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Feasibility of administering the WAIS-IV using a home-based telehealth videoconferencing model

Susan Mahon[a], James Webb[a,b], Deborah Snell[c] and Alice Theadom[a]

[a]TBI Network, Auckland University of Technology, Auckland, New Zealand; [b]Webb Psychology, Auckland, New Zealand; [c]University of Otago Christchurch, Christchurch, New Zealand

ABSTRACT

Objective: Use of telehealth to deliver neuropsychological services has proven to be a feasible approach, however, there is limited research which has examined the reliability of home-based assessment models using a comprehensive intelligence test. The aim of this study was to examine the reliability and feasibility of a home-based videoconferencing administration of the Wechsler Adult Intelligence Scales-4[th] Edition (WAIS-IV). **Method:** Thirty healthy participants (aged 18–40 years) completed the WAIS-IV both in-person and via home-based videoconferencing utilizing a randomized counter-balanced methodology to attempt to control for an order effect. Paper record forms for Coding/Symbol Search and Blocks were sent and returned via tamper proof courier packs. Participants completed an online survey of their experiences of TNP following completion of their assessments. Group mean comparisons, intra class correlation coefficients (ICCs) and Bland-Altman measures of bias were calculated. **Results:** Findings from both modalities were highly concordant across all WAIS-IV subtests and indices, with all ICCs rated as "excellent," (≥0.9). There were no significant mean group differences and no evidence of proportional bias. The majority of participants were very satisfied with the use of videoconferencing as an application for cognitive assessment and high levels of participant compliance were observed. **Conclusions:** In this non-clinical cohort home-based videoconference administration of the WAIS-IV was feasible, reliable and acceptable. TNP may offer an alternative for those consumers where there are challenges in accessing a face-to-face service delivery model, thereby improving equity, and enabling continuation of service delivery. Future research is needed with a larger and more ethnically diverse clinical population.

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Introduction

Since its inception over three decades ago, the internet has evolved to such an extent that it is now part of our daily lexicon. It has revolutionized, the way we interact

CONTACT Susan Mahon smahon@aut.ac.nz TBI Network, Auckland University of Technology, 90 Akoranga Drive, Northcote, Auckland 0627, New Zealand.

with each other on both a personal and professional level (Alvandi, 2017). Healthcare is no exception, with traditional models of service delivery being augmented by web-based platforms. There is an emerging trend in clinical service provision to move to a more distributed and distance service delivery model, relying on online teleconferencing technology (telehealth) to maintain personal contact with consumers (Hauqe, 2021). However, the situation is challenging for neuropsychological assessment services that have standardized administration procedures that typically require in-person contact (Kruse et al., 2018; Yoshida et al., 2020).

In concert with advances in remote communication technologies in the last ten years, there has been a growing body of research on the efficacy of teleneuropsychology (TNP) across clinical and research settings (Brearly et al., 2017). However, implementation of TNP into clinical practice was limited until the emergence of the COVID-19 pandemic, where the need to provide telehealth and facilitate easy access to safe, cost effective and high-quality neuropsychological services became urgent (Sozzi et al., 2020).

Test publishers have started to modify their service delivery options to permit remote testing options; for example, emailing a link to the testing interface to the respondent or presenting stimuli over their remote testing platforms) (Pearson, 2020). Evidence that this altered service delivery allows for reliable assessment is emerging. Best practice guidelines for TNP were developed prior to the COVID-19 pandemic by several organizations: the Inter Organizational Practice Committee (IOPC), a committee comprised of the major neuropsychological organizations (Bilder et al., 2020), and academic neuropsychology groups (Hewitt & Loring, 2020; Marra et al., 2020). These guidelines note that current TNP methods pose limitations to the capacity to observe and document behavior during the administration of psychometrictests. Further, these guidelines highlight concerns around the clinical utility and validity of TNP as a method of administration for neuropsychological assessment (Guidotti Breting et al., 2020).

There are clear benefits of TNP approaches, particularly using a home-based approach. TNP via a home-based method, may augment current service provision through: 1) providing a supplementary alternative to improve access to those unable to access the typical service delivery model (e.g., living rurally or with mobility difficulties); 2) increase capacity within the service through reducing the clinician's need to travel long distances, and; 3) enabling continuation of service delivery (Barr et al., 2019). Additionally, these benefits may reduce disproportionate health inequalities within vulnerable populations.

