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Teleneuropsychological Assessment During the COVID-19 Pandemic: Where Do We Go from Here?

Manu Sharma[1], Himanthri Weerawardhena[1], Alexandra K. Wall[1], Baeleigh VanderZwaag[1], Daniel L. Andruchow[1], Hawra Al-Khaz'Aly[1], Daniel R. Cunningham[1], and Brandy L. Callahan[#]

[1]University of Calgary, Calgary, AB, CA
[#]Advisor

ABSTRACT

Objective: With the rapid spread of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which causes the coronavirus disease 2019 (COVID-19), and the subsequent alterations to the delivery of health care, telehealth has become an essential service worldwide. Neuropsychology is similarly attempting to adopt telecommunication to deliver neuropsychological services to clients. The purpose this article is to review the utility and value of teleneuropsychological assessment, discuss practical issues and possible barriers related to its implementation and use, and propose considerations and achievable goals to increase the use, acceptance, and clinical utility of teleneuropsychological evaluations.

Method: We reviewed the published literature to extract information about the efficacy and limitations of the methods that are currently used to deliver teleneuropsychological services, as well as current guidelines and ethical principles most salient to teleneuropsychological practice.

Conclusions: Current literature suggests that teleneuropsychological assessment is feasible and acceptable in many patient populations. Practitioners wishing to implement teleneuropsychological assessment should consider using secure testing platforms, participate in continuing education on the topic of remote/online evaluation, and become familiar with alternative technologies. We implore clinicians, researchers, and trainees who have successfully integrated teleneuropsychology into their current practice to keep detailed records of their methods and results in hopes of adding this data to a larger data repository or to publish these results to add to the small, but growing, teleneuropsychology literature. Future research should focus on generating new normative datasets for tests administered remotely, which will involve the pooling of data from multiple sources using teleneuropsychological assessment.

Introduction

The COVID-19 pandemic, caused by SARS-CoV-2, has pushed neuropsychologists to embrace teleneuropsychological practice which, when appropriately used, can decrease risk of client and staff exposure to SARS-CoV-2 and increase accessibility to healthcare in remote areas. Further, the threat of future pandemics cannot be ignored, as risk may increase in coming years as industrial food animal production increases human's proximity to animals and animal-borne illnesses (e.g., Graham et al., 2008; Jones et al., 2008). Therefore, it is imperative that we be well-prepared for future pandemic situations that will require reduced physical access to healthcare, physical distancing, and other measures taken to reduce risk of virus contraction. At this point, neuropsychologists, researchers, and trainees must forge a path to overcome barriers and limitations to teleneuropsychology. Through the use of technology, updated psychometric theories, and large data repositories and data sharing, effective teleneuropsychological assessment practices can be achieved.

In this commentary, we briefly describe current teleneuropsychological practice and its limitations and barriers to its adoption in clinical settings. We propose some considerations and achievable goals to increase the use, acceptance, and clinical utility of teleneuropsychological evaluations.

The Current State of Teleneuropsychology

In the context of the COVID-19 pandemic, the ideal neuropsychological evaluation is one that minimizes exposure risk for both client and staff. In this respect, teleneuropsychological evaluation is a worthwhile investment because it allows for the remote (i.e., no-contact) assessment of many aspects of cognition. Remote neuropsychological assessments can be broadly categorized by administration environment: within a supervised remote site or in-home. In a supervised remote site setting, clients are assessed in-person in a facility, such as a satellite clinic, by a trained psychometrist, often using computerized measures or document cameras, and are supervised remotely over videoconferencing platforms (VC; e.g., Skype) by a neuropsychologist (Domen et al., 2019). Thus, supervised remote sites allow access to neuropsychological services in areas that do not have that level of specialty care, with the benefit of controlling the client's environment. In contrast, in-home assessments include tests conducted in one's home such as web-based measures that can be entirely self-administered, evaluations completed over the phone, and some standard paper and pen measures administered over VC. However, in-home teleneuropsychological evaluations lack any control over the client's environment (noise, interruptions, etc.). Both assessment methods therefore have the potential to allow access of neuropsychological assessment services to those in rural and underserved locations, with the added advantage of increased environmental control in at supervised remote sites.

While previous research shows strong utility for administration of neuropsychological measures via VC (Brearly et al., 2017; updated by Marra et al., 2020), aspects of teleneuropsychology remain underrepresented in research (e.g., validity and clinical utility of self-administered web-based assessment measures, and computerized testing). We will briefly provide an overview of the teleneuropsychology literature for VC administered neuropsychological measures, self-administered web-based measures, measures administered via telephone, with the specific objective to provide directions and achievable goals for the future of teleneuropsychological practice.

Videoconference Neuropsychological Evaluation

VC involves the live online administration of neuropsychological tests using a camera-embedded computer or tablet to allow the examiner to view, communicate with, and assess the individual. In-home assessments using VC typically contain high-quality audio and full-motion video for a two-way view of the individual and examiner (Adjorlolo, 2015; Brearly et al., 2017; Castanho et al., 2017).

