

Validation of the Dutch Version of the Plymouth Sensory Imagery Questionnaire

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Abstract: Mental imagery plays an important role in the onset and maintenance of psychological disorders as well as their treatment. Therefore, a reliable and valid measure of mental imagery is essential. Andrade and colleagues (2014) developed the Plymouth Sensory Imagery Questionnaire (PsiQ), which contains 35 items (long version) or 21 items (shortened version) measuring the vividness of mental imagery in seven different modalities: vision, sound, smell, taste, touch, bodily sensation, and emotion. Andrade et al. reported a seven-factor structure corresponding to the different modalities for both versions rather than a one-factor model measuring general mental imagery. The current paper reports on the translation and validation of the Dutch version of the PsiQ (PsiQ-NL-35 and PsiQ-NL-21). In two independent samples (student and mixed), the PsiQ-NL-35 showed excellent internal consistency, adequate model fit for the seven-factor model, and a poor fit for the one-factor model. Test-retest reliability (Study 1, student sample) was good. Construct validity (Study 2, mixed sample) was adequate. The PsiQ-NL-21 also showed excellent internal consistency, good test-retest reliability, adequate seven-factor model fit, and adequate construct validity. Measurement invariance between the Dutch and the English version was found, implying that both versions measure the same construct.

Keywords: mental imagery, assessment, psychometric properties, Dutch, Plymouth Sensory Imagery Questionnaire



Mental imagery can be defined as the representation and experience of perceptual stimuli in mind without the presence of an external stimulus (Pearson et al., 2015). It is often described as “seeing with the mind’s eye” or “hearing with the mind’s ear” (Kosslyn et al., 2001, p. 635). Mental imagery is used in many cognitive functions, such as motivation (Renner et al., 2019), motor performance (Cumming & Williams, 2012), and simulating future events (Moulton & Kosslyn, 2009). Mental imagery also plays an important role in the onset and maintenance of psychological disorders, such as depression (Holmes et al., 2016; Weßlau & Steil, 2014), posttraumatic stress disorder (Hackmann & Holmes, 2004), anxiety disorders (Hirsch & Holmes, 2007; Morina et al., 2011), eating disorders (Kadriu et al., 2019), and addiction (Andrade et al., 2012). Moreover,

effective psychological treatments such as imaginal exposure and imagery rescripting include the use of mental imagery (Hackmann et al., 2011).

Given the importance of mental imagery in psychological functioning, a reliable and valid measure of this construct is essential. Several measures of mental imagery exist. Most measure the vividness of a single sensory modality, such as the Vividness of Visual Imagery Questionnaire (VVIQ; Marks, 1973, 1995) and the Clarity of Auditory Imagery Questionnaire (Willander & Baraldi, 2010) for visual and auditory imagery, respectively. However, these modality-specific questionnaires do not allow for the study of individual differences in mental imagery across modalities. Betts (1909) created the Questionnaire upon Mental Imagery (QMI), which contains items regarding several sensory modalities. However, with 150 items, this questionnaire has been criticized for being overly long, and its shorter 35-item version by Sheehan (1967) does not show a consistent factor structure (see Andrade et al., 2014 for a more detailed discussion). In addition, it contains outdated items such as imagining “the sound of the steam trumpet of a

steam locomotive.” To overcome these limitations, Andrade and colleagues (2014) developed and validated the English Plymouth Sensory Imagery Questionnaire (PsiQ). It measures the vividness of mental imagery in seven sensory modalities: vision, sound, smell, taste, touch, bodily sensation, and emotion. The authors found a seven-factor structure corresponding to the seven modalities and did not find support for a single mental imagery factor structure. The full version contains 35 items (i.e., 5 per modality). The authors also created a shorter version of 21 items (i.e., 3 per modality), including the three highest loading items per factor. Currently, the only validated translation is in Spanish, which also showed a seven-factor structure similar to the English version (Pérez-Fabello & Campos, 2020). Compared to the QMI, the PsiQ has more timeless or updated items (e.g., smelling a rose) and is relatively short (35 or 21 items).