Emerging evidence supports the feasibility and validity of using videoconferencing to conduct neuropsychological assessments (Brearly et al., 2017; Dekhtyar et al., 2020; Lawson et al., 2020; Owings-Fonner, 2019; Stricker et al., 2020) within various populations (Grosch et al., 2015; Hantke & Gould, 2020; Hodge et al., 2019) and has found that TNP can distinguish cognitive impairment (Yoshida et al., 2020). Preliminary evidence from survey data also supports acceptability from both the client and neuropsychologists' experiences for this means of service delivery (Appleman et al., 2021; Chapman et al., 2020; Harder et al., 2020; Zane et al., 2021).

Limitations of TNP research to date include the restricted range of neuropsychological assessment tools studied (e.g. use of individual tests or screening measures)

(Barcellos et al., 2021; DeYoung & Shenal, 2019; Galusha-Glasscock et al., 2016; Grosch et al., 2015), conducted in controlled environments such as satellite clinics (Appleman et al., 2021; Cullum et al., 2014) and the use of an assistant/proctor to prepare the cognitive tests, provide technical support and maintain the integrity of the assessment tools (Cullum & Grosch, 2013; Dekhtyar et al., 2020; Hodge et al., 2019; Waite et al., 2010; Wright, 2018, 2020). In the context of a global pandemic, this type of delivery model is challenging due to the need for close contact between the assistant and examinee and outside of pandemic such a requirement increases the potential costs and organizational demands of TNP.

While recent research is promising and has demonstrated equivalence of TNP compared to in-person assessment using a home-based modality (Fox-Fuller et al., 2021; Harder et al., 2020; Parks et al., 2021), these studies have employed the use of a caregiver/assistant to administer instructions and collect stimulus materials (Harder et al., 2020), used abbreviated measures, excluded visual stimuli tasks and those requiring manual manipulation (Fox-Fuller et al., 2021) and used a retrospective sample (Parks et al., 2021).

To date there is a lack of TNP research utilizing a comprehensive intelligence test via a home-based model. Previous studies have examined participants' satisfaction and tolerability of TNP (Hodge et al., 2019) in pediatric populations, however there is limited survey data within adult populations. Therefore, the aim of the current study was to test equivalence, feasibility, reliability, and participant satisfaction of TNP using home-based administration of the Wechsler Adult Intelligence Scales-4th Edition (WAIS-IV) as an exemplar cognitive assessment tool and where no in-person assistant/proctor was employed.

Methods

Ethics

This study received ethical approval from the Auckland University of Technology Ethics Committee (reference AUTEC 20/164).

Design

The study employed a mixed methods approach using a randomized counter-balanced methodology to attempt to control for order effects. Half of the participants completed in-person assessment first, followed by TNP assessment (via videoconferencing) at a subsequent date. The other half completed TNP first and in-person assessment second. Following completion of both modes of TNP delivery, a Qualtrics survey (Qualtrics, 2018) was used to obtain feedback information from participants regarding the application of video-conferencing TNP.

Participants

A sample of 30 adult participants (aged 18 to 40 years) was recruited from Auckland University of Technology (AUT) following advertising across the university, excluding the psychology department. Participants were initially screened for psychiatric and neurological disorders based on Pearson Clinical criteria (Wechsler, 2008). **Inclusion and Exclusion Criteria:** Selection criteria included: 1) aged 18 years or older; 2) fluent spoken English; 3) met the general inclusion criteria outlined in the WAIS-IV Technical and Interpretive Manual;(These criteria include (a) primary language is English, (b) not primarily nonverbal or uncommunicative, (c) normal hearing and vision, (d) normal fine gross motor ability, (e) no physical conditions, illnesses, or impairments that could affect cognitive functioning, (f)no diagnosis of a pervasive developmental disorder or Intellectual Disorder, (g) no diagnosis of a psychiatric disorder, (h) no diagnosis of a neurological condition, (i) no history of a period of unconsciousness lasting 20 or more minutes, (j) no chemotherapy within the last 2 months, (k) no history of electroconvulsive therapy or radiation to the central nervous system, (l) not currently taking medication that may affect test performance and (m) has not completed the WAIS-IV or any other measure of cognitive ability in the past 6 months prior to the testing date) (Wechsler, 2008) and; 4) provided written informed consent.

