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FACTOR STRUCTURE OF THE DE JONG GIERVELD LONELINESS SCALE: AN ESEM APPROACH

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Abstract

This research aims to examine the reliability, convergent validity, and measurement invariance of the de Jong Gierveld Loneliness Scale (DJGLS). The study focused especially on the examination of the model-data fit of various competitive factor structures in a young adult sample. The results demonstrate that the bifactor-ESEM model shows a high model-data fit according to CFI and RMSEA. In this case, it has been determined that the cross-loadings defined by the bifactor-ESEM model have an increasing effect on the model-data fit. Also with the bifactor-ESEM model, DJGLS has one highly reliable general factor and two irrelevant subfactors. Metric measurement invariance according to gender was provided. DJGLS scores were correlated moderately and highly, and were statistically significant with external variables. Finally, it can be said that DJGLS is a measurement tool with construct and convergent validity and reliability in the young adult sample. In addition, DJGLS is essentially a uni-dimensional scale and shows the best model-data fit in the bifactor-ESEM model.

KEY WORDS: *loneliness, psychometric properties, factor structure, measurement invariance, bifactor-ESEM.*

Resumen

Esta investigación pretende examinar la fiabilidad, la validez convergente y la invariancia de la medida de la "Escala de soledad de de Jong Gierveld" (DJGLS). Se evaluó especialmente el ajuste de modelo-datos de varias estructuras factoriales en una muestra de adultos jóvenes. Los resultados demuestran que el modelo bifactorial-ESEM muestra un elevado ajuste modelo-datos, según el CFI y el RMSEA. En este caso, se ha determinado que las saturaciones cruzadas, definidas por el modelo bifactorial-ESEM, tienen un efecto creciente en el ajuste modelo-datos. En este modelo bifactorial-ESEM, la DJGLS tiene un factor general altamente fiable y dos subfactores irrelevantes. Se obtuvo la invarianza de las medidas métricas en función del sexo. Las puntuaciones de la DJGLS tuvieron correlaciones moderadas y altas, estadísticamente significativas, con variables externas. En conclusión, puede decirse que la DJGLS es un instrumento de evaluación fiable, con validez convergente y de constructo, en la muestra de adultos jóvenes. Además, la DJGLS es, básicamente, una escala unidimensional y muestra el mejor ajuste modelo-datos en el modelo bifactorial-ESEM.

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PALABRAS CLAVE: *soledad, propiedades psicométricas, estructura factorial, invariancia de la medida, bifactor-ESEM.*

Introduction

The main source of motivation in people's lives is a strong sense of belonging and the need to establish relationships with others. This lack of belonging and the need to relate to others affects people's thoughts, feelings, and behaviors, resulting in loneliness, which is one of the most important indicators of individual well-being (Baumeister & Leary, 1995). While loneliness reflects the individual's subjective evaluation of social inclusion or isolation, meeting the need for social relationships helps him develop a better quality of life (Jong-Gierveld & van Tilburg, 2006; Jong-Gierveld & van Tilburg, 2010). Individuals experiencing loneliness may feel that their need for belonging is not satisfied by experiencing social deprivation (Hawkley & Cacioppo, 2010).

According to Perlman and Peplau (1981) "Loneliness is the unpleasant experience that occurs when a person's network of social relationships is deficient in some important way, either quantitatively or qualitatively" (p. 31). This definition focuses on the negative side of loneliness and relates it to the intensity of one's experience. de Jong Gierveld, on the other hand, makes the definition of loneliness, which is often used in the literature, by taking into account the values, norms, and standards of a person in his life and society. According to de Jong Gierveld (1987) "Loneliness is a situation experienced by the individual as one where there is an unpleasant or inadmissible lack of (quality of) certain relationships" (p. 120). This definition can be categorized into three main elements (Jong-Gierveld, 1987; Schoenmakers, 2013). First, loneliness is a subjective phenomenon. Unlike social isolation, loneliness cannot be measured by the number of relationships one has, but rather an emotion. Second, loneliness is always an unpleasant, negative emotion. Third, loneliness occurs when the quality of social relationships a person has does not meet that person's expectations.

Most researchers have examined loneliness in the context of subjective well-being and quality of life. In various studies, loneliness and depression (Barg et al., 2006; Hawkley & Cacioppo, 2010; Vanhalst et al., 2012), anxiety (Long, & Martin, 2000), resilience (Gerino et al., 2017; Hartling, 2008), psychological distress (Gerino et al., 2017; Hyland et al., 2019) and social support (Mahon et al., 2006; Rodríguez-Blázquez et al., 2021) were found to be highly correlated. In two different meta-analysis studies (Mahon et al., 2006; Pinquart & Sörensen, 2001) aiming to reveal the relationship of loneliness with wide-ranging real-life problems; it has been stated that it is associated with a decrease in the quality of social ties, less frequency of contact, restrictions on competence in daily life, lower-income and education level. In these studies, it was also found that higher loneliness was associated with higher levels of depression, shyness, social anxiety, and lower self-esteem or social support.

