and easily administered by the participants in this study. The
13 validation process performed in this study shows that it preserves characteristics of
14 reliability and validity similar to the published English original version.

15 We found acceptable internal consistency JEF-C(H)[®] (alpha = .79). These
16 results are in line with Gilboa et al., (2017) who also reported medium internal
17 consistency (alpha = 0.62). Although significant inter-correlations were found
18 between a number of the JEF-C(H)[®] constructs, most of these included Selective
19 Thinking and the three forms of Prospective Memory. These results are also
20 consistent with the findings of Gilboa et al., (2017) who reported significant inter-
21 correlations mostly between the Prospective Memory constructs. A recent analysis
22 on the performance of over 500 participants undergoing the adult JEF[®] assessment
23 has also shown that there are consistent inter-correlations between a number of the
24 subconstructs, particularly Time-Based Prospective Memory (Pawlowska, 2020).
25 These results are unsurprising as prospective memory is implicated in the

1 performance of most complex tasks and therefore is strongly related to executive
2 functions.

3 Generally speaking research demonstrates that performance on complex EF
4 tasks improves until at least age 15, although improvement slows with increasing
5 age and varies across tasks (Best & Miller, 2010). These behavioral findings align
6 with both structural and functional imaging studies reporting a protracted
7 development of the neural substrates supporting EFs. In addition, the developmental
8 trajectory of working memory demonstrates linear increases from preschool age to
9 adolescence. Best et al., (2011) went on to propose a model of the development of
10 frontal lobe functioning which suggests a staged process that begins in early
11 childhood with the maturation of frontal functioning and continues, although at a
12 decreased rate, into adolescence and early adulthood (Best et al., 2011).

13 As predicted, a positive correlation was found between age and the JEF-
14 C(H)[®] subconstructs as well as Average scores. These results are consistent with
15 Gilboa et al., (2017) who also found a significant medium correlation between the
16 JEF-C[®] average score and age ($r=.48$, $p<.008$) among typically developing children.
17 These findings reflect past research that has consistently demonstrated an
18 ascending trend in various aspects of EFs with age especially increased working
19 memory, attentional control, cognitive flexibility, and inhibition through adolescence
20 (Poon, 2018). The lack of correlations between age and Prioritization as well as
21 Event-Based Prospective Memory, is somewhat puzzling given that these
22 correlations were obtained in the original studies using English JEF-C[®] (Jansari et
23 al., 2012). A possible contributory factor to this discrepancy could be the high SES
24 backgrounds of the current sample thereby masking some of the effect of age.

1 Clearly, more research is needed with a larger and more heterogenous and
2 representative sample.

3 Our results indicated no significant gender difference on JEF-C(H)[©]. These
4 confirm previous results where no sex differences could be detected either in
5 cognitive or behavioral aspects of EFs (Ritter, Perrig, Steinlin, & Everts, 2014). Even
6 when marginal sex differences have been identified on specific EF tasks, these
7 findings have not been consistently replicated (Wierenga, Bos, van Rossenberg, &
8 Crone, 2019). We conclude that with this inconsistency in previous studies, our
9 results demonstrate construct validity with no systematic bias within JEF-C(H)[©] with
10 respect to gender.

11 As no significant differences were found between the BRIEF total score and
12 the norms, this confirms that the participants in our study were a representative
13 sample. The concurrent validity of JEF-C(H)[©] was evaluated using BRIEF Parent
14 and Self-Report questionnaires. An interesting finding was that the MI and the overall
15 score GEC but not the BRC showed significant correlations with JEF-C(H)[©]. The
16 BRC involves processes with a more distinct emotional or motivational significance,
17 often referred to as 'hot' EFs (Zelazo & Carlson, 2012). Impaired hot EFs have a
18 strong impact on behavioral choices in everyday situations, especially when there is
19 a distinct emotional interaction with logical or cold EFs. Also, the conventional
20 method for assessing hot EFs has been performance-based decision-making tasks
21 with emotional-laden contingencies. A key challenge for participants in these tasks is
22 to make long-term advantageous decisions in uncertain and ambiguous test settings
23 (Hagen et al., 2016). 'Cool' EFs refer to the cognitive skills that are traditionally
24 perceived to encompass abilities such as working memory, inhibitory control and
25 cognitive flexibility (Tsermentseli & Poland, 2016). JEF-C(H)[©] only includes cool EFs

1 and does not include any components of hot EFs. Therefore, it was unsurprising that
2 there would be less of a correlation between JEF-C(H)[®] and the BRC component of
3 the BRIEF scores, than the MI and GEC components.

4

5 **Study limitations and future directions**

6 There are a number of limitations that we must acknowledge in our study. Firstly, the
7 participants tested were a small convenience sample across a fairly wide age range
8 as well as a higher than average SES background. We cannot determine whether
9 the results would have been different had the group been more heterogeneous with
10 respect to SES background and a narrower age range. Secondly,
11 the frequency of children with Attention Deficits Hyperactivity Disorder (ADHD) and
12 other comorbid physical or mental health diagnoses is unknown. Future studies
13 should include larger heterogeneous samples allowing control of potentially
14 confounding factors such as IQ and SES. Samples including children with EF deficits
15 (such as Traumatic Brain Injury and ADHD) will allow a better representation of the
16 general population of children and adolescents in Israel. In addition, it will be
17 important to establish test–retest reliability of JEF-C(H)[®] as well as discriminant
18 validity in distinguishing children with and without EF difficulties and to provide
19 normative data, which will require large participant pools.

20 Informal feedback from parents and discussions with participants indicated
21 the potential of JEF-C(H)[®] in terms of ecological and predictive validity. By adding
22 the BRIEF Teacher form, we could provide more information from the school setting,
23 thereby gaining a more holistic perspective. Lastly, JEF-C(H)[®] uses simple
24 technology that require an assessor to be present which involves manual rather than
25 automatic scoring. With the difficulties of in-person testing during the global Covid-19

1 pandemic, automated testing and even teleneuropsychological testing (Stolwyk,
2 Hammers, Harder, & Cullum, 2020) is going to become more necessary. Therefore,
3 a future aim is to develop more advanced versions of JEF-C(H)[©] that are fully
4 automated and also that can be delivered online.

5 **Conclusions and implications**

6 Overall, the results of this exploratory study indicate that JEF-C(H)[©] is a reliable and
7 valid instrument for the measurement of executive functions of Israeli children and
8 adolescents. The assessment is also feasible and can be considered easy to set up
9 and execute due to the minimal use of equipment and the reasonable amount of time
10 required. Therefore, we believe JEF-C(H)[©] is suitable for use in the assessment of
11 EFs in different clinical and educational settings.

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