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Article abstract

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Keywords: tolerance of ambiguity, uncertainty, TAMSAD rating scale, medical pedagogy, epistemology

Preparing students to deal with and tolerate uncertainty or ambiguity is a major issue in medical education. There are many English-language scales to assess tolerance of uncertainty and ambiguity but no French-language scale has ever demonstrated validity evidence for its scores. We selected the Tolerance of Ambiguity in Medical Students And Doctors *(*TAMSAD*) scale. Through a structured process, the original questionnaire was translated, culturally adapted, and assessed after being administered to a sampling of medical students. Test-retest reliability was verified by presenting the questionnaire to the students again after two months. The assessment of internal consistency revealed satisfactory value. Test-retest reliability is assessed by intraclass correlation that presents good reproducibility of scores obtained by students in first completion and second completion. These results indicate that the French version of the* TAMSAD *scale can be used to assess French medical students' tolerance to ambiguity.*

Mots clés : tolérance à l'ambiguïté, incertitude, échelle d'évaluation TAMSAD, pédagogie médicale, épistémologie

La formation à la gestion et à la tolérance à l'incertitude ou à l'ambiguïté dans le soin est un enjeu pédagogique majeur des études médicales. S'il existe de nombreux outils en anglais permettant l'évaluation de cette dimension, aucun questionnaire en français n'a jusqu'à présent fait l'objet d'une évaluation de ses preuves de validité. L'objectif de ce travail est de produire une version en français de l'échelle Tolerance of Ambiguity in Medical Students And Doctors *(*TAMSAD*) et de présenter les preuves de validité sur les scores obtenus avec cette échelle. Le questionnaire original a d'abord été traduit, puis adapté culturellement. Cette version en français a été soumise à un échantillon d'étudiants en médecine afin de réaliser une analyse psychométrique reposant sur l'évaluation de la consistance interne. Le questionnaire a été passé à deux reprises par les mêmes étudiants afin de tester la stabilité test-retest. Les alphas de Cronbach, mesurés au test et au retest, reflètent une bonne consistance interne. La stabilité test-retest est vérifiée par des corrélations intraclasses dont les résultats sont en faveur d'une bonne reproductibilité des résultats à la première et à la seconde passations. Nos résultats indiquent que notre version en français de la* TAMSAD *peut être utilisée pour évaluer la tolérance à l'ambiguïté des étudiants en médecine.*

Palavras chave: tolerância à ambiguidade, incerteza, escala de classificação TAMSAD, pedagogia médica, epistemologia

A formação na gestão e na tolerância da incerteza ou ambiguidade no cuidado é um grande desafio pedagógico nos estudos médicos. Embora existam muitas ferramentas em inglês que permitem avaliar esta dimensão, nenhum questionário em francês foi até agora objeto de avaliação de sua validade. O objetivo deste trabalho é produzir uma versão francesa da escala Tolerance of Ambiguity in Medical Students And Doctors *(*TAMSAD*) e apresentar as evidências de validade dos resultados obtidos com esta escala. O questionário original foi primeiramente traduzido e depois adaptado culturalmente. Esta versão francesa foi submetida a uma amostra de estudantes de medicina para a realização de uma análise psicométrica baseada na avaliação da consistência interna. O questionário foi aplicado duas vezes pelos mesmos estudantes para testar a estabilidade teste-reteste. Os alfas de Cronbach, medidos no teste e reteste, refletem uma boa consistência interna. A estabilidade teste-reteste é verificada por correlações intraclasse, cujos resultados suportam boa reprodutibilidade dos resultados na primeira e segunda rondas. Os nossos resultados indicam que a nossa versão francesa do* TAMSAD *pode ser usada para avaliar a tolerância à ambiguidade de estudantes de medicina.*

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Introduction

Medical uncertainty

Uncertainty permeates the domain of care. For more than 50 years, the definitions proposed have become increasingly rich and complex, to the point of being sometimes too imprecise to be useful (Babrow et al., 1998; Beresford, 1991; Biehn, 1982; Fox, 1980). Han et al (2011) note that theoretical contributions are slow to lead to changes in practices, due to a wide disparity in the phenomena covered by the term *uncertainty* and the lack of a clear foundational taxonomy of this notion. They propose a definition at the most fundamental level of uncertainty that addresses all the phenomena linked to the term, namely "the subjective perception of ignorance" (Han et al., 2011). Based on a review of the medical literature, as well as of the literature in communication, engineering, and psychology, they present a framework of understanding that synthesizes the different theories and perspectives regarding the phenomenon of uncertainty. This integrative conceptual taxonomy (science of classification) includes three dimensions that characterize uncertainty in care according to a) its sources (probability, ambiguity, complexity); b) its issues (scientific, practical, personal); and c) its locus. Each of the uncertainty issues can be generated by one or more of the sources.

For example, a man considering a radical prostatectomy for a newly diagnosed cancer may experience uncertainty concerning a number of issues, including the risk of recurrence after surgery; the competence of his surgeon and of the hospital he chooses; his ability to handle potential side effects (e.g., erectile dysfunction or urinary incontinence); the impact of these potential side effects on his marital life; his view of well-being; and/or his sense of having achieved life goals. In theory, probabilities exist for each of these issues, although they are unknown to varying degrees, in turn amplified by varying degrees of complexity. The third dimension of this taxonomy, the locus, corresponds to where the uncertainty in question

is expressed. The locus conveys the fact that uncertainty is part of a care relationship since it can be present, to varying degrees, in the caregiver as well as in the cared-for person or in their entourage.

