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To cite this article: Guillaume Gronier & Alexandre Baudet (2021) Psychometric Evaluation of the F-SUS: Creation and Validation of the French Version of the System Usability Scale, International Journal of Human-Computer Interaction, 37:16, 1571-1582, DOI: [10.1080/10447318.2021.1898828](https://doi.org/10.1080/10447318.2021.1898828)

To link to this article: <https://doi.org/10.1080/10447318.2021.1898828>



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Published online: 17 Mar 2021.



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# Psychometric Evaluation of the F-SUS: Creation and Validation of the French Version of the System Usability Scale

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## ABSTRACT

While the System Usability Scale (SUS) is probably one of the most widely used questionnaires to measure the perceived ease of use of interactive systems, there is currently no scientific valid translation in French. This article describes the translation and statistical validation of the French version of the SUS, called F-SUS. On the basis of two translations carried out by a committee of bilingual experts, the various psychometric analyses made it possible to select only one translation. Fidelity measurement, factor analysis and sensitivity measurement obtained results very close or similar to the original version of the SUS. Thus, the F-SUS can be used with confidence by French-speaking usability researchers and practitioners.

## 1. Introduction

Among the methods that allow the evaluation of the user experience (UX), “standardized” questionnaires are often used to capture the user’s satisfaction of a product (Maguire, 2001). The “standardized” character of these questionnaires sets them apart from “home-made” questionnaires (Hornbaek, 2006; Sauro & Lewis, 2012), due to the scientific validation that has been applied to them. This validation is mainly based on two psychometric measurements: validity and reliability (Drost, 2011; Nunnally, 1978a; Nunnally, 1978b; Peterson, 2013). Validity refers to the meaning of the research components (Drost, 2011). For example, when researchers measure behaviors, they focus on knowing if they are measuring what they intended to measure. Does an IQ test measure intelligence? Does such a usability measurement questionnaire allow the perceived ease of use of a product to be measured? These are validity questions. As for reliability, this validates the repeatability of the measurements taken with the help of a questionnaire. In this way, the questionnaire should allow us to obtain the same scores when different people take the measurements, on different occasions, in different conditions, with presumably alternative instruments that measure the same thing (Drost, 2011). In other words, reliability is the consistency with the measurements, or the stability of the measurements in different conditions in which we should essentially obtain the same results (Nunnally, 1978b).

Consequently, a standardized questionnaire is a questionnaire devised for repeated use, presenting satisfactory psychometric scores for validity and reliability, generally organized as a specific set of questions presented in a precise order according to a pre-defined format, with specific rules to

produce measurements based on the responses of the participants (Sauro & Lewis, 2012).

In the user experience (UX) domain, standardized questionnaires are part of a general framework of human-centered iterative design processes (ISO 9241-210:2010, 2010), which aim to improve the user experience of a product by making it correspond to the needs, expectations and specificities of the final target users. The ISO 13407 1999 norm (ISO 13407:1999, 1999) references questionnaires among the 12 most frequently used design methods. The norm defines them as indirect evaluation methods, which collect, by means of predefined questionnaires, the opinions of users on the interface. Hornbaek (2006) also drew up a list of questionnaires to record user satisfaction and measure the perceived usability of a system. Maguire (2001) adds that satisfaction questionnaires capture the subjective impressions of users regarding their experience with a product.

Today, we are faced with numerous standardized questionnaires measuring the UX. Most of them have been subject to a scientific validation which has been published. One of the most popular standardized questionnaires measuring perceived usability is probably the System Usability Scale (SUS), created originally as a “quick and dirty” scale (Brooke, 1996). It is this questionnaire that we have chosen to translate into French and we will come back to its history and presentation in more detail in the following section of this article.

The SUS has been the inspiration for several other questionnaires measuring the UX. We can cite the Usability Metric for User Experience (UMUX) (Finstad, 2010), which was

designed to be a more concise version of the SUS, using 4 items from it that were reformulated and for which the response methods were slightly changed. In this way, the UMUX uses every other inverted item, but modifies the forms of response to go from a 5-point Likert scale to a 7-point scale. Finstad (2010) finds a correlation between the SUS and the UMUX of above 0.80, while in a confirmatory study, Berkman and Karahoca (2016) measure a correlation of 0.74. These two values remain very high and indicate that the psychometric properties of the UMUX are very close to those of the SUS. In a similar approach, other authors have created the UMUX-LITE questionnaire (Lewis et al., 2013), which is also based on the SUS but which seeks to reduce the number of items even more than the UMUX. Thus, the UMUX-LITE uses the two odd UMUX items, that is, the non-inverted items. Its correlation with the SUS, calculated by the authors, is 0.81.

