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Translation and Validation of the Gaming Disorder Test and Gaming Disorder Scale for Adolescents into Chinese for Taiwanese Young Adults

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ABSTRACT

Purpose: To translate and cross-culturally adapt the Gaming Disorder Test (GDT) and Gaming Disorder Scale for Adolescents (GADIS-A) for use in Taiwan and to validate their internal consistency, construct validity, measurement invariance, and convergent validity in Taiwanese young adults.
Methods: The GDT and GADIS-A were translated into traditional (unsimplified) Chinese characters and culturally adapted according to standard guidelines. A sample of 608 Taiwanese university students were recruited online. All participants completed the GDT, GADIS-A, Internet Gaming Disorder Scale – Short Form (IGDS9-SF), and Depression Anxiety Stress Scale-21 (DASS-21). Internal consistency was assessed using Cronbach's α and McDonald's ω. Factor structure was examined using Confirmatory Factor Analysis (CFA). Measurement invariance in gender was assessed by three nested models in CFA. Convergent validity was determined by calculating Pearson's *r* among the GDT, GADIS-A, IGDS9-SF, and DASS-21.
Results: The GDT and GADIS-A showed adequate internal consistency (both α and ω = 0.90). The CFA results supported a one-factor structure for the GDT and a two-factor structure for the GADIS-A. Measurement invariance across gender was supported for both the GDT and GADIS-A. The convergent validity of the GDT and GADIS-A were acceptable.

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Conclusions: The Chinese versions of the GDT and GADIS-A are valid and reliable tools that can be used to assess gaming disorder in Taiwanese young adults. Measurement invariance across genders was supported for both tools. The convergent validity of the GDT and GADIS-A were also satisfactory.

1. Introduction

Playing video games has become a common leisure activity for children, teenagers and adults. However, excessive gaming may constitute a behavioral problem of public health interest due to the potential for gaming disorder (GD) [1] and accompanying negative consequences [2,3]. The global prevalence of GD has been estimated at 3.05% [4], and the prevalence of GD (using the definition of internet gaming disorder from the DSM-5) among adolescents in Taiwan has been estimated at 3.1% [5]. According to the World Health Organization (WHO), GD represents a persistent pattern of excessive gaming within a 12-month timeframe that includes: i) impaired control over gaming, ii) increased priority given to gaming such that it takes precedence over other important life interests and activities, and iii) continuation and/or escalation of gaming despite experiencing negative consequences [6]. Additionally, for a diagnosis of GD, the WHO further specified that the individual needs to have experienced marked distress or significant impairment in different life domains due to gaming [6].

GD may lead to a variety of health concerns [7,8], including but not limited to visual impairment, sleep deprivation, day-night reversal, seizures, venous embolisms, irritability, and depression [9–13]. Furthermore, GD has been associated with other psychiatric concerns such as depression, anxiety, and stress [14], in-game risky behaviors (e.g., microtransactions) [15] and other behavioral addictions [16]. Therefore, it is important to evaluate children, adolescents, and emerging/young adults for GD early to optimize prevention and treatment efforts.

Disordered gaming has been considered in two diagnostic nomenclature systems [17]. The American Psychiatric Association (APA) criteria are provided within the *Diagnostic and Statistical Manual of Mental Disorders*, Fifth Edition (DSM-5) [18], while the WHO criteria are described within the *International Classification of Diseases* 11th Revision (ICD-11) [19]. In contrast to the ICD-11 criteria for GD, the DSM-5 included internet gaming disorder (IGD) in 2013 to describe disordered behavior involving excessive gaming activity online and/or offline on any electronic device (although with a focus on massively multiplayer online games), with a total of nine diagnostic criteria in which at least five need to be endorsed for an IGD diagnosis [18]. Because each diagnostic framework defines/weighs specific criteria, symptoms, and resulting impairments differently [17,20,21], the focus of existing assessment tools for IGD and GD may also differ, despite the fact that the same construct is, or similar ones are, being measured.

As the APA framework incorporated the concept of GD earlier than the WHO framework, most assessment tools for disordered gaming have been developed based on the APA framework. As described above, the APA and WHO frameworks differ in terms of specific diagnostic criteria. Thus, the development of more assessment tools based on the WHO framework is warranted [22]. The Gaming Disorder Test (GDT) [23] and the Gaming Disorder Scale for Adolescents (GADIS-A) are two instruments assessing symptoms and severity of disordered gaming based on the WHO framework [20].

The GDT was the first brief standardized psychometric tool to assess GD based on the WHO GD criteria. The GDT has a unidimensional factor structure and has been psychometrically investigated with versions available in several languages including Bengali [24], Mandarin (in simplified Chinese characters) [23], German [17], Italian [25], Turkish [26], Polish [27], and Spanish [28]. A recent review [29] reported that of all available assessment tools for GD, the GDT was the only tool to show the highest level of validity in the operationalization of assessment criteria for GD. Furthermore, an earlier study [30] reported that the GDT presented with adequate reliability, structural validity, and criterion validity. In terms of measurement invariance, the GDT has shown scalar invariance for gender, age, and employment status.