When compared to in-person assessments, neuropsychological assessments via VC yield similar scores across several standard verbally mediated tasks, including digit span, verbal fluency, and list learning measures (Brearly et al., 2017), and common screening measures (e.g., Montreal Cognitive Assessment [MoCA]; Abdolahi et al., 2016; Chapman et al., 2019). An inherent limitation to VC administered neuropsychological measures is the difficulty with real time supervision and scoring of visually mediated and motor dependent tasks (e.g., Clock Drawing Test). However, these limitations can be overcome by validating task performance with webcams (e.g., having the webcam repositioned to capture the client's work area, or having the client hold up the response sheet to the webcam; Cullum et al., 2006; Lindauer et al., 2017; Cullum et al., 2014). It is also important to consider computer resolution when administering VC assessments. Images presented in-person may not be the same size or resolution as those administered via VC. In addition, studies involving participants with high-speed internet connections noted negligible differences in videoconference and on-site conditions; however, there was greater variability in studies utilizing poorer internet speed and older participants (Brearly et al., 2017).

VC neuropsychological evaluations have been successfully applied to individuals with stroke, cancer, dementia, mild cognitive impairment, major depressive disorder, anxiety, post-traumatic stress disorder, autism spectrum

disorder, as well as with school-based cognitive and achievement testing (Galusha-Glasscock et al., 2016; Godleski et al., 2012; Grosch et al., 2011; Hess & Audebert, 2013; Parmanto et al., 2013; Smith et al., 2017; Wadsworth et al., 2017). In fact, large percentages of clients (up to 98%) show acceptance and satisfaction for VC neuropsychological assessments (Dang et al., 2018; DeYoung & Shenal, 2019; Feenstra et al., 2018; Harrell et al., 2014; Parikh et al., 2013), with 90% of caregivers of mildly cognitively impaired patients preferring it to traditional in-clinic assessments (Dang et al., 2018). However, those with greater cognitive impairment show preference for in-person evaluation (Parikh et al., 2013). Overall, VC is an accepted and effective method of assessment for many clients, making this a viable alternative for traditional assessment.

Self-Administered Web-Based Instruments

Self-administered online instruments are web-based measures that can be completed without supervision. A multitude of online instruments have been developed for self-administration and are generally used as screening tools and assessments of general cognition (e.g., Domen et al., 2019; Feenstra et al., 2018; Mackin et al., 2018; Trustram Eve & de Jager, 2014), with some also designed to specifically monitor longitudinal changes in cognition (e.g., Ruano et al., 2016; Wesnes et al., 2017; Zakzanis & Azarbehi, 2014). Several of these self-administered online instruments have been validated in multiple patient populations (e.g., Biagianti et al., 2019; Trustram Eve & de Jager, 2014; Zakzanis & Azarbehi, 2014). Additionally, widely used and clinically-validated computerized cognitive assessments, such as the Cambridge Neuropsychological Test Automated Battery (CANTAB; Cambridge Cognition Ltd., 2019), have the potential to be offered in a web-based self-administered setting (see www.cambridgecognition.com). Access and use of these online validated tools can increase the efficiency of a teleneuropsychological assessment, in that the patient can complete the screening before meeting with the neuropsychologist.

Telephone Assessments

Some neuropsychological measures can be administered over the phone as a convenient way to provide general screening. Individuals do not need access to the internet, which makes telephone assessments especially attractive for use with patient populations who are less likely to have reliable internet access (e.g., those living in remote locations). However, without the ability to directly observe clients, these telephone assessments are limited to verbal components. Some traditionally face-to-face neuropsychological measures have been adapted for use over the phone, such as the MoCA, by reweighting items and removing visual components (Wong et al., 2015). Other neuropsychological assessments such as the Cognitive Telephone Screening Instrument (COGTEL; Kliegel et al., 2007) and Telephone Interview for Cognitive Status (TICS; Brandt et al., 1988) have been designed specifically for telephone administration. The COGTEL and the TICS (modified) have demonstrated moderate to high degrees of agreement between cognitive assessments delivered in person and conducted over the telephone (Castanho et al., 2016; Kliegel et al., 2007). Thus, telephone assessments may serve as useful screening tools when computer access is limited or is not preferred.

Current Barriers and Limitations of Teleneuropsychology

Teleneuropsychology is not without its limitations. Relatively minor shortcomings of VC include restrictions on the practitioner's view of the client and the testing environment, which limit the observations that can be made about a client's subtle behaviors. The practitioner is also unable to identify distractors that may be present in the client's environment and prevent interruptions and excessive noise that may interfere with complete attention to the task. The practitioner is not able to take in qualitative observations and develop a more personal relationship with the client. There are also logistical difficulties in administering motor-based tasks, or measures that require the client to manipulate stimuli (e.g., Block Design; Wechsler, 2008). It is important to consider clients' individual situations which may

affect their ability to complete the assessment in a home environment, such as computer access, internet quality, and ability to download programs as needed for certain tasks (Bauer et al., 2012).