According to Perlman and Landolt (1999), while the level of loneliness is high in adolescents, it decreases in middle age, and a period of loneliness is observed again in older ages. For this reason, it is seen that studies on loneliness are frequently carried out on the sample of early adolescents (Grygiel et al., 2019; Ladd & Ettekal, 2013; Woodhouse et al., 2012) and the elderly (Buz et al., 2014; Dykstra, 2009; Leung et al., 2008; Robertson, 2019; Tomás et al., 2017). However, it is also known that 71% of people between the ages of 18 and 24 sometimes or often feel lonely, and this rate is reported as 69% between the ages of 25 and 34 (Parlee, 1979). In a more recent study, it was determined that 17% of people aged 18-24 and 25-35 years old feel lonely quite often and very often (YOUGOV, 2016). It is also reported that this rate reaches 23% among university students in Amsterdam (Pijpers, 2017). In another study examining the loneliness levels of young adults and their relations with other variables (Rozek, 2013), it was determined that young adults who are not alone are more extroverted, more adaptable, more conscientious, and emotionally more stable than lonely young adults. These findings show that loneliness is an important issue that needs to be investigated in young adults as well.

For many years, measuring the loneliness trait has been very difficult for researchers. However, the number of tools developed to achieve this remains relatively low. One of these tools, the University of California, Los Angeles Loneliness Scale (UCLA; Russell, 1996), is frequently used especially in the United States. In Europe and Asia, the 11-item de Jong Gierveld Loneliness Scale (DJGLS; Jong-Gierveld & Kamphuis, 1985) is widely used. Although both measurement tools were developed to measure loneliness for adult samples, both scales can measure loneliness appropriately for almost all age groups thanks to the easy understanding of the items (Grygiel et al., 2019).

Both measurement tools have been adapted to many languages and cultures for adult samples (Çavdar et al., 2015; Iecovich, 2013; Jong-Gierveld & van Tilburg, 2010; Leung et al., 2008; Wongpakaran et al., 2020). However, it is possible to talk about some advantages of DJGLS over UCLA. While studies confirm the cross-cultural stability of DJGLS, studies on UCLA are dubious (Dodeen, 2014). DJGLS, unlike UCLA, ensures measurement invariance between adult groups (Penning et al., 2014), DJGLS (11 items) being a shorter tool than UCLA (20 items) (Grygiel, Humenny, & Rębisz, 2019) and some authors recommend DJGLS more than UCLA for age groups older than early adolescence (Penning et al., 2014).

The DJGLS was developed from a content analysis of 114 lonely people's statements about their experiences. Based on these statements, 28 items grouped in five categories related to social deprivation and affiliation were selected. Factor analysis was performed by applying these 28 items to more than 1200 individuals, and it was determined that the scale had 11 items and a uni-dimensional factor structure. These 11 items assess severe loneliness as well as less intense feelings of loneliness with both positive and negative items (Buz et al., 2014; Tomás et al., 2017).

Although it was developed with a uni-dimensional structure, a two-factor structure was obtained in the later factor structure and cross-cultural studies in DJGLS (Buz et al., 2014; Jong-Gierveld & van Tilburg, 1999, 2010). The distinction between this two-dimensional structure and the emotional and social dimensions of loneliness as theorized by Weiss (1973) is also taken into account. Emotional loneliness is related to the absence of a close relationship, while social loneliness is related to the absence of a wider, engaging social network. Five positively formulated items were related to the presence of emotionally close people (e.g., "There is always someone I can talk to about my day-to-day problems."), while six negatively formulated items were related to the emotions of lived experience because of the absence of close relationships (e.g., "I experience a general sense of emptiness.") (Buz et al., 2014; Tomás et al., 2017). However, this two-dimensional structure does not mean that this measurement tool is not uni-dimensional. Studies on the factor structure of DJGLS show that the variance explained by the sub-factors is low and the overall factor is high (Grygiel et al., 2019; Penning et al., 2014). While this shows that the scale has a strong general factor, it can also show that the sub-factors do not differ from the general factor.

A six-item short form of DJGLS was also developed by Jong-Gierveld and van Tilburg (2006). However, the 11-item full version of DJGLS is more recommended, especially since it is better in terms of reflecting the events of adult individuals' lives (Tomás et al., 2017).

This research is based on the dataset obtained from the young adult sample, which is one of the sample groups in which loneliness is least studied. Almost all previous studies of the measurement of loneliness and the factor structure of the DJGLS have been conducted on adolescents and older people. Therefore, this study aims to both measure the loneliness of the young-adult sample and to determine the factor structure of the DJGLS over the young-adult sample. In this study, various factor structures defined in the literature on the DJGLS, especially reliability, convergent validity, and measurement invariance were examined. This study is the first study in which the measurement invariance of the DJGLS was tested according to gender. Accordingly, the aim of the present study was to test the hypothesis of the 5 competitive factor structure, measurement invariance, and convergent validity and to examine the reliability of the DJGLS in a non-clinical sample of Turkish young-adult sample.

Method

Participants

The study group of this research consists of 965 young-aged adults from Turkey. The age of the participants ranged from 18 to 30 (*M*= 21.77, *SD*= 3.07). Most of the participants were women (66.01%; *n*= 637). Also, most of the participants are students (86.22%) and they are out of work (82.38%). Information on other demographic variables is given in Table 1. The inclusion criteria were being an adult between the ages of 18-30 and giving consent to participate in the study.