The GADIS-A was developed for adolescent populations and includes a total of nine items assessing GD using WHO criteria for GD [20]. The GADIS-A is available in German [20], Russian [31], and Farsi [32]. The GADIS-A has exhibited adequate internal consistency with a threshold for severity, which helps to screen for GD [18]. Although developed for different populations, the GADIS-A and GDT may be used concurrently to screen for and estimate severity of GD.

Despite the above advantages of the GDT and GADIS-A in the assessment of GD, several gaps exist. First, there is no Traditional Chinese version of the GDT and the GADIS-A. Although the GDT is available in simplified Chinese, the wording used in Taiwan and Mainland China differs, and the Chinese government (as compared to Taiwanese government) has restrictions on internet time, which may result in different patterns of internet use [33,34]. Second, the GADIS-A was developed for adolescents and not young adults. Adolescents and young adults are at developmental different stages. For example, in Erikson's developmental model, the two groups have different milestones and conflict challenges (i.e., identity vs. role confusion for adolescents, and intimacy vs. isolation for young adults [35], although more recent models highlight a role for emerging adulthood that has extended adolescence in recent cultural contexts [36]). It is not known whether the GDT and GADIS-A will work equally well with different age groups. These shortcomings may limit the utility of the GDT and GADIS-A. Therefore, the purpose of this study was to translate the GDT and GADIS-A for use in Taiwan (i.e., a traditional Chinese character written language version) and validate the two tools for Taiwanese young adults.

2. Material and methods

2.1. Study population and recruitment procedure

The test developers of the GDT and GADIS-A provided permission to the present authors to use, translate, and validate the GDT and GADIS-A in Taiwanese participants [20,23]. Pontes et al. and Paschke et al. developed the GDT and GADIS-A, respectively, based upon on the WHO framework for GD, with the GDT being suited to assess GD among clinical and general populations and the GADIS-A more suited to assess GD in children and adolescents [20,23]. This study complied with the Declaration of Helsinki and was approved by the National Cheng Kung University Human Research Ethics Committee (Approval No. NCKU HREC-E-110-486-2) and the National Cheng Kung University Hospital Institute of Review Board (IRB No. A-ER-111-445) prior to data collection.

This present cross-sectional study was conducted between August and December 2022. During this period, 608 participants in Taiwan were recruited through convenience sampling via an online survey developed in *SurveyMonkey*. The participants could access the online survey, which was publicized at the university website and social media (e.g., Facebook). All participants were informed of the study's objectives, inclusion criteria, and additional relevant information from the outset. Participants were required to provide electronic informed consent to participate. All participants provided anonymous sociodemographic information and completed the GDT, GADIS-A, Internet Gaming Disorder Scale – Short Form (IGDS9-SF), and Depression Anxiety Stress Scale – 21 (DASS-21). Participants were eligible to participate if they were i) at least 20 years old; ii) proficient in Chinese; and iii) enrolled at a Taiwanese university.

2.2. The translation procedure

The Taiwan versions of the GDT and GADIS-A (i.e., using traditional Chinese characters) were generated/translated according to accepted/standard guidelines [37]. First, two forward translations of Taiwan versions of the GDT and GADIS-A were produced by two bilingual native Chinese translators and then synthesized into one forward translation. Next, the two forward translations were synthesized into one version for back translation via discussions between the two bilingual native Chinese translators and the corresponding authors. Then, the synthesized GDT and GADIS-A were back translated into English by another bilingual native Chinese translator majoring in English literature. Finally, all GDT and GADIS-A versions (including the two forward translations, the synthesized version, and the backward translation) were discussed and evaluated by an expert panel, including three experts (i.e., a psychologist, a psychiatrist, and a public health expert) to achieve linguistic and conceptual equivalency for the final Taiwan versions of the GDT and GADIS-A. During the translation procedure, the translators and expert panel uniformly found that both the GDT and GADIS-A item descriptions fit well with the Taiwanese. Therefore, there were no items revised for cultural adaptation.

2.3. Measures

2.3.1. Sociodemographic information

Participants provided sociodemographic data including age and gender. Participants were asked questions regarding their daily time (hours) spent sleeping (weekday), outdoor activities, smartphone usage, social media usage, and online study during the last week. The mean age of participants was 29.10 ± 6.36 years, with 55% female ($n = 334$) and 45% male participants ($n = 274$).

