Online cognitive testing with Asian older adults during the Covid-19 pandemic: A proof-of-feasibility study

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Abstract

Online cognitive testing has become more commonly used in both research and clinical settings, especially since the movement restrictions linked to the Covid-19 pandemic. However, this online testing format is believed to pose significant challenges for older adults (OA). Although recent research with Western OAs has shown encouraging results, data from non-Western countries is still scarce. Here we tested the feasibility of a protocol of online testing of the Montreal Cognitive Assessment (MoCA) and the Paced Auditory Serial Addition Test (PASAT) on a sample of 120 Asian older adults living in Malaysia during the Covid-19 pandemic. We found that our participants' online performance was either similar or even superior to existing norms and we also observed that their performance was mainly predicted by education levels. Depressive symptoms and subjective social position had only a limited effect on performance. These results provide a proof of concept that carefully designed protocols can enable Asian older adults from a middle-income country to obtain robust performances on standard cognitive tests delivered in an online format.

Keywords: ageing: cognitive assessment, online cognitive testing, MoCA, PASAT.

Highlights

- Online testing is a feasible method to evaluate older adults' cognitive functioning.
- We obtained similar or superior norms for the online version of cognitive measures when compared to the in-person norms.
- This study provided evidence for the possibility of online cognitive testing with Asian older adults.

1. Introduction

The Covid-19 pandemic brought a significant challenge in the availability and feasibility of cognitive testing for older adults (OA) because they became an important risk group, which had to avoid face-to-face activities (1,2). The obvious method to make cognitive testing feasible in such a context is online cognitive testing, an approach that was already widely used for younger adults before the pandemic, especially for research purposes (3–6).

However, online testing can be particularly challenging for OAs. Using new technological devices tends to be difficult for many OAs, as the ageing process impacts a range of physical and cognitive abilities needed to learn and handle new digital technologies (7–10). It is therefore not surprising that OA's rate of utilization of technological devices is lower than young adults, even though some results suggest that they have a positive attitude towards technology (11). The technology usage rate in the older adult population depends on several factors including perceived relevance and need of using technology, interest, and the degree of training and support they receive for using technology (12–15).

Previous studies demonstrated that factors such as using a guided protocol with a clear structure, providing support, and maintaining communication with older participants while using tech-based methods, would increase their acceptance towards tech-based methods (16–18). However, cognitive ageing and technophobia (19–21) are likely to pose a persistent challenge to the utilization of online methods of cognitive testing in senior citizens (19).

Given that the occurrence of future pandemics is highly likely (22), and that online cognitive testing of OA could become useful beyond the constraints of pandemics, it is therefore necessary to develop protocols of online testing that are adapted for OA. This would be essential not only for neuropsychological assessment in clinical settings, but also for the continuity of research on cognitive ageing during pandemics or other situations that restrain participants' mobility. Protocols for online cognitive testing of older adults have been recently published. Notably, Gagnon et al. (23) have validated a video conference version of the Montreal Cognitive Assessment (MoCA), a widely used short test battery measuring a broad range of cognitive abilities, which is particularly useful to assess OA' cognitive function (24). Gagnon et al. (23) have shown that this online version of the MoCA was largely reliable on a sample of Canadian older adults, which suggests that an adequate testing protocol can lead to a successful utilization of online cognitive testing procedures with OAs. This result adds to other studies that tend to indicate that online testing is as reliable as face-to-face cognitive testing (4,5).

The purpose of the current study is to examine further the issue of whether online cognitive testing is adequate for older adults in a cultural and regional context different than most previous studies. Although existing research on this topic has yielded encouraging results, it has focused mainly on samples drawn from WEIRD (Western, Educated, Industrialized, Rich, and Democratic) countries, a common bias in psychological research (25). It remains therefore largely unknown how adaptable existing protocols of online cognitive testing for OAs would be in different cultural and regional settings. Indeed, evidence suggests that the effects of ageing on cognition differs between different cultures and or between countries at different income levels (26,27). To address this gap, the present manuscript describes a study that tested the feasibility of using online cognitive testing on a population of OAs during the height of the COVID-19 pandemic in an Asian middle-income country, Malaysia.