The current study aimed to translate the English PsiQ to Dutch and validate the PsiQ-NL in two independent samples (Study 1, student sample; Study 2, mixed sample). In Study 1, we conducted a confirmatory factor analysis (CFA) to test the appropriateness of the seven- and one-factor model (i.e., seven mental imagery modalities vs. a single mental imagery construct) for the 35- and 21-item version and tested the internal consistency and test-retest reliability. In Study 2, the factor structure analysis was replicated, and internal consistency and construct validity were tested. In line with Andrade and colleagues (2014), validity was tested using the Spontaneous Use of Imagery Scale (SUIS; Nelis et al., 2014; Reisberg et al., 2003), which measures the use of mental imagery rather than vividness, and the VVIQ-2 (Marks, 1995) which assesses the vividness of visual imagery specifically. Combining the samples in Study 1 and Study 2, we also compared the factor structure of the PsiQ-NL with the English PsiQ to assess measurement invariance. Ideally, the Dutch and English versions of the PsiQ would show measurement invariance, as this would indicate the stability of the construct over samples. The project was approved by the faculty’s ethical review board (FETC20-375).

Study 1: Confirmatory Factor Analysis, Internal Consistency, and Reliability in a Student Sample

Methods

Participants

A total of 507 participants were recruited through the university participant recruitment platform, social media, and personal contacts of the researchers. Data inclusions

and exclusions were established prior to data analysis. Given the purpose of the study, knowledge of the Dutch language was a requirement for participation. Nine participants were excluded from data analysis because of incomplete questionnaires. The remaining sample consisted of 498 participants aged between 16 and 70 years ($M = 23.90$; $SD = 7.10$). See Table 1 for all sample characteristics. Participants received a small financial imbursement or course credits for participation.

Materials

Dutch Plymouth Sensory Imagery Questionnaire (PsiQ-NL-35)

The PsiQ-NL-35 was translated to Dutch from the English PsiQ (Andrade et al., 2014) by an independent, native English-speaking professional translator. All authors independently checked this translation for accuracy in the context of psychology. The revised translation was then back-translated to English by an independent translator. The back-translated English version was subsequently checked by the authors for accuracy. No further adjustments were made after back-translation. The final PsiQ-NL-35 is added in the Appendix.

The PsiQ-NL-35 contains 35 self-report items assessing mental imagery vividness in seven imagery modalities (i.e., vision, sound, smell, taste, touch, bodily sensation, and emotion; 5 items per modality). Items are rated on an 11-point scale ranging from 0 (= *no image at all*) to 10 (= *as vivid as real life*). Each modality has a brief instruction (e.g., “Imagine the appearance of . . .” for the visual modality), followed by the five items (e.g., “a cat climbing a tree”). Internal consistencies of the English version (Andrade et al., 2014; Cronbach’s $\alpha = .93$ and $.96$ in two samples) and Spanish version (Pérez-Fabello & Campos, 2020; Cronbach’s $\alpha = .92$) were good. Test-retest reliability was good for the English version ($r = .71$; Andrade et al., 2014) and not reported for the Spanish version. In the current study, different from the Andrade and colleagues and Pérez-Fabello and Campos studies, items were presented randomly within each modality to exclude possible order effects. All items were presented on one page.

The PsiQ-NL-21 contains the same 21 items as the English 21-item version (see Table 4; Andrade et al., 2014). The English 21-item version showed excellent internal consistency (Cronbach’s $\alpha = .92$) and good model fit (Andrade et al., 2014). Internal consistency and model fit of the Spanish 21-item version (same items as the English version) were good (Cronbach’s $\alpha = .89$; Pérez-Fabello & Campos, 2020).

Procedure

The study took place online. Participants gave consent to participate after reading information about the study.

Table 1. Demographics of participants in Study 1 and Study 2

	Study 1		Study 2	
	Frequency or Mean (SD)	%	Frequency or Mean (SD)	%
Age	23.90 (7.10)		34.15 (15.88)	
Gender				
Male	97	19.5	86	36.3
Female	398	79.9	151	63.7
Other	3	0.6	0	0.0
Education level completed				
Elementary school	3	0.6	4	1.7
Junior high school	12	2.4	13	5.5
Senior high school	229	46.0	84	35.4
Bachelor's degree	174	34.9	78	32.9
Master's degree	78	15.7	50	21.2
PhD degree	2	0.4	4	1.7
Nationality				
Dutch	469	94.2	224	94.5
Belgian	3	0.6	1	0.4
Polish	1	0.2	1	0.4
German	3	0.6	4	1.7
Chinese	1	0.2	0	0.0
Other	4	0.8	1	0.4
Multiple ¹	17	3.4	6	2.5

Note. ¹All participants with multiple nationalities indicated that Dutch was one of them.