2.3.2. The Gaming Disorder Test (GDT)

Pontes et al. developed the GDT as a self-reported tool asking participants about their digital gaming activity (i.e., playing on computers, laptops, consoles, smartphones, or tablets) with both online and offline gaming activities in the previous year being considered [23]. The GDT consists of four items assessing GD symptoms and severity according to the WHO framework [23]. All items are answered using a 5-point Likert scale rated as: 1 (never), 2 (rarely), 3 (sometimes), 4, (often), and 5 (very often). GDT total scores are calculated by summing all items, with higher scores reflecting greater risk of GD [23,28]. A total GDT score over 15 suggests GD [24]. An example item of the GDT is '*I have had difficulties controlling my gaming activity*'. The internal consistency of the GDT was excellent in the original English version ($\alpha = 0.84$) and simplified Chinese version ($\alpha = 0.87$) [23]. In the present study, a high internal consistency was found ($\alpha = 0.90$).

2.3.3. Gaming Disorder Scale for Adolescents (GADIS-A)

Paschke et al. developed the GADIS-A as a self-report tool assessing past-year engagement with online and/or offline gaming [20]. The GADIS-A uses the WHO framework to assess GD symptoms in severity with a focus on adolescents [20]. The GADIS-A contains 10 items with three domains including GD negative consequences (NCs), cognitive behavioral symptoms (CBs), and frequency of problematic gaming (item 10). For the first 9 items, participants are asked about their gaming with responses rated as: 0 (strongly disagree), 1 (disagree), 2 (partially agree/partially disagree), 3, (agree), and 4 (strongly agree). Item 10 asks participants about their frequency of problematic gaming with four responses as: 0 (not at all), 1 (only on single days), 2 (during longer periods), 3 (almost daily). Total GADIS-A scores are calculated by summing and provide three domains with thresholds to indicate GD (cut-off points at over 5 for NCs; over 9 for CBs; and time criterion during longer periods or almost daily for frequency) [20,31]. An example item of an item is '*I often do not pursue interests outside the digital world because I prefer gaming. For example, I do not meet with friends/ my partner in real life, do not attend sports clubs/ societies, do not read books or make music because of gaming.*' The internal consistency of the GADIS-A was excellent for the German version ($\alpha = 0.91$ for total score; $\alpha = 0.90$ for NCs; and $\alpha = 0.87$ for CBs) and Iranian version ($\alpha = 0.85$ for total score; $\alpha = 0.70$ for NCs; and $\alpha = 0.75$ for CBs) [20,32]. Additionally, the internal consistency was excellent in the present study ($\alpha = 0.94$ for total score; $\alpha = 0.91$ for NCs; and $\alpha = 0.89$ for CBs).

The GADIS-A was developed to assess GD risk among adolescents [20,32]. Here, we tested whether the GADIS-A could be used to investigate GD in young adults given the relevance of GD to both adolescents and young adults [38].

2.3.4. Internet Gaming Disorder Scale – Short Form (IGDS9-SF)

Pontes and Griffiths developed the IGDS9-SF as a nine-item self-reported tool assessing IGD symptoms and severity using the APA framework [18,39]. All items are answered using a 5-point Likert scale with rated as: 1 (never), 2 (rarely), 3 (sometimes), 4, (often), and 5 (very often). Total IGDS9-SF scores are calculated by summing all items, with higher scores reflecting greater risk of GD [40]. An example IGDS9-SF item is, '*Do you feel preoccupied with your gaming behavior?*'. The internal consistency of the IGDS9-SF was excellent in both the English ($\alpha = 0.87$) and simplified Chinese versions ($\alpha = 0.94$) [32,41]. The internal consistency was also excellent in the present study ($\alpha = 0.94$).

2.3.5. Depression Anxiety Stress Scale - 21 (DASS-21)

Lovibond and Lovibond developed the DASS-21 to examine psychological distress (i.e., depression, anxiety, and stress), and this tool has been validated in clinical and non-clinical populations [42,43]. The DASS-21 consists of 21 items covering three domains containing seven items each [43]. All items are answered using a 4-point Likert scale rated as: 0 (did not apply to me at all), 1 (applied to me to some degree, or some of the time), 2 (applied to me to a considerable degree or a good part of time), 3 (applied to me very much or most of the time). Total DASS-21 scores are calculated by summing all items, and also separately calculated scores into three domains with each 7 item scores multiplied by two. Higher score reflect more severe psychological distress [44]. Cut-off points have been suggested for each domain, with: depression at 10–13 (mild level), 14–20 (moderate level), 21–27 (severe level), over 28 (extremely severe level); anxiety at 8–9 (mild level), 10–14 (moderate level), 15–19 (severe level), and over 20 (extremely severe level); and, stress domain at 15–18 (mild level), 19–25 (moderate level), 26–33 (severe level), and over 34 (extremely severe level) [45]. An example DASS-21 item is '*I couldn't seem to experience any positive feeling at all*'. The internal consistency of the DASS-21 was excellent in the English version ($\alpha = 0.93$ for total score; $\alpha = 0.88$ for depression; $\alpha = 0.82$ for anxiety; and $\alpha = 0.90$ for stress) [46]. The internal consistency was also excellent in the present study ($\alpha = 0.94$ for total score; $\alpha = 0.88$ for depression; $\alpha = 0.83$ for anxiety; and $\alpha = 0.84$ for stress).