Tolerance of medical uncertainty

Tolerance of medical uncertainty and training in its management have been of increasing interest over the past 30 years (Cooke & Lemay, 2017; Han et al., 2019; Russel et al., 2021). The need to invest in these topics is currently reinforced by the public health crisis induced by the coronavirus pandemic and the multiple uncertainties it generates. However, this dimension of medical practice is currently seldom addressed in initial medical training, at least as an explicit object of teaching and learning.

A cross-sectional study of all general practice department chairs at allopathic medical universities in the United States was conducted with the goal of describing how uncertainty management is intentionally and systematically taught. The study found that the teaching objective of discussing uncertainty in diagnosis or case management with the patient had the fewest teaching hours devoted to it. In fact, 38% of general practice departments even report having no dedicated training for this objective (Ledford et al., 2015).

Training healthcare professionals in uncertainty management requires a step-by-step approach:

– Define the model of understanding of uncertainty on which the pedagogical approach would be based.
– Seek an assessment tool consistent with this model available to the French-speaking community so as to evaluate the training offered.

Literature review

A great many recent publications address the issue of uncertainty management training. The taxonomy of Han et al (2011) described at the beginning of this paper clarifies the diversity and complexity of situations of uncertainty encountered in medical practice. In 2017, a paper published in *Academic Medicine* noted the prevalence of uncertainty in medical practice and highlighted the need to integrate this dimension in clinical reasoning training (Cooke & Lemay, 2017). The same year, a literature review on epistemic cognition in medical education was published in the *International Journal of Medical Education*. In it, Eastwood et al (2017) proposed a pedagogical approach that positions practice as the

ideal locus to develop new knowledge and to learn to explore uncertainty by engaging various sources of knowledge, including tacit or experiential knowledge. Two years later, this observation of uncertainty inherent to medical practice was confirmed in a paper published in *Medical Teacher*, where the authors propose 12 tips for students and faculty to improve their training (Gheihman et al., 2019).

In 2020, in *Pédagogie Médicale*, a model for understanding uncertainty as a learning object was proposed (Motte et al., 2020). This is the model that we have selected. In fact, while remaining consistent with previous publications, the model allows us to consider a comprehensive pedagogical approach to uncertainty that goes beyond ad hoc advice or an approach focused on clinical reasoning. Three main dimensions are described in the model:

1. The diversity and complexity of the components of uncertainty, as well as its inherent character in medical practice, are related to the fact that medical practice is a caring practice, rather than an applied science. Uncertainty is engendered by the complex experience of medical action.
2. Tolerance of uncertainty and its management in medicine require a reflexive capacity both in the knowledge that is brought to bear and in its concrete application, as well as in rich personal epistemologies.
3. The enrichment of personal epistemologies can take place through experiential and reflexive pedagogy when the individual, concretely confronted with the limits of his or her beliefs in dealing with a given situation, engages in a process aimed at changing them.

Depending on the types of uncertainty encountered and the context in which they are experienced, the caregiver will call upon different epistemologies in a collective (including at least the physician and the patient) and reflexive process of transaction with his or her environment. Some authors explore the implications of the key concepts of their training model and propose a pragmatic anchoring (Noiriel, 1994; Schön, 2011) of the pedagogy of medical uncertainty that could be based on three major dimensions, namely experiential, reflexive, and collective. Such an approach represents a paradigm shift with numerous fields of application. An assessment of its implementation is therefore essential and necessitates the availability of tools that have undergone a validation process.

Currently available tools for assessing medical uncertainty

Numerous rating scales have been developed over the past 50 years, mainly to assess tolerance for *uncertainty* or *ambiguity* (terms sometimes used indiscriminately to refer to the same concept) in medicine (Furnham & Ribchester, 1995; Hillen et al., 2017). However, no French-language tool having undergone a validation process has been published. As such, the French-language medical community needs to invest in and assess uncertainty training as much as the rest of the world. From this necessity stems the imperative to identify an assessment tool consistent with the above-mentioned model that could be translated and tested so as to provide evidence of validity to support inferences made from the data.

Most existing uncertainty or ambiguity assessment scales are undermined by low reliability or overly vague theoretical foundations (Furnham & Ribchester, 1995; Hillen et al., 2017). If one seeks to assess tolerance of medical uncertainty in a healthcare setting, the instrument that appears to be most widely used is the *Physicians' Reactions to Uncertainty Scale* (PRU), developed in 1990 and revised in 1995 (Gerrity et al., 1990). This scale decontextualizes anxiety about uncertainty with respect to care, worry about negative consequences, and the ability to communicate uncertainty to patients and colleagues. The diversity and complexity of uncertainty inherent in medical practice is not reflected in this assessment, nor is the link between the management of uncertainty and personal epistemologies. Therefore, the understanding of uncertainty on which the PRU is based is not sufficiently consistent with a model for understanding uncertainty as discussed above.

The *Tolerance of Ambiguity in Medical Students And Doctors* (TAMSAD; see Appendix 1) scale seems more in line with this model (Hancock et al., 2015). For these authors, ambiguity would be the stimulus, while uncertainty would be the response to an ambiguous situation. They hypothesize that an individual with more enriched personal epistemologies would be more tolerant of ambiguity. They also postulate that ambiguity tolerance is not a fixed trait, instead being prone to change with environment and context. This relationship to epistemology, as well as the fact that tolerance of uncertainty/ambiguity is changeable as a function of environment and context, are features of the model of understanding uncertainty found in this scale, and not in others. To measure ambiguity tolerance in medical students and young doctors, Hancock et al. (2015)

define the characteristics of their scale. It must contain clinically contextualized items; have a sufficient quantity and variety of items to be sensitive to subtle changes; treat ambiguity tolerance as the result of a complex, potentially multidimensional construct that is susceptible to change; and demonstrate solid reliability.