More major limitations related to teleneuropsychological assessment include difficulty in emergency management, limited variability in populations that can be assessed using this method, deviations from standardized protocols, and issues related to copyright infringement. First, emergency management is important to consider as many patients may suffer from a range of mental illnesses and health conditions, and may express suicidal thoughts or encounter a medical emergency such as a seizure. Clinicians should consider establishing an emergency protocol prior to beginning assessment, which may involve obtaining the contact information of a third party who can assist in an emergency, as well as ascertaining the patient's exact location in the event that medical help is required. Second, some populations may not be suitable for teleneuropsychological assessment, for example those with behavioral dysregulation or severe cognitive impairment. For these individuals, depending on the nature of the referral question, an in-person assessment may be necessary. A third challenge is that deviating from standardized procedures (i.e., moving paper-and-pencil tests online) essentially render the procedures experimental, though a recent review and meta-analysis suggest negligible differences in scores between in-person and VC administration (Brearly et al., 2017). An associated problem is that interpretive normative data is no longer applicable for reference; increasing use of teleneuropsychological practices will require the development of normative data specific to online tests. Lastly, copyright issues and protection of testing materials can prevent the use of certain tests through an online platform. It is the duty of the neuropsychologist to identify when copyright infringement might occur and find a way to appropriately move the task online or identify an alternate, appropriate, online neuropsychological measure. For instance, testing materials can be protected to some extent by using platforms containing test materials which are password protected, or in a format which is not easily duplicated, such as through screen-sharing during a VC assessment.

Several barriers hamper the successful implementation and integration of teleneuropsychological services. Ethical considerations include concerns regarding privacy, breaches in confidentiality, or lapses in test security (Langarizadeh et al., 2017; Stoll et al., 2020). It is critical that practitioners maintain the confidentiality and security of patient data in terms of data transmission (e.g., emails) and data storage. To mitigate the risk of compromised data security and breaches of confidentiality, neuropsychologists should keep abreast of developments in security and update security measures at their practice as appropriate (American Psychological Association, 2013; Stoll et al., 2020). In addition, practitioners should take care to use VC applications like Skype for Business, that do meet requirements for security set out by the Health Insurance Portability and Accountability Act, instead of Skype, which does not (HIPAA Journal, 2017). Overall, with thoughtful consideration for best practices, these ethical concerns can be addressed.

Legal barriers such as practicing across state lines (for example) also affect the implementation of these services. Neuropsychologists should be trained in the technical and legal aspects of teleneuropsychology prior to administering teleneuropsychological services to clients (Brearly et al., 2017). The Telebehavioral Health Institute (https://telehealth.org), for example, offers online training courses on these aspects of telepsychology, such as How to Legally Practice Over State Lines, and Essential Telehealth Technologies.

Furthermore, teleneuropsychological practice has been limited by the lack of desire or willingness on part of clinicians to use technological modalities to provide services (Chakrabarti, 2015; Fantus & Mishna, 2013; Rogove et al., 2012; Stoll et al., 2020), potentially due to concerns regarding privacy, establishing rapport, technological limitations, education and training, as well as licensing and credentials (Cowan et al., 2019). The American Psychological Association's Guidelines for the Practice of Telepsychology acknowledge that "the psychologist's knowledge and competence in the use of the telecommunication technologies being utilized" (APA, 2013, p. 791) is a significant barrier to telepsychology and, therefore, teleneuropsychology. As such, it becomes the responsibility of neuropsychologists to ensure their competency through professional training, educational experience such as attending professional training programs, consultation with other neuropsychologists, and risk management practices (APA, 2013). Further, to ensure clinician competency, clinical psychology training programs could implement modules on online

assessment as part of the regular curricula. Similarly, psychology regulatory bodies could mandate that neuropsychologists complete modules in telepsychology (e.g., Telepsychology Best Practices 101 series offered through APA) and online test administration as part of continuing education practices and professional training. Practitioners and trainees may also choose to enrol in telemental health training programs, such as the Texas A&M Telebehavioral Care Program, to learn to provide neuropsychological services through technological means (McCord et al., 2015). To improve the utility of teleneuropsychology, clinicians must not only ensure their own competency, but also become more accepting of this service modality.

Considerations to Improve Teleneuropsychology

Computerized Tests & Technology

While technological advances may seem daunting, we believe they will ultimately allow for improvements to neuropsychological assessment. One such opportunity lies in the use and development of computerized testing, which has several benefits. While there are significant initial costs of transitioning to using computerized cognitive measures (e.g., purchasing devices, software, and continued licenses; Kessels, 2019), it is a worthwhile investment. First, the reliance on human administration is substantially reduced, thereby reducing human error that is inherent in administering neuropsychological measures. For example, current paper-and-pen neuropsychological measures require adjustments to administration based on reversal and discontinuation rules (e.g., subscales of the Wechsler Adult Intelligence Scale [WAIS]). This can be automated with computerized *adaptive* testing, which makes these adjustments based on the individual's performance (see Bilder & Reise, 2019).

A further benefit of computerized testing is the potential for incorporating more modern psychometric theories to obtain more nuanced data. For example, item response theory is a statistical modelling approach that assumes that latent traits are responsible for an individual's response on each item of a test. That is, different responses on a measure with multiple possible responses hold different meaning (Preston & Reise, 2014), which may be due to some latent factor within an individual (Bilder & Reise, 2019; Reise & Waller, 2009). Similarly, when presented with multiple options on a given measure, such as Matrix Reasoning (Wechsler, 2008) which has five possible responses, each of the four incorrect responses would have different meaning. Thus, an emphasis is placed on analysis of errors and strategies used to complete tasks, rather than just total scores on a measure. In fact, research into errors and task completion strategies has been conducted on several regularly used neuropsychological measures, showing improved sensitivity to detect traumatic brain injury using the Digit Span test (Diaz-Orueta et al., 2020; Woods et al., 2011), and ability to distinguish between subjective cognitive impairment, mixed dementia and Alzheimer's disease on verbal fluency tasks (Diaz-Orueta et al., 2020; Konig et al., 2018). Incorporating item response theory while developing computerized neuropsychological measures will then increase the efficiency of neuropsychological evaluations as greater information can be gathered at the item level of a measure. Thus, a shift in the neuropsychological assessment paradigm is warranted. Specifically, we must adopt a culture of openness to change where resources are allocated to create, validate and train clinicians on using computerized neuropsychological assessment measures.