2.4. Statistical analysis

JASP version 0.16.3 was used for the statistical analysis [47]. Descriptive statistics were computed to examine participants' sociodemographic data, determine mean scores on the GDT, GADIS-A, IGDS9-SF, DASS-21, and conduct item-level analysis (i.e., skewness and kurtosis).

For structural validity, we used Confirmatory Factor Analysis (CFA) to examine the factor structures of the GDT and GADIS-A. The GDT was examined using a one-factor structure while the GADIS-A was examined using one-factor and two-factor solutions. The measurement models computed for the GADIS-A were compared using χ^2 difference tests to examine which factor structure presented the best fit. Factor loadings from the CFA and the corrected item-total correlation were used to examine all items of the GDT and GADIS-A; we expected values for both standardized factor loadings and item-total correlation to be above 0.4 [48]. Furthermore, we used a diagonally weighted least square (DWLS)

method in the CFA because the GDT and GADIS-A scales were ordinal categorical variables [49,50]. Cronbach's α and McDonald's ω were used to examine the internal consistency of both the GDT and GADIS-A with values of internal consistency being considered adequate when Cronbach's α and McDonald's ω reached 0.70 or above [51,52].

We employed standard practice to evaluate model fit indices. Model fit was assessed using with nonsignificant χ^2 and values of fit statistics including a Comparative Fit Index (CFI) over 0.90; Tucker–Lewis Index (TLI) over 0.90; Root Mean Square Error of Approximation (RMSEA) below 0.80; and Standardized Root Mean Square Residual (SRMR) below 0.80 [53,54]. We also report the χ^2 and its degree freedom along with other relevant measures to indicate fit indices, although one of the limitations of this fit index is that significant *p*-values may be obtained with large sample sizes [55].

After testing the factor structure of the GDT and GADIS-A, we examined the suitability of the one-factor solution of the GDT and the best-fitting factor structure of the GADIS-A based on the χ^2 difference test. Following this, measurement invariance across gender (i.e., males vs. females) was tested. Three nested models in the multigroup CFA (MGCFA) were sequentially assessed to test measurement invariance: (i) configural model examining the equivalence of the factor structure; (ii) metric model examining factor loadings constrained equal across gender (i.e., metric invariance); (iii) and, scalar model examining factor loadings with item intercepts constrained equal across gender (i.e., scalar invariance) [56,57]. To evaluate measurement invariance across the two groups, the three nested models tested should not be significantly different between each other as evaluated using χ^2 difference tests, or both ΔCFI and ΔTLI > -0.01, ΔRMSEA <0.03 and ΔSRMR <0.01 [58–60]. Pearson correlations were used to investigate convergent and divergent validity of the GDT and GADIS-A via correlations with IGDS9-SF and DASS-21 scores, respectively.

3. Results

3.1. Descriptive statistics and item properties of the GDT and GADIS-A

The mean GDT score was 8.12 ± 3.55, and the mean IGDS9-SF score was 16.20 ± 7.15 (Table 1). Based on the GADIS-A cut-off points, the mean scores of NCs (4.30 ± 4.30) and CBs (4.64 ± 3.78) did not meet the cut-off scores, indicating that our participants had low GD risk and that 1% ($n = 5$) of participants reached the time criterion of the frequency domain. Additionally, we found that mean scores of the three DASS-21 domains (i.e., depression, anxiety, stress) did not meet the cut-off scores, suggesting that our participants on average did not present with clinically significant psychological distress at the time of the survey.

All GDT items of the GDT were normally distributed with skewness ranging between 0.51 and 1.16 and kurtosis ranging between −0.33 and 0.90 (Table 2). Similarly, the GADIS-A scores were also normally distributed with skewness and kurtosis within expected ranges. For the NCs domain of the GADIS-A, all items had skewness between 0.89 and 1.16 and kurtosis between −0.36 and 0.64. For the CBs domain, all items had skewness ranging from 0.22 to 0.97 and kurtosis ranging from −0.98 to 0.27. Moreover, using the cutoff for the GDT total score (i.e., over 15), there were 20 individuals with problematic gaming (3.3%); using the cutoff scores for the GADIS-A (i.e., over 5 for NCs plus over 9 for CBs with time criterion during longer periods or almost daily for frequency), there were 24 individuals with problematic gaming (3.9%).

Table 1
Demographics of present sample ($n = 608$).