Instruments

a) *Ad hoc Personal Information Form.* It contains several items related to variables such as gender, age, work status, and degree of education.

Table 1
Demographic characteristics of the sample

Demographic characteristics	*n*	%
Gender		
Male	328	33.99
Female	637	66.01
Age		
18-20	430	44.60
21-24	364	37.70
25 and above	171	17.70
What is your working status?		
Working	170	17.62
Not working	795	82.38
Are you a student?		
Yes	832	86.22
No	133	13.78

b) *de Jong Gierveld Loneliness Scale* (DJGLS; Jong-Gierveld & Kamphuis, 1985); Turkish version adapted by Çavdar et al. (2015). The DJGLS is a well-known loneliness scale that is frequently used in international research (van Tilburg et al., 2004) and consists of 11 items. Six of these items are in the direction of loneliness ("I miss having a really close friend") and the other five are in the opposite direction of loneliness ("There is always someone I can talk to about my day-to-day problems"). The original scale has three response categories ("yes", "more or less" and "no"). In previous studies, the scale has been proven to be valid and reliable (Buz et al., 2014; Çavdar et al., 2015; Grygiel et al., 2019; Jong-Gierveld & Kamphuis, 1985; Jong-Gierveld & van Tilburg, 1999; Leung, et al., 2008; Rodríguez-Blázquez et al., 2021). In this study, a 4-point scale (1-Not true at all, 2-Hardly ever true, 3- True most of the time, 4-Always true) was preferred instead of the original rating scale. After reverse coding the items in the social loneliness (positively worded sub-factor) dimension, a score similar to the original scale scoring was achieved by scoring as "Not true at all"= 0, "Hardly ever true"= 0, "True most of the time"= 1, and "Always true"= 1. The total score obtained is evaluated in four different categories: 0-2 points indicate not lonely, 3-8 points indicate moderately lonely, 9-10 points indicate severely lonely, and 11 points indicate very severely lonely.

c) *10-Item Kessler Psychological Distress Scale* (K10-PDS; Kessler et al., 2002), Turkish version adapted by Altun et al. (2019). Nonspecific psychological distress experienced in the last 30 days was measured by self-assessment using K10-PDS. Previously, K10-PDS demonstrated strong psychometric properties and significant correlations between anxiety and affective disorders in a sample aged 18 years and over (Andrews & Slade, 2001; Furukawa et al., 2003). Response choices are based on a 5-point Likert-type scale ranging from 1 (none of the time) to 5 (all of the time). The scale consists of 10 items with total scores ranging from 10 to 50, with higher scores indicating higher levels of psychological distress. Previous research has shown that a score greater than 15 indicates moderate to severe psychological distress, and a score of 20 or higher indicates a higher probability of mental disorder (Andrews & Slade, 2001). In this research, the uni-dimensional structure of the K10-PDS was tested with EFA. The explained variance was found 71.2%, and the Cronbach alpha coefficient was calculated as .95.

d) *Multidimensional Scale of Perceived Social Support* (MSPSS; Zimet et al., 1988). The MSPSS is a 12-item scale that measures the adequacy of perceived social support from three different areas: family, friends, and significant others. It has a three-dimensional factor structure with each subscale comprising four items addressing practical help, emotional support, availability to discuss problems, and help in decision-making (Grey et al., 2020). Participants are asked to indicate whether they agree with the items on the 7-point Likert scale, which ranges from very strongly disagree to very strongly agree, and the scores are between 12 and 84. Scores between 12 and- 48 indicate low social support, scores between 49 - and 68 indicate moderate social support, and scores between 69 - and 84 indicate high social support. Some studies show that this scale has adequate psychometric properties in adults (Dambi et al., 2018; Eker et al., 2001; Laksmita et al., 2020). In this research, we used the Turkish version of the MSPSS translated and adapted by Eker et al. (2001). In this adaptation study, the three-dimensional structure of the scale was confirmed by EFA. Alpha reliability coefficients range from .80 to .95.

e) *10-item Connor-Davidson Resilience Scale* (CD-RISC-10; Campbell-Sills, & Stein, 2007), Turkish translated and adapted version by Kaya and Odacı (2021). The CD-RISC-10 measures psychological resilience, which means that individuals can return to their normal state after experiencing negative events. The CD-RISC-10 is based on the CD-RISC-25 (Connor & Davidson, 2003). This measurement tool consists of 10 self-report items, each rated on a Likert-type scale from 0 (not true at all) to 4 (true nearly all the time). In the original version, 10 items are loaded into a general dimension. The total score ranges from 0 to 40, with higher scores indicating greater resilience. In this research, we used the In this adaptation study, the uni-dimensional structure of the scale was confirmed by EFA and CFA (χ^2= 73.21, *df*= 34, NFI= .96, CFI= .98, RMSEA= .055, SRMR= .041). The alpha coefficient was .81.

Procedure

Ethics committee approval was obtained from the Akdeniz University Social and Human Sciences Scientific Research and Publication Ethics Committee with document number 305468. Participants were selected by convenience sampling method. Study information and data collection tools were delivered to the participants via e-mails and social media. They included a link directing people to the online survey. To provide informed consent, all participants actively chose that they agreed to participate in the study before proceeding with the questions.