The authors of the TAMSAD scale have published evidence of validity for their final 29-item scale following internationally accepted recommendations (Downing, 2003). Content validity stems from the source of the items themselves. They are all derived from a review of the educational literature, medical pedagogy theories, and pre-existing ambiguity tolerance scales.

All items were drafted as statements concerning which respondents were asked to rate their agreement on a 5-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree, with an intermediate score of 3 = neutral. Most pre-existing uncertainty rating scales also use a Likert scale for purposes of assessment (Budner, 1962; Geller et al., 1993; Gerrity et al., 1990). The response process was taken into account in the development of the scale. Inappropriate or baffling items were removed or rewritten by academics and clinicians. A pilot study was conducted with 10 students and interns who were asked to comment on items that they found difficult to understand or to answer. Data collected to test validity evidence supporting inferences made from the data were verified.

Factor analysis of a 38-item version of the TAMSAD scale indicated that these items could not be subdivided into a reduced list of interpretable factors. Extraction of the main factors showed that there were 13 factors with eigenvalues >1, but the scree plot suggested a 5-factor solution accounting for 33% of the total variance. However, the five factors did not allow for simple interpretation (even after the use of varimax rotation), and many items did not have factor loadings >0.30 or had moderate factor loading on more than one factor. The use of alternative rotation or extraction methods did not provide a simple solution. The initial Cronbach's alpha score was calculated to be 0.75, and the authors interpreted these results as suggesting that the TAMSAD scale acts as a unidimensional approach to ambiguity tolerance. They then sought to improve the concision and reliability of the scale by reducing the number of items. Removing seven items increased the internal consistency of the scale to .80. Finally, two additional items that had an adjusted item/total correlation <0.20

were also removed. Cronbach's alpha remained unchanged at 0.80. This internal consistency measure is superior to those obtained for pre-existing ambiguity tolerance scales (Budner, 1962; Geller et al., 1993).

The relationship of ambiguity tolerance as measured by the TAMSAD scale regarding other variables such as gender identity; having been on a practicum; advancing in the curriculum; or choice of specialty was investigated. The impact of undergoing the TAMSAD procedure is considered minimal. Completing the 29-item questionnaire takes 5-10 minutes, and the authors consider it unlikely that this length of time would have a negative impact on students. We therefore selected this scale for the relevance of its approach and the concepts on which it is based; for its developmental design; and for its reliability.

Our goal is to provide the medical community with a culturally adapted French translation of the TAMSAD scale for which evidence of validity of the scores obtained is assessed according to the same validation criteria as for the original scale. To do this, we will translate and culturally adapt the scale, and then verify its psychometric properties, whose strengths and weaknesses will be presented in the discussion of the five sources of validity that must be considered (Downing, 2003) namely content validity, response process, internal structure of the scale, relationship to other variables, and consequences of using the scale.

Method

Translation and cultural adaptation

To obtain a French version of this questionnaire that is as faithful as possible to the original version (TAMSAD; see Appendix 1), we sought recognized recommendations for translation and cultural adaptation (Guillemin et al., 1993). We learned that several translations must be produced by at least two independent translators, with a preference for professional translators translating into their native language, and that the same number of reverse translations must be produced by independent translators, always giving preference to professional translators translating into their mother tongue. For our work, two translations of the original scale into French were completed by two professional freelance translators

who were native speakers of French. Then, two reverse translations of the French versions into English were completed by two professional freelance translators for whom English is their mother tongue.

A review committee was formed to produce the final version of the translation based on the initial translations and reverse translations. The committee was multidisciplinary and consisted of experts in the subject matter of the questionnaire and of individuals who were the target population for the questionnaire. The presence of bilingual members was an added value. If needed, the committee could solicit the help of the lead author of the original questionnaire to ensure that the underlying concepts were maintained during the translation. He could modify or eliminate irrelevant, ambiguous, or unsuitable elements and produce more appropriate wording.

Furthermore, the wording of the questions was subject to a certain set of rules: use short sentences with key words in each statement, all as simple as possible; use the active rather than the passive voice; repeat nouns instead of using pronouns; use specific rather than general terms; and avoid using metaphors and colloquialisms, the possessive mode, adverbs, "vague" terms, and sentences with two different verbs that suggest different actions.

The objective was to achieve equivalence in the following categories:

- *semantic*: Same meaning of the terms used.
- *idiomatic*: Colloquial expressions in a given culture are not to be translated word for word. A cultural equivalent must be found in the language of translation.
- *Experiential*: When an experience is evoked in the original proposal but does not exist or rarely occurs in the target culture, an equivalent in the target culture must be found.
- *Conceptual*: Refers to the fact that sometimes the meaning of words is identical, but the concepts attached to them are different from one culture to another. The concepts evoked must be corresponding.

Our proofreading committee compared the reverse translations with the source version in order to decide on a final French version closest to the original. The committee was composed of seven individuals:

– A research physician in medical education who worked in Canada for a number of years (bilingual).
– Two general practice interns representative of the target population and with expertise derived from their ongoing dissertation research, one on the qualitative exploration of uncertainty among general practice interns, the other contributing directly to the present paper.
– A general practitioner and university clinic head, who directed the thesis on the qualitative exploration mentioned above.
– A general practitioner and teacher-researcher, who is lead author of this paper.
– A substitute general practitioner and university clinic head.
– A psychologist and teacher-researcher in psychology.

