Original Article

Validation and Cultural Adaptation of the Motors of COVID-19 Vaccination Acceptance Scale (MoVac-COVID19S) in German

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Abstract: *Background:* Context-specific standardized psychometric instruments are essential for ensuring valid and reliable assessment of health outcomes across diverse populations to aid the advancement of research and health-related interventions. However, instruments measuring attitudes toward vaccinations are lacking in the extant literature. Therefore, we performed a cross-cultural adaptation of the Motors of COVID-19 Vaccination Acceptance Scale (MoVac-COVID19S) in Germany. *Method:* During the months of June and July 2022, 475 individuals aged 18 years and older from the general population of Germany participated in an online cross-sectional survey. Participants responded to five demographic questions, a measure of COVID-19 vaccine uptake willingness, and the MoVac-COVID19S. Confirmatory Factor Analysis (CFA) fit indices were used to evaluate the factor structures of the MoVac-COVID19S. *Results:* The CFA revealed that all examined factor structures of both the 9-item and 12-item versions of the MoVac-COVID19S were acceptable among the sample. Overall, CFI, GFI, and TLI values were higher than 0.95; RMSEA and SRMR values were all less than 0.08 for all the estimated models. The one-factor model of the 9-item version of the MoVac-COVID19S exhibited best fits indices compared to the one-factor and four-factor structures of the 12-item version of the scale. The bifactor model revealed that the general factor explained a higher percentage of the Explained Common Variance (ECV; ranging from 55% to 94%) in the majority of the items, compared to the specific factors. The scale was found to demonstrate convergent validity with related measures. *Conclusion:* The German version of the MoVac-COVID19S should be considered a unidimensional rather than a multidimensional measure. Although the 9-item version of the scale performed better among the sample compared to the 12-item version, the overall scores of both versions were found to be valid and reliable measures of attitudes toward COVID-19 vaccinations. The MoVac-COVID19S has the potential to be adapted for assessing attitudes toward any future vaccination programs. *Limitations:* While our study sampled only the general German population, the criticisms of CFA warrant further research using advanced methods, such as the Rasch model, and subgroups.

Keywords: measurement, vaccination acceptance, validation, MoVac-COVID19S, German

COVID-19 represents one of the most significant global health challenges related to communicable diseases in recent history. According to the World Health Organization (WHO, 2023), the global impact of COVID-19 as of February 2023 has been severe, with around 760 million confirmed cases. Tragically, these cases have resulted in approximately seven million deaths worldwide, highlighting the devastating toll of the pandemic. In Germany, there have been a total of 38 million confirmed COVID-19 cases and approximately 170,000 deaths (WHO, 2023). Most countries have now however opened their borders, with quarantine no longer being used to prevent cases from being imported. While this might signal that COVID-19 is entering an endemic phase, concerns persist about emerging variants that continue to pose morbidity and mortality risks including to previously infected and vaccinated people (Madhi, 2021; Vasireddy et al., 2021).

Vaccination against any epidemic and pandemic including the current COVID-19 remains the most effective intervention to protect individuals from COVID-19 and prevent the spread of the virus. Since the development and deployment of COVID-19 vaccines, there has been a remarkable fall in the incidence and prevalence of COVID-19 worldwide (Hwang et al., 2021; Zheng et al., 2022). However, the success of COVID-19 vaccination relies on people's acceptability and willingness to take the vaccine.

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Available evidence suggests that vaccination drives against COVID-19 were hampered by issues such as the COVID-19 infodemic (Adu et al., 2023), which affected COVID-19 vaccination.

As interest in the facilitators and barriers to COVID-19 vaccination attitudes continues to increase among scientists and policy makers, efforts have been made to develop and validate appropriate psychometric instruments to capture these vaccination attitudes. However, challenges with current approaches used to measure COVID-19 vaccine uptake-related attitudes include some studies relying on a single measure of COVID-19 vaccination attitudes (Dong et al., 2022; Loo, 2002; Malesza & Wittmann, 2021; Umakanthan & Lawrence, 2022), the use of unvalidated instruments (Mustapha et al., 2021), and a lack of culturally validated instruments.