The future of teleneuropsychological assessment will benefit from technologies that provide supplementary objective data that can be used to assist with diagnosis and interpretation. One such tool is eye tracking, for which cognitive measures exist and are being developed. For example, the visual paired comparison task records eye movement patterns during exposure to different visual stimuli and can differentiate between cognitively healthy individuals and those with amnestic mild cognitive impairment (Seligman & Giovannetti, 2015) and Alzheimer's disease (Bott et al., 2018; Zola et al., 2013). While eye tracking is customarily measured in the laboratory environment, there is evidence to support eye tracking measurement using device-embedded cameras (e.g., camera in a laptop; Bott et al., 2018), which could be convenient to implement in teleneuropsychological assessments. With further research into the clinical uses of eye tracking, certain eye movement profiles may be identified in different patient populations (e.g., concussion; Bin Zahid et al., 2018; Samadani et al., 2016), which can further be used to help confirm a suspected deficit or diagnosis.

Other technologies show merit in providing supplementary health information to assist in teleneuropsychological evaluation and can be conveniently worn by the client. Emerging research using electroencephalography (EEG), typically acquired in a laboratory setting, shows promise as an assessment tool for cognitive impairment, with good clinical utility (Ghosh Hajra et al., 2016), and can also be measured using a portable wearable device (Fickling et al., 2019). Other wearable accessories can provide similar physiological information such as heart rate and electrocardiogram data (Bilder & Reise, 2019). Other technologies include a digitizing pen that is used in a digitized version of the Clock Drawing Test (i.e., the Digital Clock Drawing Test), often used as a screening tool for a wide range of neurological disorders, including Alzheimer's disease (Freedman et al., 1994). The digitizing pen can detect pauses in drawing, pen strokes, time, and minor tremors while drawing, and takes advantage of machine learning to create prediction models (Davis et al., 2014). The Digital Clock Drawing Test shows clinical utility in differentiating healthy controls from mild cognitive impairment and Alzheimer's disease (Davis et al., 2014) and offers possible significant improvements in accuracy to detect early cognitive impairment (Souillard-Mandar et al., 2016). We should expect and strive for the future of teleneuropsychological assessment to incorporate these multimethod measurement tools to be used in home and at remote assessment sites. In the context of a teleneuropsychological evaluation, these tools can provide supplementary information of testing experience that might go unnoticed over VC.

The development and continued improvement of computerized assessments in combination with incorporating new technologies for teleneuropsychological assessments in the near future will result in shorter teleneuropsychological assessments that optimized to provide practitioners with adequate data to make diagnoses and interpretations. It will further result in greater access to neuropsychological assessments for individuals in remote areas or who are unable to leave their home (e.g., those at higher risk of complications from COVID-19).

New Norms and Data Sharing

The development of computerized tests and use of newer technologies requires rigorous research to develop appropriate normative data for comparison and new standardized administration methods. Specific attention must be placed on hardware (i.e., differences between touchscreen, mouse, trackpad, and keyboard, and differences between desktop, laptop, and tablet) and software (e.g., latency differences in presentation of stimuli between devices; Germine et al., 2019). For example, the Trail Making Test requires the client to connect circles containing numbers or circles containing numbers and letters in ascending order, in which scoring is based on time to completion (Reitan, 1958). Time to completion is significantly impacted by screen size and type of device (touchscreen tablet vs. desktop; Germine et al., 2019).

A task of this magnitude requires significant resources. The National Institute of Mental Health (NIMH) has already developed the infrastructure for this work and is currently collecting normative data for the most widely used neuropsychological measures via the NIMH Data Archive (NDA; https://nda.nih.gov/). In support of this initiative, the National Neuropsychology Network (NNN; https://www.sistat.ucla.edu/NNNWeb/index.html) is currently conducting a demonstration program, acquiring neuropsychological data in an effort to aggregate item-level data from the most widely used neuropsychological measures into the NDA (see Bilder & Reise, 2019). The list of neuropsychological measures for which data is being acquired is extensive but does not yet include teleneuropsychological instruments. While these may not soon be added to the NDA, we, as a first step, encourage collaborative discussion and hope to increase awareness of this viable option in conducting neuropsychological evaluations that extend access to care and reduce disease exposure risk for the vulnerable.

Conclusion

The COVID-19 pandemic has forced clinicians and researchers to embrace teleneuropsychological assessment practice in order to increase access to healthcare and to continue time sensitive research (e.g., clinical trials). Although teleneuropsychological evaluation may not be suitable for all clients, its precipitated integration into the field of neuropsychology provides a unique opportunity for continued professional learning, improvement or development of

computerized measures, collaborative pooling of data to allow for development of norms, and new avenues of research on the reliability and validity of teleneuropsychological measures. We implore researchers and clinicians alike to maintain detailed records of neuropsychological test administration conducted during the COVID-19 pandemic, in hopes of adding data to the NDA and contributing valuable data to this nascent body of literature.