Procedure and materials

Participants were assessed using the core subtests of the WAIS-IV: Block Design, Similarities, Digit Span, Matrix Reasoning, Vocabulary, Arithmetic, Symbol Search, Visual Puzzles, Information and Coding. The WAIS-IV was selected because this is the most widely employed measure of intellectual ability internationally. It is also the most widely employed measure of intellectual functioning during neuropsychological assessment. These specific subtests allow calculation of the core indices of the WAIS-IV including the full-scale index score. Both administration modalities (TNP and in-person assessment) conformed to the guidelines and specific set of protocols for delivering traditional in-person administration as stated in the WAIS-IV Administration and Scoring Manual (Wechsler, 2010) and remote administration (via Q-global) of the WAIS-IV, developed by Pearson Clinical (Pearson, 2020).

Pearson Clinical provided access to the online copyright test materials for the WAIS-IV (Australia and New Zealand) (via Q-global portal) and provided blocks and response booklets for use in-person and TNP.

Zoom was used for the online videoconferencing platform (Zoom Video Communications Inc, 2016), delivered on a laptop or desktop computer with a front-facing camera (to maximise consistency participants were barred from utilising a tablet as a web-based platform for delivery of telehealth (Bilder et al., 2020). Important features of this platform are the creation of an encrypted virtual room, end to end encryption, optimal video quality even for low-bandwidth locations and HIPAA compliance (Owings-Fonner, 2019). A second camera was utilized (cell phone) to view Block Design and Symbol/Coding tasks (see Figure 1).

Assessments were delivered online and in-person by trained researchers (examiner) holding, at minimum, a post-graduate psychology degree. For the TNP administration, the examiner was based at the Neuropsychology Test Library based at AUT Department of Psychology, with the participant at home. Prior to the assessment the examiner sent a Zoom link to the participant (via email). Full instructions on how to access the online administration and set up the second camera were sent to the participant

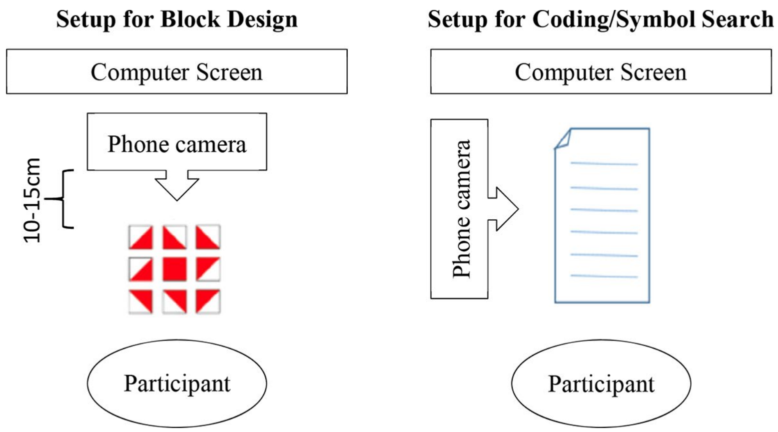

Figure 1. Illustration of TNP workspace setup.

prior to the assessment. Prior to the online home-based assessment date, paper record forms for two of the subtests (Coding and Symbol Search tasks), a set of blocks (Block Design task) and a cell phone stand were sent via courier to the participants who were allocated to the TNP group. To maximise security of the home setting, participants were asked to arrange their workspace in a private room with their back to the door (allowing the computer camera to detect any intrusion into the workspace). Prior to beginning testing the participant was asked to scan the room with the phone camera allowing the examiner to confirm that there was no third-party observer. TNP participants were required to open the sealed courier packs with the record forms and test materials in front of the examiner and to remove materials on instruction from the examiner. The placement of test materials and second camera is demonstrated in Figure 1 below. Following completion of each of the processing speed tasks (Coding and Symbol Search), the participant was required to hold up the completed record form to the computer camera, and the examiner took a screenshot of the record form, then the participant was asked to place the completed form in the return envelope on-camera. At conclusion of testing the participant placed the response booklet, cell phone stand and blocks in the pre-paid courier envelope and sealed the envelope on-camera.

For the in-person assessment, the examiner and participant were in the same room located in the Neuropsychology Testing Library based at AUT. All responses for the individual subtests were manually recorded during each allocated administration method by the researcher on paper forms. Qualified neuropsychologists (Drs Mahon and Webb) scored the subtests, and scaled scores were entered into the REDcap database (Harris et al., 2009). A $NZ50 gift voucher was provided to each participant upon completion of the two testing sessions.