They first completed demographic questions, followed by the PsiQ-NL-35. One week later, participants completed it for the second time. After the second completion, participants were thanked and debriefed and received their reimbursement.

Data Analysis

All analyses were performed for the PsiQ-NL-35 as well as the PsiQ-NL-21. The CFA was done using the *lavaan* package for R (Rosseel, 2012). The seven-factor model was tested first. In order to test for a possible single mental imagery dimension, a CFA was also conducted on the one-factor model. Given that the assumption of normality was violated, the Satorra-Bentler scaled test statistic correction was applied to the maximum likelihood estimator (Curran et al., 1996; Satorra & Bentler, 1994). Model fit was assessed by the Root Mean Square Error of Approximation (RMSEA), Standardized Root Mean Square Residual (SRMR), and Comparative Fit Index (CFI). Values of RMSEA < .06, SRMR < .08, and CFI > .95 indicate good model fit (Hooper et al., 2008; Hu & Bentler, 1998, 1999; Schermelleh-Engel et al., 2003). Internal consistency was assessed for the PsiQ-NL total score and for each modality

subscale. This was initially done with Cronbach's α (using SPSS 26.0) to be able to compare our results with the English and Spanish versions as reported in Andrade and colleagues (2014) and Pérez-Fabello and Campos (2020). However, as the PsiQ-NL was not unidimensional, we also calculated ω using the MBESS package for R (Dunn et al., 2014; Kelley, 2022; McDonald, 1999).¹ Test-retest reliability was assessed using Pearson correlations in SPSS 26.0.

Results

All statistics are displayed in Tables 2, 3, 4, and 5. Table 2 shows the factor loadings of the seven-factor model of the PsiQ-NL. Table 3 presents an overview of Cronbach's α and ω values, mean scores, and standard deviations for the full scale and each modality subscale. Correlations between the modality subscales and the total score of the PsiQ-NL can be found in Table 4. See Table 5 for test-retest reliability of the full scale and the modality subscales.

PsiQ-NL-35

Confirmatory Factor Analysis

The seven-factor model showed good fit on all measures, RMSEA = .035 (90% CI [.030, .040]), SRMR = .038, CFI = .958. The one-factor model did not show good fit, RMSEA = .083 (90% CI [.079, .087]), SRMR = .070, CFI = .752. Factor loadings for the seven-factor model were generally acceptable to good. Note that within each modality factor, the three highest loading items corresponded to the highest loading items in the English version for the vision and emotion subscales. The highest loading items for the other modality factors differed from the English version.

Internal Consistency

Internal consistency for the full scale was excellent (Cronbach's α = .944, ω = .945). Internal consistency for the modality subscales was acceptable to good, with Cronbach's α ranging from .756 (bodily sensation) to .865 (smell) and ω ranging from .757 (bodily sensation) to .865 (smell).

Test-Retest Reliability

In total, 414 participants (83%) completed the PsiQ-NL-35 a second time 1 week later. The test-retest reliability of the full scale was good, r = .827. Test-retest reliability of the modality subscales was moderate to sufficient and ranged from r = .674 (sound) to r = .751 (smell).

¹ We thank the reviewer for this suggestion.

Table 2. Factor loadings (standardized regression weights) of the seven-factor model of the PsiQ-NL-35 and the PsiQ-NL-21 in Study 1 and Study 2

Item	Factor loading ^a			
	Study 1		Study 2	
	PsiQ-NL-35	PsiQ-NL-21	PsiQ-NL-35	PsiQ-NL-21
Factor 1: Vision				
A bonfire*	.775	.802	.827	.842
A sunset*	.765	.771	.768	.805
A cat climbing a tree*	.660	.670	.753	.744
A friend you know well	.628		.661	
The front door of your house	.548		.699	
Factor 2: Sound				
Hands clapping in applause*	.755	.763	.826	.853
The sound of a car horn*	.712	.722	.762	.736
The mewling of a cat	.703		.753	
The sound of children playing	.701		.750	
An ambulance siren*	.677	.661	.705	.744
Factor 3: Smell				
Fresh paint	.784		.873	
Newly cut grass*	.776	.761	.862	.841
Burning wood*	.760	.784	.832	.855
A stuffy room	.733		.645	
A rose*	.699	.703	.685	.675
Factor 4: Taste				
Lemon*	.794	.745	.851	.779
Toothpaste	.749		.818	
Black pepper*	.719	.779	.730	.796
Sea water	.686		.727	
Mustard*	.674	.728	.668	.731
Factor 5: Touch				
Warm sand*	.813	.819	.754	.737
A soft towel*	.809	.824	.766	.821
The point of a pin	.732		.765	
Icy water	.731		.790	
Fur*	.569	.563	.597	.565
Factor 6: Bodily sensation				
Having a sore throat	.677		.733	
Walking briskly in the cold*	.676	.673	.745	.764
Relaxing in a warm bath*	.631	.638	.652	.630
Jumping into a swimming pool*	.624	.651	.675	.682
Threading a needle	.527		.627	
Factor 7: Emotion				
Excited*	.749	.732	.808	.855
Relieved*	.728	.734	.733	.802
Scared*	.626	.623	.532	.453
Furious	.599		.628	
In love	.538		.519	