Data analysis

Before statistical analysis, the data set was examined in terms of missing data and outliers. Since the data is collected online and the system gives a warning when the item is left blank, there is no missing data. In the study, skewness (Sk) and kurtosis (Ku) coefficients for univariate outliers were examined and it was determined that all items met the necessary conditions (Sk< |3| and Ku< |8|-|10|; Kline, 2011). The presence of multivariate outliers was determined using the Mahalanobis distance. Although there are possible multivariate outliers for some cases, the findings did not change in the new case resulting from the deletion of these data points. These outliers were left untouched to maximize the sample size.

Five different potential factor structures of the 11-item DJGLS were tested in this study. As far as we know, this research has the feature of testing the largest number of potential factor structures of DJGLS. These models are uni-dimensional model (model 1), two-factor correlated model (model 2), general factor and a method factor (model 3), bifactor model (model 4), and bifactor exploratory structural equation modeling (ESEM; Asparouhov & Muthén, 2009; model 5).

Uni-dimensional model (model 1). It is the original factor structure of DJGLS (Jong-Gierveld & Kamphuis, 1985). However, uni-dimensional factor structure was rarely found in later studies (e.g. Buz et al., 2014). In this factor structure, it is assumed that all items are included in a single latent trait.

Two-factor correlated model (model 2). It is the most studied factor structure of DJGLS in the literature (Bonsaksen et al., 2019; Penning et al., 2014; Uysal-Bozkir et al., 2017). It was developed with the assumption that two different sub-factors, emotional (negatively worded items) and social (positively worded items) loneliness, are correlated to each other.

General factor and a method factor model (model 3). In the original DJGLS (Jong-Gierveld & Kamphuis, 1985) the authors recognized that there was evidence of a second relevant dimension attributed to a methodological artifact associated with negatively worded items. In later studies (Moorer & Suurmeijer, 1993), there was evidence that there is a second factor in addition to the uni-dimensional factor structure and that this factor include negatively worded items. Some recent studies (Grygiel et al., 2013; Tomás et al., 2017) have provided the validity and reliability of DJGLS with this factor structure.

Bifactor model (model 4). A bifactor model in which a general trait (loneliness) is assumed to underlie all items is proposed as model 4. In the bifactor models, all factors are assumed to be orthogonal (uncorrelated), so that all covariance is partitioned either into loadings on the general factor or onto the domain-specific factors. Some recent studies (Jong-Gierveld & van Tilburg, 2010; Grygiel et al., 2019) provided the validity and reliability of DJGLS with this factor structure.

Bifactor-ESEM model (Model 5). It has been argued recently that CFA's structure that forces the cross-loadings to zero may be overly restrictive for multidimensional structures (Marsh et al., 2009). On the other hand, it is stated that EFA generally displays more precise and less biased parameter estimates because it allows cross-loadings (Marsh et al., 2013). Therefore, Asparouhov and Muthén (2009) developed a new approach, exploratory structural equation modeling

(ESEM), which combines the advantages of EFA and CFA. The bifactor-ESEM model will take into account the presence of cross-loading of substances in other sub-factors, even where a researcher did not initially assume. In this study, it was assumed that all items of DJGLS would have significant factor loading in the general factor. At the same time, all positively worded items had approximately zero loadings on the negatively worded sub-factor; all negative items were defined to have nearly zero loadings on the factor expressed as positive. Besides, parameter estimations in all CFA models were made by fixing the variances of the latent factors to one. In ESEM models, targeted all cross-loadings are to be as close to zero as possible. The ESEM model was estimated using target rotation, while bifactor-ESEM was estimated using bifactor-target rotation. This model allows estimations of cross-loadings along with estimations of a general factor that can represent the systematic common variance by estimating not only the hypothetical dimension of the items but also the correlations with all dimensions (Merino-Soto et al., 2022). There is only one study in the literature that tests the factor structure of DJGLS with this model (Grygiel et al., 2019). In this research, it is stated that DJGLS has a bifactor model because the bifactor model has a better model-data fit than the bifactor-ESEM model. There is no study yet stating that DJGLS best fits the bifactor-ESEM model. The factor structures of all competitive models are given in Figure 1.

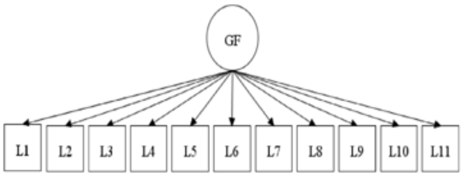
In all CFA models, parameter estimations were made by fixing the variances of the latent factors to 1. By using target rotation in the bifactor-ESEM model, the cross-loadings are close to 0 and the main factor loadings can be estimated freely.

Based on the discussions on the previous factor structure of DJGLS, five different models were developed. Model-data fit of all of these models was tested and compared. For this purpose, Mplus software (Muthen & Muthen, 2017), and MLR (Robust Maximum Likelihood) estimation method were used in the model test. This estimation method was chosen because the data set did not provide Mardia's multivariate normal distribution. To evaluate the model-data fit and compare the models, five different model-data fits were reported, but the model-data fit was decided over three different commonly used fit indices: (a) root mean square error of approximation (RMSEA), (b) Tucker-Lewis index (TLI), and (c) comparative fit index (CFI). The following criteria were used to declare that a model fits the data well: CFI and TLI above .90 (better if above .95) and RMSEA below .08 (Marsh et al., 2004). The model with a lower RMSEA value and higher CFI and TLI values reflects the "actual" factor structure of the scale.

