Original Article

Video Teleconference Administration of the Addenbrooke's Cognitive Examination-III for the Assessment of Neuropsychological Status: An Experience in Indian Subjects with Cognitive Dysfunction

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Abstract

Objective: To determine the feasibility, reliability, and acceptability of video teleconference (VTC)-based neuropsychological assessment using Addenbrooke's cognitive examination-III (ACE-III). **Methods:** This study was performed from January 2022 to April 2022, during the third wave of the COVID-19 pandemic in India. We administered ACE-III using video-teleconferencing and compared the scores to face-to-face (FTF) testing for the eligible participants. We also conducted a participant's satisfaction survey of VTC-administered ACE-III compared to FTF-administered ACE-III, using a 7-point Likert scale. **Results:** We screened 37 participants and 24 (64.9%) successfully underwent ACE-III testing through VTC. We included 20 patients (mean age: 62.7 ± 10 years, mean education: 12.0 ± 4.6 years, 85% men) for final analysis, (who completed both VTC and FTF-administered ACE-III). Nine patients had major neurocognitive disorder (dementia), eight had mild neurocognitive disorder (MCI), and three had subjective cognitive decline (SCD). The two tests were administered at a median gap of 36 (18,74.5) days. The Intraclass correlation coefficients (ICC) of ACE-3 total scores (0.97) and the subdomain scores was high (>0.8). There was "very low" to "no" bias on the Bland–Altman plots, across all domains. The mean overall satisfaction score was 4.1, indicating that VTC is "as good as" FTF. **Conclusions:** Results support the feasibility and acceptability of remote administration of ACE-III via VTC. There is a good agreement between the ACE-III scores across VTC and in-person conditions.

Keywords: Addenbrooke's cognitive examination-III, cognitive dysfunction, neuropsychological assessment, video teleconference

Introduction

Cognitive evaluation is an integral part of dementia care. The process entails a detailed informant-assisted face-to-face (FTF) interview, recording symptoms, disease course, comorbid risk factors, and neuropsychological testing to facilitate the diagnosis. Such facilities may be jeopardized during alarming universal emergencies like the COVID-19 pandemic, making it imperative to establish pathways to safely access and deliver health care. The telehealth approach seems promising in this context.[1]

Few studies have evaluated the use of telehealth for dementia disorders. Videoconference-based neuropsychological evaluation using tests like Mini-Mental Status Examination (MMSE), Montreal Cognitive Assessment (MoCA), Repeatable battery for the assessment of neuropsychological status (RBANS), Hopkins verbal learning test—revised, ADAS-cog, and language assessments have demonstrated clinical relevance and effectiveness in the diagnosis of dementia, brain damage, and other neurological illnesses.[2-8] Preliminary studies using tele-neuropsychology have reported positive patient and physician acceptability including economic, time and environmental cost savings, and increased accessibility of participants for assessment.[9-11] However still there are concerns about the feasibility, acceptability, and reliability of data obtained from telecommunication.

Webb *et al.*[11] investigated the impact of COVID-19 on the modality of formal cognitive assessments (in-person versus remote) through a web-based survey from healthcare professionals. The authors reported that during the pandemic, the use of telephone and video conferencing cognitive assessments increased by 10% and 18%, respectively. In this survey, the commonly used tests for remote assessments included MoCA (by 23.1% of respondents), Weschler Adult

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Intelligence Scale, Rey Auditory Verbal Learning Test and Orpington Prognostic scale (15.4% each), and the Wechsler Intelligence Scale for Children, Oxford cognitive screen, Addenbrooke's Cognitive examination, the Gray Oral Reading test, and the Developmental Profile 3 (by 7.7% each). Many of the tests used were the same as in pre-pandemic period, without an available validation of the remote format, thus affecting interpretation. 17.5% of respondents reported the lack of validated tests to use for remote assessment as one of the barriers to remote testing.

Through this study we report the viability of Addenbrooke's cognitive examination-III (ACE-III), comparing videoconference (VTC) with FTF conditions, in patients with cognitive impairment in Indian population, to answer if cognitive screening using this tool, is feasible, acceptable, and reliable for virtual use.