References

Abdolahi, A., Bull, M. T., Darwin, K. C., Venkataraman, V., Grana, M. J., Dorsey, E. R., & Biglan, K. M. (2016). A feasibility study of conducting the Montreal Cognitive Assessment remotely in individuals with movement disorders. *Health Informatics Journal*, *22*(2), 304–311. https://doi.org/10.1177/1460458214556373

Adjorlolo, S. (2015). Can Teleneuropsychology Help Meet the Neuropsychological Needs of Western Africans? The Case of Ghana. *Applied Neuropsychology: Adult*, *22*(5), 388–398. https://doi.org/10.1080/23279095.2014.949718

American Psychological Association. (2013). Guidelines for the practice of telepsychology. *American Psychologist*, *68*(9), 791–800. https://doi.org/10.1037/a0035001

Bauer, R. M., Iverson, G. L., Cernich, A. N., Binder, L. M., Ruff, R. M., & Naugle, R. I. (2012). Computerized Neuropsychological Assessment Devices: Joint Position Paper of the American Academy of Clinical Neuropsychology and the National Academy of Neuropsychology. *Archives of Clinical Neuropsychology*, *27*(3), 362–373. https://doi.org/10.1093/arclin/acs027

Biagianti, B., Fisher, M., Brandrett, B., Schlosser, D., Loewy, R., Nahum, M., & Vinogradov, S. (2019). Development and testing of a web-based battery to remotely assess cognitive health in individuals with schizophrenia. *Schizophrenia Research*, *208*, 250–257. https://doi.org/10.1016/j.schres.2019.01.047

Bilder, R. M., & Reise, S. P. (2019). Neuropsychological tests of the future: How do we get there from here? *Clinical Neuropsychologist*. *33*(2), 220-245. https://doi.org/10.1080/13854046.2018.1521993

Bin Zahid, A., Hubbard, M. E., Lockyer, J., Podolak, O., Dammavalam, V. M., Grady, M., Nance, M., Scheiman, M., Samadani, U., & Master, C. L. (2018). Eye Tracking as a Biomarker for Concussion in Children. *Clinical Journal of Sport Medicine*, *Publish Ah*. https://doi.org/10.1097/JSM.0000000000000639

Bott, N., Madero, E. N., Glenn, J., Lange, A., Anderson, J., Newton, D., Brennan, A., Buffalo, E. A., Rentz, D., & Zola, S. (2018). Device-Embedded Cameras for Eye Tracking–Based Cognitive Assessment: Validation With Paper-Pencil and Computerized Cognitive Composites. *Journal of Medical Internet Research*, *20*(7), e11143. https://doi.org/10.2196/11143

Brandt, J., Spencer, M., & Folstein, M. (1988). The telephone interview for cognitive status. *Neuropsychiatry, Neuropsychology and Behavioral Neurology*, *1*(2), 111–117.

Brearly, T. W., Shura, R. D., Martindale, S. L., Lazowski, R. A., Luxton, D. D., Shenal, B. V., & Rowland, J. A. (2017). Neuropsychological Test Administration by Videoconference: A Systematic Review and Meta-Analysis. *Neuropsychology Review*, *27*(2), 174–186. https://doi.org/10.1007/s11065-017-9349-1

CANTAB® [Cognitive assessment software]. Cambridge Cognition (2019). All rights reserved. www.cantab.com

Castanho, T. C., Portugal-Nunes, C., Moreira, P. S., Amorim, L., Palha, J. A., Sousa, N., & Santos, N. C. (2016). Applicability of the Telephone Interview for Cognitive Status (Modified) in a community sample with low education level: association with an extensive neuropsychological battery. *International Journal of Geriatric Psychiatry, 31*(2), 128-136. http://doi.org/10.1002/gps.4301

Castanho, T. C., Sousa, N., & Santos, N. C. (2017). When New Technology is an Answer for Old Problems: The Use of Videoconferencing in Cognitive Aging Assessment. *Journal of Alzheimer's Disease Reports*, *1*(1), 15–21. https://doi.org/10.3233/ADR-170007

Chakrabarti, S. (2015). Usefulness of telepsychiatry: A critical evaluation of videoconferencing-based approaches. *World Journal of Psychiatry*, *5*(3), 286. https://doi.org/10.5498/wjp.v5.i3.286

Chapman, J. E., Cadilhac, D. A., Gardner, B., Ponsford, J., Bhalla, R., & Stolwyk, R. J. (2019). Comparing face-to-face and videoconference completion of the Montreal Cognitive Assessment (MoCA) in community-based survivors of stroke. *Journal of Telemedicine and Telecare*, 1357633X1989078. https://doi.org/10.1177/1357633X19890788

Cowan, K. E., McKean, A. J., Gentry, M. T., & Hilty, D. M. (2019). Barriers to Use of Telepsychiatry: Clinicians as Gatekeepers. *Mayo Clinic Proceedings*, *94*(12), 2510–2523. https://doi.org/10.1016/j.mayocp.2019.04.018