Specifically, we tested the videoconference version of the MoCA (23), and the Paced Auditory Serial Addition Test ***(***PASAT) (28), for which we also developed a protocol of online testing. Both MoCA and PASAT are routinely used in ageing research (29–34). MoCA provides a brief yet diverse assessment of a range of cognitive functions (24) whereas PASAT focuses on response speed and working memory (WM) updating (28,35,36). We hypothesized that if online cognitive testing was valid for our sample of Malaysian older adults, then their average performance would not be significantly lower than existing norms obtained from face-to-face testing. Furthermore, we also asked the question of whether online cognitive testing performance in older adults would be modulated by education level, a factor typically known to predict test performance in ageing individuals (37–39). Specifically, we explored if education levels, while controlling for perceived socioeconomic status, age and gender were significant predictors of online cognitive performance (37,40,41). Finally, we also examined whether depressive symptoms could predict test performance. This question was motivated by three well-known pieces of evidence: First, depression tends to be common in OA (42,43). Second, depression was highly prevalent during the Covid-19 pandemic (44–46). Third, evidence shows that depression levels predict cognitive performance (47–49).

2. Materials and Methods

This study employed a cross-sectional approach to examine older adults cognitive functioning during the COVID-19 pandemic in Malaysia. The data for this study have been collected between June 2020 and April 2021, when Malaysia was under conditions of severe government-imposed movement restrictions aimed at curbing the transmission of Covid-19. Participants were recruited from senior citizen clubs from the larger Kuala Lumpur Metropolitan area.

2.1 Participants

Participants were 120 healthy older adults, including 101 female and 19 males, aged 60 years and above (M= 65.72, SD= 4.85). Out of 120 recruited participants, 100 participants were Malaysian-Chinese, 16 were Malaysian-Indians, 2 were ethnic Malays, and 1 identified as an ethnic minority. All the participants were fully briefed about the study, and they signed informed consent forms.

The inclusion criteria were that participants had to (a) be 60 years of age or above, (b) be able to communicate in English, (c) be able to read and write with no difficulty, (d) have access to the Internet, (e) have access to a smartphone and/or a personal computer, (f) be generally healthy, i.e., without past history of neurological or psychiatric conditions.

It is important to note that all participants achieved a score of 18 or above on the MoCA, indicating that none of them was at risk of mild cognitive impairment (MCI), as previous research shows that this threshold is accurate for detecting the risk of MCI in the Malaysian population (50). Therefore, our participants' performance on the MoCA suggests that poor performance on online cognitive performance is unlikely to be explained by deficits linked to pathological ageing.

This study has been approved by the ethics committee of Sunway University, Malaysia (ethics code: PGSUREC2020/014). Participants received online food vouchers (35 RM /~9 USD) after completing all the required assessment sessions.

2.2 Procedure and materials

This study implemented an online assessment procedure. To avoid assessment fatigue, participants completed three online assessment sessions totalling 2 hours on average, separated by intervals of four days on average. All the sessions were conducted through Zoom. Prior to the first session, participants were presented with pictorial instructions designed at briefing them on how to install and work with Zoom (see the supplementary file 1). These instructions were received through WhatsApp (a platform that our participants were already familiar with). For those who were unable to install Zoom with this instruction, a voice/video call through WhatsApp prior to the first session (date and time was scheduled based on the participant's availability) was arranged with the researchers. The detailed online testing protocol has been provided in Supplementary File.

2.2.1 Online questionnaire

The online questionnaires included a range of measures that were part of a larger research project on ageing. We report here only the variables relevant to the research questions of the current study. Specifically, we focused on perceived socioeconomic status (SES), education levels and depressive symptoms. We measured perceived socioeconomic status using MacArthur's scale of subjective social status. This scale involves asking participants to determine their socioeconomic status in comparison with other individuals living in their country and their community on an image of a ladder with 10 rungs. The lowest rung (number 1) reflects the lowest social position, whilst the highest rung (number 10) reflects the highest possible social status. In addition, we also estimated SES using a measure of participants' level of education. Here, we asked participants to indicate their level of educational attainment which was categorized as follows: (1) participant did not finish school, (2) completed secondary school, (3) completed an undergraduate degree (e.g., diploma, certificate or bachelor's degree), (4) completed a post-graduate degree. Finally, we used the 15-items version of the Geriatric Depression Scale (51), a very well-known measure of depressive symptoms for older adults.

