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Assessing clinical reasoning in optometry using the script concordance test

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Caroline Faucher* OD PhD
Marie-Pier Dufour-Guindon† OD
Gabrielle Lapointe‡ OD
Robert Gagnon§ PhD
Bernard Charlin§ MD PhD
*École d'optométrie, Université de Montréal, Montréal, Canada
†VU, Montréal, Canada
‡Clinique d'optométrie Lapointe et Qualizza, Montréal, Canada
§Centre de pédagogie appliquée aux sciences de la santé, Faculté de médecine, Université de Montréal, Montréal, Canada
E-mail: caroline.faucher@umontreal.ca

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Background: Clinical reasoning is central to any health profession but its development among learners is difficult to assess. Over the last few decades, the script concordance test (SCT) has been developed to solve this dilemma and has been used in many health professions; however, no study has been published on the use of the script concordance test in optometry. The purpose of this study was to develop and validate a script concordance test for the field of optometry.

Methods: A 101-question script concordance test (27 short clinical scenarios) was developed and administered online to a convenience sample of 23 second-year and 19 fourth-year students of optometry. It was also administered to a reference panel of 12 experienced optometrists to develop the scoring key. An item-total correlation was calculated for each question. Cronbach's alpha coefficient was used to evaluate the script concordance test reliability and a t-test compared the two groups.

Results: A final 77-question script concordance test was created by eliminating questions with low item-total correlation. Cronbach's alpha for this optimised 77-question script concordance test was 0.80. A group comparison revealed that the second-year students' scores (n = 23; mean score = 66.4 ± 7.87 per cent) were statistically lower ($t = -4.141$; $p < 0.001$) than those of the fourth-year students (n = 19; mean score = 75.5 ± 5.97 per cent).

Conclusion: The online script concordance test developed for this study was found to be both reliable and capable of discriminating between second- and fourth-year optometric students. These results demonstrate that the script concordance test may be considered as a new tool in the optometric educators' assessment arsenal. Further studies will be needed to cover additional levels of professional development.

Key words: assessment, clinical reasoning, education, optometry, script concordance test

Clinical reasoning or the set of thought processes and decision making associated with clinical practice,[1] is fundamental to the practice of all health professions. Faucher and colleagues[2] have defined clinical reasoning more specifically with regard to optometry as 'the competency by means of which an optometrist, interacting with the patient and other people involved if necessary, resolves a clinical case by progressively constructing a mental representation of the patient's clinical situation, in parallel with the management plan, using pertinent knowledge and other resources, as well as planning, investigation and analysis/reflection processes.' Clinical reasoning is a complex process. Clinicians face diverse situations daily. To solve clinical problems, each clinician must make use of the network of well-structured knowledge he or she has built up over years of experience. Schmidt, Norman and Boshuizen[3] have described the development of clinical expertise as a progressive organisation of knowledge. Novice learners quickly develop rich, elaborated causal networks that help them explain the causes and consequences of diverse anomalies and diseases in terms of physiological, pathological or biological processes. When faced with a clinical problem, they will try to understand each sign and symptom by relating it systematically to their theoretical knowledge, without necessarily recognising that these signs and symptoms may be interrelated. This long, exacting process is poorly adapted to clinical practice, where decisions must be made without delay. By applying knowledge through regular practice with patients, associative links develop progressively between various features that characterise the clinical manifestation of a disease or of an anomaly. This is the process known as 'script formation,' where 'scripts' are cognitive structures stored in the memory, containing a complex network of meaningful links among clinical features that will allow the clinician to resolve problems encountered in clinical practice, via diagnosis, investigation or treatment.[4] Each student's growing experience helps him or her to internalise many examples of diseases and anomalies (various presentations, degrees of severity, rates of progression and responses to treatment), which enrich any script they have already stored. Later on, when an experienced clinician recognises a disease or an anomaly (script activation), what is needed for appropriate case management comes to mind without having to handle pathophysiological knowledge in detail. Indeed, scripts contain information on the enabling conditions, causes and consequences of specific diseases or anomalies. Script activation happens in a global, automatic and nearly unconscious way, using available clinical information. More than simply putting forward hypotheses, script activation is a representational construction of the clinical situation leading to the formulation of useful hypotheses.