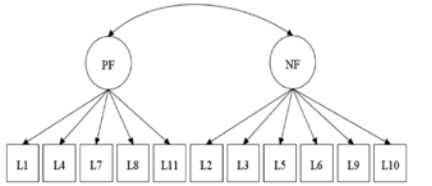
The internal consistency and composite reliability of DJGLS were evaluated with omega coefficients. The omega coefficient gives the internal consistency coefficient obtained when all items are loaded in the general factor in "simple" factor structures. OmegaS (omega subscale) gives the sum of the reliable variance source of the items in the sub-factor. It is the specialized version of the omega coefficient for the sub-factor. Omega and OmegaS coefficients of .70 and above indicate that the scale is reliable (Nunnally, 1978). Two more omega coefficients are calculated for bifactor models. OmegaH (omega hierarchical) refers to the sum of the variances of all items in the scale associated with a single general dimension. A coefficient of .70 and above (Reise et al., 2013) indicates that the scale is essentially uni-dimensional. OmegaHS (omega

Figure 1

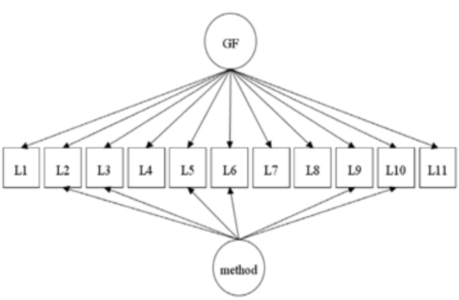
The tested models of the de Jong Gierveld Loneliness Scale (DJGLS)



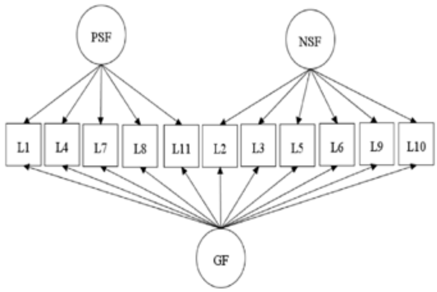
A. Uni-dimensional model (model 1)



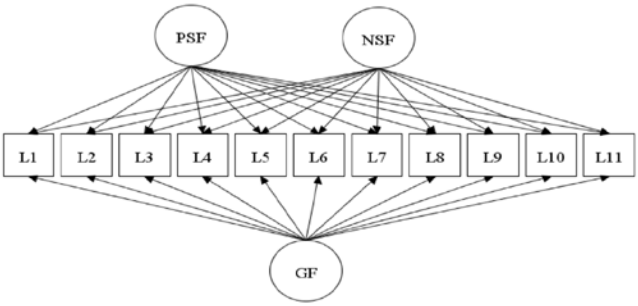
B. Two-factor Correlated model (model 2)



C. General factor and a method factor model (model 3)



D. Bifactor model (model 4)



E. Bifactor-ESEM model (model 5)

Note. DJGLS= de Jong Gierveld Loneliness Scale; PF= positively worded factor; NF= negatively worded factor; PSF= positively worded sub-factor; NSF= negatively worded sub-factor; method= methodological artifact associated with negatively worded items; GF= general factor.

hierarchical subscale) shows the remaining variance of the general factor, that is, the amount of variance explained by the sub-factors. The fact that this coefficient is .50 or less (Reise et al., 2013) indicates that the reliable source of variance is the general factor, not the specific factor. This situation is interpreted as essentially uni-dimensional. As additional proof of uni-dimensionality, the explained common variance (ECV) coefficient was calculated for the general factor and sub-factor. For the general factor, ECV refers to the total variance attributed to the general factor, while for the sub-factor, ECV refers to the total variance attributed to the sub-factor.

When ECV for the general factor is high (> .60), the scale can be considered essentially uni-dimensional (Reise et al., 2013). All omega and ECV coefficients were computed with Dueber's (2017) excel macro.

The measurement invariance of DJGLS was tested by gender. While it was seen that the Longitudinal Measurement Invariance tests of this scale were conducted according to the longitudinal measurement invariance (Grygiel et al., 2019) and age (Penning et al., 2014), no study was found in which measurement invariance was tested by gender group. However, measurement invariance according to gender was tested for the Interpersonal Acceptance-Rejection Loneliness Scale and the three-item loneliness scale. Both studies provided strict invariance (Czerwiński & Atroszko, 2021; Senese et al., 2020). Measurement invariance was examined through four nested models: (i) configural invariance, (ii) metric invariance, (iii) scalar invariance, and (iv) strict invariance. Marsh, Hau, & Wen's (2004) criteria were used for configural invariance (explained in the model-data fit evaluation section). It is known that chi-square test statistics tend to be highly sensitive to sample size (Marsh, Balla, & McDonald, 1988). This is why this statistic was not used as a criterion. In the testing of nested models, it was decided according to the criteria of ΔCFI< .010, ΔTLI< .010, and ΔRMSEA< .015 (Chen, 2007; Cheung & Rensvold 2002). ΔCFI, ΔTLI, and ΔRMSEA are the differences in CFI, TLI, and RMSEA, respectively.