2.2.2 Montreal Cognitive Assessment (MoCA)- Videoconference version

The videoconference version of MoCA has been previously validated by Gagnon et al. (23). The Montreal Cognitive Assessment Test (MoCA), a cognitive screening tool originally developed to assess the risk of mild cognitive impairment (MCI) and dementia, which is widely used as a brief neuropsychological assessment tool. It can also be used in non-clinical settings for research purposes as it contains a brief yet reliable set of tasks that tap a diverse range of cognitive functions.

The MoCA comprises thirteen cognitive tasks tapping seven domains. The Executive-visuospatial domain is linked to the following tasks: trail-making task, clock drawing task and three-dimensional cube copying task. The “Naming” domain was tapped by a task requiring participants to name specific animals depicted on images. Attention was assessed by a digit forward and backward a letter tapping task and a serial subtraction task. Language was assessed by a task involving the repetition of two syntactically complex sentences and by a phonemic fluency task. Abstraction was assessed by a two-item verbal similarity task and Memory by delayed recall task. The orientation domain involved a task assessing the participants’ ability to remember information about the city and the institution where the experimenter was located.

2.2.3 The online Paced Auditory Serial Addition Test (PASAT)

PASAT is classically used to assess the speed of auditory information processing (28). However, it is also consistently used as a reliable measure of working memory updating processes (35,36,52,53).

The PASAT task involves listening to a series of single digits, while summing up the two most recent digits and verbally saying out loud their answer. For instance, if the digits were “4”, “5”, and “2”, the participant’s correct responses should be “9” and “7” respectively. The examiner checked participants' responses with the PASAT answer key while they were answering the task. To double check the accuracy of their responses, the examiner checked the recorded video of the session once again after the session to make sure no examiner-related mistakes have been made while checking participants' answers during the task. PASAT-2 and PASAT-3 had 60 trials each and participants received 1 score for each correct response and a zero for the incorrect answers. The total score would be the sum of all the correct answers in PASAT-2 and PASAT-3. It has been suggested that scores below 32 in participants with 12 or less years of education or scores below 35 in participants with more than 12 years of education in PASAT-3 are indicators of cognitive impairments. In addition, scores below 20 in participants with 12 or less years of education and scores below 23 in participants with more than 12 years of education in PASAT-2 represent the possibility of cognitive impairment. There was no specific discontinuation rule for PASAT except the time that a participant is unable to get at least 2 correct answers in the 3-second practice trial. Consequently, the examiner should not proceed to the main trial. Moreover, if the participant was unable to get any correct answers to the main trial, the examiner had to indicate that they were not able to complete PASAT due to cognitive limitation (54).

For both the second and third sessions, participants were asked to switch on their videos (this was only for participants without Internet-related problems). The justification for switching on the video was to check that participants were following standard procedures. For instance, for memory tasks, researchers verified that participants were not using memory aids such as writing down information that had to be recalled later. Another method used to control their response authenticity during memory tasks involved asking participants to close their eyes during recall. If despite those methods, participants were still using recalling techniques that were not allowed (such as writing down), then a null score was recorded for the trial during which these practices were observed.

3. Results

To examine the first hypothesis of this study, data from our sample was compared with existing "face-to-face" normative data of PASAT and MoCA using Z-tests. The second hypothesis of this study has been evaluated using multiple linear regression in which age, social status, occupation, and educational attainment were considered as predictors while participants' scores in cognitive measures including MoCA, and PASAT were the outcome variables. Finally, we also examined whether depression would predict test scores in our sample. For this specific aim, we added depression to the multiple linear regression model described above. Moreover, the intercorrelation between all relevant variables has been examined and reported in Table 2.

The objectives of the data analysis were threefold: First, we wanted to check whether our participants' scores on online cognitive tests were significantly lower than normative scores. Second, we wanted to check if online cognitive performance was predicted by education levels, and finally we examined if depressive symptoms predicted online test performance. Data were analysed using R Statistical Software (v4.2.2; (55) and SPSS version 26. Univariate outliers that were identified using the Z score threshold of ± 3 were winsorised once to the same threshold. Subsequently, a visual inspection of histograms indicated that the distribution of all continuous variables were approximately normal. We included in Supplementary Table 1 all the descriptive statistics derived from winsorised scores.