Lastly, a pre-test can be carried out on a sample of the population responding to the questionnaire in order to identify errors or discrepancies in translation (Guillemin et al., 1993).

Psychometric quality of the French version

Data collection

The final version of the French-language questionnaire (TAMSAD fr; see Appendix 2) is a 29-item scale, like the original version. For each of these items, the respondent is asked to rate his or her (dis)agreement with a statement using a 5-point Likert scale: 1 = strongly disagree; 2 = disagree; 3 = neutral; 4 = agree; and 5 = strongly agree.

TAMSAD fr was submitted to fourth and sixth year medical students of a French faculty of medicine and maieutics through an online questionnaire on the Sphinx platform. In addition to the TAMSAD fr scale, the questionnaire collected the following information: age, gender identity, and medical specialties the respondents would like to enter after their national classifying examinations (*Épreuves classantes nationales*, or ECN). Emails were requested in order to be able to match the responses during the two separate data collection periods. The responses were anonymized using a correspondence table.

Data collection from sixth year medical students was conducted for the test and retest phases on electronic tablets provided by the faculty prior to an examination. Fourth-year students used their own computer media in

the faculty at the beginning of a lecture for the test phase. For the retest phase, they were invited to fill out the questionnaire again via an email with the link to the online questionnaire.

All students were instructed in the retest phase to answer the questions as if for the first time, without trying to remember the answers they had selected the previous time around. The interval between the two test runs ranged from 8 weeks to 12 weeks and 1 day. This time interval was decided upon so that it would be long enough for the students to forget their responses and short enough that their tolerance for ambiguity would have remained virtually unchanged. The entire research protocol received a favorable opinion from the research committee of the departments of medicine and maieutics of the home university in December 2018. The faculty of medicine and maieutics of the institution authorized this research.

Data analysis

From the Sphinx platform interface, data were collected on Microsoft Excel and analyzed using Statistica 10.0 data processing software (StatSoft). Questionnaires that were missing data needed for the TAMSAD fr scale were not used for analysis.

Primary endpoint

The English version of the TAMSAD scale was factor analyzed by its authors during its creation and validation process. TAMSAD fr is a French translation that respects the number, order, and meaning of the items in the original version.

The primary endpoint is the measure of internal consistency of TAMSAD fr with the calculation of Cronbach's alpha (raw values without standard deviations) from the 5-point response scale. Cronbach's alpha (α) is used to test the consistency with which multiple items in a study or test assess the same skill or characteristic. It is therefore suitable for assessing the internal consistency of a unidimensional scale (which measures a single construct) such as the TAMSAD scale (Taber, 2018). The closer Cronbach's alpha is to 1, the stronger the correlation of items. An index greater than 0.70 (considered an acceptable result) indicates that the items are likely measuring the same construct, which is sought to demonstrate good internal consistency (Schweizer, 2011). Comparisons of means are made with Student's t-test and results with effect sizes are presented by Cohen's d.

Secondary endpoints

Each student's TAMSAD fr score was calculated. The authors of the TAMSAD scale provided a calculation for converting the means of the scores from 1 to 5 on their scale into a score from 0 to 100 for ease of comparison. As with the original version (see Appendix 1), some items, marked with an asterisk, require a reversal of the response for the calculation (1 becomes 5; 2 becomes 4; 3 remains 3). The mean score of the scale from 1 to 5 must then be transformed into a score from 0 to 100 using the formula: New score = 25 (Old score - 1).

These scores were used to

– Investigate the influence of various factors on the level of tolerance for ambiguity (gender identity, level of medical education, and intended specialty, as in the validation of the original scale by Hancock et al., 2015).
– Assess test/retest stability (intraclass correlation).

RESULTS

Translation and cultural adaptation

Procedure

At the committee meeting, both translations by the two professional translators were proposed for each item in English. The members had to agree on which one was closer to the original version and then adapt it if necessary, following the recommendations described in the method outlined above.

No items were removed and the order of presentation of the items remained identical to that of the original scale. For four items, the committee kept the translation proposed by one of the two professional translators without modification. For seven items, the version retained is a combination of the formulations proposed by the two professional translators. For the remaining items, the committee composed the French version from formulations proposed by the professional translators, supplemented by proposals made by the committee members to respect the objectives of cultural adaptation (clarity and equivalence, as detailed in the method above).

Example

For example, with respect to item 1, the original wording in English was "I would enjoy tailoring treatments to individual patient problems." The French translations read as follows: *Je prendrai plaisir à aménager les traitements aux problèmes individuels des patients* and *J'aimerais bien établir des traitements sur mesure correspondant aux problèmes particuliers de chaque patient*. The reverse translations were "I take pleasure in adapting treatments to the individual problems of patients" and "I would like to offer personalized treatments specific to each patient's problems." The final version elaborated and adopted by the committee is *J'apprécierais d'adapter les traitements aux problèmes individuels des patients*.

Right of modification and clarifications of the lead author of the original version

For some items, in accordance with the methodology, the committee was able to make a modification, resulting in a new wording, sometimes a mixed formulation borrowing from the two proposed translations. However, when opinions differed or when the committee could not decide on the wording to be adopted, the lead author of the original English version of the scale was consulted by email. The hesitations were mainly related to certain terms that could have several meanings in French.