As with the SUS, other UX questionnaires were created during the 1990s to measure the instrumental quality of a system. We propose a brief overview of them in order to position the SUS against other questionnaires measuring user experience. This is particularly the case with the Computer System Usability Questionnaire (CSUQ) (Lewis, 1995), a questionnaire containing 19 items to measure the usefulness of a system, the quality of its information and the quality of its interface. The CSUQ is based on the Post-Study System Usability Questionnaire (PSSUQ) (Lewis, 1995), from which it takes the items but formulates them differently: the PSSUQ was designed to be used after a user test in order to measure user satisfaction with the system he/she was confronted with, while the CSUQ wants to appear more generic and adapted to less controlled situations. Thus, for example, the PSSUQ uses the formulation "this system was easy to use" while the CSUQ uses "this system is easy to use". These two questionnaires complement the After-Scenario Questionnaire (ASQ) (Lewis, 1995), which applies after the user has carried out a predefined task with one system as part of the user tests.

During roughly the same period, the Questionnaire for User Satisfaction (QUIS) (Chin et al., 1988) was designed to find out the satisfaction of users concerning several aspects that make up the man-machine interface. Five main dimensions were selected by the authors: the general consensus of users, screen quality, terminology and information system, how easy it is to learn and system performance. On a structure that is similar on several dimensions, the Software Usability Measurement Inventory (SUMI) (Kirakowski & Corbett, 1993; Van Veenendaal, 1998) is built around five subscales: the perceived efficiency of the system, measured impact, perceived usefulness, the feeling of controlling the system and how easy it is to learn. More recently, the Design-Oriented Evaluation of Perceived Usability (DEEP) (Yang et al., 2012) was developed, combining certain items from the following questionnaires: Purdue Usability Testing Questionnaire (PUTQ) (Lin et al., 1997), Web Analysis and Measurement Inventory (WAMMI) (Kirakowski & Cierlik, 1998) and Usefulness, Satisfaction, and Ease of use (USE) (Lund, 2001). Other items are inspired by the heuristic methods put forward by Perlman (1997) (Practical Heuristics for Usability Evaluation - PHUE) and those of Bolchini and Garzotto (2008) (MiLE+). Specifically dedicated to website

assessment, DEEP consists of 19 items spread out over the following dimensions: perceived content, perceived structure and information architecture, perceived navigation, perceived cognitive effort, coherence between the perceived layout and perceived visual guidance.

Certain questionnaires differentiate themselves from those mentioned above by the fact that certain items are oriented toward collecting users' emotions, something which constitutes an important component of the UX. The modular evaluation of key Components of User Experience (meCUE) (Minge et al., 2016) relies directly on the CUE (Components of User Experience) model and is based on four main dimensions, designated modules by the authors. These dimensions encompass the perception of the product by its instrumental qualities (usefulness and usability) and non-instrumental qualities (visual esthetics, status and commitment), positive and negative emotions experienced by the user, the consequences of the interaction with the product in terms of loyalty and intention of use and the global assessment of the product. The User Experience Questionnaire (UEQ) (Laugwitz et al., 2008; Schrepp et al., 2014) is also based on the differentiation of the pragmatic and hedonic qualities of a product. In this way, in this questionnaire, the attractiveness of a product is based on measuring the insight, efficiency and loyalty on the pragmatic side and on measuring the stimulation and novelty on the hedonic side.

In conclusion, the AttrakDiff questionnaire (Hassenzahl et al., 2003), presented in the form of semantic differentiators, also distinguishes the perceived pragmatic qualities of a product, which represents a full dimension, the hedonic-stimulation qualities and the hedonic-identity qualities, two other dimensions centered on the user emotions. A fourth dimension, measuring the global attractiveness of the product, is based on the perception of the pragmatic and hedonic qualities of the product.

Today, very few questionnaires have been the subject of a scientifically validated French translation. We can cite for example, the AttrakDiff translated by Lallement et al. (2015). However, the scientific community and UX professionals often use questionnaires to measure the perceived quality of a product (Hornbaek, 2006). It therefore seemed necessary for us to continue working on a translation of questionnaires measuring UX in order to focus on one of the very first questionnaires that is still very often used today: the System Usability Scale (SUS).

## 2. The System Usability Scale (SUS)

### 2.1. Presentation of the SUS

Created in 1986 by Brooke as part of an engineering programme on the usability of the systems, the SUS questionnaire was distributed quickly to assess the usability of the interactive systems (Brooke, 1996, 2013). The SUS was first designed as a "quick and dirty" questionnaire, in order to transfer user tests to the laboratory via a subjective perceived usability measurement, while guaranteeing a fast and non-binding handover for the users questioned.



The SUS comprises ten items, formulated as affirmative statements, for each of which the user states his/her position, by expressing his/her agreement or disagreement on a 5-point Likert scale (1 = do not agree at all; 5 = completely agree). If the user does not know what to answer for an item, he/she is requested to answer nevertheless by ticking the middle of the scale (score 3).

The 10 items of the definitive version of the SUS were selected from a preliminary list of 50 items, designed to cover the three main usability concepts according to the ISO norm 9241-11: effectiveness, efficiency and satisfaction (ISO 9241-11:2018, 2018). The 50 items were first submitted to a panel of 20 users to evaluate two interactive systems, one considered to be really easy to use (a linguistic tool), the other almost impossible to use, even for highly technically skilled users (a tool for system programmers). Then, only the ten items with the most extreme answers were retained, i.e. the items that best discriminate between the two systems. (Brooke, 1996).

