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Short Grit Scale (Grit-S): New evidence based on CFA and MIRT models

Escala breve de Grit (Grit-S): Nueva evidencia basada en los modelos AFC y TRIM

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Abstract
Studying grit's measurement helps to understand this psychological phenomenon associated with success. Grit-S structures of one-factor and two-factor have been reported in the literature, but there is a lack of reports based on Item Response Theory (IRT). Therefore, two objectives were proposed: to determine the factorial structure of the Spanish version of the Grit-S and explore the instrument through a Multidimentional Item Response Theory (MIRT) analysis. A nonprobabilistic sample of 899 subjects (41.0% female) was evaluated. The 8 items grit scale was used. The Confirmatory Factor Analysis (CFA) showed that the two-factor model obtained a good fit (CFI = 0.97, TLI = 0.95, RMSEA [90%CI] = 0.08 [0.07, 0.10]) unlike the one-dimensional model. An exploratory comparison analysis by MIRT also revealed that the two-factor model performed better ($p < 0.001$). Consequently, a confirmatory analysis determined an adequate fit of the two-factor model (C2 = 45.4; RMSEA [90%CI] = 0.05 [0.04 - 0.07]; TLI = 0.97; CFI = 0.99). Multidimensional discrimination values were within the expected range (> 1; > 1.5), although item 2 had low discrimination. Regarding difficulty, all items had a monotonic increase. The two-factor model fits the data by both CFA and MIRT. Both complementary analyzes demonstrate the potential of Grit-S to measure latent consistency and perseverance factors.

Resumen
Estudiar la medición del grit ayuda a comprender este fenómeno psicológico asociado al éxito. En la literatura se han reportado estructuras de Grit-S de uno y dos factores, pero se carece de reportes basados en la Teoría de Respuesta al Ítem (TRI). Por ello, se propusieron dos objetivos: determinar la estructura factorial de la versión española del Grit-S y explorar el instrumento mediante un análisis de la Teoría de Respuesta al Ítem Multidimensional (TRIM). Se evaluó una muestra no probabilística de 899 sujetos (41,0% mujeres). Se utilizó la escala grit de 8 ítems. El análisis factorial confirmatorio (AFC) mostró que el modelo de dos factores obtenía un buen ajuste (CFI = 0,97, TLI = 0,95, RMSEA [90%CI] = 0,08 [0,07, 0,10]) a diferencia del modelo unidimensional. Un análisis exploratorio de comparación mediante TRIM también reveló que el modelo de dos factores funcionaba mejor ($p < 0,001$). En consecuencia, un análisis confirmatorio determinó un ajuste adecuado del modelo de dos factores (C2 = 45,4; RMSEA [IC 90%] = 0,05 [0,04 - 0,07]; TLI = 0,97; CFI = 0,99). Los valores de discriminación multidimensional se encontraban dentro del rango esperado (> 1; > 1,5), aunque el ítem 2 presentaba una baja discriminación. En cuanto a la dificultad, todos los ítems tuvieron un incremento monotónico. El modelo bifactorial se ajusta a los datos tanto por AFC como por TRIM. Ambos análisis complementarios demuestran el potencial de Grit-S para medir factores latentes de consistencia y perseverancia.

Palabras clave / Keywords
Psychometrics; Educational psychology; Higher education; Measuring instruments; Achievement motivation; Factor analysis; University students; Psychological research.
Psicometría; Psicología de la educación; Enseñanza superior; Instrumento de medida; Motivación de logro; Análisis factorial; Estudiante Universitario; Investigación psicológica.

1. Introduction

Some students achieve their goals, and others do not. A characteristic of the first is their desire to succeed; they persist for years to become professionals, whereas the second does not show the same level of interest or projection. In particular, this difference can be attributed to grit, which is the ability to persevere in achieving long-term goals (Duckworth et al., 2007). However, it is also known as determination and perseverance (Datu et al., 2017). Therefore, grit has shown a significant influence on academic success. For example, suppose that someone wants to study at a public university. In that case, it will be necessary to have grit to achieve his/her goal. Otherwise, his chances of admission will be diminished by a lack of motivation, drive to succeed, effort, directionality, and participation.