Dang, S., Gomez-Orozco, C. A., van Zuilen, M. H., & Levis, S. (2018). Providing Dementia Consultations to Veterans Using Clinical Video Telehealth: Results from a Clinical Demonstration Project. *Telemedicine and E-Health*, *24*(3), 203–209. https://doi.org/10.1089/tmj.2017.0089

Davis, R., Libon, D. J., Au, R., Pitman, D., & Penney, D. L. (2014). THink: Inferring Cognitive Status from Subtle Behaviors. *Proceedings of the ... AAAI Conference on Artificial Intelligence. AAAI Conference on Artificial Intelligence*, *2014*(3), 2898–2905. https://doi.org/10.1609/aimag.v36i3.2602

DeYoung, N., & Shenal, B. V. (2019). The reliability of the Montreal Cognitive Assessment using telehealth in a rural setting with veterans. *Journal of Telemedicine and Telecare*, *25*(4), 197–203. https://doi.org/10.1177/1357633X17752030

Diaz-Orueta, U., Blanco-Campal, A., Lamar, M., Libon, D. J., & Burke, T. (2020). Marrying Past and Present Neuropsychology: Is the Future of the Process-Based Approach Technology-Based? *Frontiers in Psychology*, *11*, 361. https://doi.org/10.3389/fpsyg.2020.00361

Domen, A. C., Weijer, S. C. F., Jaspers, M. W., Denys, D., & Nieman, D. H. (2019). The validation of a new online cognitive assessment tool: The MyCognition Quotient. *International Journal of Methods in Psychiatric Research*, *28*(3), e1775. https://doi.org/10.1002/mpr.1775

Fantus, S., & Mishna, F. (2013). The Ethical and Clinical Implications of Utilizing Cybercommunication in Face-to-Face Therapy. *Smith College Studies in Social Work*, *83*(4), 466–480. https://doi.org/10.1080/00377317.2013.833049

Feenstra, H. E., Vermeulen, I. E., Murre, J. M., & Schagen, S. B. (2018). Online Self-Administered Cognitive Testing Using the Amsterdam Cognition Scan: Establishing Psychometric Properties and Normative Data. *Journal of Medical Internet Research*, *20*(5), e192. https://doi.org/10.2196/jmir.9298

Fickling, S. D., Smith, A. M., Pawlowski, G., Ghosh Hajra, S., Liu, C. C., Farrell, K., Jorgensen, J., Song, X., Stuart, M. J., & D'Arcy, R. C. N. (2019). Brain vital signs detect concussion-related neurophysiological impairments in ice hockey. *Brain*, *142*(2), 255–262. https://doi.org/10.1093/brain/awy317

Freedman, M., Leach, L., Kaplan, E., Winocur, G., Shulman, K. I., & Delis, D. C. (1994). *Clock drawing: A neuro-psychological analysis.* Oxford University Press.

Galusha-Glasscock, J. M., Horton, D. K., Weiner, M. F., & Cullum, C. M. (2016). Video Teleconference Administration of the Repeatable Battery for the Assessment of Neuropsychological Status. *Archives of Clinical Neuropsychology*. https://doi.org/10.1093/arclin/acv058

Germine, L., Reinecke, K., & Chaytor, N. S. (2019). Digital neuropsychology: Challenges and opportunities at the intersection of science and software. *The Clinical Neuropsychologist*, *33*(2), 271–286. https://doi.org/10.1080/13854046.2018.1535662

Ghosh Hajra, S., Liu, C. C., Song, X., Fickling, S., Liu, L. E., Pawlowski, G., Jorgensen, J. K., Smith, A. M., Schnaider-Beeri, M., Van Den Broek, R., Rizzotti, R., Fisher, K., & D'Arcy, R. C. N. (2016). Developing Brain Vital Signs: Initial Framework for Monitoring Brain Function Changes Over Time. *Frontiers in Neuroscience*, *10*, 211. https://doi.org/10.3389/fnins.2016.00211

Godleski, L., Darkins, A., & Peters, J. (2012). Outcomes of 98,609 U.S. Department of Veterans Affairs Patients Enrolled in Telemental Health Services, 2006–2010. *Psychiatric Services*, *63*(4), 383–385. https://doi.org/10.1176/appi.ps.201100206

Graham, J. P., Leibler, J. H., Price, L. B., Otte, J. M., Pfeiffer, D. U., Tiensin, T., & Silbergeld, E. K. (2008). The animal-human interface and infectious disease in industrial food animal production: rethinking biosecurity

and biocontainment. *Public Health Reports (Washington, D.C. : 1974)*, *123*(3), 282–299. https://doi.org/10.1177/003335490812300309

Grosch, M. C., Gottlieb, M. C., & Cullum, C. M. (2011). Initial Practice Recommendations for Teleneuropsychology. *The Clinical Neuropsychologist*, *25*(7), 1119–1133. https://doi.org/10.1080/13854046.2011.609840

Harrell, K. M., Wilkins, S. S., Connor, M. K., & Chodosh, J. (2014). Telemedicine and the Evaluation of Cognitive Impairment: The Additive Value of Neuropsychological Assessment. *Journal of the American Medical Directors Association*, *15*(8), 600–606. https://doi.org/10.1016/j.jamda.2014.04.015