## 2.2. SUS score calculating method

The global SUS score is calculated to take into account inverted items (even pairs) and to obtain a total score of between 1 and 100. For this, it is calculated in three steps:

- (1) First of all, one point is subtracted from the score ticked by the user for items 1, 3, 5, 7 and 9 (odd numbers, not inverted).
- (2) Then, for items 2, 4, 6, 8 and 10 (even numbers, inverted), the calculation is 5 minus the score ticked by the user.
- (3) The 10 new scores recalculated in this way are added together and multiplied by 2.5.

Brooke (2013) explains that this calculation method was defined in order to respond more to marketing requirements than scientific requirements. When the SUS was created, Brooke and his team considered that the project managers, product managers and engineers were more likely to understand a scale that went from 0 to 100 than a scale from 10 to 50 (with 50 being the maximum mark that could have been obtained using the usual calculation method for scales with inverted items). Brooke also indicated that obtaining a mark out of 100 makes it easier to understand the score and the comparison between different systems, since the differences between several scores are perceived as bigger than if the marks were out of 50.

Bangor et al. (2008) sought to give meaning to the SUS scores calculated out of 100. The authors relate that the meaning of the score was always a problem when they had to report the result of a study to a project manager or design team. Therefore, a pilot programme was launched to determine whether adjectives could be linked to SUS scores in order to come up with a more absolute mark. An evaluation scale with 7 adjectives was then used to complement the SUS. 212 participants were invited to complete the SUS, then to answer the question: "Overall, I would rate the user-friendliness of this product as".

The participants had to choose one of the following 7 adjectives: Worst imaginable, Horrible, Poor, OK, Good, Excellent, Best imaginable. A little later, the authors replicated the same study with a larger sample of participants (959 usable results) (Bangor et al. 2009). All adjectives obtained significantly different scores, except "Worst imaginable" and "Horrible". As a result, Bangor et al. (2009) selected 6 adjectives: Worst imaginable, Horrible, OK, Good, Excellent, Best imaginable.

## 2.3. The SUS, a unidimensional scale?

Some authors have been interested in the statistical validity of the SUS, and in particular in its factor structure. In a first large-scale study on the statistical properties of SUS, including 2324 surveys, Bangor et al. (2008) confirmed the unidimensional nature of SUS, i.e. that the ten items converge toward a single overall score, in line with the way SUS was designed by Brooke (1996). In 2009, Lewis and Sauro challenged the analyses of Bangor et al. (2008) and identified two factors, one comprising eight items relating to usability and the other comprising two items relating to learning. The authors then invited practitioners to use these two dimensions of SUS (usability and learnability) to refine their results, in addition to the overall score.

Borsci et al. (2009) sought to clarify these two divergent results by testing 3 alternative models of SUS: a one-factor model according to the results of Bangor et al. (2008), a two uncorrelated factors model according to the results of Lewis and Sauro (2009), and a two correlated factors including usability and learnability with the same items (1, 2, 3, 5, 6, 7, 8, 9 for the usability; 4 and 10 for the learnability). Statistical analyses revealed that the third model, with the two correlated factors, was the most satisfactory. The authors therefore recommended that the Lewis and Sauro (2009) guidelines of differentiating between usability (factor 1) and learning (factor 2) scores be followed, while indicating that certain conditions (such as the population studied, or the system being assessed) could lead to a high correlation between the two factors.

Later, Lewis and Sauro (2017) revisited the factor structure of SUS by compiling a database of 9156 completed questionnaires. A confirmatory factor analysis (CFA) approach was applied to 3 new models, the first testing the unidimensional SUS, the second testing the bidimensional SUS including usability and learnability factors, the third testing the bidimensional SUS including the positive-tone (odd-numbered) and negative-tone (even-numbered). The new analyses by Lewis and Sauro showed that the two-factor factor structure based on positive and negative tones was the most satisfactory, even though it was not interesting for use by usability practitioners as it did not allow the distinction of particular dimensions in relation to the system being evaluated.

Thus, to this day and until further contradictory research on the factor structure of SUS, SUS should be considered and analyzed as a unidimensional scale.

## 2.4. Scope of use

Designed to be applied to all types of system as for example, websites (Hussain et al., 2015), mobile applications (Adinda & Suzianti, 2018; Beul-Leusmann et al., 2014), expert systems (South et al., 2017; Yang et al., 2015), serious games (Tolentino et al., 2011) or e-learning systems (Peruri et al., 2017), the SUS has been used to assess a large number of systems, from the creation of the questionnaire up to today. Without being able to be exhaustive, we propose in Appendix A an inventory of SUS uses, only considering studies published after 2010. This classification allows us one hand to take into account a very large scope of application for SUS, and on the other to highlight the capability of SUS to be adapted to modern technologies despite the criticisms that Brooks may have received (Brooke, 2013).