In this sense, grit is a variable that has been shown to predict personal and professional success. It also increases psychological well-being, quality of life, performance, satisfaction, optimism, commitment, and emotional intelligence (Ain et al., 2021; Fernández-Martín et al., 2020; Sharkey et al., 2017). It also decreases depression, dishonesty, emotional burnout, risk behaviors, anxiety, burnout, and stress (Fernández-Martín et al., 2020; Guerrero et al., 2016; Salles et al., 2017). In other words, a gritty person will try to achieve their goal despite the difficulties that may arise and delay it. Therefore, studying this phenomenon can help explain success or failure behaviors.

There are two grit instruments developed by Duckworth et al. (2007); these are Grit-O (12 items) and Grit-S (8 items). In this study, we focus on the short version, which has been adapted to different languages such as German, Italian, French, Polish, and Chinese (Li et al., 2018; Schmidt et al., 2019; Sulla et al., 2018; Wyszyńska et al., 2017). Additionally, Grit-S has also been translated into Spanish initially in Spain (Arco-Tirado et al., 2018; Barriopedro et al., 2018) and subsequently in Mexico (Marentes-Castillo et al., 2019), Argentina (Tortul et al., 2020), and Colombia (Collantes-Tique et al., 2021).

Few of the studies mentioned above have studied its factor structure employing exploratory factor analysis (EFA), while the majority have performed confirmatory factor analysis (CFA). The latter studies showed that the two-factor structure has an adequate fit index (Collantes-Tique et al., 2021; Datu et al., 2017; Luo et al., 2020; Marentes-Castillo et al., 2019; Tortul et al., 2020; Wyszyńska et al., 2017; Zhong et al., 2018). This proposal is also consistent with Grit-S studies in different languages. However, two other studies suggested the unidimensionality of Grit-S (Arco-Tirado et al., 2018; Stephen et al., 2018), which is consistent with the original study by Duckworth et al. (2007). On the other hand, few studies explored different factor structures as a bifactor and second-order model (Barriopedro et al., 2018; Credé et al., 2016; Li et al., 2018). The model with two factors is the one that best represents the grit construct through Consistency of Interest and Perseverance of Effort. However, in a current study, Duckworth et al. (2021) suggest continuing the review of the Grit-S because there is no consensus on its structure.

So far, evidence of Girt-S has been demonstrated using Classical Test Theory (CTT), but there is no evidence of Item Response Theory (IRT). In this sense, it is beneficial to explore through IRT models because it establishes probabilistic models using observable variables and obtaining discrimination (a) and difficulty (b) parameters, which provides evidence of the accuracy of the measurement of each item (Van der Linden & Hambleton, 1997). That is, an individual's responses on an item express his or her level of ability on the latent trait (Hambleton et al., 1991). On the other hand, IRT models are usually applied to unidimensional models. However, there are psychological constructs that, by nature, are multidimensional. In that case, Multidimensional Item Response Theory (MIRT) is a way to explore models with two or more factors because it analyzes items that measure a construct of multiple abilities (Ackerman, 1994). Therefore, MIRT models help explore multidimensional instruments to obtain more precise psychological measurements.

1.1. Purpose of the present study

The literature on Grit-S reports one-factor and two-factor models. However, this reality is presented in different languages and contexts. Based on this, the first objective (a) was established to determine the factorial structure of the Spanish version of the Grit-S; this objective is intended to confirm the most appropriate structure among the predominant models in the literature. Likewise, to perform a more robust psychometric analysis of the instrument, the second objective (b) was established to validate the instrument through an IRT analysis for one- or two-factor structures. This way, a gap in the literature on the Grit-S approach is filled since there are no psychometric reports based on Item Response Theory (IRT).