Methods

Settings and study design

We did this cross-sectional evaluation at the All India Institute of Medical Sciences, New Delhi, India. Patients who were referred to the neurology outpatient services with a history of cognitive impairment were enrolled in a prospective dementia cohort study after a written informed consent. This cohort study is an ongoing study, started after an ethics approval from the Institute's Ethics committee (Ref No. IEC-473/02.07.2021, RP-02/2021, dated 12th November 2021). All participants and their legal representatives were given detailed information regarding the study protocol.

Inclusion and exclusion criteria

In this study, we included participants (age ≥40 years) with cognitive complaints pertaining to any of the six major cognitive domains (memory, language, attention, executive functions, perceptual-motor, and behavior/social cognition), who were referred to the neurology outpatient services for cognitive evaluation (from January 2022 to April 2022, during the third wave of COVID-19 pandemic in India), and gave written informed consent for participation. We excluded the participants who were illiterate, not cooperative [could not perform on the cognitive screening tool—Addenbrooke's cognitive examination-III (ACE-III) during Video-tele-conferencing (VTC) and/or FTF sessions due to restlessness, behavioral issues, severe inattention, lack of comprehension] or were unable to connect virtually due to technology issues. We also excluded participants who did not give an informed consent, had a significant vision and hearing disability precluding any neuropsychological testing, and known cases of a psychiatric illness like major depression, or schizophrenia. We tried to recruit patients with a wide range of cognitive functions but no specific recruitment process was performed to balance the number of participants in each cognitive function group.

Test procedure

The study design comprised the administration of the Indian version of ACE-III by Virtual Tele Communication and then FTF testing for the entire sample. ACE-III is a cognitive screening test used to detect cognitive impairment. This screening tool comprises tests of five cognitive domains, Attention, Memory, Verbal Fluency, Language, and Visuospatial abilities. ACE-III takes ~ 15–20 minutes to administer. The total maximum score of the test is 100 and each cognitive domain consists of the subtotal score, i.e., Attention = 18 points, Memory = 26 points, Verbal Fluency = 14 points, Language = 26 points, and Visuospatial = 16 points. Higher scores indicate better cognitive functioning. The Indian version of ACE-III has a high sensitivity (0.90–1.00) and specificity (0.94–1.00) for the diagnosis of dementia at the optimum cut-off points ranging from 80 to 85, good sensitivity and specificity for MCI (0.83–1.00) at corresponding cut-off values of 84–89, and is comparable to English ACE-III.[12] The VTC and FTF assessments in the study were conducted by three trained psychologists. VTC ACE-III was administered to patients using a laptop and internet facility at their respective residences. FTF ACE-III was administered to patients in the hospital facility on their follow-up visits. Both the assessments were done by the same psychologist, except for three patients for whom a different psychologist did the FTF assessment. The carer was instructed to be there with the patient during testing and keep the patient's glasses, hearing aid, few sheets of blank paper, and a pencil ready before the test. The carer was instructed not to provide any help or prompts with the answers. Most of the instructions were verbal and did not require any adaptation. During the comprehension task, the carer was instructed to adjust the camera so that the view includes the pencil and paper. Also the carer was asked to place the pencil and paper in front of the subject before each command. Share screen was used to present the naming stimuli and the mouse cursor was used to point to the target picture. Share screen was also used to present the infinity diagram, wire cube, dots, and fragmented letters. To assess the nonverbal tests (writing sentences, copying diagram/cube, drawing clock), the carer gave separate sheets of paper to the patient. After task completion, the carer was instructed to remove the response, show the camera, and also mail the record for detailed scoring.