For our first objective, the sample's average scores on MoCA, PASAT-2 and PASAT-3 were compared with available normative data using Z tests. Table 1 depicts the comparison between the sample characteristics and normative data. For both MoCA (56) and PASAT (57), we used norms that took into account the educational levels of our sample. Based on the Z test results, participants in the present study had significantly higher means in MoCA, PASAT-2, and PASAT-3 compared to the normative data (see Table 1), which suggests that our sample of OAs successfully adapted to an online format of cognitive test performance during the movement restrictions of the Covid-19 pandemic in Malaysia.

Table 1. Comparison of the sample's performance with existing norms

Performance on the online cognitive tests	Norms' Mean (SD)	Norm's Reference	Sample's Mean (SD)	Z score	Cohen's *d*
MoCA	23.36 (3.99)	(56)	24.6 (2.49)	3.67***	.33
PASAT-3	44.9 (12.1)	(57)	49.1 (9.66)	3.81***	.34
PASAT-2	36.4 (12.1)	(57)	42.55 (10.85)	5.59***	.50

Note. * p <.05; ** p <.01, *** p <.001

For our second and third objectives, we first computed a series of correlations between all the relevant measures (See Table 2). Our results show that MoCA, PASAT-2 and PASAT-3 scores were positively correlated with education, whereas GDS scores did not significantly correlate with these online cognitive tests. We also found subjective social status to be positively correlated with PASAT-3, but not the other two tests. Interestingly, gender significantly correlated with MoCA, but given the gender imbalance of our sample, this finding needs to be considered with caution.

Table 2. Intercorrelation table for all relevant variables

	1	2	3	4	5	6	7	8
1. Gender	--							
2. Age	.09	--						
3. Education	-.03	-.07	--					
4. Subjective social status	.12	.03	.32***	--				
5. Depression	-.12	-.08	-.10	-.18*	--			
6. PASAT-2	-.18*	-.20*	.29**	0.18	-.02	--		
7. PASAT-3	-.21*	-.14	.28**	.22*	-.17	.80***	--	
8. MoCA	-.37***	.07	.19*	0.14	-.07	.20*	.34***	-
M / %	16%	65.64	3.00	6.24	1.66	42.78	49.33	24.61
SD	-	4.55	0.70	1.15	2.00	10.74	9.11	2.48

Note. $N = 120$. Gender was coded as 0 = *female* and 1 = *male*; $*p < .05$, $**p < .01$, $***p < .001$.

To further test whether education and depressive symptoms predicted performance on online cognitive tests, multiple linear regressions and logistic regressions were computed. Statistical assumptions relevant to multiple regression analyses were examined prior to analyses. The assumptions of multicollinearity (VIFs < 5), and normality, linearity, and homoscedasticity of residuals, assessed through a visual inspection of residual vs predicted values scatterplots, were met for all models. Cook's distance did not exceed the value of 1 for any cases, indicating that multivariate outliers were not a concern when performing multiple linear regression analyses. For logistic regression analyses, residual-related assumptions and dispersion were assessed using the 'DHARMa' package (58).

As shown in Table 3 and Figure 1, results from multiple linear regressions confirmed education predicted performance on the PASAT-2 and PASAT-3, but not MoCA when age, gender, SES and depressive symptoms were controlled for. Females tended to perform better than males across all three tasks although the gender imbalance of our sample does not enable us to generalize this finding to the general population. Finally, age variation within our sample of OAs was a predictor of poorer performance on PASAT-2.