The SUS also acts as a benchmark against which to validate the reliability of new questionnaires measuring usability. For example, Santos et al. (2015) compared the results obtained with the SUS and the HARUS (Handheld Augmented Reality Usability Scale) questionnaire, a scale for measuring the usability of portable augmented reality systems. Karlin and Ford (2013), for their part, created a perceived usability measurement scale dedicated to an ecological feedback scale, the UPscale, inspired in particular by the SUS items.

## 2.5. SUS translations

Following numerous assessments that the SUS was used for, several translations were done. Thus, in a scientific approach, the SUS has been translated into Indonesian (Sharfina & Santoso, 2016), Portuguese (Martins et al., 2015), Polish (Borkowska & Jach, 2017), Arabic (AlGhannam et al., 2018), Slovenian (Blažica & Lewis, 2015), Greek (Katsanos et al., 2012) and Persian (Dianat et al., 2014). There is also a German version (Rummel, 2015), although this has not been published. While the SUS is used to assess systems in France (see, for example, Larue, 2009), there has never been an official translation and scientific validation.

Finally, we note that the SUS has been transcribed into American Sign Language (Berke et al., 2017), as well as pictorial language (Baumgartner et al., 2019).

**Table 1.** The two translations of the SUS, word-for-word and literary. Items 9 and 10 were translated in the same way. N.B. The literary translation will be the official version used for the F-SUS.

Original items	Word-for-word French translation	Literary French translation
1. I think that I would like to use this system frequently.	Je pense que je voudrais utiliser ce système fréquemment.	Je voudrais utiliser ce système fréquemment.
2. I found this system unnecessarily complex.	Je trouve que ce système est inutilement complexe.	Ce système est inutilement complexe.
3. I thought the system was easy to use.	J'ai trouvé que ce système est facile à utiliser.	Ce système est facile à utiliser.
4. I think that I would need the support of a technical person to be able to use this system.	Je pense que j'aurais besoin du soutien d'un technicien pour être capable d'utiliser ce système.	J'aurais besoin du soutien d'un technicien pour être capable d'utiliser ce système.
5. I found the various functions in this system were well integrated.	J'ai trouvé que les différentes fonctionnalités de ce système sont bien intégrées.	Les différentes fonctionnalités de ce système sont bien intégrées.
6. I thought there was too much inconsistency in this system.	J'ai pensé qu'il y a trop d'incohérences dans ce système.	Il y a trop d'incohérences dans ce système.
7. I would imagine that most people would learn to use this system very quickly.	J'imagine que la plupart des gens apprendront à utiliser ce système très rapidement.	La plupart des gens apprendront à utiliser ce système très rapidement.
8. I found this system very cumbersome to use.	J'ai trouvé ce système très lourd à utiliser.	Ce système est très lourd à utiliser.
9. I felt very confident using the system.	Je me suis senti-e très en confiance en utilisant ce système.	Je me suis senti-e très en confiance en utilisant ce système.
10. I needed to learn a lot of things before I could get going with this system.	J'ai eu besoin d'apprendre beaucoup de choses avant de pouvoir utiliser ce système.	J'ai eu besoin d'apprendre beaucoup de choses avant de pouvoir utiliser ce système.

## 3. Methodology for the French translation of the SUS

### 3.1. Translation of the SUS

To undertake the translation of the French-System Usability Scale (F-SUS), we drew on the method proposed by Vallerand (1989). This author proposes a transcultural validation methodology for psychological questionnaires. This methodology is made up of seven steps, enabling the translation and validation of English-language questionnaires into French. For our translation needs, we selected three distinct steps, described below.

#### 3.1.1. Step 1: preparation of an experimental version

The first step consisted of preparing an experimental version of the original questionnaire in the target language (in this case, French). Several methods are possible, including traditional translation where the researcher does the translation on his/her own, the committee method and the back translation method. For our study, and in order to minimize the bias of traditional translation as cited in Vallerand (1989), we have opted for a committee translation. In this context, three bilingual researchers, all French citizens, were requested to propose a translation of the 10 items from the SUS. First, each translator did his/her own individual translation. Secondly, the researchers presented their translations and had a group discussion on the content of the translations.

At the end of the committee session, two versions of the SUS were selected: a first “word-for-word” translation that kept the original formulations from the beginning of the sentences in the SUS (“I think that”, “I found that …”, “I thought that …”) and a second, more literary version, which is closer to a natural formulation in French. Nevertheless, the two versions agree on the sense of the translations; the translators’ discussions focused on the wording of the sentences. The two versions are presented in Table 1. Note that items 9 and 10 have the same translation for both the word-for-word and literary version.

Following the committee translation, a back translation was done on the two translations by five other French-English bilingual researchers who were French native speakers. The back translation consists of doing a “blind” translation (that is,

without seeing the original version), from the target language translation back to the source language. For our study, the aim was to verify that the translations into French allowed us to rediscover the sense of the original items in English. All the back translations allowed us to validate the committee translations, in particular, for the word-for-word translation. For the literary translation, the back translation allowed us to check that the sense of the items was kept, but the formulations “I think that”, “I find that” were obviously not found.