In various studies, loneliness and resilience (Gerino et al., 2017; Hartling, 2008), psychological distress (Gerino et al., 2017; Hyland et al., 2019), and social support (Mahon et al., 2006; Rodríguez-Blázquez et al., 2021) were found to be highly correlated. To assess the convergent validity of the DJGLS, the correlations between the total score of DJGLS with (a) the Multidimensional Scale of Perceived Social Support scales' sub-factor and total points (b) the 10-Item Kessler Psychological Distress Scale total points, and (c) the total score obtained from the 10-item Connor-Davidson Resilience Scale were calculated. All correlation coefficients are expected to be high and statistically significant.

Results

Preliminary analysis

Table 2 shows means, standard deviations, skewness and kurtosis values, and intercorrelations for each item on the DJGLS. Mean item scores ranged from 1.930 (L5) to 2.704 (L7), and the distributions of all item scores were normal. Regarding the inter-item correlation, strong-to-moderate correlations, at significant levels of $p < .05$, were found among the individual items of the DJGLS.

Model comparisons

Findings on model-data fit for each alternative model are presented in Table 3. First of all, it can be said that the CFI, TLI, and RMSEA values of model 1 (uni-dimensional model) do not have acceptable values (CFI and TLI > .90; RMSEA< .08). Therefore, the factor structure of model 1 was not confirmed. Although the model-data fit values of model 2 (two-factor correlated model), which is the most studied

Table 2
Summary of means, standard deviations, skewness, kurtosis and Intercorrelations for items on the De Jong Gierveld Loneliness Scale (JGLS)

Items	*M* (*SD*)	Skewness	Kurtosis	1	2	3	4	5	6	7	8	9	10
1	1.976 (.90)	.719	-.186	--									
2	2.226 (1.07)	.312	-1.188	.303	--								
3	2.496 (1.05)	-.025	-1.195	.208	.269	--							
4	2.303 (.93)	.243	-.785	.607	.343	.338	--						
5	1.930 (.95)	.713	-.502	.407	.551	.414	.409	--					
6	2.569 (.99)	-.069	-1.025	.270	.359	.392	.395	.447	--				
7	2.704 (.97)	-.203	-.949	.358	.246	.308	.608	.301	.374	--			
8	2.146 (.92)	.476	-.510	.538	.379	.331	.612	.484	.418	.456	--		
9	2.176 (.95)	.299	-.917	.290	.461	.369	.304	.566	.408	.233	.321	--	
10	1.962 (.59)	.682	-.509	.304	.343	.576	.317	.485	.416	.275	.344	.409	--
11	2.047 (.88)	.568	-.360	.483	.345	.165	.563	.358	.244	.385	.515	.204	.281

model as factor structure of DJGLS in the literature, are better than model 1, it is seen that a sufficient model-data fit value is obtained only for CFI. In this case, the factor structure of model 2 was not confirmed either.

In the study where the original scale was developed, model 3 (general factor and a method factor model) was defined as a factor structure that has been confirmed in some studies, and there is evidence that there may be a second relevant dimension attributed to a methodological artifact associated with negatively worded items. It can be said that the model-data fit of this model is quite similar to model 2. As in model 2, only the CFI value shows sufficient model-data fit.

Model 4 (bifactor model), one of the bifactor models in this study, shows high model-data fit according to CFI and sufficient model-data fit according to TLI and RMSEA. In this case, it can be said that model 4 is confirmed. However, as previously defined, the main factor structure of DJGLS will be the model with a lower RMSEA value and higher CFI and TLI values. Therefore, model 5 should also be examined. It has been determined that the model-data fit values of model 5 (bifactor-ESEM model) are better than model 4. Model 5 shows high model-data fit according to CFI and RMSEA but is sufficient according to TLI. In this case, it has been determined that the cross-loadings defined by the bifactor-ESEM model have an increasing effect on the model-data fit. For this reason, it was decided that the model that best reflects the factor structure of DJGLS is the bifactor-ESEM model. However, since the model-data fit values of the bifactor model are sufficient, factor loadings and omega coefficients of model 4 are also reported.

Table 3
Model fit indices for alternative models of the de Jong Gierveld Loneliness Scale (JGLS)

Models	χ^2	*df*	CFI	TLI	RMSEA (90% CI)	SRMR
Model 1	786.00**	44	.766	.707	.132 [.124, .140]	.080
Model 2	330.19**	43	.909	.884	.083 [.075, .092]	.047
Model 3	314.88**	38	.913	.874	.087 [.078, .096]	.043
Model 4	175.03**	33	.955	.925	.067 [.057, .077]	.034
Model 5	108.26**	25	.974	.942	.059 [.048, .070]	.021

Notes: Model 1= uni-dimensional model; Model 2= two-factor correlated model; Model 3= general factor and a method factor model; Model 4= bifactor model; Model 5= bifactor-ESEM model. ***p*< .01.