Statistical analysis

Descriptive statistics were generated to summarize the demographic characteristics of the sample. Means (standard deviations; SD) are presented for each subscale and index. Data collected from the two testing sessions across the ten WAIS-IV subtests were analyzed quantitatively using SPSS version 25 software, all statistical tests were two sided, and $p = 0 <. 05$ indicated significant results. The variable of interest was the concordance of findings between the two assessment sessions. Concordance was calculated using statistical strategies that are most commonly employed in this literature (Grosch et al., 2015) namely comparison of group means (repeated measures ANOVA), Bland-Altman analysis and correlation of findings between the groups (intra-class correlation). All survey data were analyzed quantitatively employing SPSS software.

Results

Demographic characteristics of the sample ($N = 30$) included a Mean age of 23 years (ranging from 18 to 40 years). Just over half of the sample identified as New Zealand (NZ) European ($n = 17$), the remainder identifying as Asian. A majority identified as Female ($n = 19$), and the sample had an average of 16 years education. The median time between testing sessions was seven days (range = 24 days). Linear regression analyses were undertaken for each of the main indices to examine the effect of time between testing sessions on the discrepancy between index scores from the first to the second testing. No effect of duration of re-test delay was noted for each of the major indices (F range: .49 − 2.56; all p's >.05; p range: .12 − .49).

Compliance with security procedures was assessed by visual comparison of the returned booklets with the screenshot images of the response booklet and by examining the returned envelopes for evidence of tampering. There were no security breaches among participants and there was 100% compliance with the return of the test materials via secure prepaid courier packs. On one occasion the courier failed to collect the test materials despite two requests, and the participant returned the materials to the university themselves.

Paired-sample statistics were conducted for each of the subscales and indices comparing in-person with TNP testing modality. A series of repeated measures one-way ANOVAs were conducted to examine between-group differences for each of the subscales and major indices and no between group differences were evident (all p's > 0.05; p range: .23–.94). Means for all subscales and major indices across both modalities were very similar (Table 1). Repeated Levene's statistics showed no significant deviation from the assumption of homogeneity of variance between the two groups across all subscales and major indices (all p's > .05; p range: .62–.99).

Analysis of reliability was undertaken by examining the Intraclass Correlation Coefficient (ICC) for each subscale and index. All ICCs were very high (≥ .90 see Table 1) suggesting a high level of reliability between the testing modalities.

Bland-Altman plots (Altman & Bland, 1983) were examined visually and statistically. Both forms of analysis confirmed the similarities of all results between test modalities (in-person and TNP). Examining the plots at the 95% confidence intervals for difference between the conditions (in-person and TNP) showed no evidence of bias across the range of abilities.

To examine for proportional bias, linear regression was calculated to predict the difference between the means based on the mean for each of the two (in-person and TNP) major index scores. In each case, no significant findings were evident and

Table 1. Descriptive statistics and intraclass correlation coefficients examining the relationships between in-person and Teleneuropsychology administrations on the subscale and index scores of the Wechsler Adult Intelligence Scales-IV ($N = 30$).

	In-person Subscale Mean (*SD*)	Teleneuropsychology Subscale Mean (*SD*)	Intraclass Correlation Coefficient*
Block Design	10.93 (3.50)	11.13 (3.70)	0.97
Similarities	12.97 (2.68)	13.07 (3.05)	0.93
Digit Span	10.57 (2.46)	10.45 (2.65)	0.96
Matrix Reasoning	11.10 (2.70)	10.93 (2.88)	0.90
Vocabulary	12.43 (3.08)	12.40 (3.20)	0.98
Arithmetic	10.30 (2.83)	10.50 (2.99)	0.96
Symbol Search	12.60 (3.15)	12.20 (3.09)	0.90
Visual Puzzles	11.50 (3.00)	11.20 (3.02	0.94
Information	11.57 (3.09)	11.77 (3.45)	0.98
Coding	12.00 (3.04)	12.10 (2.92)	0.93
	In-person Composite Mean (SD)	Teleneuropsychology Composite Mean (SD)	
VCI	113.17 (14.77)	113.57 (15.94)	0.98
PRI	107.60 (14.68)	106.40 (15.27)	0.97
WMI	102.30 (13.04)	102.57 (13.75)	0.97
PSI	112.40 (14.69)	111.60 (13.92)	0.90
Full Scale IQ	111.00 (14.51)	110.93 (12.25)	0.98

Note. * = all statistics $p < .001$; VCI = Verbal Comprehension Index; PRI = Perceptual Reasoning Index; WMI = Working Memory Index; PSI = Processing Speed Index. SD = Standard Deviation. IQ = Intelligence Quotient.

no significant regression equations were identified. Table 2 shows the main findings of the regression analyses.