### 3.1.2. Step 2: pretest of the experimental versions

The second step consisted of pretesting the two experimental versions of the F-SUS (word-for-word and literary), in order to determine whether the items that made up these two versions were clear, written without ambiguity and in language that is relatable to the target population (Vallerand, 1989). To do this, we submitted each of the experimental versions to a different panel of UX practitioners. We asked them to indicate the level of understanding of each of the items on a scale of 1 (not at all understandable) to 5 (completely understandable). 15 practitioners contributed to the assessment of the word-for-word version and 17 practitioners to the literary version. The means and standard deviation for each item of the SUS are presented in [Table 2](#).

The results of the pretest show that, overall, neither of the two translations stood out as being different to the other. Furthermore, no item seems to pose any comprehension problems, with the least well-rated item having a score of 3.24 (item 5 for the literary translation), which we considered acceptable since this score is above 3 on a scale of 5.

In agreement with these results, we chose to preserve both versions for the statistical evaluations and to keep the translations as they were written during the experimental version phase.

### 3.2. Step 3: psychometric evaluation of the F-SUS

Even with a meticulous translation of the items, it cannot be guaranteed that the F-SUS has the same psychometric characteristics as the original English version (Van De Vijver & Leung, 2001). The following step consists therefore of carrying out a psychometric assessment of the F-SUS. Several statistical analyses were undertaken in order to measure the accuracy, factor structure, sensitivity and validity of the content.

**Table 2.** Scores on the level of understanding of the SUS items for the word-for-word and literary translations on a scale of 1 (not at all understandable) to 5 (completely understandable).

SUS item	Word-for-word translation (n = 15)		Literary translation (n = 17)	
	Mean	Standard deviation	Mean	Standard deviation
1	4.40	0.88	4.29	0.96
2	4.53	0.62	4.12	1.13
3	4.60	0.71	4.94	0.24
4	4.27	1.00	4.82	0.51
5	3.93	0.93	3.24	1.39
6	3.93	0.93	4.35	0.76
7	4.60	0.61	4.71	0.75
8	3.80	0.91	4.00	1.14
9	4.40	0.80	4.35	0.76
10	4.53	0.88	4.76	0.42

The minimum recommended sample size for psychometric tests, and more specifically for factor analysis, is to have at least five participants per item, which for the SUS with 10 items, corresponds to a minimum of 50 participants (Nunnally, 1978b).

For the psychometric assessment, we gave the F-SUS to 215 users. Either the word-for-word or the literary translations were distributed randomly. The volunteer users were students in human and social sciences, who were asked to think of a system that they knew well or to display a system to assess on a screen, for example, on their computer or smartphone. We deliberately did not take an interest in the system assessed. Indeed, we considered that the system was of little importance, but it was essential that it was always the same system that was assessed for all the SUS items. The users were made aware of this particular point.

In the end, after having selected the questionnaires that were fully and correctly completed, we retained 79 users for the word-for-word translations (22 women, 57 men; average age = 21.59 years old, standard deviation = 2.79; minimum age = 18; maximum age = 40) and 88 users for the literary translation (78 women, 10 men, average age = 19.66 years old, standard deviation = 3.85; minimum age = 17; maximum age = 42).

## 4. Results

### 4.1. Measure of reliability

The Cronbach alpha coefficients of our two translations are positive and confirm sufficient reliability, with a threshold above .70, as recommended by Landauer (1997) or Kline (2005). Therefore, for the word-for-word translation of the SUS, we obtain an alpha of .904; and an alpha of .899 for the literary translation. These two reliability scores are among the highest measured during the different translations of the SUS (Lewis, 2018). They are close to those observed for example, by Lewis and Sauro (2009) (alpha of .91) or Bangor et al. (2008) (alpha of .911).

No item deletion, in either version, brings any significant advantage.

### 4.2. Factor analyses

A principal component factor analysis (PCA) was carried out to test the construct validity of the two translations of the SUS. The interest of a PCA is to check whether the factor structure of our translations is similar to the structure of the original questionnaire (Brooke, 1996).

Cattell's scree plot (Cattell, 1966) (Eigenvalues) suggests a 2-factor structure for the two translations ([Figure 1](#)). If this result does not converge toward a structure with a single factor, as in the SUS designed by Brooke (1996) and confirmed by Bangor et al. (2008), it joins that obtained by Lewis and Sauro (2009), then verified by Borsci et al. (2009).

[Table 3](#) presents the 2-factor Varimax rotation for the 10 SUS items and for each of the translations.