Note. *Items included in the PsiQ-NL-21 (see Andrade et al., 2014). ^aFactor loadings are ordered from highest to lowest factor loading per modality.

PsiQ-NL-21

Confirmatory Factor Analysis

Model fit for the seven-factor model was good, RMSEA = .039 (90% CI [.030, .048]), SRMR = .037, CFI = .969.

The one-factor model did not show good fit, RMSEA = .104 (90% CI [.097, .110]), SRMR = .074, CFI = .760. Factor loadings for the seven-factor model were generally acceptable to good.

Table 3. Means and standard deviations (SDs) for each modality subscale and the full scale and internal consistency (Cronbach's α and ω) of the PsiQ-NL-35 and PsiQ-NL-21

	PsiQ-NL-35				PsiQ-NL-21			
	Mean	SD	Cronbach's α	ω	Mean	SD	Cronbach's α	ω
Study 1								
Vision	7.81	1.38	.800	.800	7.63	1.53	.781	.781
Sound	7.29	1.64	.834	.835	7.30	1.74	.756	.761
Smell	6.13	1.97	.865	.865	6.09	2.09	.790	.791
Taste	6.65	1.86	.837	.838	6.22	2.12	.786	.802
Touch	7.16	1.62	.840	.840	7.09	1.69	.753	.755
Bodily sensation	6.97	1.45	.756	.757	7.15	1.52	.691	.693
Emotion	7.05	1.52	.767	.770	7.29	1.54	.739	.740
Full PsiQ-NL	7.01	1.27	.944	.945	6.97	1.29	.913	.914
Study 2								
Vision	7.93	1.66	.858	.863	7.62	1.90	.840	.841
Sound	7.57	1.84	.870	.871	7.64	1.91	.813	.814
Smell	6.85	2.05	.879	.876	6.98	2.11	.813	.820
Taste	6.77	2.04	.862	.860	6.44	2.25	.810	.812
Touch	7.15	1.78	.845	.847	7.04	1.81	.716	.721
Bodily sensation	7.03	1.68	.813	.815	7.36	1.65	.736	.746
Emotion	7.12	1.61	.782	.772	7.21	1.67	.707	.724
Full PsiQ-NL	7.20	1.45	.955	.956	7.18	1.46	.928	.929

Table 4. Correlations^a among the modality subscales and the full PsiQ-NL-35 in Study 1 and Study 2

	Sound	Smell	Taste	Touch	Bodily Sensation	Emotion	PsiQ-NL-35
Study 1							
Vision	.627	.499	.458	.459	.444	.425	.708
Sound		.539	.559	.542	.530	.457	.783
Smell			.702	.566	.549	.414	.810
Taste				.597	.586	.452	.822
Touch					.658	.493	.797
Bodily sensation						.555	.790
Emotion							.689
Study 2							
Vision	.755	.585	.582	.536	.577	.398	.787
Sound		.661	.533	.493	.545	.422	.788
Smell			.715	.620	.663	.484	.856
Taste				.637	.570	.438	.812
Touch					.792	.581	.828
Bodily sensation						.601	.840
Emotion							.687

Note. ^aAll correlations were significant at the $p < .001$ level.

Table 5. Test-retest reliability (Pearson's r^a) for the full PsiQ-NL-35 and PsiQ-NL-21 and the modality subscales in Study 1

	PsiQ-NL-35	PsiQ-NL-21
Vision	.695	.620
Sound	.674	.648
Smell	.751	.729
Taste	.740	.748
Touch	.693	.667
Bodily sensation	.674	.627
Emotion	.708	.637
PsiQ-NL	.827	.819

Note. ^aAll correlations were significant at the $p < .001$ level.