This was the case for two items. Firstly, regarding item 2, "I have a lot of respect for consultants who always come up with a definite answer", the term "consultants" suggested to some committee members highly experienced, educated physicians (generalists or specialists) corresponding to "professors"; whereas to others, the term called to mind physicians who are specialists in a particular organ or discipline (non-generalists).It turned out that the lead author's intention was to refer to specialist physicians. The committee therefore adopted the following translation: *Les médecins spécialistes que je respecte beaucoup sont ceux qui apportent toujours une réponse tranchée*. The members of the review committee were asked by email for their approval, after having read the clarification of the lead author.

Secondly, for item 14 "Being confronted with contradictory evidence in clinical practice makes me feel uncomfortable", the lead author was also asked about the term "evidence" to determine whether it referred to scientific evidence that can sometimes be contradictory or to the elements

(clinical, paraclinical, etc.) of a situation for a patient that are sometimes contradictory. The author's response directed the translation to *données contradictoires* in reference to a specific clinical situation.

In addition, item 21, "I feel uncomfortable when textbooks or experts are factually incorrect", was modified several times. The words "factually incorrect," initially translated by the committee as *manifestement dans l'erreur*, were finally changed to *inexacts dans les faits*. The first translation was considered too forceful, inexorably leading to a response in agreement with the proposal. The phrase *inexacts dans les faits* seemed to provide a more subtle distinction and invited the respondent to express a personal position or take a stand.

The final version (see Appendix 2) was validated by the entire committee as being as close as possible to the original questionnaire. It was not possible to carry out a pre-test to check the clarity of the items. However, the participation in the committee of general medicine interns, representing part of the scale's target population, made it possible to verify the clarity of the items during the translation process.

The clarity of the items was also checked at the time of presentation of the TAMSAD fr scale to the students in order to verify psychometric qualities. When students completed the questionnaire in the faculty pre-session, members of the study team were on hand to address any difficulties and to provide clarification as required. No clarifications were requested, which suggests a good understanding of the questionnaire and its administration.

Psychometric analysis

Response rate

In the test phase, the questionnaire was distributed to 105 sixth year students and 52 fourth year students (n = 157). All responded. One questionnaire was excluded because it was only partially completed (response rate = 99%).

In the retest phase, the same 157 students were approached. Of these, 30 students did not respond to the questionnaire (19%). In sixth year, 84 students responded and 9 questionnaires were incomplete; in fourth year, 43 students responded and 3 questionnaires were incomplete. In total, 115 questionnaires were usable (response rate = 73%). The breakdown of the study population (completed TAMSAD fr questionnaires) is presented in Table 1 below.

Table 1
Sub-population sizes in the medical student sample

	Non-respondents	Incomplete questionnaires	Complete questionnaires	Sub-populations studied
Test	0	1 (1%)	156 (99%)	104 women, 52 men
				52 in fourth year and 104 in sixth year
Retest	30 (19%)	12 (8%)	115 (73%)	81women, 33 men, 1 non-gendered
				40 in fourth year, 75 in sixth year

Internal consistency of scores

Cronbach's alpha was calculated using the fully completed questionnaires collected, i.e., with a response for all 29 items, for all test and retest respondents, but also for subpopulations based on gender identity or academic progress (4th or 6th year of medical school). The results are presented in Table 2 below.

Table 2
Cronbach's alphas calculated according to sub-populations

Study population	No.	α
Test phase		
All students	156	0.68
Women	104	0.71
Men	52	0.63
Fourth year of medicine	52	0.58
Sixth year of medicine	104	0.72
Retest phase		
All students	115	0.76
Women	81	0.79
Men	33	0.67
Fourth year of medicine	40	0.76
Sixth year of medicine	75	0.76

The values are more heterogeneous and lower in the test batch than in the retest grouping. Cronbach's alpha is measured at 0.68 for all questionnaires collected at test and 0.76 at retest. The lowest Cronbach's alpha value is measured at 0.58 for the results of the fourth year students on the first retest.

For the calculation of test-retest stability, only questionnaires that could be matched (between the first and second rounds) were useful. Among the 115 usable responses in the second round, questionnaires for which the email address was not provided or was incorrect could not be matched; the questionnaires of 6 students were therefore excluded. Hence, the calculation of the stability of the scale was based on 109 students, or 218 questionnaires. The intra-class correlation coefficient was measured at 0.77 (p = 0.00), which allows us to conclude that our questionnaire is highly reproducible.

Scores

A score for TAMSAD fr was calculated for each student based on responses on the test and retest. The mean scores, standard deviations, and minimum and maximum values based on the sub-populations studied are presented in Table 3 below.

Table 3
Mean scores out of 100 on the TAMSAD fr test and retest according to sub-populations

Study population	No.	M	SD	Min.	Max.
Test phase					
All students	156	53.9	7.7	29.3	76.7
Women	104	53.7	7.8	29.3	76.7
Men	52	54.2	7.4	38.8	75.9
Fourth year of medicine	52	52.9	6.9	36.2	69.8
Sixth year of medicine	104	54.4	8	29.3	76.7
Retest phase					
All students	115	55.3	8.3	32.7	75
Women	81	55	8.7	32.8	75
Men	33	56.2	7.4	44	72.4
Fourth year of medicine	40	54.5	8.4	39.7	70.7
Sixth year of medicine	75	55.8	8.3	32.8	75

Thus, the mean score for all students who completed the test is 53.9 (SD= 7.7). It can be seen that the mean scores fluctuate between 52.9 (SD = 6.9) and 56.2 (SD = 7.4) and are slightly higher on retest, without the difference being significant: mean on test = 53.9 (SD = 7.7); mean on retest = 55.3 (SD = 8.3); $t(75) = 1.43$; $p = .15$; effect size d = .17. The small effect size shows the lack of difference in mean score between the two tests.