A recently developed and validated COVID-19 vaccination acceptance scale called Motivators of COVID-19 Vaccination Acceptance Scale (MoVac-COVID19S; also known as the Drivers of COVID-19 Vaccination Acceptance Scale [DrVac-COVID19S]) has been beneficial in assessing attitudes and consideration toward COVID-19 vaccination (Adjaottor et al., 2022). This scale was adapted from the Motors of Influenza Vaccinations Acceptance Scale (MoVac-Flu Scale; Vallée-Tourangeau et al., 2018) by changing the word *flu* to *COVID-19* (Chen et al., 2021), an implication that the scale has the potential to be adapted in the future for assessing attitudes toward vaccination for any emerging infectious diseases. Basically, four theoretical cognitive constructs derived from the Cognitive Model of Empowerment (CME) underpinned the development of the scale (Thomas & Velthouse, 1990). The scale assesses four aspects of an individual's cognition: First, the value they place on accepting the COVID-19 vaccine; second, the feeling of the impact of the COVID-19 vaccine; third, the knowledge they possess on the acceptance of the COVID-19 vaccine; and fourth, the feeling of autonomy to accept the COVID-19 vaccine.

A relatively small number of studies have validated and assessed the psychometric properties of the MoVac-COVID19S in different cultures. So far, Confirmatory Factor Analysis (CFA) results have indicated better fit indices and internal consistency for the 9-item version of the MoVac-COVID19S compared to the 12-item version of the MoVac-COVID19S among Chinese university students (Chen et al., 2021). Pramukti et al. (2022) also found out that the one-factor structure of the MoVac-COVID19S fitted well among Indonesian and Malay university students compared to Taiwanese participants; however, the four-factor structure was fully supported among participants in each of these countries (see also Chen et al., 2022).

Thus far, the MoVac-COVID19S has been translated into only three languages other than English: Chinese, Malay, and Bahasa Indonesian. The participants in the various validations were mainly students from a limited number of countries. Finally, internal consistencies for the scales were not reported in the majority of previous research. These shortcomings demonstrate that there is not enough evidence to accept the MoVac-COVID19S as a universally reliable instrument for assessing attitudes toward COVID-19 vaccination, highlighting the need for rigorous cross-cultural adaptation and validation of the MoVac-COVID19S. We aimed to translate the MoVac-COVID19S survey into the German language and then culturally adapt and validate the survey for the German population.

Method

Participants

The sample comprised 475 participants from the general population in Germany, and the age range was from 18 to 87 years (M_{age} = 43; SD = 16.27). The data were collected during the months of June and July 2022. From the total

Table 1. Sociodemographic characteristics of participants (*N* = 475)

Variables	Frequency	(%)
Educational levels		
No education (Kein Schulabschluss)	6	1
General secondary school (Hauptschule)	56	12
Practical secondary school (Mittlere Reife)	156	33
Academic secondary school (Abitur)	116	24
Bachelor, Master (Universitätsabschluss)	128	27
PhD (promotion)	5	1
Did not specify	8	2
Total	475	100
Gender		
Men	223	47
Women	244	51
Did not specify	8	2
Total	475	100
Marital status		
Married	212	44
Unmarried	255	54
Did not specify	8	2
Total	475	100
Employment status		
Unemployed	128	27
Employed	339	71
Did not specify	8	2
Total	475	100

sample who attempted the survey, only 23 participants did not complete some survey items while the remaining participants provided complete data with no missing responses. The majority of the participants identified as Germans (83%; $n = 396$), and others were 17% ($n = 79$). More than half (51%; $n = 244$) of the participants identified as women, and 2% ($n = 8$) did not specify their biological sex (Table 1). We have conducted a power analysis using the a-priori sample size calculator for structural equation models software (version 4.0), estimating the minimum sample required to detect a specified effect. For our CFA to detect an effect size of 0.10, with power of 80% and significance level of 0.05, a minimum of 200 cases was required for our model structure (Soper, 2021), while our sample exceeds this number. This further assures the reliability of our findings, demonstrating that our sample size is adequate not just for model evaluation, but also for the detection of even small effects. Therefore, the current sample was sufficient to conduct CFA of the MoVac-COVID19S.

Procedure

Instrument Translation (MoVac-COVID19S)

We used a recommended standard guideline for cross-cultural instrument validation and adaptation (Borsa et al., 2012; Cha et al., 2007). The English version of the MoVac-COVID19S was forward translated by a bilingual native German, followed by a backward translation by a second bilingual German native, who was knowledgeable in instrument validation (Brislin, 1970). The final German version of the MoVac-COVID19S (see Appendix) was verified by three independent German bilingual health-related researchers for full assessment of the comprehensibility, and verification of the cross-cultural equivalence of the source and the final version of the translation. This involved ensuring appropriate semantic meaning, idiomatic expressions, and colloquialisms, as well as experiential and conceptual equivalence (Borsa et al., 2012). The final questionnaire was piloted with students and academic colleagues to ensure formatting and instructions were appropriate (Hertzog, 2008). We relied on the data collection company Qualtrics for the data in our study. This online data collection was employed due to the protocols associated with the COVID-19 pandemic. Participants 18 years and older were allowed to participate in the current study. Participation in the current study was voluntary, and the average time for responding to the survey was 15 min.