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2. Methodology

2.1. Participants

A Monte Carlo simulation was used to calculate the sample size for Confirmatory Factor Analysis (Beaujean, 2019). A minimum sample of 800 subjects was required for the factor analysis; therefore, a sample of 899 subjects was obtained through nonprobabilistic sampling. The participants were Peruvian undergraduate students with an average age of 24.42 years (SD = 8.74 years). There were 41.0% of male students and 59.0% of female students. Some of them were single (84.9%), married (8.1%), divorced (1.2%), and cohabiting (5.8%). Furthermore, 47.7% were studying, and 52.3% were studying and working. Most students take remote classes (58.8%), hybrid (37.8%), and face-to-face (3.4%). Also, 53.28% receive support for their studies, while 46.8% do not. Whether or not they had failed a course, 31.7% said yes. Students perceived their average grade as 15.96 (SD = 1.41). All participants gave their informed consent to be included in the study.

Table 1.
Sociodemographic characteristics.

Variables	Data
Age (M ± SD)	24.42 ± 8.74
Sex, n (%)	
Male	369 (41.0%)
Female	530 (59.0%)
Marital status, n (%)	
Single	763 (84.9%)
Married	73 (8.1%)
Divorced	11 (1.2%)
Cohabitants	52 (5.8%)
Study & Work, n (%)	
Study only	429 (47.7%)
Study and Work	470 (52.3%)
Study modality, n (%)	
Remote	528 (58.8%)
Face-to-face	31 (3.4%)
Hybrid	340 (37.8%)
Do you receive support for your studies?, n (%)	
Yes	478 (53.2%)
No	421 (46.8%)
Have you failed a course?, n (%)	
Yes	285 (31.7%)
No	614 (68.3%)
Semester average grade (M ± SD)	15.96 ± 1.40

2.2. Measure

Short Grit Scale (Duckworth et al., 2007). We used the spanish version adapted and translated at a cross-cultural level by Arco-Tirado et al. (2018) (Appendix). It consists of a test of eight items grouped into a general factor that obtained adequate fit indices (χ^2= 233.21; CFI= 0.95; RMSEA = 0.071). Arco-Tirado et al. (2018) also found that the two-factor model maintains adequate fit indices, although not superior to the unidimensional model. Each item is answered on a Likert-type scale from 1 ("Totally disagree") to 5 ("Totally agree"). On reliability, the alpha coefficient of the total scale was 0.75; the alpha of consistency of interest was 0.77, and the perseverance of effort was 0.48.

2.3. Procedure

The study was approved by the Research Institute of the Universidad de Ciencias y Humanidades through Act CEI No. 029 (Code-043-22). After approval, a virtual form was prepared to apply the measurement instruments. The form presented the objectives of the study and informed consent. If the participant agreed to

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participate in the study, he/she had to complete an initial sociodemographic form and the measurement instruments. The application of the form was carried out from August 2022 to September 2022. Data availability and syntaxes can be requested from the main author.

2.4. Data Analysis

The R Studio environment (v. 4.2.2) was used for all statistical analyzes (R Core Team, 2019). For the first objective, we began to analyze the items through their normal distribution following the univariate normality criteria of the skewness (± 2) and kurtosis (± 8) coefficients (Finney & DiStefano, 2013). Next, the relationships between the variables were evaluated through a polychoric matrix because they were categorical variables. Subsequently, the study models were tested through the diagonally weighted least squares with mean and variance corrected (WLSMV) estimator. An oblique rotation was used for the two-factor model. The chi-square test (χ^2), degrees of freedom (df), RMSEA, and SRMR were used where values below 0.05 indicate a good fit, and values between 0.05 - 0.08 indicate an acceptable fit (Kline, 2016). Likewise, the Comparative Fit Index (CFI) and the Tucker-Lewis Index (TLI) were evaluated, where values greater than 0.95 indicate a good fit, and values greater than 0.90 indicate an acceptable fit (Schumacker & Lomax, 2016). Reliability was evaluated using the omega coefficient for categorical data, which must be greater than 0.70 to be considered acceptable (Viladrich et al., 2017). Regarding factor loadings, we followed the criterion that values greater than 0.40 are considered adequate (Dominguez-Lara, 2018).