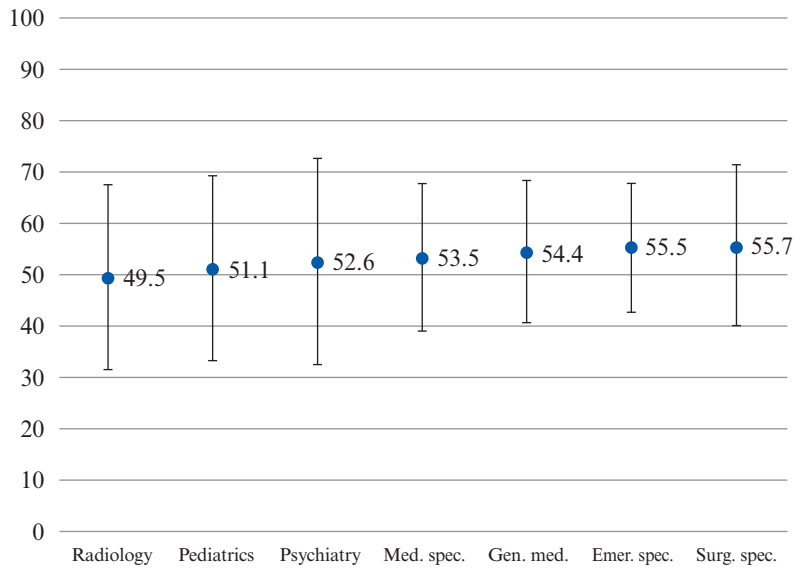
A secondary aim of this work was to identify the influence of different factors on ambiguity tolerance, as in the validation process of the original scale by Hancock et al. (2015). We looked for a possible influence on the score of gender identity, level of medical education, and specialty considered during the French national classifying examinations (ECN).

Student t-test results showed no significant difference between male and female respondents' test scores: mean male = 54.2 (SD= 7.4); mean female = 53.7 (SD= 7.8); $t(75) = 0.33$; $p = 0.74$; effect size d = 0.06. The small effect size shows the similarity in mean score between tests performed by men and those performed by women.

There was also no significant difference in respondent scores between fourth year and sixth year students: mean fourth year = 52.9 (SD= 6.9); mean sixth year = 54.4 (SD= 8); $t(75) = .90$; $p = .34$; effect size d = .16. The small effect size shows the similarity in mean score between tests taken by fourth year students and those taken by sixth year students.

The different specialties to be chosen in the scale were previously classified into seven groups: medical specialties; surgical specialties; emergency specialties (including resuscitation and emergency medicine); pediatrics; psychiatry; radiology; and general medicine. This grouping was modeled on the clustering chosen by the authors of the original scale. The information in Figure 1 is presented for descriptive purposes only, as the numbers in the different specialty subgroups are insufficient to perform a comparative analysis.

Figure 1
Mean TAMSAD fr score with 95% confidence interval based on the student's intended specialty at the time of testing



DISCUSSION

With regard to translation and cultural adaptation, the main good practice recommendations (Guillemin et al., 1993) were respected, but some recommendations could not be implemented due to time and budget constraints. For example, Guillemin et al recommend using four teams of translators rather than four individual translators whenever possible. They also underline the value of a pre-test stage as a means of bringing to light possible errors, which would be revealed by a misunderstanding or hesitation on the part of the interviewee.

While these additional recommendations could not be applied, adherence to the main recommendations resulted in a French-language questionnaire approved by the entire committee, following a process that included comments on the reverse translations into English by the lead author of the original scale. Furthermore, during the first administration to the target population, students were given the opportunity to respond

or ask questions of one of the study authors on hand. The students did not report any difficulties in understanding the questionnaire or ask any questions about its content or the way it was administered.

Upon publishing their scale, the TAMSAD authors presented the sources of validity of their tool that need to be considered (Downing, 2003; Hancock et al., 2015). Given that our French translation of the scale respects the number, response process, order, and meaning of the items in the original version, we consider the validity arguments of the authors of the English TAMSAD scale regarding the content, response process, and unidimensionality of the scale to be transferable to the French TAMSAD. The unidimensionality of the English TAMSAD was supported by a factor analysis, which could be performed on the French TAMSAD at the time of its future use. It is this unidimensionality that enables the use of Cronbach's alpha to assess the internal consistency of the French TAMSAD (Raykov & Marcoulides, 2010). We chose to verify the internal consistency of TAMSAD fr as evidence of validity.

Thus, the Cronbach's alpha of TAMSAD fr is calculated to be 0.68 on test and 0.76 on retest. The interpretation of Cronbach's alpha values varies widely in the literature (Taber, 2018). However, when used to assess the internal consistency of a unidimensional scale, the result is most often considered satisfactory between 0.70 and 0.90. Our results therefore support a good internal consistency of TAMSAD fr as translated. Hence, there was no need to remove or modify any items after the fact.

However, our alphas are lower than those of the original English scale ($\alpha = 0{,}80$). The main explanation for this difference may be the absence of graduate or internship physicians in our sample, whereas in the original paper presenting the TAMSAD scale, 411 medical students and 75 foundation doctors (British equivalent of internship physicians) were recruited to complete the questionnaire. In our study, all participants were graduate medical students. The sample in the original paper was therefore more heterogeneous in its educational background, and competence (tolerance of ambiguity) was therefore more dispersed. Greater dispersion of aptitude in a population leads to an increase in the consistency of the tool, i.e., an increase in Cronbach's alpha, in the case of our questionnaire.