The 2-factor PCA shows that for the two translations, items 1, 2, 3, 5, 6, 7, 8 and 9 are aligned with the first factor and items 4 and 10 are aligned with the second factor. These

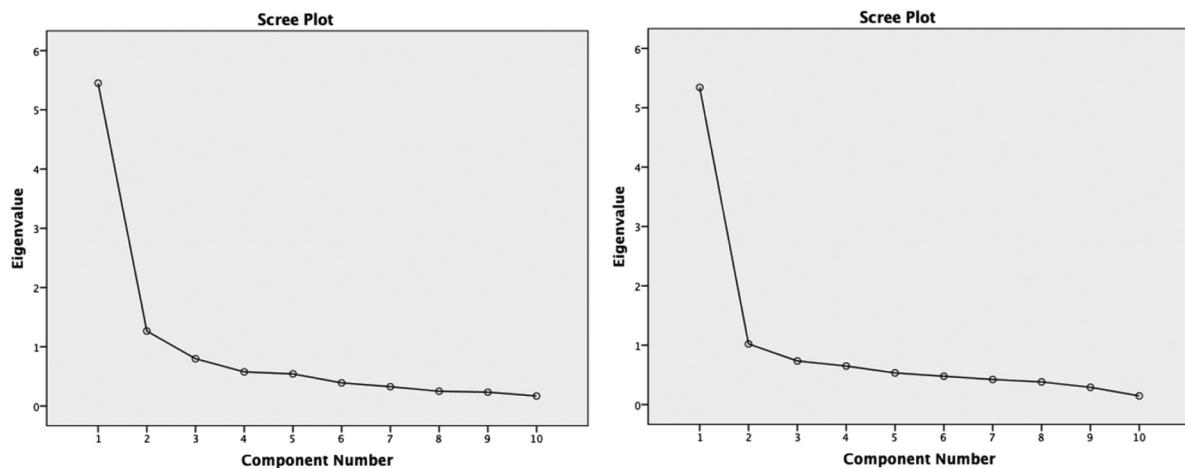


Figure 1. Scree plot for word-for-word translation (left) and literary translation (right).

Table 3. 2-Factor Varimax rotation for the 10 SUS items for word-for-word translation and literary translation.

Item	Word-for-word translation		Literary translation	
	Factor 1	Factor 2	Factor 1	Factor 2
1	.849	.096	.728	.098
2	.720	.114	.757	.280
3	.851	.261	.675	.275
4	.208	.812	.344	.682
5	.809	.199	.678	.400
6	.780	.188	.852	.143
7	.602	.538	.710	.303
8	.855	.210	.847	.250
9	.569	.247	.735	.049
10	.112	.893	.054	.878

results are in accordance with the factor analyses led by Lewis and Sauro (2009). The authors entitled the scale identified by the first factor "Usability" and the second scale identified by the second factor (with items 4 and 10) "Learning". Nevertheless, it should be remembered that the authors later went back on these conclusions, and showed that the SUS has a two factors structure, but this structure was not really interesting to take into account because it was in fact based on the SUS's positive-tone (odd-numbered) and negative-tone (even-numbered).

We also note that the factor structure of the literary translation seems to be the most coherent with regard to its better distinction in terms of saturation between the two factors on all items, and particularly for items 7 and 9 where the saturation difference is well over +0.3.

### 4.3. Sensitivity measurement

#### 4.3.1. Gender effect

In order to check whether the translations are gender-sensitive, we undertook T-tests for independent samples. Whether for the word-for-word translation or for the literary translation, we observed that the variances were not significantly different for all items. We can therefore conclude that no gender difference or effect is observed for both translations.

These results are consistent with most of the results obtained in the studies that investigated the gender question on SUS ratings. In a general overview of the SUS, Lewis (2018) identified six studies that have focused on the influence of gender. Of these, 5 found no significant effect (Bangor et al., 2008; Berkman & Karahoca, 2016; Kortum & Sorber, 2015; Kortum & Bangor, 2013; Tossell et al., 2012). Only Kortum and Oswald (2018) study found a significant gender-related difference in responses to SUS, but this difference is rather due to a personality difference between the participants.

#### 4.3.2. Trends toward extreme answers

In order to check possible trends toward extreme answers related to our translations or to possible cultural variables, the 5% trimmed means were investigated: no significant difference was observed.

Shown graphically, the different scatter plots related to the items do not imply any trends toward extreme answers.

## 5. Discussion

### 5.1. Choice of translation of the SUS

Consequently, it was a question of choosing between the two translations that we produced, word-for-word or literary, to select only one. In view of the statistical results, the literary version seems to us to obtain the best results, in particular, concerning factor analyses. Indeed, the Varimax rotation obtains more contrasted values between the two factors than for the word-for-word version, in particular, for item 7 ("J'imagine que la plupart des gens apprendront à utiliser ce système très rapidement"). This item seems to cause comprehension problems for the word-for-word version, which uses the beginning of the sentence of the original version of the SUS: "I would imagine that". We therefore think that the formulation "j'imagine que" introduces ambiguity in the understanding of the item. Indeed, contrary to the other items of the SUS that encourage the user to express a personal opinion by means of introductory formulations like "je pense que" ("I think that") or "je

trouve que" ("I find that"), the formulation "j'imagine que" requires the user to guess something, to make an assumption without being able to check it. For the user therefore, it is a question of giving a speculative opinion, which can generate SUS answers with little contrast.

We also observe that the translation committee did not select the conditional form of the formulation "j'imaginerais" ("I would imagine"), (the committee translated "j'imagine que la plupart des gens apprendront à utiliser ce système très rapidement"), which would usually apply with the auxiliary verb "would", i.e. "I would imagine that most people would learn to use this system very quickly". The translation committee justified this by the rare and redundant use of the conditional, in French, with verbs such as "imaginer" (to imagine), which already expresses a possibility, hypothesis or projection in the future.