Reliability and dimensionality

As seen in Table 4, Omega and OmegaS coefficients were calculated to determine the internal consistency for the latent general factor and sub-factors, and the general factor and sub-factors of DJGLS were determined to be reliable (Omega > .70 and OmegaS > .70). The OmegaH coefficient, which is the essential uni-dimensionality test, is above .70 for both the bifactor model and the bifactor-ESEM model. Values below .50 were obtained for the OmegaHS coefficients, which were excluded from the variance in the general factor and showed the reliability of the subscales. This shows that it is not appropriate to interpret the sub-factors without the general factor because of the little reliable variance explained. According to ECV, the overall factor of DJGLS explains the majority of all common variance (66.5% in the bifactor model; 63.5% in the bifactor-ESEM model). Therefore, the DJGLS is essentially a uni-dimensional scale. The fact that the ECV values calculated for the sub-factors are also quite low is another indication that the scale is essentially uni-dimensional.

Standardized factor loadings

Standardized factor loadings are given in Table 5. It was previously determined that DJGLS is suitable for the bifactor-ESEM model and is essentially a uni-dimensional scale. In this case, it is expected that the factor loadings of the general factor are as high as possible (> .50) and the factor loadings of the sub-factors are not high (< .50). It was determined that the standardized factor loadings of the general factor belonging to the bifactor-ESEM model were mostly above .50 (except L1, L7, and L11). The factor loadings of the general factor of L1, L7, and L11 are quite high, though not above .50. However, it was determined that most of the factor loadings of the sub-factors (except NSF: L3; PSF: L4 and L7) were below .50. In addition to this situation, it is expected that the factor loadings of the sub-factors should not exceed the factor loadings of the general factor. It has been determined that this situation is mostly provided (except for L3, L4, L7, and L11). When these findings are evaluated together with the findings related to dimensionality, it can be said that DJGLS tends to measure general loneliness rather than a two-dimensional structure.

Table 4
Omega and ECV's of the de Jong Gierveld Loneliness Scale (JGLS)

Coefficients	Bifactor model			Bifactor-ESEM		
	GF	NSF	PSF	GF	NSF	PSF
Omega	.901	-	-	.904	-	-
OmegaS	-	.848	.846	-	.863	.902
OmegaH	.764	-	-	.746	-	-
OmegaHS	-	.031	.470	-	.022	.136
ECV	.665	-	-	.635	-	-
ECVS	-	.101	.235	-	.114	.251

Note: GF= General factor; PSF= Positively worded sub-factor; NSF= Negatively worded sub-factor; ECV= Explained common variance coefficient; ECVS= Explained common variance coefficient for sub-factors.

Table 5
Standardized factor loadings of the de Jong Gierveld Loneliness Scale (JGLS)

Items	Bifactor model			Bifactor-ESEM		
	GF	NSF	PSF	GF	NSF	PSF
L1	.468	-	.503	.494	-.092	**.483**
L2	.660	-.187	-	.661	**-.123**	.006
L3	.563	.549	-	.528	**.662**	.022
L4	.519	-	.723	.519	.068	**.722**
L5	.818	-.086	-	.829	**-.038**	-.024
L6	.591	.117	-	.563	**.172**	.124
L7	.408	-	.501	.387	.158	**.518**
L8	.579	-	.458	.587	.003	**.451**
L9	.671	-.027	-	.677	**.029**	-.091
L10	.630	.401	-	.606	**.371**	-.006
L11	.423	-	.494	.448	-.119	**.482**

Note: L= Loneliness; GF= General factor; PSF= Positively worded sub-factor; NSF= Negatively worded sub-factor. Factor loadings of items on their subscales are bolded.

Measurement invariance

The findings of the measurement invariance of DJGLS by gender according to the bifactor-ESEM model are given in Table 6. To ensure measurement invariance, the RMSEA, CFI, and TLI values of the models should not change significantly (ΔCFI< .010, ΔTLI< .010, ΔRMSEA< .015) when compared to the more constrained models. The Configural model was validated (CFI= .977, TLI= .949, RMSEA= .056) in this study. To ensure metric invariance, the model-data fit of the metric model should not change significantly compared to the configural model. When the change in model-data fit was examined (ΔCFI= .000, ΔTLI= .017, and ΔRMSEA= .011), there was no significant change in model-data fit according to two of the three fit indices (ΔCFI, and ΔRMSEA). For this reason, metric invariance of DJGLS according to gender was provided. To ensure scalar invariance, the model-data fit of the scalar model should not change significantly compared to the metric model. When the change in model-data fit was analyzed (ΔCFI= .010, ΔTLI= .011, and ΔRMSEA= .007), there was no significant change in model-data fit for only one of the three fit indices (ΔRMSEA). Therefore, it can be said that the scalar invariance of DJGLS is not provided.

Table 6
Fit indices of measurement invariance models across gender

Model	χ^2	*df*	CFI	TLI	RMSEA	ΔCFI	ΔTLI	ΔRMSEA
Configural	124.81	50	.977	.949	.056	--	--	--
Metric	147.71	74	.977	.966	.045	.000	.017	.011
Scalar	188.54	82	.967	.955	.052	.010	.011	.007

Note. CFI= comparative fit index; TLI= Tucker-Lewis index; RMSEA= root mean square error of approximation; ΔCFI= CFI values difference; ΔTLI= TLI values difference; ΔRMSEA= RMSEA values difference.