Internal Consistency

Internal consistency for the full scale was excellent, Cronbach's $\alpha = .913$, $\omega = .914$. Internal consistency for the modality subscales was moderate to acceptable, with Cronbach's α ranging from .691 (bodily sensation) to .790 (smell) and ω ranging from .693 (bodily sensation) to .802 (taste).

Test-Retest Reliability

Test-retest reliability ($N = 414$; 83%) for the full PsiQ-NL-21 was good, $r = .819$. Test-retest reliability for the modality

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subscales was moderate to sufficient, ranging from $r = .620$ (vision) to $r = .748$ (taste).

Study 2: Replication of the Factor Structure and Construct Validity in a Mixed Sample

Methods

Participants

In total, 318 participants² were recruited through the university participant recruitment platform, social media, and personal contacts of the researchers. Inclusion and exclusion criteria were established before data analysis. Knowledge of the Dutch language was a requirement for participation. Eighty-one participants were excluded from data analysis because of non-compliance to the instructions ($n = 1$) or incomplete questionnaires ($n = 80$). The remaining sample consisted of 237 participants (59.1% community members, $n = 140$; 40.9% students, $n = 97$) aged between 16 and 76 years ($M = 34.15$; $SD = 15.88$). See Table 1 for all sample characteristics. Participants received a small financial imbursement or course credits for participation.

Materials

PsiQ-NL-35

See Study 1.

Spontaneous Use of Imagery Scale (SUIS)

The SUIS consists of 12 items assessing the use of mental imagery in daily life (Nelis et al., 2014; Reisberg et al., 2003). Participants rate the items (e.g., “whenever I go out, I imagine what I would look like wearing different combinations of clothes”) on a 5-point scale anchored 1 (= *never applicable*), 3 (= *applicable half of the time*), and 5 (= *always completely applicable*). Cronbach’s α ranged from .72 to .76 for the Dutch version of the SUIS (Nelis et al., 2014). Internal consistency of the SUIS was sufficient in the current sample (Cronbach’s $\alpha = .72$).

Vividness of Visual Imagery Questionnaire (VVIQ-2)

The VVIQ-2 (Marks, 1995) consists of four sets of four items measuring the vividness of visual imagery. Participants are asked to imagine a scene or place (e.g., a shop they often visit) and to rate the vividness of four details of this scene or place (e.g., the shopping window with all the colors, shape, and details of the items that are sold)

on a 5-point scale anchored 1 (= *perfectly clear and equally vivid as normal vision*), 2 (= *clear and reasonably vivid*), 3 (= *moderately clear and vivid*), 4 (= *vague and dim*), and 5 (= *no image at all, I only “know” that I am “thinking” of something*). The Dutch VVIQ-2 was found to have good internal consistency, Cronbach’s $\alpha = .89$ (Nelis et al., 2014), and showed excellent internal consistency in the current sample, Cronbach’s $\alpha = .93$. The VVIQ-2 and the English PsiQ showed a correlation of $r = .67$ (Andrade et al., 2014). In addition, the VVIQ-2 also correlated with the visual subscale of the English and Spanish PsiQ, $r = .52$ and $r = .33$, respectively (Andrade et al., 2014; Pérez-Fabello & Campos, 2020).

Procedure

The procedure was similar to Study 1, except that participants also completed the SUIS and VVIQ-2. All questionnaires were presented on separate web pages (one page per questionnaire) and in random order per participant.

Data Analysis

Deviating from standard scoring of the VVIQ-2, all VVIQ-2 items were reverse-coded to improve interpretability (i.e., higher scores now mean higher vividness of visual imagery). The CFA and internal consistency analyses were performed as described in Study 1. Construct validity was established using Pearson correlations in SPSS 26.0 by correlating the PsiQ-NL (−35 and −21) total scores with the SUIS total score and correlating the PsiQ-NL (−35 and −21) total score and visual subscale with the VVIQ-2 total score.

Results

All statistics are displayed in Tables 2, 3, and 4.