The study design was not counterbalanced (the sequence of VTC versus FTF) as it was not possible due to the COVID-19 surge. The same forms were used during the second assessment due to the non-availability of alternate forms. The history, examination, and neuropsychological results were analyzed by the treating neurologist. The DSM-5 criteria[13] were used to diagnose dementia (major neurocognitive disorder) and mild cognitive impairment (MCI). Subjective cognitive decline (SCD) was diagnosed on the basis of SCD-I criteria.[14] Appropriate blood investigations and magnetic resonance imaging of the brain were done to rule out reversible causes and dementia mimics. Patients in active delirium were not included. The clinical dementia rating (CDR) scale was used to assess the severity of cognitive impairment.

Satisfaction survey

We conducted a participant's satisfaction survey of VTC-administered ACE-III compared to FTF-administered

ACE-III, using the 7-point Likert scale with six questions regarding participants' VTC-administered ACE-III experience. The six questions inquired about the "visual clarity," "voice clarity," "comfort level," "ability to express oneself," "comprehension—ability to understand the examiner," and the "overall satisfaction" with VTC compared to FTF. Higher scores indicated greater levels of satisfaction with VTC-administered ACE-III in each item (1 = VTC is much worse than FTF, 2 = VTC is moderately worse than FTF, 3 = VTC is slightly worse than FTF, 4 = VTC is as good as FTF, 5 = VTC is slightly better than FTF, 6 = VTC is moderately better than FTF, 7 = VTC is much better than FTF). Each patient or care giver (when patient had a major neurocognitive disorder) answered this survey after both the assessments were done. If the participant could not understand the questions, the clinical raters read the survey aloud and explained what each question meant.

Statistical analysis

Statistical analysis was carried out using Stata 16.0 (Stata Corp LLC, Texas, USA). Quantitative variables were summarized as mean ± SD or median (inter-quartile range) and qualitative variables were presented as number (%). Intraclass correlation coefficients (ICCs) were calculated using a mixed effect model to assess the agreement between the two (VTC vs FTF administered) settings. Based on the guidelines provided by Koo and Li, we regarded ICC values of less than 0.5, between 0.5 and 0.75, between 0.75 and 0.9, and greater than 0.9 as indicative of poor, moderate, good, and excellent reliability, respectively.[15] We also used the Student's paired t-test to compare the means of subdomain and total scores of ACE-III between the two settings. The Bland–Altman plots were used to depict the magnitude of the differences between the two settings, and the results were reported as mean difference and 95% limits of agreement. The two-sided P value < 0.05 was considered as statistically significant.

Results

We screened a total of 37 participants for this study [Figure 1]. Thirteen patients were excluded for the following reasons: three were illiterate, five were not cooperative for cognitive examination, two tested positive for SARS-CoV-2 when their test was scheduled, and three were not able to operate their devices either due to poor internet connectivity or incompetence to use their electronic devices. So, 24 participants (64.9%) underwent ACE-III testing through VTC. Out of these, three patients were restless and not cooperative when FTF interview was scheduled, one developed a stroke in the interval between the two interviews. Hence, we included 20 patients for analysis in this study, who completed both VTC and FTF-administered ACE-III.

The mean age of the participants was 62.7 ± 10 years. 85% were males, with a mean education of 12.0 ± 4.6 years. Nine patients had major neurocognitive disorder (dementia), eight had mild neurocognitive disorder (MCI) and three had SCD. The median clinical dementia rating—sum of boxes (CDR-SOB) was

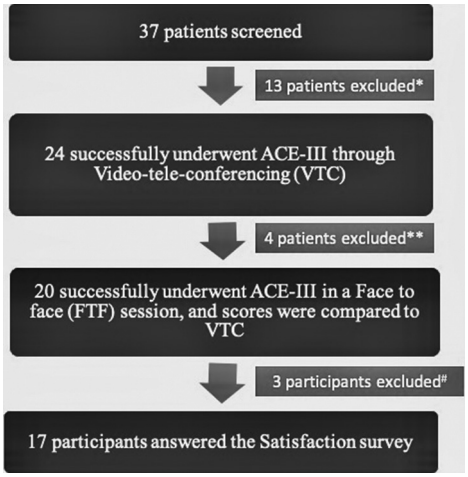

Figure 1: Patient flow diagram. *3: Illiterate, 2: Tested COVID positive, 3: Technical incompetence or Internet issues, 5: Not cooperative (inattention/restlessness/comprehension issues) **3: Not cooperative for ACE-III testing during FTF session, one developed stroke in the interval between VTC and FTF. #3: Different caregivers during the VTC and FTF session. ACE-III—Addenbrooke's cognitive examination-III, VTC—Video-teleconferencing, FTF—Face-to-face