Measures

The instrument chosen was the Motors of COVID-19 Vaccination Acceptance Scale (MoVac-COVID19S), originally developed by Chen et al. (2021). This self-report instrument measures attitudes toward COVID-19 vaccination, capitalizing on four cognitive facets (Value, Impact, Knowledge, and Autonomy). The full scale contains nine positively and three negatively worded items, utilizing a 7-point scale ranging from 1 = *strongly agree* to 7 = *strongly disagree*. The positively worded items form the 9-item version of the scale. Specifically, each subscale of the 12-item version of the MoVac-COVID19S contains three items. The value subscale items include: "It is important that I get the COVID-19 jab;" "The COVID-19 jab plays an important role in protecting my life and that of others;" and "The contribution of the COVID-19 jab to my health and well-being is very important." The impact subscale includes the following items: "Vaccination is a very effective way to protect me against the COVID-19;" "Vaccination greatly reduces my risk of catching COVID-19;" and "Getting the COVID-19 jab has a positive influence on my health." The knowledge subscale contains the following items: "I know very well how vaccination protects me from the COVID-19;" "I understand how the flu jab helps my body fight the COVID-19 virus;" "How the COVID-19 jab works to protect my health is a mystery to me." Finally, the autonomy items include: "I feel under pressure to get the COVID-19 jab;" "I can choose whether to get a COVID-19 jab or not;" and "I get the COVID-19 jab only because I am required to do so." Table 2 includes participants' scores on each of the items. In addition to the MoVac-COVID19S, participants responded to five demographic questions and a single question measure of COVID-19 vaccine uptake willingness. The average time for responding to the survey was 15 min.

Data Analyses

The data were exported to the statistical package for the social sciences (IBM SPSS; version 28) and screened for missing values using the MCAR test (Little, 1988). We found that any missing data were missing completely at random ($p > .05$). Missingness was handled using the expectation maximization (EM) algorithm data imputation technique (Dellaert, 2002). Skewness and kurtosis ranged from −3 to 3, favoring the use of parametric statistical tests (Tabachnick et al., 2013). We used the Jeffreys' Amazing Statistics Program (JASP Team, 2022) to describe the demographic variables and the MoVac-COVID19S item scores (Tables 1 and 2). We also used Jamovi statistical software version 2.3 (*lavaan, semtools, and semplot* packages; Epskamp et al., 2019; Jorgensen et al., 2019; Rosseel, 2012; The Jamovi Project, 2022) to examine all other models, including the bifactor model, and we assumed that the general factor was uncorrelated to the specific factors in the

Table 2. Item scores of the Motors of COVID-19 Vaccination Acceptance Scale (MoVac-COVID19S) among Germans (*N* = 475)