PsiQ-NL-35

Confirmatory Factor Analysis

The seven-factor model showed moderate fit, RMSEA = .062 (90% CI [.055, .069]), SRMR = .061, CFI = .899. The one-factor model did not show good fit, RMSEA = .105 (90% CI [.100, .111]), SRMR = .086, CFI = .699. Within each modality factor, the three highest loading items corresponded to the highest loading items in the English version for the Vision subscale only. The highest loading items for the other modality factors differed from the English version. The three highest loadings per modality subscale also differed from Study 1 for touch, bodily sensation, and emotion.

² In the preregistration, it was stated that 219 participants were recruited. However, after the registration, it turned out that 80 participants (36.5%) did not complete the questionnaires. Therefore, data collection was continued to have a minimum of 200 participants with completed questionnaires.

Internal Consistency

Internal consistency of the full scale was excellent, Cronbach's $\alpha = .955$, $\omega = .956$. Internal consistencies of the modality subscales were acceptable to good, with Cronbach's α ranging from .782 (emotion) to .879 (smell) and ω ranging from .772 (emotion) to .876 (smell).

Validity Tests

The PsiQ-NL-35 showed a moderate correlation with the SUIS, $r = .323$, and the VVIQ-2, $r = .399$ (full scale) and $r = .389$ (visual modality scale), all $ps < .001$.

PsiQ-NL-21

Confirmatory Factor Analysis

The PsiQ-NL-21 seven-factor model showed moderate fit, RMSEA = .054 (90% CI [.041, .067]), SRMR = .053, CFI = .953. The one-factor model showed bad fit, RMSEA = .118 (90% CI [.108, .128]), SRMR = .083, CFI = .742.

Internal Consistency

Internal consistency of the full PsiQ-NL-21 was excellent, Cronbach's $\alpha = .928$. Internal consistencies of the modality subscales were acceptable to good, with Cronbach's α ranging from .707 (emotion) to .840 (vision) and ω ranging from .721 (touch) to .841 (vision).

Validity Tests

The PsiQ-NL-21 showed a moderate correlation with the SUIS, $r = .304$, and VVIQ-2, $r = .390$ (full scale) and $r = .346$ (visual modality scale), $ps < .001$.

Measurement Invariance Between the Dutch and the English Version

The factor structure of the PsiQ-NL ($N = 735$, for Study 1 and 2 combined) was compared to the factor structure of the English PsiQ (Study 1, $n = 404$; Study 3, $n = 212$; from Andrade et al., 2014), leading to a total sample of $N = 1,351$. The Dutch 35-item version was compared to the English 35-item version, and the Dutch 21-item version was compared to the English 21-item version. In Study 2 from Andrade et al., a different rating scale was used for the PsiQ. Therefore, this sample was not included in the current analysis, as determined pre-analysis.

Data Analysis

The analyses were done separately for the PsiQ-35 and the PsiQ-21. To assess measurement invariance, two multi-group CFAs (MG-CFA) were conducted in R using the

lavaan (Rosseel, 2012) and *semTools* (Jorgensen et al., 2021) packages. Dutch and English samples were collapsed into one group per language. A stepwise comparison method was applied, adding model restrictions in each step (Cheung & Rensvold, 1999; Meade et al., 2008). First, the configural model was tested. This model states that the items belonging to each factor are equal for both groups. In the second model, factor loadings are constrained to be equal between groups, testing whether the items measure a similar construct in both groups. Third, intercepts were constrained to be equal between groups in addition to the factor loadings, testing whether scores between groups can be compared. Measurement invariance can be assumed when the more restricted model does not show a significantly worse fit than the less restricted model. Change in model fit was assessed with Δ CFI and Δ RMSEA, where a decrease of $\leq .010$ in CFI supplemented by an increase of $\leq .015$ in RMSEA indicates invariance (Chen, 2007; Cheung & Rensvold, 2002).

Results

PsiQ-35

The configural model showed adequate fit, CFI = .941, RMSEA = .047. The model with constrained factor loadings did not show worse fit, CFI = .941 (Δ CFI $< -.001$), RMSEA = .047 (Δ RMSEA $< .001$). The model with constrained factor loadings and intercepts showed slightly worse fit on the CFI, Δ CFI = $-.015$. However, Δ RMSEA = .005, which is below the threshold of $\leq .015$. Therefore, we can assume measurement invariance for the PsiQ-35.

PsiQ-21

The configural model showed good fit, CFI = .970, RMSEA = .044. The model with constrained factor loadings did not show worse fit, CFI = .970 (Δ CFI = $-.001$), RMSEA = .044 (Δ RMSEA = .001). The model with constrained factor loadings and intercepts showed worse fit on the CFI, Δ CFI = $-.021$. The increase in RMSEA was below the cut-off, Δ RMSEA = .012, thus measurement invariance was assumed for the PsiQ-21.