Furthermore, item understanding scores (Table 2) very slightly favor the literary version ( $M = .299$  for the word-for-word version,  $M = .358$  for the literary version), even if the difference could be considered insignificant. The standard deviation is also weaker for the literary version ( $ES = .827$  for the word-for-word version;  $ES = .806$  for the literary version).

Lastly, and less statistically, the French language generally favors direct turns of phrase, with the least possible ambiguity, for formulating questionnaire items. Therefore, the literary version displays an editorial structure better adapted to francophone culture. The complete version of the F-SUS selected by our study is presented in Annex A.

## 5.2. A two-factor scale?

The question of the single factor of the SUS has already been the subject of several research studies (Borsci et al., 2009; Lewis & Sauro, 2009). Our factor analyses revealed a two-factor scale for the SUS, regardless of whether the translation is literary or word-for-word. This is for items 4 (J'aurais besoin du soutien d'un technicien pour être capable d'utiliser ce système) and 10 ("J'ai eu besoin d'apprendre beaucoup de choses avant de pouvoir utiliser ce système", which differ from the other items. As we have highlighted, these results correspond to those found by Lewis and Sauro (2009), which named "Learning" as the dimension formed by items 4 and 10 and "Usability" as the second dimension. In 2009, Lewis and Sauro were surprised that the "Learning" dimension did not include item 7 ("La plupart des gens apprendront à utiliser ce système très rapidement"), which also clearly addresses the concept of learning in its formulation. They justified the exclusion of item 7 by the fact that this item highlights the awareness of others rather than the skills of the user him/herself.

Later, Lewis and Sauro (2017) carried out new factor analyses and called into question the two-dimension structure (Usability - Learning) of the SUS. According to the authors, their new results suggest (but do not prove) that there could be certain research contexts in which items 4 and 10 appear as an independent factor. Thus, still according to Lewis and Sauro (2017), the SUS is above all unidimensional, as other authors have verified (Bangor et al., 2008; Borsci et al., 2009),

and its two-dimensional structure is only validated for its mixed tonality structure, that is, for its alternance between positive and negative items (remember that one in two items is inverted).

Our research may thus rekindles the debate concerning a two-dimensional scale, since our results are in the line with those of Lewis and Sauro in 2009. We find interesting to note that we see the same factor analyses for both translations that we produced (word-for-word and literary), something that cannot be a coincidence. Remember that each of these translations was submitted to an independent group of users, that is, it was not the same users that completed the word-for-word translation and the literary translation. Therefore, there cannot be a "subject" effect. On the other hand, since the users had the same instructions, there may be a "context" effect, as indicated by Lewis and Sauro (2017).

Nevertheless, we should point out that these results were obtained from a small sample size ( $N = 167$ ). However, when the samples are large, the two-factor structure of the SUS tends to disappear. This is what happened with the Lewis and Sauro (2017) and Bangor et al. (2008) complementary studies. Therefore, we are considering a complementary study on a larger sample, before making a more categorical statement on the factor structure of the French SUS.

## 6. Conclusion and research perspectives

This research aims to propose a French translation for the System Usability Scale, one of the questionnaires measuring usability of the most popular systems in the area of user experience. By relying on Vallerand's transcultural validation methodology (Vallerand, 1989), we first selected two French translations of the SUS, one that resumed all the items word-for-word and another that came closer to the customary linguistic formulations in French with a more literary translation. The psychometric assessments for each of these two scales, and in particular the factor analyses, encouraged us to select the literary version of the F-SUS.

Complementary studies, some of which are already underway, could be carried out in order to continue the French-language distribution of the SUS.

### 6.1. Studies on other systems and other populations

Our statistical analyses were based on the questionnaires completed by students in human and social sciences, by asking them to think of a system that they knew well or to display it on a screen. By doing this, we were not affected by the characteristics of the system to be assessed. We considered that the coherence of the individual answers prevailed over the coherence of the collective answers. This methodological approach has proven to be valid since we noticed a very strong internal consistency for each of the translations.

To go further, we currently envisage questioning different populations (students, active persons and UX professionals) in order to assess predefined systems. To date, we have gathered numerous assessments from a university digital workspace by students, from the website of a large European bank by the workforce, and from a bibliographic

document management system by UX professionals. We have chosen these different systems so that the users find out about them, and are then able to give their opinion by using the F-SUS. We think that these complementary studies will enable us to continue with the validation of the literary version of the F-SUS, and we hope to validate our first factor analyses, especially concerning the two-dimensionality of the SUS.

## 6.2. Comparison with other scales

We also consider it important to compare the results of the F-SUS with other francophone UX or usability measurement scales. Unfortunately, to date there are few translated scales that have been scientifically validated. We can mention the AttrakDiff scale (Hassenzahl et al., 2003), which was translated in 2015 by Lallement et al. With AttrakDiff presenting four distinct dimensions relating to the user experience (hedonic quality identity, hedonic quality stimulation, pragmatic quality and global attractiveness), of which only one can be clearly related to the usability measurement (pragmatic quality), we are considering comparing the results of the F-SUS with those obtained by the pragmatic dimension of AttrakDiff.