Hess, D. C., & Audebert, H. J. (2013). The history and future of telestroke. *Nature Reviews Neurology*, *9*(6), 340–350. https://doi.org/10.1038/nrneurol.2013.86

HIPAA Journal. (2017, October 17). *Is Skype HIPAA Compliant?* Retrieved May 2020, from HIPAA Journal: https://www.hipaajournal.com/skype-hipaa-compliant/

Jones, K. E., Patel, N. G., Levy, M. A., Storeygard, A., Balk, D., Gittleman, J. L., & Daszak, P. (2008). Global trends in emerging infectious diseases. *Nature*, *451*(7181), 990–993. https://doi.org/10.1038/nature06536

Kessels, R. P. C. (2019). Improving precision in neuropsychological assessment: Bridging the gap between classic paper-and-pencil tests and paradigms from cognitive neuroscience. *The Clinical Neuropsychologist*, *33*(2), 357–368. https://doi.org/10.1080/13854046.2018.1518489

Kliegel, M., Martin, M., & Jäger, T. (2007). Development and Validation of the Cognitive Telephone Screening Instrument (COGTEL) for the Assessment of Cognitive Function Across Adulthood. *The Journal of Psychology*, *141*(2), 147–170. https://doi.org/10.3200/JRLP.141.2.147-172

Konig, A., Satt, A., Sorin, A., Hoory, R., Derreumaux, A., David, R., & Robert, P. H. (2018). Use of Speech Analyses within a Mobile Application for the Assessment of Cognitive Impairment in Elderly People. *Current Alzheimer Research*, *15*(2), 120-129. https://doi.org/10.2174/1567205014666170829111942

Langarizadeh, M., Moghbeli, F., & Ali, A. (2017). Application of Ethics for Providing Telemedicine Services and Information Technology. *Medical Archives*, *71*(5), 351–355. https://doi.org/10.5455/medarh.2017.71.351-355

Lindauer, A., Seelye, A., Lyons, B., Dodge, H. H., Mattek, N., Mincks, K., Kaye, J., & Erten-Lyons, D. (2017). Dementia Care Comes Home: Patient and Caregiver Assessment via Telemedicine. *The Gerontologist*, *57*(5), e85–e93. https://doi.org/10.1093/geront/gnw206

Mackin, R. S., Insel, P. S., Truran, D., Finley, S., Flenniken, D., Nosheny, R., Ulbright, A., Comacho, M., Bickford, D., Harel, B., Maruff, P., & Weiner, M. W. (2018). Unsupervised online neuropsychological test performance for individuals with mild cognitive impairment and dementia: Results from the Brain Health Registry. *Alzheimer's & Dementia: Diagnosis, Assessment & Disease Monitoring*, *10*(1), 573–582. https://doi.org/10.1016/j.dadm.2018.05.005

Marra, D. E., Hamlet, K. M., Bauer, R. M., & Bowers, D. (2020). Validity of teleneuropsychology for older adults in response to COVID-19: A systematic and critical review. *The Clinical Neuropsychologist*, 1–42. https://doi.org/10.1080/13854046.2020.1769192

McCord, C. E., Saenz, J., Armstrong, T., & Elliott, T. R. (2015). Training the next generation of counseling psychologists in the practice of telepsychology. *Counseling Psychology Quarterly* , *28*(3), 324–344. https://doi.org/10.1080/09515070.2015.1053433

Cullum, C., Hynan, L. S., Grosch, M., Parikh, M., & Weiner, M. F. (2014). Teleneuropsychology: Evidence for Video Teleconference-Based Neuropsychological Assessment. *Journal of the International Neuropsychological Society*, *20*(10), 1028–1033. https://doi.org/10.1017/S1355617714000873

Cullum, C., Weiner, M. F., Gehrmann, H. R., & Hynan, L. S. (2006). Feasibility of Telecognitive Assessment in Dementia. *Assessment*, *13*(4), 385–390. https://doi.org/10.1177/1073191106289065

Parikh, M., Grosch, M. C., Graham, L. L., Hynan, L. S., Weiner, M., Shore, J. H., & Cullum, C. M. (2013). Consumer Acceptability of Brief Videoconference-based Neuropsychological Assessment in Older

Individuals with and without Cognitive Impairment. *The Clinical Neuropsychologist*, *27*(5), 808–817. https://doi.org/10.1080/13854046.2013.791723

Parmanto, B., Pulantara, I. W., Schutte, J. L., Saptono, A., & McCue, M. P. (2013). An Integrated Telehealth System for Remote Administration of an Adult Autism Assessment. *Telemedicine and E-Health*, *19*(2), 88–94. https://doi.org/10.1089/tmj.2012.0104

Preston, K. S. J., & Reise, S. P. (2014). Estimating the Nominal Response Model Under Nonnormal Conditions. *Educational and Psychological Measurement*, *74*(3), 377–399. https://doi.org/10.1177/0013164413507063

Reise, S. P., & Waller, N. G. (2009). Item Response Theory and Clinical Measurement. *Annual Review of Clinical Psychology*, *5*(1), 27–48. https://doi.org/10.1146/annurev.clinpsy.032408.153553