Test-retest reliabilities were examined for each subscale and index, comparing first test administration with second test administration. Test-retest reliabilities were high ranging from a low of .90 for Matrix Reasoning to a high of .98 for Full Scale IQ.

Following the two testing sessions participants were sought to respond to a series of closed and open survey questions; 25 out of the 30 participants completed the survey. All participants rated their confidence with computing as 'Average' or higher and all but four participants reporting having had some prior experience of video-conferencing. Overall satisfaction with the TNP modality appeared to be high. The median response to each of the survey items was 'Very Satisfactory'. Most respondents (22 of 25) indicated that they would be 'Likely' or 'Very Likely' to be willing to undergo cognitive assessment via TNP modality in the future. Almost all participants rated the practicality of the TNP modality as 'Adequate' or higher (24 of 25).

Table 3 depicts comparison data across a number of dimensions of the assessment modalities. Taken *in toto*, in terms of participant experience there was a modest but significant preference for the in-person modality over the TNP modality. In general participants reported the audio quality, stimuli quality, and privacy to be superior in the in-person modality than the TNP modality. More people expressed a preference for in-person modality over TNP (15:10). Women preferred the privacy of the in-person modality over men (X^2 (2, $N = 25$) = 0.89, p = .004). That finding was due to women being more likely than men to report the privacy of in-person modality as "Excellent", but there was no gender difference in the reporting of satisfaction with TNP privacy (X^2 (3, $N = 25$) = 3.21, p = .36). Audio quality represented the weakest dimension of the TNP modality, with five of the participants rating audio quality, "Less than Satisfactory".

A series of open survey questions were administered. One survey item asked about perceived cultural barriers experienced during the TNP modality and no participants

Table 2. Regression of difference between in-person and Teleneuropsychology administration of the Wechsler Adult Intelligence Scales-IV index based on mean of both index scores (N = 30).

WAIS-IV Index	Regression Gradient (β)	t (df)	Significance (p)	R^2
Verbal Comprehension Index	.05	1.08 (29)	.34	.03
Perceptual Reasoning Index	.04	.58 (29)	.57	.01
Working Memory Index	.04	.55 (28)	.59	.01
Processing Speed Index	-.06	-.49 (29)	.63	.01
Full Scale IQ	.05	.96 (29)	.34	.03

Table 3. Participant satisfaction survey findings comparing experience of Teleneuropsychology and in-person modalities ($n = 25$).

Survey item	*Median in-person rating*	*Median Teleneuropsychology rating*	Z^1	p	r^2
Audio quality	4	3	−4.12	<.001	-.58
Visual stimulus quality	4	3	−3.79	<.001	-.54
Privacy	4	3	−3.82	<.001	-.54
Comfort	3	3	−1.33	.18	-.19
Convenience	3	3	−1.32	.19	-.19
Ease of use	3	3	−2.54	.01	-.36

who identified with an ethnic minority group, identified any such barriers. A second question asked respondents for their experiences of difficulties and barriers experienced during the TNP administration. One participant noted the presence of distraction during assessment (children in the home), five noted challenges in the form of setting up the workspace to ensure privacy and security of the setting, also pragmatics associated with setup of the second camera. Two participants noted some anxiety regarding the unfamiliar context of tele-conferencing and a lack of confidence in their ability to manage the demands of software and cameras. Three participants recommended having a 'meet and greet' session prior to testing to set up and practice the TNP modality prior to testing (familiarization). Three participants noted challenges with audio and two of those referenced difficulty discerning digits during Digit Span. Two participants noted finding the TNP session fatiguing and one recommended dividing the session.

Discussion

This study examined the feasibility, and test-retest reliability of a home-based videoconferencing model for administration of a comprehensive intelligence test. Findings indicated that there was a high level of concordance between WAIS-IV test results from in-person and TNP modalities, with all ICCs falling within a range described as excellent (Koo & Li, 2016). In this sample ICCs for all subtest and indices were comparable or superior to the published test-retest reliabilities of the WAIS-IV (Wechsler, 2008). These findings reflect a high level of reliability, and it is noteworthy that the ICCs are generally superior to those seen in other studies (e.g., Cullum et al., 2014; Fox-Fuller et al., 2021) where ICCs have typically fallen about or below 0.90.