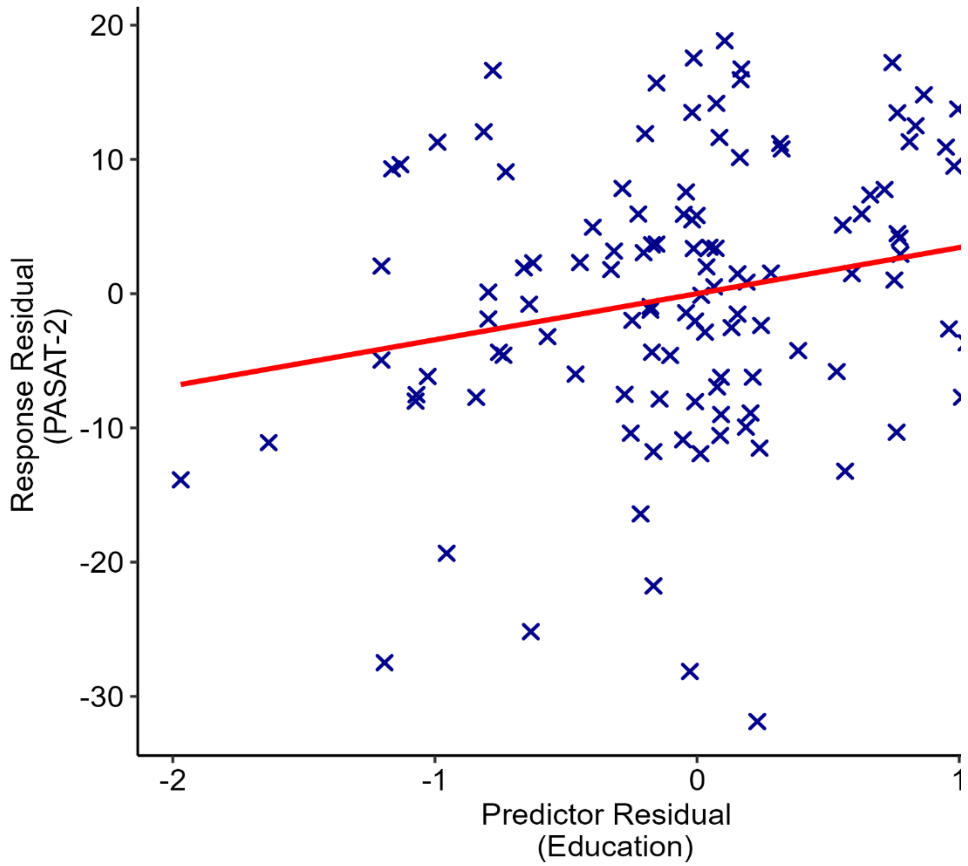
Table 3. Unstandardized (b) and Standardized (β) Regression Coefficients for Each Predictor in Models Predicting Performance on MoCA and PASAT Tasks.

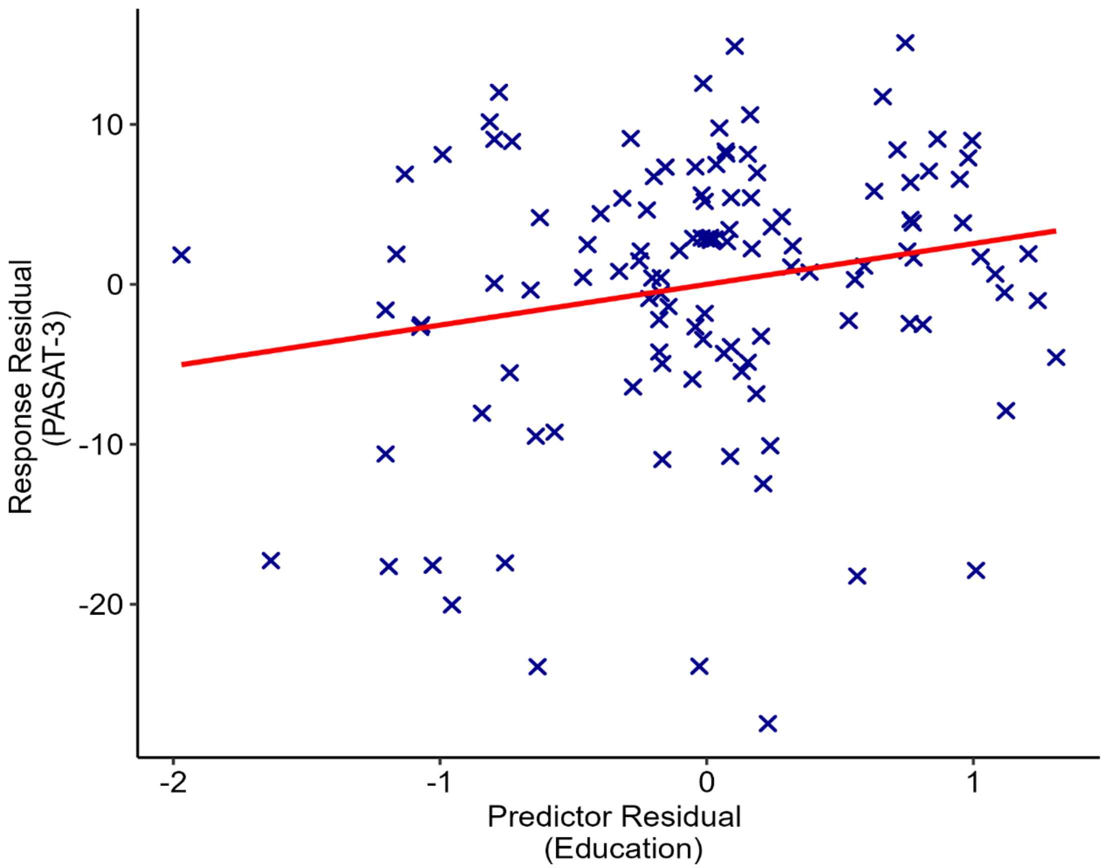
Predictor	MoCA		PASAT-2		PASAT-3	
	B [95% CI]	*β*	*B* [95% CI]	*β*	*B* [95% CI]	*β*
Gender: Male	-2.68 [-3.82, -1.53]***	-0.40	-5.12 [-10.21, -0.03]*	-0.17	-5.72 [-9.97, -1.48]**	-0.23
Age	0.06 [-0.03, 0.15]	0.10	-0.42 [-0.83, -0.01]*	-0.18	-0.25 [-0.59, 0.09]	-0.13
Education	0.46 [-0.17, 1.08]	0.13	3.43 [0.64, 6.23]*	0.22	2.55 [0.22, 4.88]*	0.20
Subjective social status	0.28 [-0.11, 0.67]	0.13	1.23 [-0.49, 2.94]	0.13	1.29 [-0.14, 2.72]	0.16
Depression	-0.09 [-0.30, 0.12]	-0.08	-0.05 [-0.99, 0.89]	-0.01	-0.70 [-1.48, 0.09]	-0.15
R^2	.20***		.16**		.18***	