3.75 (1.25, 8.5) and ranged from 0.5 to 11. The two tests were administered at a median gap of 36 (18,74.5) days, with a range of 9 to 198 days. Six subjects were monolingual, nine were bilingual and five were polyglots. The demographic and clinical characteristics of the participants are summarized in Table 1.

The ICC of ACE-III total scores (0.97) and the subdomain scores was high [Table 2], indicating good to excellent reliability. The mean composite score of VTC-administered ACE-III (69.2 ± 20.1) was lower than the FTF-administered ACE-III (72.1 ± 19.1). The mean difference and the 95% limits of agreement between the two scores were −2.90 (−12.65, 6.85), P = 0.017 [Table 2]. On the Bland–Altman plots, only 5% of the patient scores were beyond the 95% limits of agreement [Figure 2].

Among the subdomain scores, the VTC-administered memory score was lower than the FTF memory score, the mean difference being statistically significant [−2.70 (−10.52, 5.12), P = 0.006], Table 2. No significant difference was seen between the scores of the other sub-domains (Attention, Fluency, Language, and Visuospatial). The Bland–Altman plots for the subdomain scores are provided in the supplementary file.

The patient satisfaction scores are depicted in Figure 3. As per the mean scores, the patients rated VTC "as good as" FTF in the overall satisfaction, self-expression, and comfort level. On the components of "visual clarity," "voice clarity," and "understanding the examiner," the mean rating indicated that VTC is slightly worse as compared to FTF.

Discussion

In this study we investigated the feasibility, acceptability, and reliability of using ACE-III, a neuropsychological test

commonly employed in the evaluation of dementia, on a virtual platform.

Nearly 65% of participants (of the total screened) could undergo a successful administration of ACE-III virtually. From the feasibility perspective, the results are encouraging for resource-poor settings, where in general technology use and availability is considered to be a disadvantage due to economic and literacy reasons.

We found good agreement between the VTC- and traditional FTF-administered ACE-III scores in terms of high ICCs. For the composite score and the memory subdomain score, though the paired *t*-test was significant, and the means for VTC were lower than in the FTF condition, a review of the Bland–Altman plots was found to show very low to no bias. Overall, the results underscore the psychometric similarity between the two test conditions. To the best of our knowledge, this is the first Indian study of a neuropsychological assessment administered by videoconference, and also the first one testing ACE-III as the assessment tool. On the reliability front, the results show a good agreement between VTC and FTF administration and add to the repertoire of neuropsychological tests that may be administered virtually.

Table 1: Demographic and clinical characteristics of participants (*n*=20)

Characteristics	Total (*n*=20)
Age (years), Mean±SD	62.7±10.0
Males, *n* (%)	17 (85%)
Education (years), Mean±SD	12.0±4.6
Diagnosis, *n* (%)	
Dementia	9 (45)
MCI	8 (40)
Subjective cognitive decline	3 (15)
Addenbrooke's Cognitive Examination- III composite score, Mean±SD	
Remote	69.2±20.1
In-person	72.1±19.1
Clinical Dementia Rating Scale-Sum of Boxes, Median (IQR)	3.75 (1.25, 8.5)
Interval (days) between two administrations, Median (IQR)	36 (18,74.5)

The results are consistent with findings from previous studies on videoconferencing[4,6,16] which have been published mostly from the West, and have validated other neuropsychological screening tests like MMSE, MoCA, and few detailed batteries.