Item number with descriptions	*M* (*SD*)	*n* (%)						
		1	2	3	4	5	6	7
1. Vaccination is a very effective way to protect me against the COVID-19 (Die Impfung ist ein sehr effektiver Weg, um mich vor COVID-19 zu schützen).	4.67 (2.10)	63 (13.3)	38 (8.0)	29 (6.1)	77 (16.2)	56 (11.79)	80 (16.8)	132 (27.8)
2. I know very well how vaccination protects me from the COVID-19 (Ich weiß sehr gut darüber Bescheid, wie mich die Impfung vor COVID-19 schützt).	4.96 (1.67)	24 (5.1)	27 (5.7)	31 (6.5)	94 (19.8)	89 (18.74)	107 (22.5)	103 (21.7)
3. It is important that I get the COVID-19 jab (Es ist sehr wichtig, dass ich die COVID-19 Impfungen erhalte)	4.89 (2.04)	56 (11.8)	27 (5.7)	26 (5.5)	75 (15.8)	57 (12.0)	90 (18.9)	144 (20.3)
4. Vaccination greatly reduces my risk of catching COVID-19 (Die Impfung reduziert maßgeblich mein Risiko, mich mit COVID 19 anzustecken).	4.49 (2.09)	63 (13.3)	48 (10.1)	40 (8.4)	68 (14.3)	67 (14.1)	78 (16.4)	111 (23.4)
5. I understand how the flu jab helps my body fight the COVID-19 virus (Die Impfung hilft meinem Körper gegen COVID-19 anzukämpfen.	4.98 (1.98)	50 (10.5)	28 (5.9)	21 (4.4)	67 (14.1)	65 (13.7)	107 (22.5)	137 (28.8)
6. The COVID-19 jab plays an important role in protecting my life and that of others (Die Impfung spielt eine wichtige Rolle dabei, mein Leben und das der anderen zu schützen).	4.84 (2.03)	56 (11.8)	28 (5.9)	29 (6.1)	73 (15.4)	65 (13.7)	87 (18.1)	137 (28.8)
7. I feel under pressure to get the COVID-19 jab* (Ich fühle mich unter Druck, mich gegen COVID-19 impfen zu lassen*)	4.43 (2.16)	70 (14.7)	40 (8.4)	60 (12.6)	70 (14.7)	41 (8.6)	67 (14.1)	126 (26.5)
8. The contribution of the COVID-19 jab to my health and well-being is very important (Die COVID-19 Impfung ist sehr wichtig für meine Gesundheit und mein Wohlbefinden).	4.70 (2.02)	60 (12.6)	23 (4.8)	39 (8.2)	81 (17.1)	70 (14.7)	80 (16.8)	122 (25.7)
9. I can choose whether to get a COVID-19 jab or not (Ich kann frei entschieden, ob ich die COVID-19 Impfung erhalte oder nicht)	5.14 (2.01)	41 (8.6)	25 (5.2)	40 (8.4)	61 (12.8)	47 (9.9)	75 (15.8)	186 (39.2)
10. How the COVID-19 jab works to protect my health is a mystery to me* (Es ist mir unklar, wie die COVID-19 Impfung meine Gesundheit schützen soll*).	4.86 (1.90)	34 (7.2)	31 (6.5)	46 (9.7)	99 (20.8)	42 (8.8)	94 (19.8)	128 (26.9)
11. I get the COVID-19 jab only because I am required to do so* (Ich lasse mich gegen COVID-19 impfen, weil es von mir gefordert wird*).	4.65 (2.01)	46 (9.7)	34 (7.2)	58 (12.2)	97 (20.4)	42 (8.8)	64 (13.5)	133 (28.0)
12. Getting the COVID-19 jab has a positive influence on my health (Die COVID-19-Impfung hat einen positiven Einfluss auf meine Gesundheit	4.40 (1.94)	62 (13.1)	29 (6.1)	38 (8.0)	126 (26.5)	54 (11.4)	79 (16.6)	87 (18.3)

Note. Items with asterisks are reverse-coded items; 1 = *strongly disagree* (widerspreche voll und ganz); 2 = *disagree* (widerspreche); 3 = *slightly disagree* (widerspreche teilweise); 4 = *neutral* (stimme weder zu noch widerspreche ich); 5 = *slightly agree* (stimme teilweise zu); 6 = *agree* (stimme zu); 7 = *strongly agree* (stimme voll und ganz zu).

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bifactor model (Hagan et al., 2022). We applied the diagonally weighted least squares (DWLS) estimator for our CFA (Muthén et al, 1997), which provides test statistics and standard errors that are based on the second-order correction. The DWLS is the most recommended estimator in CFA literature, as it was specially designed for ordinal data. This study incorporated two previously validated versions of the scale: a 12-item version and a 9-item version. These versions were independently analyzed to assess their suitability within the sample and research context. It is crucial to note that no item removal or manipulation was performed, ensuring the use of scales as they have been recognized and validated in the prior literature.

Confirmatory Factor Analysis Parameters

Confirmatory factor analysis (CFA) is a statistical technique employed to verify the fit of a hypothesized measurement model that outlines the relationships between observed and latent variables (Prudon, 2015). This process assesses model fit through the analysis of goodness-of-fit indices and identifies the observed variables most strongly related to each latent variable. CFA enables (1) construct validity evaluation; (2) response pattern comparison; and (3) competing model comparison. Model fit is commonly assessed using indices such as comparative fit index (CFI), Tucker–Lewis Index (TLI), root-mean-square error of approximation (RMSEA), and standardized root-mean-square residual (SRMR). Acceptable model fit typically requires CFI, TLI > .95, and RMSEA, SRMR < .08 (Hu & Bentler, 1999).