On the other hand, IRT has a set of techniques that assume one latent variable. However, MIRT is considered an extension of IRT that attempts to account for multiple latent variables (te Marvelde et al., 2006). Both have the particularity of assessing latent skills/traits of the subjects. For this study, MIRT and the multidimensional extension of the graded response model (Samejima, 1969, 1997) were used. The 2-parameter model extension is applied for polytomous variables (Hambleton et al., 1991). Therefore, the *mirt* package was used for the IRT analysis (Chalmers, 2012). We started with an exploratory process of the one-factor and two-factor models, in which both models were compared using the Akaike information criteria (AIC), Bayesian information criteria adjusted to the sample size (SABIC), Bayesian information criteria (BIC), and ANOVA between both models. The model with lower values was considered to have a better fit to the data. Subsequently, we proceeded with the confirmatory process of the multidimensional model. First, the model was specified, and the goodness-of-fit indices of the model were evaluated. The adequacy of the model was evaluated using the C2 test for ordinal items (Cai & Monroe, 2014), RMSEA < 0.08, SRMR < 0.05 (Maydeu-Olivares & Joe, 2014), CFI and TLI with the criteria described for the CFA models, as suggested in the scientific literature (Cai et al., 2021). At the same time, the Multidimensional Discrimination parameters (a) were evaluated, where values between 0.5 and 1.0 indicate poor discrimination, 1.0 to 1.5 moderate discrimination, and greater than 1.5 indicate excellent discrimination. Multidimensional Difficulty (b) was also evaluated to show the individual ability of the items to differentiate between subjects (Reckase & McKinley, 1991). Finally, the expected total score, test information, test standard errors, and item trace were established for Grit-S.

3. Results

3.1. Descriptive analysis

The analysis of the items shows that items 4 (I am a hard worker) and 8 (I am diligent) have a lower mean compared to the other items (1.86 and 1.97, respectively). On the other hand, the skewness and kurtosis of all items were within the expected range, which evidences univariate normality (Finney & DiStefano, 2013). In addition, the matrix of polychoric correlations of the items was obtained, and statistically significant associations were found (Table 2).

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Table 2.
Polychoric correlation matrix and descriptive analysis of the items.

	1	2	3	4	5	6	7	8
item 1	-							
item 2	0.22**	-						
item 3	0.39**	0.16**	-					
item 4	0.28**	0.34**	0.19**	-				
item 5	0.34**	0.26**	0.44**	0.24**	-			
item 6	0.42**	0.23**	0.40**	0.30**	0.63**	-		
item 7	0.34**	0.31**	0.35**	0.47**	0.40**	0.42**	-	
item 8	0.25**	0.29**	0.15**	0.47**	0.21**	0.25**	0.52**	-
M	3.14	2.52	3.13	1.86	2.76	2.85	2.16	1.97
SD	1.03	1.02	1.08	0.77	1.11	1.1	0.91	0.8
g_1	-0.36	0.47	-0.25	0.82	0.12	0.09	0.66	0.73
g_2	-0.58	-0.37	-0.73	1.11	-0.85	-0.85	0.18	0.84

Note. M = median; SD = standard deviation; g_1 = skewness; g_2 = kurtosis.

3.2. Confirmatory Factor Analysis and Reliability

Therefore, we proceeded with the confirmatory factor analysis, in which the two specified models were tested: one factor and two correlated factors (Table 3). The one-factor model did not obtain adequate fit indices (χ^2[df] = 256.1 [14], CFI = 0.90, TLI = 0.84, RMSEA[90% CI] = 0.14 [0.12, 0.15], SRMR = 0.07). The second model with correlated factors was tested, and adequate fit indices were obtained in contrast to the unidimensional model (χ^2[df] = 140.6 [19], CFI = 0.97, TLI = 0.95, RMSEA [90%CI] = 0.08 [0.07, 0.10], SRMR = 0.04). Adequate internal consistency was obtained for the factor Consistency of Interest (ω = 0.77) and Perseverance of Effort (ω = 0.74). The factor loadings were within the expected range (>0.40) (Figure 1).

Table 3.
One-factor and two-factor fit indices

Models	Factors	ω	χ^2	df	CFI	TLI	RMSEA	CI90%	SRMR
One factor	Grit	0.72	256.1	14	0.90	0.84	0.14	0.12, 0.15	0.07
Two factors	CO	0.77	140.6	19	0.97	0.95	0.08	0.07, 0.10	0.04
	PE	0.74							

Note. CO = Consistency of Interest; PE = Perseverance of Effort.