The findings suggest that the TNP methodology employed here may be a reliable method to assess intelligence and related cognitive processes. Several studies have shown subtle differences in task performance between TNP compared to in-person testing (Grosch et al., 2015; Wadsworth et al., 2018), while other studies have shown similar findings to the current study with no differences (Dekhtyar et al., 2020; DeYoung & Shenal, 2019; Galusha-Glasscock et al., 2016; Harder et al., 2020; Wright, 2018, 2020). Prior research has validated TNP in a variety of clinical and research settings, however greatest empirical support has been shown for verbal cognitive tests without manipulated stimuli in highly controlled environments (Brearly et al., 2017; Hewitt & Loring, 2020).

New and emerging research has supported home-based TNP as a valid assessment method (Fox-Fuller et al., 2021; Harder et al., 2020; Parks et al., 2021), however studies have been limited by a restricted range of neuropsychological assessment tools and employed assistant/proctors. To the best of our knowledge this is the first study which has administered the entire WAIS-IV including tasks requiring manual manipulation of test materials and using an in-home TNP assessment modality without assistance of a proctor or assistant.

Findings under these controlled conditions suggested that test results obtained by in-home testing procedures can be practical and reliable. Although more participants preferred the in-person modality to the TNP modality, most also reported a high level of satisfaction with the TNP modality and rated themselves as likely to make use of the TNP modality if that was offered in future. Several participants recommended having a 'meet and greet' session prior to testing; this is consistent with a recent protocol (Hewitt & Loring, 2020). These findings have been replicated in other studies which have reported overall satisfaction with TNP (Chapman et al., 2020; Harder et al., 2020; Parikh et al., 2013). TNP via a home-based model may offer significant advantages and opportunities for increasing access to, and decreasing costs of, neuropsychological services for both the client and neuropsychologist. TNP modalities offer the potential to reduce healthcare inequalities and reduce the relative health burden of people who live in regional and remote areas and/or those with mobility difficulties – those who have limited access to specialist services including neuropsychology services.

Some technical challenges (provision of testing materials to participant homes then returning them to the specialist in a secure and reliable manner) were able to be managed in this educated and motivated sample of participants. Quality of audio, privacy, the fatiguing nature of the TNP modality and the effort required for the participant to arrange their testing space remain perceived barriers to satisfaction with TNP, but those variables do not appear to measurably negatively impact on TNP test performances and, despite challenges, participant satisfaction with TNP was generally rated to be very high. Home-based TNP using this methodology is not complex but is logistically demanding on the assessor and may be challenging to coordinate in high volume clinical settings or in settings with low levels of administrative support.

It has been previously observed that there are health inequalities in respect of access to technology for TNP (Marra et al., 2020). While TNP offers the potential to expand access to geographically isolated communities, financial constraints are likely to limit access to technology and cultural variables may limit acceptability by some groups (Scott et al., 2021). A limitation to the current feasibility study is the restricted range of participant ethnicities employed and therefore the generalizability of the findings to more culturally diverse clinical populations. Although logistical challenges and test material security issues were able to be managed in this volunteer sample of educated and motivated participants, this has not been demonstrated in a diverse clinical population where cognitive capacity and motivation may be reduced.

The reason for the higher-than-usual ICCs in this study is not known but may relate to sample-specific variables including the healthy young and relatively homogenous non-clinical sample, the high level of standardization of administration and scoring procedures of the WAIS-IV in comparison with other frequently used measures in this literature (e.g., Clock Drawing), and potential practice effects caused by the short re-test intervals. Examiner expectation effects need to be considered as a possible confounding factor and might in future studies be managed by blinding and randomizing allocation of examiners and administrations.

This feasibility study has successfully employed a methodology for delivering and returning test materials to and from the participant's home, while aiming to maximize security of the test materials and the testing setting in the procedure. Full compliance with all directions was obtained in this educated volunteer sample however it is not clear that would be the case in a clinical sample. Additionally, the use of an in-home second camera (cell phone) afforded the tester with very good evidence as to compliance with test instructions and security measures; however, this added a level of complexity to the assessment, and it is not yet clear that lower cognitive functioning clinical samples will be able to cope with the technical demands of running a second camera. Further research is required to establish feasibility of these approaches with clinical samples before this strategy should be used in clinical settings.

In conclusion, TNP has the potential to significantly improve access to neuropsychological services, especially for those people who are unable to get access to cognitive assessment due to financial barriers, geographical isolation, transport difficulties or other reasons.

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ORCID

Deborah Snell http://orcid.org/0000-0003-1664-0603
Alice Theadom http://orcid.org/0000-0003-0351-6216

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