To complement the χ^2 test and adjust for its potential issue of being influenced by sample size, the ratio of χ^2 to degrees of freedom (χ^2/df) is often employed, with values < 5 generally indicating an acceptable fit (Alavi et al., 2020; Kline, 2015). In this study, we assessed the fit of one-factor model structures for both the 9-item and 12-item versions of the MoVac-COVID19S. For the 12-item version, a four-factor model composed of four cognitive factors (i.e., impact, value, knowledge, and autonomy) was also evaluated. However, such a structure is not feasible for the 9-item version, as some theoretical domains would contain only one or two items, insufficient for valid factors.

Bifactor Model (Confirmatory Factor Analysis) Parameters

The traditional multifactor models of CFA do not vividly demonstrate the degree to which a particular subscale or submeasure is a psychometrically justifiable indicator of a specific construct. In other words, CFA fails to answer the question, "How much reliable information does a subscale score give beyond the total score of the scale?" Consequently, we further evaluated the MoVac-COVID19S using the bifactor model with the overarching latent trait of the MoVac-COVID19S to demonstrate whether the MoVac-COVID19S subscales adequately represent the overarching construct. Basically, a bifactor model provides a comprehensive understanding of how the observed variables of both the general and unique factors relate and provides evidence of unidimensionality of the overarching construct if an acceptable fit is evident (Reise et al., 2010, 2013). To further establish unidimensionality, three different ω coefficients were estimated to determine the amount of variance in the composite observed scores explained by all common sources of variance (Reise et al., 2013), they are Total omega (ω), Subscale Omega (ω_s), and Hierarchical omega (ω_H). For the purpose of interpretation, a hierarchical ω value of .80 for any of the scales indicates that the scale adequately measures the underlying construct (Reise et al., 2013). Further, explained variances by factors and factor loadings were used to provide more evidence for the unidimensionality of the scale. Notably, an item that loads equally on both general and specific factors favors the general factor only especially if the general factor and the specific underlying construct are highly correlated (Reise et al., 2013).

Reliability Estimates

We estimated internal consistency for full scales and subscales of the 12-item scale version. Although reliability estimates using McDonald's omega (ω) are found to be the best substitute for Cronbach's alpha (α), as ω provides more accurate parameters even under the violation of the congeneric tenet compared to α (TrizanoHermosilla & Alvarado, 2016), our internal consistency estimates included results from these two approaches as a means of triangulation (i.e., increasing evidence to provide more confidence in the scale). Finally, construct validity was computed for the MoVac-COVID19S with a measure of COVID-19 vaccination willingness scale using Pearson's correlation coefficient.

Results

One-Factor and Multifactor Models (Confirmatory Factor Analysis)

The CFA revealed an excellent fit for the one-factor structure of the 9-item version of the MoVac-COVID19S (Table 3). Overall, CFI, and TLI values were higher than .95; RMSEA and SRMR values were all less than .08 for the one-factor models of both the 9-item and 12-item versions of the scale and the four-factor model of the 12-item version, demonstrating relatively high fit indices for all estimated models. Of note, RMSEA and SRMR showed acceptable fit indices for all the factor structures of the 12-item version of the MoVac-COVID19S through model modification, all negatively worded items loaded on each

Table 3. Confirmatory factor analysis testing the structure of the Motors of COVID-19 Vaccination Acceptance Scale (MoVac-COVID19S) (*N* = 475)

Models	χ^2/df	CFI	TLI	RMSEA	SRMR
9-item: one factor	1.08 (p = .352)	1.000	1.000	.013	.017
12-item: one factor	2.20 (p < .001)	.999	.999	.050	.042
12-item: four factors	2.13 (p < .001)	1.000	.999	.049	.039
Bifactor model	2.07 (p < .001)	1.000	.999	.047	.030

Note. CFI = comparative fit index, TLI = Tucker–Lewis index, RMSEA = root-mean-square error of approximation, SRMR = standardized root-mean-square residual.

other (Table 3). In the context of our models, the calculated ratio of chi-square to degrees of freedom, which was consistently found to be below five across all models in our sample suggests a closer match between the observed and predicted data patterns, thus representing a more reliable model in accurately representing the structure in the data (Table 3). Finally, all factor loadings were found to be good ranging from .64 to .97 for the 9-item version of the MoVac-COVID19S. Item 11 loaded low on both factor structures of the 12-item version of the MoVac-COVID19S; factor loadings for other items were good for this version of the scale (Table 4; see Figure E1 and E2 in Electronic Supplementary Material 1).