The difference in the composite scores in our study was probably driven by the difference in the scores of the memory subdomain. This could possibly be due to a "learning or practice effect" as the FTF administration always followed the VTC administration. Also, we did not use alternate test forms to avoid learning effects. Galasko *et al.*[17] looked at the short-term variation of MMSE and Information-Memory-Concentration test scores in 39 patients with Alzheimer's disease, tested four times over 6 weeks. In the repeated measure models that allowed a potential learning effect, between the first and second test sessions, scores increased significantly, by 1.12 +/- 0.47 points for the MMSE and 1.04 +/- 0.43 points for the IMC Test. Zheng *et al.*[18] used alternate versions of RBANS in 502 cognitively unimpaired participants, aged 60-85 years, at a median gap of 3.5 months. Participants' total scale, immediate memory, and delayed memory indices were significantly higher in the second test (Cohen's d_z = 0.48, 0.70, and 0.35, $P < 0.001$) as compared to the baseline. Goldberg *et al.*[19] also reported that practice related gains may amount to an effect size of 0.25 for composite cognitive measures in older populations (assessed three times in a 6 to 12-month period).

The videoconferencing assessment procedure was well accepted by the subjects (overall satisfaction score was four on a Likert scale of 7, indicating VTC to be as good as FTF). The participants rated VTC as better than FTF for the "comfort level" and inferior to FTF wherever "clarity" was in question (visual/verbal/understanding the examiner). Iiboshi *et al.*[4] found similar concerns with "voice clarity" when comparing VTC-administered MoCA to FTF conditions. Use of better technologies may help compensate for these technical issues in future studies.

Inclusion of participants with a wide range of cognitive functions, use of a satisfaction questionnaire, and applicability to resource limited settings add to the strengths of the study. Limitations of our study include a small sample size, lack of random allocation of the sequence of VTC and FTF session,

Table 2: Comparison and levels of agreement between the ACE-III Total Score and Sub-group Scores Derived Through Two Methods of Administration

ACE-III-DOMAINS	Mean±SD		Mean Difference (95% LOA)	*P*	ICC*
	VTC	FTF			
Attention	13.8±4.0	13.2±4.4	0.55 (−3.55, 4.65)	0.25	0.88
Memory	15.2±8.5	17.9±7.0	−2.70 (−10.52, 5.12)	0.006	0.87
Fluency	6.9±3.1	6.6±3.4	0.35 (−2.29, 2.99)	0.26	0.91
Language	22.1±4.1	22.5±3.9	−0.45 (−5.23, 4.33)	0.42	0.81
Visuospatial	11.3±3.8	11.9±3.8	−0.65 (−4.88, 3.58)	0.19	0.84
Composite score (total)	69.2±20.1	72.1±19.1	−2.90 (−12.65, 6.85)	0.017	0.97

*All *P*<0.001. ACE-III—Addenbrooke's cognitive examination-III, VTC—Video-teleconferencing, FTF—Face-to-face, LOA—Limits of agreement, ICC—Intraclass correlation coefficient

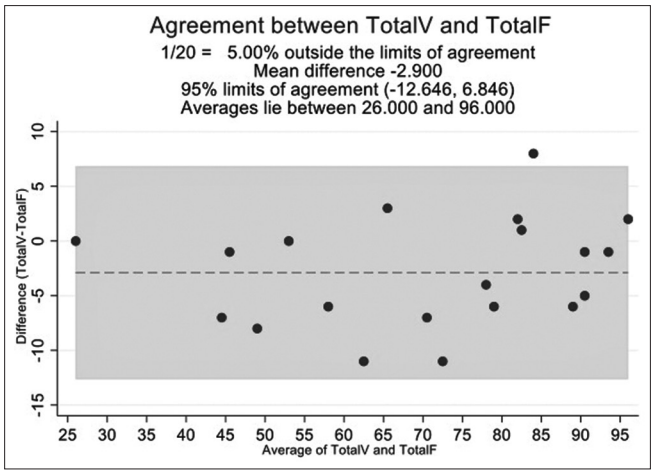

Figure 2: Bland–Altman Plot for the total score of ACE-III. TotalV—Total score of ACE-III obtained through video-teleconference administration. TotalF—Total score of ACE-III obtained through FTF administration