Variable	N (%)	Mean (SD)
Age (year)	–	29.10 (6.36)
Gender		
Female	334 (55%)	–
Male	274 (45%)	–
Daily hours on sleeping (weekday)	–	6.96 (1.27)
Daily hours on outdoor activities	–	1.66 (1.82)
Daily hours on smartphone usage	–	5.32 (2.92)
Daily hours on social media usage	–	2.85 (2.34)
Daily hours on online study	–	1.65 (1.91)
GDT (Total score)	–	8.12 (3.55)
GADIS-A	–	
Negative consequences	–	4.30 (4.30)
Cognitive behavioral symptoms	–	4.64 (3.78)
Frequency (during longer periods)	5 (1%)	–
IGDS9-SF (Total score)	–	16.20 (7.15)
DASS-21 (Total score)		13.04 (10.95)
Depression subscale score	–	4.10(4.19)
Anxiety subscale score	–	3.78(3.66)
Stress subscale score	–	5.16(4.06)

SD - Standard deviation.
GDT - The Gaming Disorder Test.
GADIS-A - GAming DIsorder Scale for Adolescents.
IGDS9-SF - Internet Gaming Disorder Scale - Short Form.
DASS-21 - Depression Anxiety Stress Scale – 21.

3.2. Internal consistency and factor structure of the GDT and GADIS-A

We found excellent internal consistency for the GDT total scores (both α and $\omega = 0.90$). Similarly, the internal consistency for the GADIS-A scores were excellent (both α and $\omega = 0.91$ for NCs; both α and $\omega = 0.89$ for CBs). All GDT item scores showed satisfactory psychometric properties in terms of standardized factor loadings (0.74–0.89) and corrected item-total correlations (0.70–0.83). All GADIS-A item scores were satisfactory in relation to standardized factor loadings (0.75–0.90 for NCs; 0.71–0.90 for CBs) and corrected item-total correlations (0.67–0.82 for NCs; 0.72–0.81 for CBs).

According to CFA (Table 3), the GDT showed a one-factor structure with a good fit index (nonsignificant χ^2, CFI = 1.000; TLI = 1.000; RMSEA = 0.008; and SRMR = 0.025). For the GADIS-A, the two models (i.e., one-factor and two-factor structures) were investigated to ascertain which solution provided the best fit. Both models revealed overall good fit to the data. However, the two-factor structure had significantly better fit than the one-factor structure as shown by the χ^2 difference test ($\Delta\chi^2 = 4.6$, $p = 0.03$).

3.3. Measurement invariance of the GDT and GADIS-A across gender

Nested models investigated measurement invariance for each gender (i.e., male vs. female; Table 4). In the nested model comparison of the GDT and GADIS-A, the models had a good fit with respect to changes in χ^2 ($\Delta\chi^2$), nonsignificant χ^2, and acceptable fit on all criteria of ΔCFI, ΔTLI, ΔRMSEA, and ΔSRMR. However, factor-loading constraints presented significant χ^2 difference from the configural models across gender, in addition to factor loading and thresholds constrained models presenting significant χ^2 difference from the factor loadings constrained across gender due to large sample size of our participants ($n = 608$). In sum, measurement invariance (including metric and scalar invariance) across gender was supported for both the GDT (in a one-factor structure) and GADIS-A (in a two-factor structure).

3.4. Convergent and divergent validity of the GDT and GADIS-A

Convergent and divergent validity of the GDT and GADIS-A was determined by investigating associations of the GDT and GADIS-A with IGDS9-SF and DASS-21 scores using Pearson correlations (Table 5). The GDT and GADIS-A (NCs and CBs domain scores) were significantly and positively correlated with both IGDS9-SF and DASS-21 (total score and each domain score). The GDT was significantly and positively correlated with the GADIS-A (NCs and CBs scores).

Table 2
Psychometric properties of the GDT and GADIS-A in item level.

	[a]Factor loadings	Item-total correlation	Mean (SD)	Skewness	Kurtosis	α	ω
GDT			8.12(3.55)	0.77	0.22	0.90	0.90
Item 1	0.81	0.76	2.29(1.04)	0.51	−0.33		
Item 2	0.89	0.82	2.07(1.01)	0.71	−0.18		
Item 3	0.89	0.83	1.98(1.04)	0.88	0.07		
Item 4	0.74	0.70	1.78(0.95)	1.16	0.90		
GADIS-A						0.94	0.94
Factor I			4.30(4.30)	0.83	0.03	0.91	0.91
Item 3	0.75	0.67	0.97(1.03)	0.89	0.17		
Item 6	0.90	0.82	0.87(0.99)	1.04	0.55		
Item 7	0.83	0.80	0.93(1.06)	0.85	−0.36		
Item 8	0.82	0.81	0.74(0.95)	1.16	0.64		
Item 9	0.83	0.81	0.80(0.96)	1.09	0.59		
Factor II			4.64(3.78)	0.44	−0.53	0.89	0.89
Item 1	0.71	0.74	1.54(1.21)	0.22	−0.98		
Item 2	0.80	0.81	1.24(1.12)	0.55	−0.57		
Item 4	0.88	0.77	1.03(1.07)	0.72	−0.42		
Item 5	0.89	0.72	0.83(0.95)	0.97	0.27		

