Title:

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

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Abstract

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

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

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INTRODUCTION

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

Developments in EFs co-occur with substantial structural and functional changes in neural systems involving prefrontal cortex (Zelazo & Carlson, 2012). During childhood, considerable cognitive progression in the realm of EFs is made within a relatively short time (Spiess, Meier, & Roebers, 2016). Cognitive flexibility, goal setting and information processing undergo a critical period of development between seven and nine years of age, and are relatively mature by 12 years of age. At the beginning of adolescence, ‘executive control’ is likely to emerge and further improve into late adolescence (Best, Miller, & Naglieri, 2011). Executive dysfunction in adolescents has been connected to long-term psychosocial limitations, including poor community integration with social isolation (Chevignard, Câmara-Costa, Doz, & Dellatolas, 2016), risky driving habits and motor vehicle accidents, substance abuse, making and keeping friends, academic success as well as getting and keeping a job (Bailey, 2007).

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

In response to this, three ecologically valid approaches to assess EFs in children have been summarized (Chevignard et al., 2012). They include: 1. Performance in naturalistic contexts such as direct observation of the child in various situations; examples include activities at school, the home or in standardized open-ended settings, providing an ‘ecological’ task such as the ‘Children’s Cooking Task’ (CCT) (Chevignard et al., 2009); 2. Paper-and-pencil assessments developed with ecological validity in mind, for example, the Behavioural Assessment of Dysexecutive Syndrome Test Battery for Children (BADS-C)Emslie, Wilson, Burden, Nimmo-Smith, & Wilson, 2003) which provide opportunities for problem solving, planning, time management etc. in different settings; and 3. Questionnaires asking parents, teachers, or caregivers to rate the child's everyday behavior in various contexts, for example the Behavior Rating Inventory of Executive Function (BRIEF) (Gioia, Isquith, Guy, & Kenworthy, 2000), which assesses the child's strengths and weaknesses in EFs.

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

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

A children's version of this task, JEF-C© (the Jansari assessment of Executive Functions for Children) has been developed (Jansari, Edmonds, Gordon, Nwosu, & Leadbetter, 2012) and a French translation used successfully with children and adolescents (Gilboa et al., 2017). The Gilboa et al (2017) was able to demonstrate the sensitivity of the task in detecting deficits in EFs following paediatric brain injury. Run on a standard laptop, whereby the participant organizes a birthday party and overcomes certain problems which arise during the party, this test assesses eight constructs portraying the different aspects of EFs, such as planning, adaptive thinking and prospective memory (see Method for further details).

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

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

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

METHODS

Participants

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

Materials

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

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

TABLE 1 ABOUT HERE

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

To run the assessment, basic technology is required including a standard laptop running a Windows operating system as well as some desk space for hard-copy paperwork needed during the administration as seen in Figure 1. While most of the tasks are completed in the virtual environment, for ease, some of the tasks (such as Selective Thinking and Planning tasks) are executed in the ‘real world’ on hard copy; this blend of traditional and computer-based items in the assessment makes it a mixed-reality approach (see above). The assessment takes between 30 and 35 minutes to complete. As the participant completes each task, their performance is recorded manually by the assessor on a scoring proforma according to each cognitive construct.

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

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

Insert Figure 1 about here.

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

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

Insert Figure 2 about here.

The Behavior Rating Scale Inventory (BRIEF) - Parents Form (Gioia et al., 2000) Hebrew version (Linder, Kroyzer, Maeir, Wertman-Elad, & Pollak, 2010)

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

These two composite scores lead to a Global Executive Composite (GEC) as well as two validity scales (Inconsistency and Negativity). Parents rate their child's behavior for each question on a 3-point Likert scale (never, sometimes, and often). T-scores are calculated with a mean score of 50 (SD = 10) and the level of clinical significance is defined at 1.5 SD (i.e., a T-score ≥ 65). A higher score indicates poorer EFs. Mean internal consistency ratings reported for clinical populations using the BRIEF Parent Form range from 0.82 to 0.98. Three-week test–retest correlations for clinical populations on the Parent Form range from 0.72 to 0.84 (Gioia et al., 2000).

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

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

Procedure

The study took place between April 2018 and November 2019. Approval for this study was obtained from the ethics committee of the Faculty of Medicine, Hebrew University of Jerusalem and written informed consent was obtained from all participants and their parent. With permission of the author, Dr. Ashok Jansari, JEF-C© was translated and culturally adapted to the Israeli population. Thereafter, children and adolescents were recruited via convenience sampling, and were assessed either in their homes or in a clinic located in the vicinity of their homes. The participant underwent JEF-C(H)© and BRIEF SR assessment, which was performed in a session of approximately an hour. The parents filled in the BRIEF parent form and the demographic questionnaires, which took approximately 15 minutes.

Data analysis

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

RESULTS

Participant characteristics

Characteristics of the sample are shown in Table 2. Socio-Economic Status (SES), which included the highest maximal education level achieved by either of the two parents and family income indicated a very high percentage of the parents (95%) achieved superior studies after graduation from high school and the majority of the participants' parents had a high (37.5%) or average (55%) family income, indicating participants from a medium to high socio-demographic population.

Insert Table 2 about here.

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

Internal consistency

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

Insert Table 4 about here

Construct validity

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

Insert Table 5 about here

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

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

We found acceptable internal consistency JEF-C(H)© (alpha = .79). These results are in line with Gilboa et al., (2017) who also reported medium internal consistency (alpha = 0.62). Although significant inter-correlations were found between a number of the JEF-C(H)© constructs, most of these included Selective Thinking and the three forms of Prospective Memory. These results are also consistent with the findings of Gilboa et al., (2017) who reported significant inter-correlations mostly between the Prospective Memory constructs. A recent analysis on the performance of over 500 participants undergoing the adult JEF© assessment has also shown that there are consistent inter-correlations between a number of the subconstructs, particularly Time-Based Prospective Memory (Pawlowska, 2020). These results are unsurprising as prospective memory is implicated in the performance of most complex tasks and therefore is strongly related to executive functions.

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

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

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

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

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

Study limitations and future directions

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

Informal feedback from parents and discussions with participants indicated the potential of JEF-C(H)© in terms of ecological and predictive validity. By adding the BRIEF Teacher form, we could provide more information from the school setting, thereby gaining a more holistic perspective. Lastly, JEF-C(H)© uses simple technology that require an assessor to be present which involves manual rather than automatic scoring. With the difficulties of in-person testing during the global Covid-19 pandemic, automated testing and even teleneuropsychological testing (Stolwyk, Hammers, Harder, & Cullum, 2020) is going to become more necessary. Therefore, a future aim is to develop more advanced versions of JEF-C(H)© that are fully automated and also that can be delivered online.

Conclusions and implications

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

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Conflict of interests

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