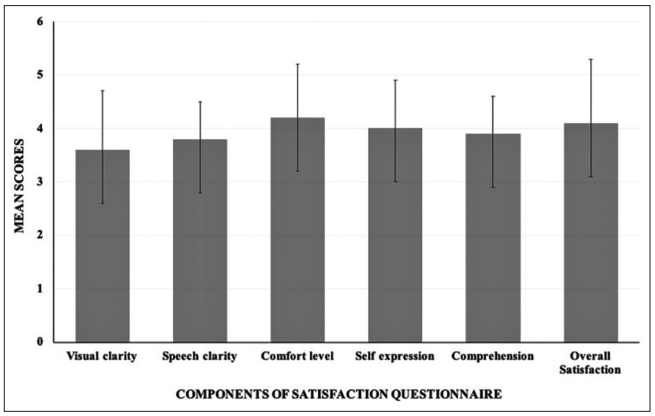

Figure 3: Participant's satisfaction with VTC-Administered ACE-III. Values are shown as Mean ± SD. Each component was scored on a Likert scale ranging from 1 to 7 (1: VTC is much worse than FTF, 2: VTC is moderately worse than FTF, 3: VTC is slightly worse than FTF, 4: VTC is as good as FTF, 5: VTC is slightly better than FTF, 6: VTC is moderately better than FTF, 7: VTC is much better than FTF). VTC—Video-teleconferencing, FTF—Face-to-face

lack of alternate form use for repeat testing, variation in the interval of administration between the two tests (range: 9 days to 198 days) and predominantly male participants (85% of the subjects were males). It is also not clear how level of cognitive impairment might impact the validity of VTC-based testing, although our range of ACE-III scores went as low as 26. This suggests that even patients with rather severe levels of impairment can potentially be tested via VTC using similar procedures, although apathy and other behavioral factors might indicate which subjects may not be appropriate for remote assessment, particularly in the absence of a family member in the room. Our patients needed the presence of at least one family member or caretaker to help with the audio or visual transmission.

To summarize, VTC-based neuropsychological screening using ACE-III appears to be a useful alternative in the Indian population to traditional FTF testing. Future studies may test this in larger sample size, design the protocol taking practice effects into account, test the cost and time effectiveness, and validate other detailed batteries to find out potential benefits and pitfalls of a VTC administration. Also, studies can look at the effect of age, education, lingualism, and dementia severity on the VTC performance. If successful, VTC administration may cut down the travel time and cost for the patients, and give them a comfortable home environment to perform neuropsychological measures.

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Nil.

Conflicts of interest
There are no conflicts of interest.