GDT - The Gaming Disorder Test.
GADIS-A - GAming DIsorder Scale for Adolescents.
Factor I - GAming DIsorder Scale for Adolescents (negative consequences domain).
Factor II - GAming DIsorder Scale for Adolescents(Cognitive behavioral symptoms domain).
SD - Standard deviation.
α - Cronbach alpha coefficient.
ω - McDonald omega coefficient.
[a] Factor loadings are standardized factor loadings which derived from Confirmatory Factor Analysis. Moreover, all factor loadings were significant with p-values <0.001.

Table 3
Index of fit in the confirmatory factor analysis for the GDT and GADIS-A.

	GDT	GADIS-A	GADIS-A
	One-factor model	One-factor model	Two-factor model
Fit indices			
χ^2 (*df*)	2.08 (2)	64.54 (27)	59.94 (26)
p-value	0.353	< 0.001	< 0.001
CFI	1.000	0.994	0.995
TLI	1.000	0.993	0.993
RMSEA (90% CI)	0.008 (0.000,0.081)	0.048 (0.033,0.063)	0.046 (0.031,0.062)
SRMR	0.025	0.054	0.052

Note. χ^2 difference test for GADIS-A one-factor and two-factor model comparisons: $\Delta\chi^2 = 4.6$; $\Delta df = 1$; p-value = 0.03.
GDT - The Gaming Disorder Test.
GADIS-A - GAming DIsorder Scale for Adolescents.
CFI - Comparative fit index.
TLI - Tucker-Lewis index.
RMSEA - Root mean square error of approximation.
SRMR - Standardized root mean square residual.

4. Discussion

This study aimed to translate the GDT and GADIS-A into Chinese for Taiwanese young adults using a rigorous methodology for cross-cultural psychometric adaptation. Additionally, the study aimed to assess the reliability and validity of the GDT and GADIS-A for Taiwanese young adults. The procedure of translation and cross-cultural adaptation followed standard guidelines [37], leading to the development of Taiwan versions of the GDT and the GADIS-A. Overall, both tools showed adequate internal consistency, construct validity, and convergent validity, suggesting that the GDT and GADIS-A will be useful resources for Taiwanese healthcare professionals and researchers seeking to screen for GD in young adults.

The results further showed that the GDT total scores and GADIS-A domains of NCs and CBs were ≥ 0.89, suggesting that the GDT and two GADIS-A domains had satisfactory levels of internal consistency. Because the GDT and the two GADIS-A domains include relatively few items (i.e., < ten items) and demonstrated good internal consistency, both the GDT and GADIS-A appear to efficient for identifying GD issues among young adults. For example, the two instruments may facilitate studying gaming-related individual and group differences, such as those before and after a treatment, although this warrants direct examination.

The fit indices of the CFA indicated that the GDT appear best measured using a one-factor structure and the GADIS-A with a two-factor structure, lending support to previous studies [20,23]. In addition, the CFA-based fit indices indicated that GADIS-A can conceptualized within a one-factor or two-factor structure. This may be due to the high correlation between the two domains (Pearson's $r = 0.79$). Considering that the two-factor structure had significantly better fit than the one-factor structure as shown by the χ^2 difference test, and given the structure of the original GADIS-A model, we adopted a two-factor structure in subsequent analyses.

Past studies have shown that males of all ages invest more time and effort in gaming than females [61,62], and about four-fifths of individuals playing massively multiplayer online role-playing games are male [63]. Therefore, it is important to examine if both the GDT and GADIS-A work well across males and females. The present results suggest the factor structures of these two tools remained invariant across male and females (i.e., configural invariance, metric invariance, and scalar invariance). In other words, researchers may confidently compare GDT and GADIS-A scores for men and women.

The results showed that the GDT and GADIS-A (NCs and CBs domains) were significantly and positively correlated with both the IGDS9-SF and DASS-21. The GDT and the GADIS-A domains exhibited significant and positive correlations. It was anticipated that GDT, GADIS-A and IGDS9-SF scores would positively correlate with one another as all three tools assess gaming problems. Similarly, the positive correlations between the two GD instruments (i.e., GDT and GADIS-A) and DASS-21 (including the total score and its three domains of depression, anxiety, and stress) fit with expectations, as previous studies have shown that people with GD often experience psychological distress [64,65]. Moreover, associations between GDT, GADIS-A, and IGDS9-SF scores were numerically greater than those between the two GD instruments and the DASS-21 (Table 5). This suggests that GDT and GADIS-A scores may be more strongly associated with instruments assessing similar construct (i.