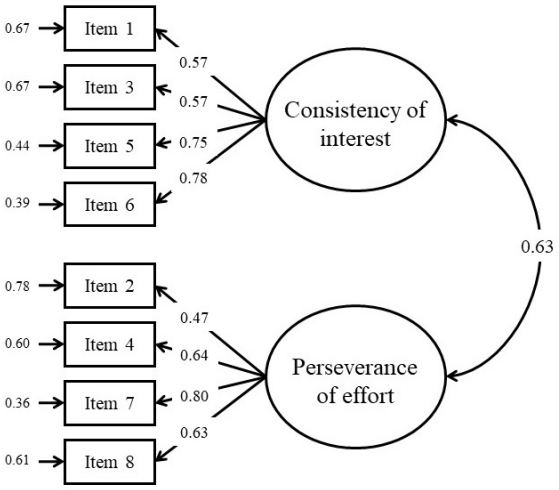

Figure 1. Two Factor Model

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3.2. Multidimensional Item Response Theory

As presented, the CFA obtained a two-factor model. For the IRT analysis, both models were respecified to ensure the differences between them. There were statistically significant differences between both models ($p < 0.001$). Furthermore, the two-factor model had lower values of the fit indices (AIC = 17701.3; SABIC = 17777.7; BIC = 17926.9), in contrast to the one-dimensional model (AIC = 17945.6; SABIC = 18010.6; BIC = 18137.7), which means that the two-factor model had a better fit to the data. Therefore, a confirmatory analysis was performed in which the two-factor model was specified; its fit indices were adequate (C2 = 45.4, df = 13, $p < 0.001$; RMSEA [90%CI] = 0.05 [0.04 - 0.07]; SRMSR = 0.05; TLI = 0.97; CFI = 0.99) (Table 4).

Table 4.
Multidimensional Item Response Theory

Factors	Item	Items parameters						Loadings	
		a1	a2	b_1	b_2	b_3	b_4	CO	PE
Consistency of Interest	1	1.20	–	-3.35	-0.43	1.22	3.08	0.58	–
	3	1.33	–	-3.08	-0.45	1.11	3.12	0.62	–
	5	2.26	–	-4.65	-1.60	0.38	3.15	0.80	–
	6	2.56	–	-4.77	-1.51	0.61	3.82	0.83	–
Perseverance of Effort	2	–	0.98	-3.72	-1.81	-0.38	2.07	–	0.50
	4	–	1.75	-3.08	-0.45	1.11	3.12	–	0.72
	7	–	1.89	-5.89	-3.53	-1.44	1.78	–	0.74
	8	–	1.86	-6.38	-4.69	-2.04	1.45	–	0.74
Fit index		**C2**	**df**	***p***	**RMSEA**	**CI90%**	**SRMSR**	**TLI**	**CFI**
		45.4	13	0.001	0.05	0.04, 0.07	0.05	0.97	0.99

Note. a = discrimination parameters; b = difficulty parameters. CO = Consistency of Interest; PE = Perseverance of Effort.

The items of the Consistency of Interest factor had multidimensional discrimination > 1.5 and > 1, while those in the Perseverance of Effort factor had discrimination > 1.5, except for item 2, which had poor discrimination (b < 1). On the other hand, a monotonic increase was observed in the difficulty parameters (b). Likewise, the MIRT specifies the factor loadings of the items in its factor; all the values were greater than 0.50. On the other hand, the Item Information Function Surface of the items shows that Consistency of Interest has a greater impact on items 1, 3, 5, and 6; the last two items discriminate better than 1 and 3 (Figure 2). On the other hand, it can be seen that Perseverance of Effort has a greater impact on items 2, 4, 7, and 8; item 2 is the only one that has difficulty discriminating adequately between subjects. Finally, the Expected Total Score, Test Information, and Standard Errors are presented in Figure 2, showing that the Grit-S can provide an optimal evaluation of the parameters.