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Supplementary File

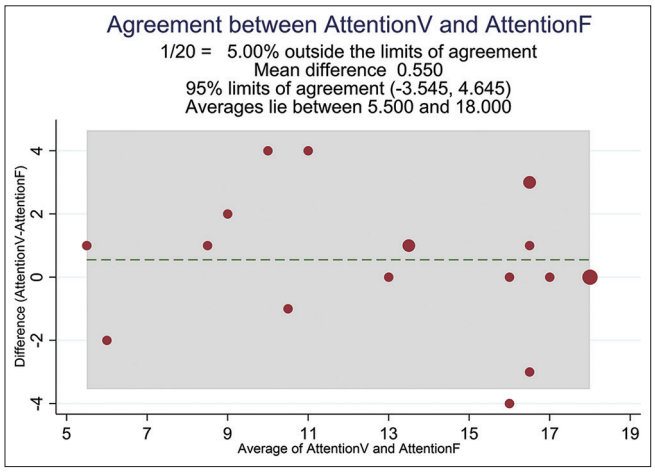

Figure 1a: Bland Altman plot for the subdomain Attention

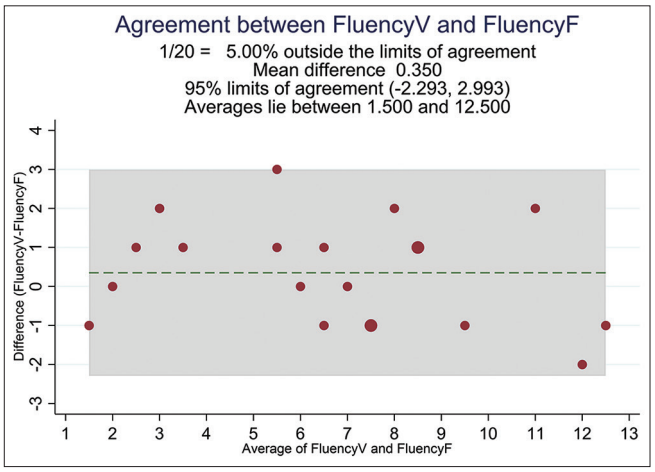

Figure 1b: Bland Altman plot for the subdomain Fluency

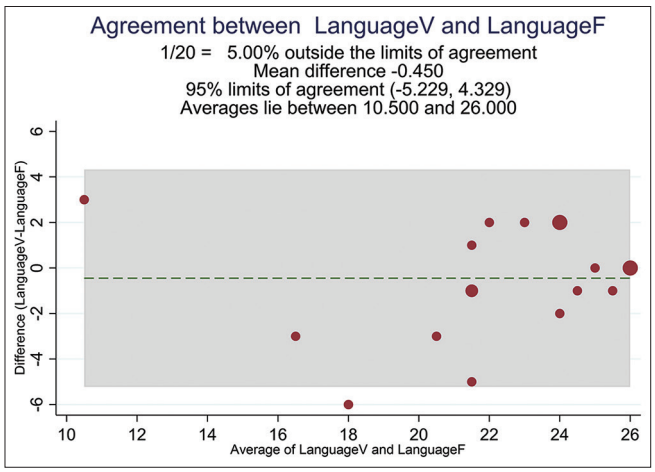

Figure 1c: Bland Altman plot for the subdomain Language

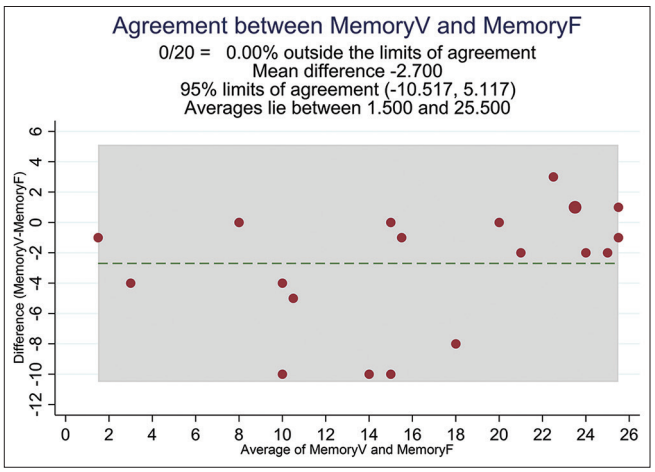

Figure 1d: Bland Altman plot for the subdomain Memory

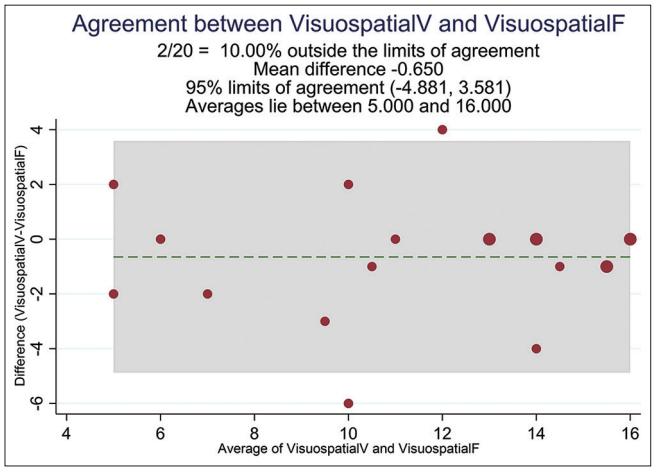

Figure 1e: Bland Altman plot for the subdomain Visuospatial