Table 4
Measurement invariance gender on GADIS-A with one factor and two factor structures.

	GDT					GADIS-A (two factor structure)				
	M1 (df = 4)	M2 (df = 7)	M3 (df = 10)	M2-M1 (Δdf = 3)	M3-M2 (Δdf = 3)	M1 (df = 52)	M2 (df = 59)	M3 (df = 66)	M2-M1 (Δdf = 7)	M3-M2 (Δdf = 7)
χ^2 or $\Delta\chi^2$	2.76	3.11	5.86	0.35	2.75	64.23	91.62	95.54	27.39	0.789
p-value	0.599	0.875	0.827	0.950	0.432	0.119	0.004	0.010	0.0002	0.006
CFI or ΔCFI	1.000	1.000	1.000	0.000	0.000	0.998	0.995	0.995	−0.003	0.000
TLI or ΔTLI	1.004	1.006	1.005	0.002	−0.001	0.997	0.994	0.995	−0.003	0.001
RMSEA or ΔRMSEA	0.000	0.000	0.000	0.000	0.000	0.028	0.043	0.038	0.015	−0.005
SRMR or ΔSRMR	0.026	0.028	0.030	0.002	0.002	0.056	0.066	0.061	0.01	−0.005

M1 - Configural model.
M2 - Loadings constrained equal.
M3 - Loadings and thresholds constrained equal.
GDT - The Gaming Disorder Test.
GADIS-A - GAming DIsorder Scale for Adolescents.
CFI - Comparative fit index.
TLI - Tucker-Lewis index.
RMSEA - Root mean square error of approximation.
SRMR - Standardized root mean square residual.

Table 5
Correlation among GDT, GADIS-A, IGDS9-SF and DASS-21.

Variable	GDT-T	GADIS-F1	GADIS-F2	IGDS9-T	DASS-T	DASS-D	DASS-A	DASS-S
GDT-T	–							
GADIS-F1	0.68*	–						
GADIS-F2	0.78*	0.85*	–					
IGDS9-T	0.78*	0.79*	0.80*	–				
DASS-T	0.35*	0.40*	0.33*	0.37*	–			
DASS-D	0.37*	0.41*	0.34*	0.39*	0.92*	–		
DASS-A	0.33*	0.41*	0.31*	0.36*	0.92*	0.77*	–	
DASS-S	0.26*	0.30*	0.25*	0.27*	0.92*	0.75*	0.79*	–

GDT-T - The Gaming Disorder Test (Total score).
GADIS-F1 - GAming DIsorder Scale for Adolescents (Negative consequences domain score).
GADIS-F2 - GAming DIsorder Scale for Adolescents (Cognitive behavioral symptoms domain score).
IGDS9-T - Internet Gaming Disorder Scale - Short Form (Total score).
DASS-T - Depression Anxiety Stress Scale – 21 (Total score).
DASS-D - Depression Anxiety Stress Scale – 21 (Depression domain score).
DASS-A - Depression Anxiety Stress Scale – 21 (Anxiety domain score).
DASS-S - Depression Anxiety Stress Scale – 21 (Stress domain score).
* $p < 0.001$.

e., gaming problems) than those assessing different but related constructs (i.e., psychological distress), although this was not explored directly. Therefore, the findings suggest satisfactory convergent validity and divergent validity for the GDT and GADIS-A.

In addition to the self-reported GD scale as a criterion for convergent validity, external rating scales can also be included to investigate validity in the future. Both the GADIS-A and GDT are self-administered questionnaires, and respondents investigated have been adolescents or young adults. Responses may be influenced by age, cognitive dysfunction, or psychiatric problems experienced by respondents, leaving to biased responses. External rating scales completed by parents, primary caregivers, or teachers (e.g., Gaming Disorder Scale for Parents [66]) could provide independent information and serve as comparison, and such studies may be conducted in the future.

The present study found a unidimensional structure of the GDT, which is in agreement with all previous literature reporting the GDT's factor structure [17,23–28]. Moreover, the present internal consistency findings of the GDT in emerging Taiwanese adults are acceptable (α = 0.90), and this finding echoes prior ones regarding the GDT's internal consistency: 0.87 for a simplified Chinese version [23], 0.84 for an English version [23], 0.78 for a Bengali version [24], 0.89 for a Spanish version [28], 0.88 for a Turkish version [26], and 0.92 for a Polish version [27]. Notably, the present psychometric properties of a traditional Chinese GDT are comparable to those of a simplified Chinese version [23], despite age differences between the samples in testing the simplified (mean [SD] age = 19.22 [1.57]) and traditional (mean [SD] age = 29.10 [6.36]) Chinese versions. Moreover, both the simplified and traditional Chinese GDTs were associated with psychological distress. These findings suggests that the GD concept assessed via the GDT is comparable between simplified Chinese (used in mainland China) and traditional Chinese (used in Taiwan) versions. Nevertheless, given that the present study did not directly compare the psychometric properties between simplified and traditional Chinese versions, future studies are needed to provide cross-cultural evidence for measurement invariance.