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Considering this progressive organisation of knowledge with clinical practice, the measure of clinical reasoning becomes an important issue in the context of training, compared to the simple measure of knowledge acquisition. Clinical reasoning is hard to evaluate objectively, given the complex nature of clinical practice, the conditions of uncertainty under which decisions are made and the ensuing limitations on accessing mental processes. Furthermore, unlike theoretical questions, clinical problems rarely have 'right' answers: one problem can be solved in different ways by several experienced clinicians, without any of their solutions being inappropriate. The script concordance test (SCT) is a written evaluation tool designed to assess clinical decision making in ill-defined situations, such as those in which health professionals practice, while at the same time taking the diversity of opinion of experienced clinicians into account as a correction key.[5]

The script concordance test can be used as an evaluation tool as well as a learning aid, both in initial training and in continuing education.[5] Computerising the script concordance test and making it accessible online[6] facilitates its use and allows for diverse uses such as image interpretation.[7]

Script concordance tests have been employed in a number of medical specialties, such as urology,[8] otorhinolaryngology,[9] surgery,[10] neurology,[11] paediatrics,[12] radiology[7] and other health sciences, such as veterinary medicine[13] and nursing.[14] Nothing has been published on script concordance test usage in optometry. The goal of this study was to develop and validate an optometry-focused script concordance test to determine if this tool may be applied to optometric training. A script concordance test was developed and administered to a reference panel composed of experienced optometrists and to students in optometry at two different stages in their training. As the script concordance test is recognised as a valid tool for detecting progress in experience-based clinical reasoning,[15] the research hypothesis for this study posited that students in optometry with longer clinical experience (fourth-year students) would perform better on the test than those with very little experience with actual patients (second-year students).

METHODS

This study was approved by our institution's health sciences ethics committee and conducted in accordance with the Declaration of Helsinki. Informed consent was obtained from the participants, after the nature of the study and its possible consequences were explained to them.

Drawing up the clinical scenarios

The method used for drawing up the script concordance test was based on a method developed by Charlin and colleagues.[5] The script concordance test was made up of short, realistic clinical scenarios, each accompanied by several questions. Table 1 shows an example of a clinical scenario with three questions. Each clinical scenario contained several bits of information but not enough to 'solve' the scenario. Each accompanying question suggested a plausible initial hypothesis (diagnosis, investigation, intervention or treatment, in Column 1). In Column 2, a new bit of information was provided. The participant was asked to decide to what extent each new bit of information reinforced or weakened the initial hypothesis, using a Likert scale (Column 3). The five-point Likert scale is the one most often used for the script concordance test.[16] In it, a participant must decide if, given the new information provided, the initial hypothesis is much less likely, less likely, neither more nor less likely, more likely or much more likely. These elements may be worded differently to suit therapeutic or investigative options rather than diagnoses. Lastly, the participant must consider his or her answer to each question on its own, without taking into account other answers already given for the same scenario.

The first three authors of this study each wrote up several clinical scenarios and their accompanying questions individually. Then all scenarios and questions were pooled for revision and adaptation. At the time of the study, MPDG and GL were in their final year of studies in optometry and thus, had sufficient clinical experience to imagine plausible clinical scenarios. The first author (CF, a professor with 18 years of experience as an optometrist) finalised and approved the version of the script concordance test that would be placed online. This was done by ensuring that the clinical scenarios reflected plausible optometric clinical situations incorporating the uncertainty of practice (with no pre-determined correct answer) and also by ensuring that the proposed hypotheses were relevant for those situations. Various fields of optometric practice were covered, such as refractive disorders, binocular vision and ocular disease but the number of scenarios dedicated to each topic was not predetermined. To ensure that any lower results obtained by second-year students would be due to less-developed clinical reasoning skills and not simply to lack of knowledge, the clinical scenarios were based on concepts that had already been taught to the second-year students. For example, no scenarios were specifically related to contact lens adjustments or to retinal disease. A total of 32 scenarios were written; 27 of them were selected.