Discussion

In two studies, we assessed the factor structure, reliability, and validity of the Dutch version of the Plymouth Sensory Imagery Questionnaire (PsiQ-NL), 35-item and 21-item versions. Regarding the 35-item version, results indicated that a seven-factor structure corresponding to the seven sensory modalities was appropriate in both samples, which is in line with the English and Spanish versions of the PsiQ-35

(Andrade et al., 2014; Pérez-Fabello & Campos, 2020). The one-factor model, corresponding to a general vividness of mental imagery construct, did not show a good fit in either sample, supporting the existence of multiple sensory imagery dimensions. Correlations among modality subscales were only moderate, which suggests that they may at least partially measure different forms of mental imagery. Internal consistency and test-retest reliability of the full scale and the modality subscales were good. Measurement invariance between the Dutch and English versions of the PsiQ-35 and PsiQ-21 was tested and found, indicating that the factor structure of the PsiQ is similar in both languages and that scores from the Dutch and the English versions can be compared. This also implies that the same construct is measured by the Dutch and English versions. Together, these results imply that the PsiQ-NL-35 is a reliable questionnaire that assesses mental imagery vividness for seven sensory modalities.

Concerning validity, only low to moderate correlations were found among the PsiQ-NL-35 and the SUIS and VVIQ. Perhaps the different questionnaires capture different elements of mental imagery that function more or less independently. The use of mental imagery in daily life, as measured by the SUIS, may not be very strongly related to subjective imagery vividness as assessed with the PsiQ (Nelis et al., 2014; Reisberg et al., 2003). The VVIQ, on the other hand, also measures vividness of (visual) mental imagery similar to the PsiQ, yet was only moderately correlated with the visual subscale of the PsiQ. This might be explained by the different instructions of the PsiQ and the VVIQ. Whereas the PsiQ asks respondents to imagine the general appearance of persons, objects, or situations (e.g., the appearance of a friend you know well), the VVIQ asks respondents to focus on visual details of the image (e.g., the face, shoulders, and body of a person). Perhaps individuals differ in their vividness when imagining detailed versus more general (visual) images. Another possibility may be that the visual imagery ratings of the PsiQ are in some way influenced by respondents having to rate images in other modalities as well, which is not assessed with the VVIQ. Future research may focus on teasing out possible differing (cognitive) processes of mental imagery assessed with these questionnaires to aid researchers in choosing the appropriate questionnaire for their research question.

The PsiQ-NL-21, which included the same 21 items as the English version, also showed good fit (seven-factor model), internal consistency, test-retest reliability, and validity. Although measurement invariance was present, the factor loadings of the individual items in our study differed from those in Andrade and colleagues (2014). For example, the English version includes the item “scared” (and not “furious”) on the emotion subscale, whereas we

found that the loading of “furious” was higher than “scared” for the Dutch version in Study 2 (but not Study 1). In other words, for the PsiQ-NL-21 different items would have been psychometrically preferred over the current items in the English PsiQ-21. These differences in the factor loadings of individual items may be due to differences between the samples. For example, the sample of Study 1 in Andrade et al. and the current paper included more females than our Study 2 sample. Different factor loadings for example, “scared” and “furious” may reflect gender differences in imagining these emotions (see e.g., Brebner, 2003; Campos, 2014). In line with this, other individual differences that were not assessed in the current study (e.g., specialized backgrounds, see Isaac & Marks, 1994) might have influenced the factor loadings differently in the different samples. Obviously, using different items depending on the translation of the PsiQ is not recommended as it prohibits direct comparison of studies using different translations and promotes confusion in the use of the PsiQ-21. This could be a reason to prefer the PsiQ-35 over the 21-item version. Furthermore, users interested in specific items may also prefer the 35-item version. This could be especially the case for the emotion subscale, as these items reflect basic emotions that are not interchangeable (e.g., whereas fear is included in the 21-item version, feeling furious is not).

Our study has a few limitations that need to be addressed. First, Study 1 contained mainly female university students, limiting the generalizability to the general population. However, the mixed sample in Study 2 was more diverse and showed similar results to Sample 1 with regard to factor structure and internal consistency. Second, eighty participants did not complete the questionnaire in Sample 2 for unknown reasons, and there is a possibility of sample bias that we cannot rule out. It should also be noted that the model fit was slightly better in the first sample.