The GADIS-A was initially developed for adolescents, and this study was conducted with university students in order to investigate and potentially expand the generalizability of the GADIS-A by studying its applicability to a wider age group. However, the present study did not recruit children or adolescents aged below 18. Therefore, the present findings might not be generalizable to the population aged below 18 years in Taiwan. Nevertheless, in other studies testing the psychometric properties of the GADIS-A in people younger than 18, the GADIS-A has been found to be psychometrically sound. This indicates that the GADIS-A could expand its target age populations from adolescents to emerging adults. Indeed, when comparing our findings to other studies that have validated the GADIS-A, all other studies [20,31,32] were conducted with adolescents (e.g., grades 7–12), and our study recruited solely young adults. All studies reported acceptable internal consistency of the

GADIS-A: α = 0.70 to 0.85 in a Farsi version [32]; 0.82 to 0.89 in a Russian version [31]; 0.87 to 0.91 in the original German version [20]; and 0.89 to 0.94 in our Chinese version for Taiwan emerging adults. Moreover, the GADIS-A was found to have a two-factor structure across all studies assessing its psychometric properties [20,31,32]. In sum, the GADIS-A is a promising tool to assess GD among Taiwan populations; however, its psychometric properties in Taiwanese adolescents need to be further examined.

The present study has limitations. First, participants were recruited online through convenience sampling, and there is no guarantee that the demographic information they answered is completely correct or that the sample is representative. Second, no diagnoses should be derived based solely on screening tools (e.g., the GDT and GADIS-A), and clinical interviews represent the gold standard for making diagnoses, and such information would provide important validation. Third, this study only recruited university students from Taiwan, so the reliability and validity analyses conducted cannot be extrapolated to other age groups, non-university students and/or those from other cultural backgrounds.

5. Conclusion

The Chinese versions of the GDT and GADIS-A for Taiwanese young adults are valid and reliable tools. According to the validity and reliability findings, both instruments could be used to assess GD in university students in Taiwan. Specifically, both tools showed suitable internal consistency, construct validity, measurement invariance, and convergent and divergent validity. The GDT and the GADIS-A may be used in schools or clinical settings to assess severity of GD. As indicated, students with GADIS-A scores above cut-off points may be referred for further treatment.

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Ethical approval

National Cheng Kung University Human Research Ethics Committee (Approval No. NCKU HREC-E-110-486-2) and the National Cheng Kung University Hospital Institute of Review Board (IRB No. A-ER-111-445) and the study was in accordance with the principles of 1964 Helsinki Declaration.

CRediT authorship contribution statement

Tzu-Yi Wu: Conceptualization, Validation, Writing – original draft. **Shih-Wei Huang:** Conceptualization; Methodology; Validation; Resources; Writing–review and editing. **Jung-Sheng Chen:** Conceptualization, Software, Formal analysis, Resources, Writing – review & editing, Funding acquisition. **Kamolthip Ruckwongpatr:** Methodology, Software, Validation, Formal analysis, Data curation, Writing – original draft, Writing – review & editing, Visualization. **Shikha Kukreti:** Methodology, Software, Data curation, Writing – review & editing. **Carol Strong:** Methodology, Software, Data curation, Writing – review & editing. **Halley M. Pontes:** Methodology, Validation, Writing – review & editing. **I-Ching Lin:** Conceptualization, Methodology, Investigation, Resources, Writing – review & editing, Project administration, Funding acquisition. **Chung-Ying Lin:** Conceptualization, Methodology, Software, Investigation, Resources, Writing – original draft, Writing – review & editing, Supervision, Project administration, Funding acquisition. **Marc N. Potenza:** Methodology, Validation, Writing – review & editing. **Amir H. Pakpour:** Methodology, Validation, Writing – review & editing.

Declaration of Competing Interest

Dr. Potenza discloses that he has consulted for and advised Game Day Data, Addiction Policy Forum, AXA, Idorsia, Baria-Tek, and Opiant Therapeutics; been involved in a patent application involving Novartis and Yale; received research support from the Mohegan Sun Casino, Children and Screens and the Connecticut Council on Problem Gambling; consulted for or advised legal, gambling and non-profit entities on issues related to impulse control, internet use and addictive behaviours; provided clinical care related to impulse-control and addictive behaviours; performed grant reviews; edited journals/journal sections; given academic lectures in grand rounds, CME events and other clinical/scientific venues; and generated books or chapters for publishers of mental health texts. The other authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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