Studies have shown that at least 60 questions are needed to obtain a good estimate of the questionnaire's reliability and that an optimal number of two to four questions nested into 15 to 25 cases represents the best combination.[17] Therefore, during a script concordance test's early development, a greater number of questions is required. The script concordance test is then optimised by administering an early script concordance test to a first group and then discarding the least useful questions: those showing low item-total correlation, thereby adding little or nothing to the script concordance test's reliability.[18] Item-total correlation is the correlation between the score on an individual question and the collective score on all the remaining questions.[19] In short, questions with low item-total correlations do not produce responses that are consistent with the remainder of the test. To allow for the eventual elimination of questions, the initial script concordance test for this study consisted of 27 clinical scenarios, each containing three to five questions, for a total of 101 questions. The script concordance test was administered in the French language.

Scoring

Unlike multiple-choice questions, a question on the script concordance test does not elicit a single 'correct' answer. Participants' answers are compared to those given by a reference panel composed of experienced clinicians. The score for each question is obtained according to the proportion of experienced clinicians choosing each possible answer.[5] Table 2 shows how each answer's score was calculated. For each question, one point was assigned to the answer chosen most often by the members of the reference panel (the modal response). Partial scores were attributed to the other answers, depending on the number of members on the reference panel who chose these answers. An answer not chosen by any reference panel member

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A 21-year-old man presents with redness and pain in his right eye that he has felt since this morning.						
If you are thinking of	**And then you find that**	**Your hypothesis becomes**				
1. An anterior uveitis	The right pupil is miotic	-2	-1	0	+1	+2
2. A recurrent corneal erosion	The patient is photophobic	-2	-1	0	+1	+2
3. An infiltrative keratitis	The patient is a contact lens wearer	-2	-1	0	+1	+2

Table 1. An example of a script concordance test clinical scenario with three questions. Answer -2 = much less likely; -1 = less likely; 0 = neither less nor more likely; +1 = more likely; +2 = much more likely.

Answer	**-2**	**-1**	**0**	**+1**	**+2**
Number of experienced optometrists who have chosen each answer	0	0	1	3	8
Score	0/8	0/8	1/8	3/8	8/8
Credit for each possible answer	0	0	0.125	0.375	1

Table 2. An example of the script concordance test scoring system. Suppose a panel of 12 experienced optometrists was asked to respond to a script concordance test question and one experienced optometrist chose answer 0, three experienced optometrists chose answer +1 and eight experienced optometrists chose answer +2. The scoring for this question would be: answers -2 and -1, both 0 point; answer 0, 0.125 point; answer +1, 0.375 point; and answer +2, 1 point.

was rated zero. The total score for the script concordance test was then calculated using the sum of credits obtained for each question, divided by the total obtainable credit for the script concordance test as a whole. This total was multiplied by 100 to yield the result as a percentage.[15]

Participants

THE REFERENCE PANEL

To ensure score reliability, a reference panel must be composed of at least 10 members; a panel of over 20 members does not significantly increase reliability.[20] For this study, the reference panel consisted of 12 optometrists practising in the school of optometry's clinic, where they supervise student in-house internships. To ensure that these optometrists had sufficient experience, it was stipulated that they had to have been in practice for at least six years. This criterion was selected based on studies in the development of professional expertise, which concluded that at least six to 10 years of experience are needed to attain 'expert' level, although experience alone is insufficient.[21,22]