When comparing Cronbach's alphas across populations and by test or retest, the lowest alpha is for younger students on the test, but there is a homogenization of results on the retest. A better understanding and

application of the questionnaire probably emerges with use. This phenomenon appears to be accelerated as users advance in their studies, perhaps increasing their knowledge of medical uncertainty.

Despite less data being collected during the retest phase and notwithstanding the matching of the questionnaires, which enabled the analysis of 109 students (out of 157 approached), reproducibility (or test-retest reliability) was demonstrated, since stability was observed among the mean scores of the students between the two administration periods (intraclass correlation coefficient = 0.77; $p = 0.00$). Cronbach's alpha and test-retest reliability therefore provide arguments for the internal structure validity of TAMSAD fr. These arguments can be verified in future uses of the scale and other measures such as the coefficient omega could enrich such an assessment (Béland & Michelob, 2020).

Regarding the relationship to other variables, our study did not find a significant association between the ambiguity tolerance score and the different factors studied: gender identity, advanced medical education, or having a particular attraction to general medicine or another specialty.

The first hypothesis we formulate to explain this lack of difference between the groups is insufficient predictive power due to the small size of our sample. The second hypothesis is that the result is indeed a reflection of reality, because in the literature, to date, no consensus has emerged with respect to the influence of these different factors. Several authors who have studied the issue have come up with contradictory results (Geller et al., 1990; Han et al., 2015; Politi & Légaré, 2010).

TAMSAD fr was used in this study for descriptive purposes only and no impact on students was identified. To our knowledge, it is the only French ambiguity tolerance scale with evidence of validity. There are numerous English-language assessment scales of tolerance of uncertainty or ambiguity based on a wide variety of approaches to tolerance, uncertainty, or ambiguity, a detailed comparison of which has been published recently (Hillen et al., 2017). We justify the choice of the TAMSAD scale as a tool made available to the Francophone community by the consistency of the concepts drawn upon for its design with those put forward by the model of understanding uncertainty that we selected for its rich pedagogical perspectives (Motte et al., 2020) and by the rigor with which Hancock et al. (2105) have presented evidence of validity for their TAMSAD scale.

Medical uncertainty is a rich and complex phenomenon. TAMSAD fr should make it possible to better assess its tolerance in the Francophone population. However, other dimensions will have to be assessed in the context of training. For example, some authors suggest using the Script Concordance Test (SCT) to assess clinical reasoning in a context of uncertainty (Charlin, 2006; Charlin et al., 2005). The communication of uncertainty and its assessment are also promising areas of research that will require concerted efforts on the part of teaching and research teams (Han et al., 2019; Kalke et al., 2021).

CONCLUSION

The psychometric assessment of the French version of the TAMSAD scale attests that this translation of the scale constitutes a cohesive and reliable tool. However, these results need to be confirmed in subsequent applications. Use of the scale in larger samples would allow for differential item functioning (DIF) analysis to determine the extent to which each item can measure different abilities for members of distinct subgroups, and also for person-fit analysis to detect respondents who deviate from expected responses with respect to TAMSAD fr.

The concepts drawn upon during the design of the original English scale are in line with those developed in recent publications dedicated to the understanding of medical uncertainty, which open up new pedagogical perspectives (Cooke & Lemay, 2017; Eastwood et al., 2017; Han et al., 2011; Motte et al., 2020). The availability of this reliable and timely tool, TAMSAD fr, to the French-speaking scientific community enables educational and research teams to assess their students' tolerance of ambiguity as it currently stands or during educational initiatives in uncertainty management training.

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Appendix 1: Original version of the TAMSAD scale (Hancock et al., 2015)

Tolerance of Ambiguity of Medical Students and Doctors **(TAMSAD): 29 item version**

Please place a X or a √ in the box that most applies to you for each statement.

No.	Statement	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)
1	I would enjoy tailoring treatments to individual patient problems					
2	I have a lot of respect for consultants who always come up with a definite answer*					
3	I would be comfortable if a clinical teacher set me a vague assignment or task					
4	A good clinical teacher is one who challenges your way of looking at clinical problems					
5	What we are used to is always preferable to what is unfamiliar*					
6	I feel uncomfortable when people claim that something is "absolutely certain" in medicine					
7	A doctor who leads an even, regular work life with few surprises, really has a lot to be grateful for*					
8	I think in medicine it is important to know exactly what you are talking about at all times*					
9	I feel comfortable that in medicine there is often no right or wrong answer					
10	A patient with multiple diseases would make a doctor's job more interesting					
11	I am uncomfortable that a lack of medical knowledge about some diseases means we can't help some patients*					
12	The unpredictability of a patient's response to medication would bring welcome complexity to a doctor's role					
13	It is important to appear knowledgeable to patients at all times*					
14	Being confronted with contradictory evidence in clinical practice makes me feel uncomfortable*					
15	I like the mystery that there are some things in medicine we'll never know					
16	Variation between individual patients is a frustrating aspect of medicine*					