To conclude, evidence was found for a seven-factor structure of the PsiQ-NL corresponding to seven sensory modalities. The 35-item and the 21-item versions show good reliability and validity, as well as measurement invariance between the Dutch and the English versions. Based on the informational value of individual items and differences in factor loadings between translations, we recommend using the long version if possible.

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Conflict of Interest

The authors declare no conflicts of interest with respect to the authorship or the publication of this article.

Publication Ethics

The project was approved by the faculty's ethical review board (FETC20-375).

Authorship

Mandy Woelk, Muriel A. Hagens, Julie Krans, Conceptualization; Mandy Woelk, Formal analysis; Muriel A. Hagens, Julie

Krans, Funding acquisition; Mandy Woelk, Writing – original draft; Mandy Woelk, Muriel A. Hagens, Julie Krans, Writing – review and editing.

Open Science

We report how we determined our sample size, all data exclusions, all data inclusion/exclusion criteria, whether inclusion/exclusion criteria were established prior to data analysis, all measures in the study, and all analyses, including all tested models. If we use inferential tests, we report exact *p* values, effect sizes, and 95% confidence or credible intervals.

Open data: The data and the R code for the CFA and ω calculation (Study 1 and 2) can be found at <https://doi.org/10.17605/osf.io/6ebnw> (Woelk et al., 2022). We confirm that there is sufficient information for an independent researcher to reproduce all of the reported results, including the code book.

Open materials: All questionnaires in the Materials section are accompanied by a citation and accessible through the cited articles (Study 1 and 2). The PsiQ-NL-35 is provided in the Appendix of this article. The Dutch version of the VVIQ-2 used in Study 2 is available on request from the authors.

Preregistration of Studies and Analysis Plans: Study 1 was not preregistered. The data analysis plan (but not the study design) of Study 2 was preregistered on the Open Science Framework and can be found at <https://doi.org/10.17605/osf.io/6ebnw> (Woelk et al., 2022).

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Appendix

Dutch Version of the Plymouth Sensory Imagery Questionnaire (PsiQ-NL-35)

PsiQ: De Plymouth Sensory Imagery vragenlijst

Probeer de hieronder beschreven zaken in te beelden en geef een beoordeling van elke mentale verbeelding op de volgende schaal: 0 (helemaal geen verbeelding) tot 10 (verbeelding zo helder en levendig als in het echt). Vink het juiste vakje aan voor elk item. Beoordeel elk item.

Beeld je eens in dat je het volgende ziet:	0	1	2	3	4	5	6	7	8	9	10
een vriend die je goed kent	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
een kat die in een boom klimt	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
een zonsondergang	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
de voordeur van je huis	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
een kampvuur	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Beeld je eens in dat je het volgende geluid hoort:	0	1	2	3	4	5	6	7	8	9	10
de sirene van een ambulance	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
klappende handen die applaus geven	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
het miauwen van een kat	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
het geluid van een claxon	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
het geluid van spelende kinderen	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Beeld je eens de volgende geur in:	0	1	2	3	4	5	6	7	8	9	10
een muffe kamer	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
een roos	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
nieuwe verf	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
vers gemaaid gras	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
brandend hout	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Beeld je eens de volgende smaak in:	0	1	2	3	4	5	6	7	8	9	10
mosterd	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
tandpasta	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
citroen	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
zeewater	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
zwarte peper	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Beeld je eens in dat je het volgende aanraakt:	0	1	2	3	4	5	6	7	8	9	10
warm zand	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
een zachte handdoek	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
het puntje van een naald	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
ijswater	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
bont	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Beeld je eens in welk lichamenlijk gevoel je ervaart bij het volgende:	0	1	2	3	4	5	6	7	8	9	10
ontspannen in een warm bad	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
een pijnlijke keel	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
het rijgen van draad door een naald	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
het springen in een zwembad	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Een flinke wandeling door de kou	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Beeld je eens in dat je het volgende voelt:	0	1	2	3	4	5	6	7	8	9	10
opwinding	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
opluchting	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
woede	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
verliefdheid	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
angst	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Om de score te bepalen neem je de gemiddelde reactie voor elke subschaal of de algemene reactie.

Vermeld bij elk gebruik van deze vragenlijst de volgende gegevens: (Andrade et al., 2014; as well as this article)