Sauro (2014) also proposes a translation of the SUPR-Q (Sauro, 2015) that could be exploited.

## 6.3. Validation of the French version of the SUS in a "positive" version

The research of Lewis and Sauro (Sauro & Lewis, 2011; Lewis & Sauro, 2017) showed that a positive version of the SUS, that is, not including inverted items, could avoid careless mistakes and misunderstandings among users. Furthermore, a positive version could stop researchers making coding mistakes. In addition, Kortum et al. (2020) demonstrated that the positive version of SUS had the same statistical properties as the standard SUS. These two versions could therefore be used interchangeably, although it was always preferable to compare scores obtained using the same version of SUS.

It therefore appears interesting to continue these studies by focusing on validating a positive version of the F-SUS and comparing the results we obtain with those of Lewis and Sauro.

## 6.4. Validation of the French version of the UMUX and UMUX-LITE

Finally, as a streamlined version of the SUS, the UMUX (Finstad, 2010) and UMUX-LITE scales (Lewis et al., 2013) will also be able to be translated and validated in a French version. These two questionnaires appear interesting to us since they allow us to keep a global score out of 100, just like the SUS, from a reduced number of items (4 for the UMUX, 2 for the UMUX-LITE) and without any inverted items for the UMUX-LITE. These questionnaires thus correspond to the new forms of remote handovers, which require streamlined protocols with the fewest possible sources of completion errors for users.

## Acknowledgments

The authors would like to thank Laurence Johannsen, Pierre-Jean Barlatier and Anne-Laure Mention who were involved in the translation process of the F-SUS.

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## Appendix A: Referencing of different SUS applications.

Category	Application	Reference
Mobile application	Government Information Application Application for public transport Mood assessment application Smartphone screen sizes on perceived usability Mobile recommendation system based on context and personality Logbook dedicated to physical exercise Online health record on mobile phones Mobile health system for diabetes	(Adinda & Suzianti, 2018) (Beul-Leusmann et al., 2014) (Hafiz et al., 2018) (Raptis et al., 2013) (Braunhofer et al., 2014) (Heinonen et al., 2012) (Fritz et al., 2012) (Georgsson & Staggers, 2016) (Meldrum et al., 2012)
Application in the field of Health	Use of the Nintendo Wii Fit Plus® for the treatment of balance disorders in vestibular and neurological diseases Remote monitoring of the health of older people and people suffering from heart failure VibroTactile Feedback System for Stroke Survivors Health Awareness Web Portal Tool for Reducing Inappropriate Diagnosis (STRIP) Comparison of reporting in telemedicine Emergency services information system by nurses Customized sensor-based system for pervasive healthcare Online telehealth system Electronic Diabetes Management System Gamified project management system, Core	(Evans et al., 2016) (Held et al., 2017) (Hussain et al., 2015) (Meulendijk et al., 2015) (Lacerda et al., 2014) (Kim et al., 2012) (Triantafyllidis et al., 2014) (Dhillon et al., 2012) (Lutes et al., 2006) (Ašeriškis & Damaševičius, 2014) (Tolentino et al., 2011) (Nawaz et al., 2014)
Gamification and Serious Game	Serious Game for Health Balance exercises for seniors Comparison of the Shadow serious game system with a traditional SHADE system koALA Measuring acceptance of the eClass learning management system CIRCLE classification learning environment Augmented reality assisted solid geometry learning system eClass and Moodle learning management systems Affective tutoring system in remedial accounting education e-Learning environment based on a predefined task model describing low-level interactions Interactive learning system, based on augmented reality, for fish conservation Augmented reality system for teaching Euclidean vectors	(Hookham et al., 2016) (Blecken et al., 2010) (Revythi & Tselios, 2019) (Peruri et al., 2017) (Lin et al., 2015) (Orfanou et al., 2015) (Lin et al., 2014) (Harrati et al., 2016) (Lin et al., 2011) (Martin-Gonzalez et al., 2016)
Learning platform (e-learning)	Medical secretarial system Banking biometric system Software process modeling system Monitoring and visualization of collective behavior on a large scale (NationTelescope)	(South et al., 2017) (Tassabehji & Kamala, 2012) (Kerzazi & Lavallee, 2011) (Yang et al., 2015)
Expert systems	Online dialogue management system (AdChat) Platform for young people to explore their interests in the digital society (WYRED) Safety signs GPG client Interactive map design Voice-based user interfaces Portable fitness equipment Augmented reality for children in a confirmation task Comparison of user efficiency for tablet and smartphone users Measuring the impact of smartphone screen size on perceived usability	(Aguilar-Reyes et al., 2015) (García-Peñalvo et al., 2018) (Ng et al., 2011) (Ruoti et al., 2015) (Çöltekin et al., 2009) (Ghosh et al., 2018) (Liang et al., 2018) (Munsinger & Quarles, 2019) (Botella et al., 2014) (Raptis et al., 2013)
Other		