Note. N = 120. Gender was coded as 0 = *female* and 1 = *male*; **p* < .05, ***p* < .01, ****p* < .001

We also examined how education and other predictors related to specific MoCA factors. To achieve this goal, Multiple linear regression models were fitted with the same predictors as the ones described in Table 3, with each factor of MoCA as the outcome (see Supplementary Tables 2 and 3). Given the restricted range of scores from the naming and abstraction tasks, these variables were recoded into binary variables (0 = lower, 1 = higher) to be fitted into logistic regression models. For the abstraction task, scores of 0 and 1 were recoded as “lower” while the score of 2 were recoded as “higher”. Results showed that education significantly predicted the Delayed Recall and Abstraction factors, subjective social status predicted performance on the Visuospatial factor, and the Naming Factor was predicted by both depressive symptoms and age variations.

Figure 1. Partial regression plots depicting the positive associations between education and both PASAT-2 and PASAT-3 while other predictors are held constant.





4. Discussion

In this study, we aimed at examining whether Malaysian older adults could adapt to online protocols of cognitive testing during the Covid-19 pandemic. We found that their performance on videoconference versions of MoCA, PASAT-2 and PASAT3 tests were either similar or superior to expected norms, suggesting that this format of testing was feasible and can be done successfully with OAs in this cultural context. Further, we also found that education levels were significant predictors of PASAT-2 and PASAT-3 scores, even when controlling for subjective SES, gender and age. Education levels did not significantly predict MoCA total scores after controlling for these same covariates. However, they did predict performance in two MoCA factors, Delayed Recall and Abstraction when all other predictors were controlled for. Finally, performance on online tests were largely uncorrelated with depressive symptoms measured by the Geriatric Depression Scale, except for the Naming subscale of MoCA. Hereafter, we discuss potential interpretations and implications of these results.

One of the guiding hypotheses of this study was that test scores would be significantly lower than normative scores could potentially reflect an outcome of inadaptation of Asian OAs to online protocols of cognitive testing. As it stands, scores were actually higher than available norms, which indicates that OAs in our sample were able to successfully adapt to a videoconference format of standard cognitive tests. This result is in line with Gagnon et al. (23) results showing that Canadian OAs were able to adapt to a videoconference version of the MoCA. Our results further indicate that adaptability of OAs to online cognitive testing extends to non-Western samples. This result is important as it strengthens the case for establishing and optimizing online protocols of cognitive testing and neuropsychological assessment as valid alternatives to classical face- to face testing of ageing individuals across different cultural settings.