Reitan, R. M. (1958). Validity of the Trail Making Test as an Indicator of Organic Brain Damage. *Perceptual and Motor Skills*, *8*(3), 271–276. https://doi.org/10.2466/pms.1958.8.3.271

Rogove, H. J., McArthur, D., Demaerschalk, B. M., & Vespa, P. M. (2012). Barriers to Telemedicine: Survey of Current Users in Acute Care Units. *Telemedicine and E-Health*, *18*(1), 48–53. https://doi.org/10.1089/tmj.2011.0071

Ruano, L., Sousa, A., Severo, M., Alves, I., Colunas, M., Barreto, R., Mateus, C., Moreira, S., Conde, E., Bento, V., Lunet, N., Pais, J., & Tedim Cruz, V. (2016). Development of a self-administered web-based test for longitudinal cognitive assessment. *Scientific Reports*, *6*(1), 19114. https://doi.org/10.1038/srep19114

Samadani, U., Li, M., Qian, M., Laska, E., Ritlop, R., Kolecki, R., Reyes, M., Altomare, L., Sone, J. Y., Adem, A., Huang, P., Kondziolka, D., Wall, S., Frangos, S., & Marmar, C. (2016). Sensitivity and specificity of an eye movement tracking-based biomarker for concussion. *Concussion*, *1*(1), cnc.15.3. https://doi.org/10.2217/cnc.15.3

Seligman, S. C., & Giovannetti, T. (2015). The Potential Utility of Eye Movements in the Detection and Characterization of Everyday Functional Difficulties in Mild Cognitive Impairment. *Neuropsychology Review*, *25*(2), 199–215. https://doi.org/10.1007/s11065-015-9283-z

Smith, C. J., Rozga, A., Matthews, N., Oberleitner, R., Nazneen, N., & Abowd, G. (2017). Investigating the accuracy of a novel telehealth diagnostic approach for autism spectrum disorder. *Psychological Assessment*, *29*(3), 245–252. https://doi.org/10.1037/pas0000317

Souillard-Mandar, W., Davis, R., Rudin, C., Au, R., Libon, D. J., Swenson, R., Price, C. C., Lamar, M., & Penney, D. L. (2016). Learning classification models of cognitive conditions from subtle behaviors in the digital Clock Drawing Test. *Machine Learning*, *102*(3), 393–441. https://doi.org/10.1007/s10994-015-5529-5

Stoll, J., Müller, J. A., & Trachsel, M. (2020). Ethical Issues in Online Psychotherapy: A Narrative Review. *Frontiers in Psychiatry*, *10*, 993. https://doi.org/10.3389/fpsyt.2019.00993

Trustram Eve, C., & de Jager, C. A. (2014). Piloting and validation of a novel self-administered online cognitive screening tool in normal older persons: the Cognitive Function Test. *International Journal of Geriatric Psychiatry*, *29*(2), 198–206. https://doi.org/10.1002/gps.3993

Wadsworth, H. E., Dhima, K., Womack, K. B., Hart, J., Weiner, M. F., Hynan, L. S., & Cullum, C. M. (2017). Validity of Teleneuropsychological Assessment in Older Patients with Cognitive Disorders. *Archives of Clinical Neuropsychology*, *33*(8), 1040–1045. https://doi.org/10.1093/arclin/acx140

Wechsler, D. (2008). Wechsler Adult Intelligence Scale - Fourth Edition: Administration and Scoring Manual. In *Psychological Corporation*. https://doi.org/10.1037/t15169-000

Wesnes, K. A., Brooker, H., Ballard, C., McCambridge, L., Stenton, R., & Corbett, A. (2017). Utility, reliability, sensitivity and validity of an online test system designed to monitor changes in cognitive function in clinical trials. *International Journal of Geriatric Psychiatry*, *32*(12), e83–e92. https://doi.org/10.1002/gps.4659

Wong, A., Nyenhuis, D., Black, S. E., Law, L. S. N., Lo, E. S. K., Kwan, P. W. L., Au, L., Chan, A. Y. Y., Wong, L. K. S., Nasreddine, Z., & Mok, V. (2015). Montreal Cognitive Assessment 5-Minute Protocol Is a Brief, Valid, Reliable, and Feasible Cognitive Screen for Telephone Administration. *Stroke*, *46*(4), 1059–1064.

https://doi.org/10.1161/STROKEAHA.114.007253

Woods, D. L., Herron, T. J., Yund, E. W., Hink, R. F., Kishiyama, M. M., & Reed, B. (2011). Computerized analysis of error patterns in digit span recall. *Journal of Clinical and Experimental Neuropsychology*, *33*(7), 721–734. https://doi.org/10.1080/13803395.2010.550602

Zakzanis, K. K., & Azarbehi, R. (2014). Introducing BRAIN screen : Web-Based Real-Time Examination and Interpretation of Cognitive Function. *Applied Neuropsychology: Adult*, *21*(2), 77–86. https://doi.org/10.1080/09084282.2012.742994

Zola, S. M., Manzanares, C. M., Clopton, P., Lah, J. J., & Levey, A. I. (2013). A Behavioral Task Predicts Conversion to Mild Cognitive Impairment and Alzheimer's Disease. *American Journal of Alzheimer's Disease & Other Dementiasr*, *28*(2), 179–184. https://doi.org/10.1177/1533317512470484