Convergent validity

By the bifactor-ESEM model, the correlations of the latent score of DJGLS's general dimension with external variables are given in Table 7. Loneliness latent trait was found to be negatively correlated with family, significant others, and friends which are the sub-factors of MSPSS, and the general latent trait score of MSPSS, as expected. In addition, it was determined that the latent feature of loneliness showed a negative correlation with psychological resilience (CD-RISC-10). As expected, loneliness scores showed a positive correlation with psychological distress (P10-PDS). All correlation coefficients are statistically significant at the .01 level.

Table 7
Pearson's correlations for general factor of the De Jong Gierveld Loneliness Scale (JGLS) and external variables

Variables or instruments	1	2	3	4	5	6
1. Loneliness (DJGLS)						
2. Family subscale of MSPSS	-.50**					
3. Significant other subscale of MSPSS	-.36**	.32**				
4. Friends subscale of MSPSS	-.65**	.49**	.30**			
5. Overall MSPSS scores	-.64**	.75**	.79**	.74**		
6. K10-PDS	.48**	-.41**	-.21**	-.27**	-.37**	
7. CD-RISC-10	-.32**	.23**	.14**	.17**	.22**	-.37**

Notes: DJGLS= De Jong Gierveld Loneliness Scale; MSPSS= Multidimensional Scale of Perceived Social Support; K10-PDS= 10-Item Kessler Psychological Distress Scale; CD-RISC-10= 10-item Connor–Davidson Resilience Scale. ***p*< .01.

Discussion

The aim of this research is to examine the reliability, convergent validity, and measurement invariance, especially examining the model-data fit of various competitive factor structures defined in the literature of DJGLS through a young adult sample. When the model-data fits of competitive factor structures are examined, it has been determined that the bifactor and bifactor-ESEM models come to the fore. Among these two models, the bifactor-ESEM model has come to the fore with the best model-data fit. All validity and reliability findings show that some items having significant cross-loadings in non-target factors may indicate that cross-loadings should also be considered in the model. In addition, the fact that the model-data fit of the bifactor-ESEM model is higher than that of the bifactor model may be due to the fact that this model is a model that considers cross-loadings too. For this reason, it can be said that the "actual" factor structure of DJGLS is the bifactor-ESEM model. As far as we know, this study is the first research in which DJGLS was validated with the bifactor-ESEM model.

With the bifactor-ESEM model, the general factor explains 74.6% of the total variance. The sub-factors had little reliable variance explained (PSF= 13.6%; NSF= 2.2%) and the Omega and OmegaS coefficients were also very high (Omega= .904; OmegaS= .863, .902) indicating that DJGLS is essentially uni-dimensional. This shows that the two-dimensional structure (social and emotional) of the scale, which is frequently used in the literature, is suspicious.

It was determined that the standardized factor loadings of the general factor of the scale were mostly high (>.50) and the standardized factor loadings of the items belonging to the sub-factors were mostly low (<.50). This is essentially a requirement for scales with uni-dimensional properties. However, it was determined that the factor loadings of the negatively worded sub-factor were quite low. The fact that the variance explained by this factor is quite low (OmegaHS= .022; ECVS= .114) and that the scale is essentially uni-dimensional can be shown as the reasons for this situation.

As far as we know, in this study, which is the first study to test the measurement invariance of DJGLS according to gender, metric measurement invariance according to gender was provided. Ensuring metric invariance means that there are equal factor loadings between groups. Providing metric invariance means that men and women contribute equally to the latent trait scores, which makes it possible to compare the correlations between the total scores (Becht et al., 2016).

For the convergent validity of DJGLS, its correlations with three different scale scores that are expected to be related to loneliness were examined. DJGLS scores were correlated negatively, moderately and highly, and statistically significant with social support and psychological resilience, and they showed positive, moderate, and statistically significant correlations with psychological distress. These values demonstrate the convergent validity of DJGLS and are similar to many other studies (Gerino et al., 2017; Hartling, 2008; Hyland et al., 2019; Mahon et al., 2006; Rodríguez-Blázquez et al., 2021).

Undoubtedly, the study has some limitations. The first of these limitations is the exclusion of early adolescents and middle-aged and older-aged adults from the sample. The reason for this is to choose a less studied sample since the number of studies conducted in younger and older groups is quite large. As the second limitation, it can be shown that sample-independent parameters cannot be obtained by performing analysis based on Item Response Theory, such as Rasch analysis, in which the original scale was developed. The third limitation is that scalar and strict measurement invariance can not be achieved according to gender. And as the last limitation, instead of the five-point rating, which is the original answer category of the scale, the four-point rating used by Çavdar et al. (2015), who adapted the scale to Turkish culture, was applied.

In addition to these limitations, some strengths of this study can also be mentioned. As far as we know, it is the most comprehensive study in the literature in which all competitive factor structures of DJGLS are tested. In addition, as far as we know, it is the first study to test the measurement invariance of DJGLS by gender.

Finally, it can be said that DJGLS is a measurement tool with construct and convergent validity and reliability in the young adult sample. In addition, DJGLS is essentially a uni-dimensional scale and shows the best model-data fit in the bifactor-ESEM model. By using this measurement tool, it is possible to plan clinical interventions and create useful services and programs that can alleviate loneliness. Loneliness is also a concern for the young-adult sample and can lead to many other psychological problems such as depression. Therefore, it can be said that such research should be expanded to develop interventions aimed at alleviating loneliness.

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