The fact that our participants had higher scores than available norms can easily be explained by the fact that our participants were all from a relatively high socioeconomic status (SES) background. This was caused by the fact that low-SES OAs in Malaysia were difficult to reach out using videoconference methods during the pandemic, and many of them would simply not possess the technological devices necessary for online testing. We acknowledge that this is a limitation of our study, as it does not allow us to generalize our conclusions to low-SES individuals. However, our results suggest, *a minima*, that online protocols of cognitive testing can be successfully used with non-Western OAs from a relatively middle to high SES status. Future research will be needed to explore these issues with OAs drawn from a lower socioeconomic background.

Furthermore, we observed that levels of education significantly predicted PASAT and specific MoCA factors. That education levels predict PASAT is in line with previous research (59–61) and it further argues in favor of the validity of our results. Importantly, the relationship between education levels and both PASAT -2 and PASAT-3 scores remained significant even after controlling for another indicator of SES (scores on MacArthur's scale, (62), as well as age and gender, which strongly suggests that online cognitive testing needs to take into account participants' level of education.

For total MoCA scores, the correlation coefficient (r=.19) was statistically significant. This is in line with data suggesting that education plays a major role in MoCA performance (63,64). Even though total MoCA scores were not significantly predicted by education in our multiple regression analysis when other predictors were controlled for, two of MoCA's subfactors including abstraction and delayed recall were successfully predicted by education in similar multiple regression analyses. These results suggest the educational background of OAs seems to play a role in online cognitive test performance that depends on the type of cognitive function under assessment, although further research will be needed to replicate this finding. In particular, the relationship between education with both MoCA's delayed recall subfactor and performance in the PASAT tests are consistent with a wide body of evidence showing that delayed recall and executive function correlate with education levels (e.g., 65,66). Further research will be needed to explore whether specific cognitive functions are affected by levels of education and SES, and whether these relationships differ compared to classical face-to-face testing.

It is worth noting that depressive symptoms measured by the GDS did not significantly correlate with the majority of cognitive test scores recorded in the current study, indicating that the online cognitive test performance of OAs in our sample was largely impervious to fluctuations in depression levels, an issue of relevance during the Covid-19 pandemic. The only exception that we noted was the Naming subscale, for which lower scores were predicted by depressive symptoms in a logistic regression. This result is in line with evidence indicating that depressive symptoms are negatively corelated with cognitive performance in general (e.g. 48), but it is contradictory with results showing that the Naming subscale of

MoCA is not predicted by depression (67). Given that this is the only subscale for which we found a relation with GDS scores, further research will be needed to see if this specific result is replicated. Apart from the MoCA Naming subscale, the overall absence of a relationship between cognitive performance and GDS scores in our sample is encouraging as it tentatively suggests that a videoconference format of testing is not biased by depressive states in OAs. However, this finding has to be considered with caution: Depressive symptoms are less prevalent in the socioeconomic group from which our participants were drawn (68–70), and therefore future research should investigate the impact of depression on online cognitive performance in low-SES samples. Finally, we found that subjective social position and age variations predicted the Naming subfactor. Although we did not have priori hypotheses about this finding, they are consistent with literature on how verbal abilities are affected by age and socioeconomic status (71,72).

In summary, our study found that OAs living in Malaysia were able to successfully adapt to online protocols of cognitive testing during the Covid-19 pandemic. We also observed that these results were dependent on education levels, and that they were largely unaffected by variations in depressive symptomatology. These results indicate that online protocols of cognitive testing can be generalized to Asian samples of OAs, although further research will be needed to investigate these issues in low-SES and clinical populations of ageing individuals.

5. Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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8. Authors Contribution

AS and SV contributed to the conception and design of the present study. The online testing protocol has been designed by SV. Next, SV, ASA, and DS collected the data. JZO and SV performed the statistical analyses. SV prepared the introduction, methods, supplementary file, and a part of the results sections. JZO contributed to the write-up of the statistical analyses in the result section and supplementary file. The discussion part has been prepared by AS. MHY, YCC, and AS supervised the data collection and AS supervised the statistical analyses. All authors contributed to the manuscript revision, read, and approved the submitted version.

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10. Data Availability Statement

The data that support the findings of this study are available from the corresponding author, upon reasonable request.