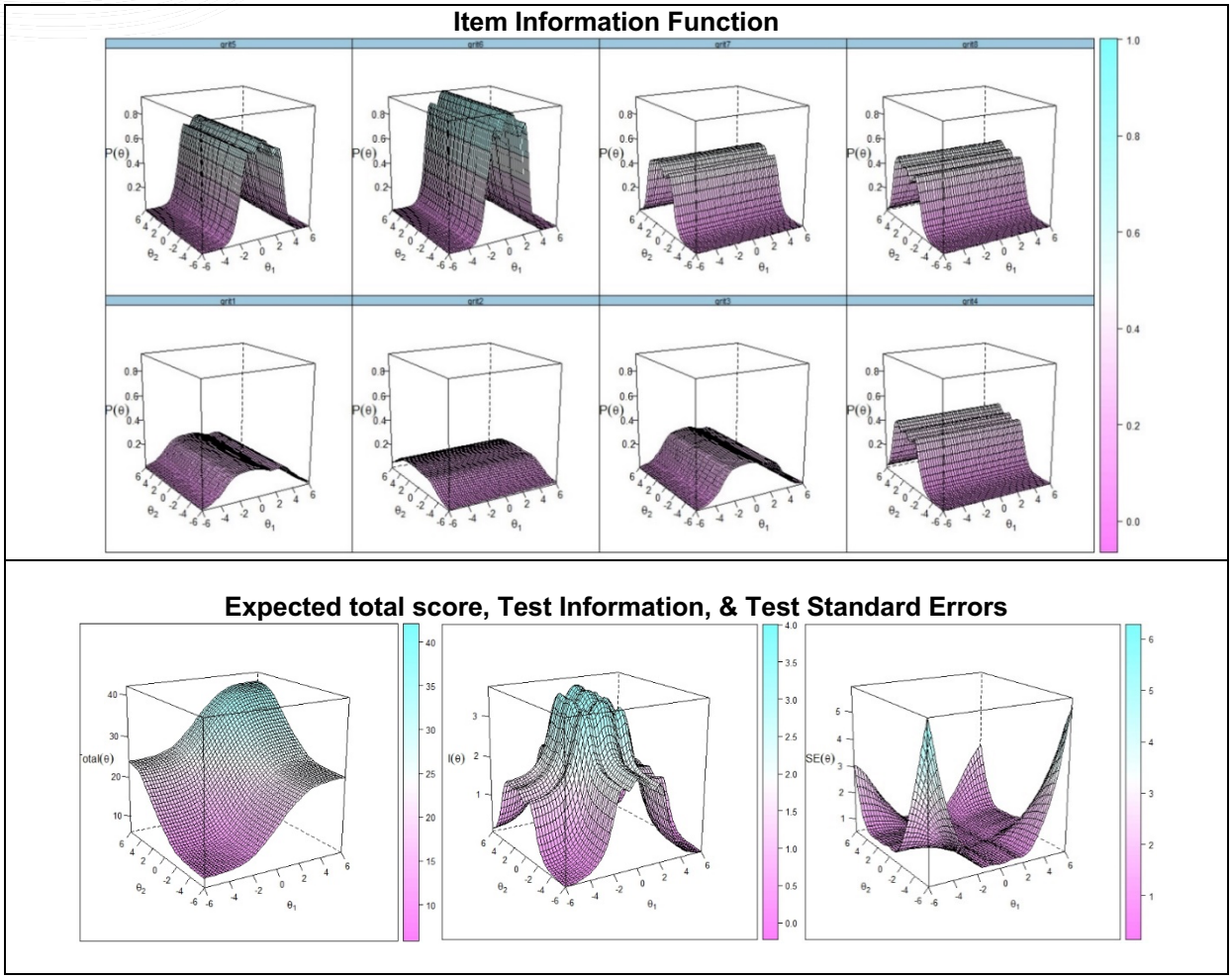

Figure 2. Item Information Function, Expected total score, Test Information, & Test Standard Errors for Grit-S