Bifactor Model (Confirmatory Factor Analysis)

While all the fit indices for the bifactor model were found to be excellent (Table 3), indicating a strong match between our model and the observed data, it is important to clarify that this does not automatically infer the dominance of the general factor in explaining the variance in the items. The adequacy of the model fit and the proportion of variance attributed to the general factor are separate considerations. Again, more than half of the items in the full scale loaded higher on the general construct than on the specific factors of the MoVac-COVID19S. For example, Item 1 loaded .99 on the general factor compared to .35 on the impact subscale, and Item 5 loaded .96 onto the general factor as opposed to .30 onto the autonomy subscale. Overall, 10 items loaded high on the general factor (accounting for 83% of the total items) compared to two items (17%) on the specific factors (Table 4). To provide a more comprehensive view of the model, we considered the Explained Common Variance (ECV), which assesses the proportion of common variance explained by the general factor, in comparison to the specific factors. The general factor demonstrated a substantial contribution to the ECV across nine items, accounting for approximately 55% to 94% of the shared variance per item (Table 4). This represents a considerable proportion (75%) of all items. For example, the general factor explained 94% of the ECV shared by item 6. This indicated that many of the items generally measure one underlying construct. The hierarchical ω reliability coefficient for the value subscale was .12, the impact subscale was .13, the knowledge subscale .08, the autonomy subscale .12, and the general factor was .26. While none of the coefficients reached the threshold for making a tentative decision regarding the factors, the relatively high coefficient of the general factor suggest a slight indication of the dominance of this factor. This revised statement provides clarity by specifying the numerical values of the coefficients and their comparison. Finally, Item 3 and Item 6 were found to load 1.04 and 1.05, respectively, on the general factor. This coefficient may not be ideal but acceptable considering the magnitude of the value after one

Table 4. Factor loadings of the 9-item and 12-item versions of the MoVac-COVID19S, including factor loadings of the General and Specific factors, and Explained Common Variance (ECV) of General Factor in the Bifactor Model for the MoVac-COVID19S (*N* = 475)

Item	One-factor structure (9-item)	One-factor structure (12-item)	Four-factor structure (12-item)	General factor	Value subscale	Impact subscale	Knowledge subscale	Autonomy subscale	ECV
3	.96	.96	.96	1.04	.33				.92
6	.97	.97	.97	1.05	.35				.94
8	.92	.92	.92	1.00	.33				.85
1	.89	.89	.87	.99		.35			.78
4	.85	.90	.84	.93		.25			.72
12	.84	.84	.75	.93		.28			.70
2	.74	.74	.74	.75			.28		.55
5	.94	.95	.96	.96			.30		.89
10		.42	.43	.32			1.42		.00
7		.43	.50	.71				.60	.71
9	.64	.64	.77	.78				.37	.47
11		.08	.12	.28				.92	.37

Table 5. Bivariate correlations matrix between all the scales of the Motors of COVID-19 Vaccination Acceptance Scale (MoVac-COVID19S) (*N* = 475)

Variable	1	2	3	4	5	6	7
1. COVID-19 vaccination willingness	—						
2. 12-item version	.59**	—					
3. Value subscale	.66**	.93**	—				
4. Impact subscale	.61**	.92**	.90**	—			
5. Knowledge subscale	.48**	.88**	.79**	.76**	—		
6. Autonomy subscale	.21**	.65**	.428**	.41**	.46**	—	
7. 9-item version	.62**	.97**	.97**	.96**	.84**	.48**	—

Note. $^{**}p < .01$.

and the theoretical relevance of these items, including the overall model fit (West et al., 2012). However, Item 10 loaded relatively higher (1.40) on the knowledge subscale, which may indicate the limitations of the specific domains (i.e., knowledge) of the MoVac-COVID19S (Table 4).

Internal Consistency (Reliability)

Whereas the internal consistency for the full versions of the MoVac-COVID19S (12-item: α = .91, ω = .92; 9-item: α = .94, ω = .95) were found to be excellent, the subscales ranged from excellent to below acceptance. The value subscale (α = .95; ω = .95) was found to be excellent, but the impact subscale (α = .86; ω = .86) showed very good internal consistency. However, the knowledge (α = .68; ω = .71) and autonomy (α = .56; ω = .58) subscales were found to be below the acceptable range.