No.	Statement	Strongly disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)
17	I find it frustrating when I can't find the answer to a clinical question*					
18	I am apprehensive when faced with a new clinical situation or problem*					
19	I feel uncomfortable knowing that many of our most important clinical decisions are based upon insufficient information*					
20	No matter how complicated the situation, a good doctor will be able to arrive at a yes or no answer*					
21	I feel uncomfortable when textbooks or experts are factually incorrect*					
22	There is really no such thing as a clinical problem that can't be solved*					
23	I like the challenge of being thrown in the deep end with different medical situations					
24	It is more interesting to tackle a complicated clinical problem than to solve a simple one					
25	I enjoy the process of working with a complex clinical problem and making it more manageable					
26	A good job is one where what is to be done and how it is to be done are always clear*					
27	To me, medicine is black and white*					
28	The beauty of medicine is that it's always evolving and changing					
29	I would be comfortable to acknowledge the limits of my medical knowledge to patients					

Scoring

If you wish to compare your scores to our published study, you will need to calculate your TAMSAD score out of 100 using the following steps:

Step 1 Reverse the codes for the items asterisked (e.g. a 2 becomes a 4).

Step 2 Calculate your mean score out of 5 across the 29 items (e.g. 3.14).

Step 3 Transform your mean score from a 1–5 scale to a 0–100 scale using the formula: *New score = 25 (Old score - 1)*. So for example, using the previous example, the new score would be 25(3.14-1) = 25*2.14 = 53.5.

Annexe 101 : Version finale de l'échelle TAMSAD fr

Tolérance à l'ambiguïté chez les étudiants en médecine et les médecins

Pour chaque affirmation, veuillez cocher [X] la case qui vous correspond le mieux.

N°	Affirmation	Pas du tout d'accord (1)	Pas d'accord (2)	Neutre (3)	D'accord (4)	Tout à fait d'accord (5)
1	J'apprécierais d'adapter les traitements aux problèmes individuels des patients					
2	Les médecins spécialistes que je respecte beaucoup sont ceux qui apportent toujours une réponse tranchée*					
3	Je serais à l'aise si un enseignant clinicien me confiait une mission ou une tâche vague.					
4	Un bon enseignant clinicien est celui qui remet en question votre façon d'aborder des problèmes cliniques					
5	Ce à quoi nous sommes habitués est toujours préférable à ce qui ne nous est pas familier*					
6	Je me sens mal à l'aise lorsque les gens affirment que quelque chose est « absolument certain » en médecine					
7	Un médecin qui mène une vie professionnelle stable, régulière et avec peu de surprises peut vraiment s'estimer chanceux*					
8	Je pense qu'il est important, en médecine, de toujours savoir exactement de quoi on parle*					
9	Je suis à l'aise avec l'idée qu'il n'y a souvent pas de bonne ou de mauvaise réponse en médecine					
10	Un patient atteint de multiples pathologies rendrait le travail du médecin plus intéressant					
11	Je suis mal à l'aise avec le fait qu'un manque de connaissances médicales sur certaines maladies implique que l'on ne puisse pas aider certains patients*					
12	Le caractère imprévisible de la réaction d'un patient à un traitement médicamenteux apporterait au rôle du médecin une complexité appréciable					
13	Il est important de toujours paraître bien informé(e) aux yeux des patients*					
14	Être confronté(e) à des données contradictoires en pratique clinique me met mal à l'aise*					
15	J'aime le mystère lié au fait qu'il y a certaines choses en médecine que nous ne saurons jamais					

N°	Affirmation	Pas du tout d'accord (1)	Pas d'accord (2)	Neutre (3)	D'accord (4)	Tout à fait d'accord (5)
16	Les variations d'un patient à l'autre sont un aspect frustrant de la médecine*					
17	Lorsque je ne peux pas trouver la réponse à une question clinique, je trouve ça frustrant*					
18	J'éprouve de l'appréhension lorsque je suis confronté(e) à une nouvelle situation ou à un nouveau problème clinique*					
19	Je suis mal à l'aise de savoir que beaucoup de nos décisions cliniques les plus importantes reposent sur des informations insuffisantes*					
20	Peu importe la complexité de la situation, un bon médecin sera capable d'arriver à une réponse claire de type oui/non*					
21	Je me sens mal à l'aise quand les manuels de référence ou les experts sont inexacts dans les faits*					
22	Un problème clinique qui ne peut être résolu, ça n'existe pas*					
23	J'aime le défi d'être livré à moi-même face à différentes situations médicales					
24	Il est plus intéressant de s'attaquer à un problème clinique complexe que d'en résoudre un simple					
25	J'apprécie la démarche de travailler sur un problème clinique complexe et de le rendre plus gérable					
26	Un bon travail est celui pour lequel les choses à faire et la façon de les faire sont toujours claires*					
27	Pour moi, la médecine, c'est tout blanc ou tout noir*					
28	La beauté de la médecine tient au fait qu'elle évolue et change en permanence					
29	Je serais à l'aise de reconnaître les limites de mes connaissances médicales face aux patients					

Score

Pour comparer votre score à ceux publiés dans l'étude de validation de la TAMSAD, vous devez calculer votre score TAMSAD sur 100 en suivant ces étapes :

Étape 1 Inversez les codes des items signalés par un astérisque (ex. : un 2 devient un 4).

Étape 2 Calculez le score moyen sur 5 des 29 items (ex. : 3,14).

Étape 3 Transformez ce score moyen sur une échelle de 1 à 5 en un score sur une échelle de 0 à 100 en utilisant cette formule : *nouveau score = 25 (vieux score - 1)*. Si l'on utilise l'exemple ci-dessus, le nouveau score serait 25(3,14-1) = 25 × 2,14 = 53,5.