4. Discussion

The study aimed to determine the factorial structure of the Spanish version of the Grit-S and to explore the instrument through an IRT analysis. First, the associations between items were statistically significant; however, a weak association was observed between items 3 and 8. However, other research showed that item 2 ("Setbacks do not discourage me" ["Los contratiempos no me desaniman"]) is usually the item that is eliminated due to its weak factor loading, resulting in a better model fit (Cerda et al., 2018; Fernández-Martín et al., 2020; Fosnacht et al., 2019; Karaman et al., 2019). Furthermore, other studies tend to correlate errors for items 1 and 6 (Collantes-Tique et al., 2021), 4 and 8 (Gonzalez et al., 2020), 7 and 8 (Schmidt et al., 2019), and 5 and 8 (Arco-Tirado et al., 2018). Nevertheless, unlike those studies, items 2 and 8 were retained because there were insufficient grounds for their exclusion.

Two models from the literature were tested: one-factor and two-factor. The one-factor model obtained stable factor loadings; however, the fit was unfavorable. This result agrees with some studies that found a poor fit for the one-factor model. On the other hand, the two-factor solution has been reported in most Grit-S measure studies. Similarly to these findings, a good fit of the model was found (Datu et al., 2017; Frontini et al., 2022; Tortul et al., 2020; Wyszyńska et al., 2017; Zhong et al., 2018), and its reliability was adequate. Duckworth et al. (2021) suggest adding the scores of both factors to obtain an overall grit. Based on this study, it can be assured that the two-factor measurement allows for a greater understanding of scream as a function of Consistency and Perseverance. However, it is suggested that future studies explore a bifactor model and ensure the presence of a general factor.

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Based on the MIRT analysis, an adequate adjustment of the two-factor model was found, allowing the multidimensional discrimination and difficulty parameters to be estimated. A previous study explored a Russian version through the Rash model (Tyumeneva et al., 2019), where the discrimination and difficulty indices were acceptable. However, in our study, we applied the Graded Response Model (GRM) for multidimensional structures. Some studies suggest the removal of item 2 (Cerda et al., 2018; Fernández-Martín et al., 2020; Fosnacht et al., 2019; Karaman et al., 2019); however, despite having poor discrimination, its difficulty parameter was monotonic like the other items, so there would not be enough evidence to eliminate it from the model. It can be supported by a study that worked with a nine-item version and showed that item 2 had adequate discrimination (Midkiff et al., 2017). Therefore, it is suggested that new studies be cautious about item 2 and use the necessary evidence from the literature and the present study.

However, there were also limitations to the study. The first limitation was the sampling method: a nonprobabilistic convenience sample was used. The second limitation was that the study was restricted to university samples, which limits the generalizability of the findings to other populations. Nevertheless, these limitations are an opportunity to conduct new psychometric studies of the Grit-S with different types of analysis.

5. Conclussion

In conclusion, the CFA concluded that the two-factor model best represents the Grit-S. Therefore, its multidimensional structure, as found in the literature, is confirmed. Likewise, the Grit-S obtained adequate reliability for internal consistency, which suggests that it is an adequate instrument to measure Consistency and Perseverance. On the other hand, MIRT analysis confirmed that the two-factor model best represented the data. It was also observed that the discrimination of the items was within the expected range, although item 2 had the lowest discrimination. Finally, this study collects new psychometric evidence for Grit-S that supports the two-dimensional structure through CFA and MIRT.

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Appendix

Spanish versión of Grit-S

Items	1	2	3	4	5
1. Las ideas y proyectos nuevos a veces me distraen de ideas y proyectos anteriores					
2. Los contratiempos me desaniman.					
3. He estado obsesionado/a con alguna idea o proyecto durante un tiempo breve, pero después he perdido el interés.					
4. Soy muy trabajador/a.					
5. A menudo me pongo una meta pero después cambio a otra diferente.					
6. Tengo dificultades para mantener mi atención en proyectos que requieren más de unos meses en completarse.					
7. Termino siempre todo lo que empiezo.					
8. Soy diligente (es decir, cuidadoso, activo y que ejecuta con celo y exactitud lo que está a su cargo).					

1 = Totalmente em desacuerdo
2 = En desacuerdo
3 = Ni de acuerdo ni en desacuerdo
4 = De acuerdo
5 = Totalmente de acuerdo

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