Support for Unidimensionality

Overall, the analyses conducted revealed evidence supporting the unidimensionality of both the 12-item and 9-item scale versions reflected by high ω estimates above .91 for both scale versions as it accounts for factor loadings and lower ω for subfactors (e.g., .56). High latent correlations observed in the data further suggest the presence of a single underlying factor responsible for the responses to the items on each scale, affirming the unidimensionality (see Figure E2 in ESM 1). As such, the exploration of alternative models with fewer factors was not deemed necessary. These findings indirectly contribute to the evidence supporting the validity of the unidimensional factors of the two scale versions, reinforcing their suitability for use within this research context and sample.

Convergent Validity

A positive association between the single item measure of COVID-19 vaccine uptake willingness and the latent constructs operationalized by the 9-item ($r = .62$, $p < .001$) and the 12-item ($r = .59$, $p < .001$) versions of the MoVac-COVID19S was found (using Pearson's correlation coefficient). Similarly, COVID-19 vaccine uptake willingness was positively correlated with the impact ($r = .61$, $p < .001$), value ($r = .66$, $p < .001$), autonomy ($r = .21$, $p < .001$), and knowledge attitudes subscales toward COVID-19 vaccination. Finally, the positive intercorrelation between all the scales of the MoVac-COVID19S ranged from moderate ($r = .48$) to strong positive ($r = .97$; Table 5).

Discussion

We have adapted and validated the MoVac-COVID19S in German language and assessed its psychometric properties using the general population in Germany. Importantly, such adaptation potential of the scale highlights the perpetuality of the use of this scale for all future vaccination attitudes. For instance, the scale can be adapted by simply replacing the existing name of the virus in the scale with the name of any newly emerged infectious disease (Chen et al., 2022). Findings from the CFA supported the unidimensionality measure of the one-factor models of both the 9-item and 12-item versions of the MoVac-COVID19S. This implies that COVID-19 vaccination attitudes can be measured with a sum score from the MoVac-COVID19S using either version of the scale. Similarly, the subscales of the 12-item version of the MoVac-COVID19 were found to be valid for measuring the underlying constructs being assessed. Item 11 loading low on the 12-item version of the MoVac-COVID19 implies that this item may be a weak indicator of the underlying construct, but other items are good measure of the underlying latent variable. This item still offers conceptual importance to the model; hence it is acceptable to retain this item especially with the evidence of the good model fit (Hair et al., 2010). Addedly, we successfully replicated findings in previous research (Chen et al., 2022), suggesting that the subscales are measuring respective underlying construct. Nevertheless, this traditional multifactor model result is limited to determine such dimensionality, a limitation in the literature that required further testing, as discussed below.

The 9-item version of the MoVac-COVID19S demonstrated a good fit, based on Asparouhov and Muthén (2018), which was superior to previous scale validations conducted in Taiwan, Indonesia, and Malaysia (Pramukti et al., 2022). This highlights the critical role of cultural appropriateness in psychometric assessments, advocated by the classical test theory, and reaffirms our version's validity in a German sample (Cooper, 2023; Yeh et al., 2021). Notably, our work yielded higher reliability coefficients than some past validations (Chen et al., 2021), although knowledge and autonomy subscales had comparatively lower reliability, possibly due to the negative item wording (Chen et al., 2022; Lee et al., 2016).

Our results also demonstrated good convergent validity, with strong correlations between all scale types and the COVID-19 vaccination willingness scale, suggesting a common underlying factor (Chin & Yao, 2014). However, the strong correlations imply potential issues in scale differentiation. The bifactor model test further confirmed this, showing the scale as a unidimensional measure, indicating that total scores provide a more accurate measure of COVID-19 vaccination attitudes than specific domains. We recognize the challenges posed by the lack of reliable and valid measures for the validation of vaccination willingness, which initially led us to employ a single item approach. However, we acknowledge that this might limit the scope of validation due to the complexity of the construct.

Strengths, Limitations, Future Directions

Despite the limitations such as a nonrepresentative sample and the criticisms of CFA as a method, this work was the first to validate MoVac-COVID19S in a German population. We found the scale best treated as a unidimensional measure, contradicting some previous literature and necessitating further examination of its purported multidimensionality. Moreover, the 9-item version offered a notably excellent fit among respondents. Future research should address the limitations noted, testing psychometric properties in different German subgroups and using advanced methodological approaches such as Rasch model (Medvedev & Krägeloh, 2022; Rasch 1993). Redevelopment may be necessary to address subscale distinctiveness. The 12-item scale model modifications, particularly for the negatively worded items, suggest potential improvements for this scale. Finally, future studies should consider the development of a general vaccine attitude scale, of which the current MoVac-COVID19S could serve as a foundation.

Conclusions

In this study, we conducted a cross-cultural adaptation and validation of the MoVac-COVID19S, assessing its psychometric properties using a sample from the general population in Germany. Our aim was to facilitate the evaluation of attitudes and considerations toward COVID-19 vaccination, with potential instrument for assessing attitudes related to viral or bacterial vaccination. Our findings reveal that both the 9-item and 12-item versions of the MoVac-COVID19S exhibit high reliability when applied to the German sample, while also demonstrating promising construct and convergent validity. We recommend interpreting the scores from the MoVac-COVID19S as a general score, emphasizing its unidimensional nature and focusing less on the various facets of the scales. This study contributes valuable insights into the application of the MoVac-COVID19S within different cultural contexts, enhancing our understanding of vaccination attitudes and informing future research in the field.

Electronic Supplementary Materials

The electronic supplementary material is available with the online version of the article at 10.1027/2698-1866/a000064

ESM 1. Include path diagrams illustrating the factor structures of both the 9 and 12-item versions of the MoVac-COVID19, along with the bifactor model.

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Conflict of Interest
Authors declare no competing interests.

Publication Ethics
This validation research was approved by the author's Human Research Ethics Committee board (#0000029770), and the study was in line with the Declaration of Helsinki, which outlines fundamental ethical principles for health research involving the use of human participants (World Medical Association, 2013). Participants 18 years and older were allowed to participate in the current study for ethical reasons. Participation in the current study was voluntary, and every participant provided an informed consent before completing the survey.

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Study participants did not consent to having their data shared publicly. The deidentified participant dataset generated during the current study can be made available to researchers with relevant permissions upon a reasonable request to the corresponding author.

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Appendix

Box A1. Full German version of the 12-item of the Motors of COVID-19 Vaccination Acceptance Scale (MoVac-COVID19S)

1. Die Impfung ist ein sehr effektiver Weg, um mich vor COVID-19 zu schützen.
2. Ich weiß sehr gut darüber Bescheid, wie mich die Impfung vor COVID-19 schützt.
3. Es ist sehr wichtig, dass ich die COVID-19 Impfungen erhalte.
4. Die Impfung reduziert maßgeblich mein Risiko, mich mit COVID 19 anzustecken.
5. Die Impfung hilft meinem Körper gegen COVID-19 anzukämpfen.
6. Die Impfung spielt eine wichtige Rolle dabei, mein Leben und das der anderen zu schützen.
7. Ich fühle mich unter Druck, mich gegen COVID-19 impfen zu lassen*
8. Die COVID-19 Impfung ist sehr wichtig für meine Gesundheit und mein Wohlbefinden
9. Ich kann frei entschieden, ob ich die COVID-19 Impfung erhalte oder nicht.
10. Es ist mir unklar, wie die COVID-19 Impfung meine Gesundheit schützen soll*
11. Ich lasse mich gegen COVID-19 impfen, weil es von mir gefordert wird*
12. Die COVID-19-Impfung hat einen positiven Einfluss auf meine Gesundheit

Note. Items with asterisks are reverse-coded items.

Box A2. Full German version of the 9-item of the Motors of COVID-19 Vaccination Acceptance Scale (MoVac-COVID19S)

1. Die Impfung ist ein sehr effektiver Weg, um mich vor COVID-19 zu schützen.
2. Ich weiß sehr gut darüber Bescheid, wie mich die Impfung vor COVID-19 schützt.
3. Es ist sehr wichtig, dass ich die COVID-19 Impfungen erhalte.
4. Die Impfung reduziert maßgeblich mein Risiko, mich mit COVID 19 anzustecken.
5. Die Impfung hilft meinem Körper gegen COVID-19 anzukämpfen.
6. Die Impfung spielt eine wichtige Rolle dabei, mein Leben und das der anderen zu schützen.
7. Die COVID-19 Impfung ist sehr wichtig für meine Gesundheit und mein Wohlbefinden
8. Ich kann frei entschieden, ob ich die COVID-19 Impfung erhalte oder nicht.
9. Die COVID-19-Impfung hat einen positiven Einfluss auf meine Gesundheit

Note. Scale anchors: 1 = *widerspreche voll und ganz*; 2 = *widerspreche*; 3 = *widerspreche teilweise*; 4 = *stimme weder zu noch widerspreche ich*; 5 = *stimme teilweise zu*; 6 = stimme zu; 7 = *stimme voll und ganz zu*.