THE STUDENTS

In the institution where the study was conducted, the optometric curriculum includes a two-term preparatory class (pre-optometry or year 'zero'), followed by nine terms in the optometric program per se (from the first to the fourth year, including internships and externships). This study was conducted with a convenience sample of students in optometry from two different learning levels: second and fourth years. Given the low number of students (42 to 46 per learning level) and given that answering the script concordance test was not part of their curriculum, the study was conducted over two consecutive years: February-March 2014 and February 2015. The students volunteered after receiving invitations to participate via their institutional email. Students who had already taken a script concordance test were excluded. All the students who were in the middle of their second year of studies in the optometric program were invited to participate (42 in 2014 and 46 in 2015). Twenty-six of them volunteered; twenty-three of these students went on to complete the script concordance test (nine in 2014 and 14 in 2015): these students had little clinical experience, having examined only a few patients (mostly classmates, friends and relatives). Fifty-nine fourth-year students were also invited to participate in the study (all the 42-student class in 2014 and only 17 students in 2015 because the other students in this class had already taken a script concordance test before). Twenty-three of them volunteered; 19 completed the script concordance test (16 in 2014 and three in 2015). The study took place approximately three months before the fourth-year students' graduation and licensure. These fourth-year students had accumulated nearly two years of clinical experience, including one full year as full-time interns and externs. They had examined approximately 700 patients, with supervision (complete eye examinations, including ocular health management), although this number varied from one student to another. The respect for confidentiality has prevented us from knowing the exact number of patients examined by every participant but the School of Optometry's Studies Committee makes sure that all the graduates have about the same amount of clinical experience.

Each student and each member of the reference panel was given a link to the Web platform housing the script concordance test for optometry, along with a username and modifiable password. Upon accessing the script concordance test online, the participants were shown ethical information relevant to their participation; participants were asked to give their informed consent by clicking on an icon containing the words 'I accept these conditions.' Next, instructions for the script concordance test were provided, including a sample clinical scenario accompanied by a set of questions. All the participants were required to answer the full 101-question script concordance test. Participants could stop their sessions when necessary, if they preferred completing the script concordance test in more than one session. No time limit was set. Connection

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time was not taken into account because it was impossible to determine whether a participant was taking a short break or working on the script concordance test. The deadline for completing the script concordance test was initially set at one week, but, given an unsatisfactory initial student participation rate, another five days were added in 2014 and seven days in 2015.

Statistical analysis

To shed light on which questions to retain to optimise the script concordance test, item-total correlation was calculated for each question, based on the answers provided by both the members of the reference panel and the students. After discarding the least useful questions, Cronbach's alpha reliability coefficient was used to assess the script concordance test's internal consistency. Cronbach's alpha is commonly used to describe the reliability of psychometric instruments. For example, it measures how well a set of questions evaluates a single unidimensional construct.[23] The Kolmogorov–Smirnov test was used to assess the normality of the distributions and the Levene's test was used to assess the equality of variances. Finally, a t-test was used to compare the scores of students at both levels. Data were analysed using SPSS 20 software (Version 20; SPSS Inc., Chicago, Illinois, USA).

RESULTS

The script concordance test was optimised by discarding the questions with negative item-total correlations. The resulting script concordance test consisted of 27 scenarios: one one-question scenario, seven two-question scenarios, 14 three-question scenarios and five four-question scenarios, for a total of 77 questions. Table 3 indicates the topics and age groups addressed in the 27 clinical scenarios. These 77 questions made up the final version of the script concordance test for calculating scores and comparing groups. The final script concordance test is not published because the authors plan to use the scenarios and questions for educational purposes in their institution. Subject to certain conditions, the script concordance test is made available upon request from the corresponding author.

Cronbach's alpha for the 77-question script concordance test was 0.80. The Kolmogorov–

	Topics of the scenarios					Age of patients in the scenarios			
Scenario number	Refraction	Binocular vision	Reduction of vision	Anterior segment disease	Glaucoma / neurological disease	0-18	19-64	65+	Unspecified
1	x						x		
2			x				x		
3	x		x					x	
4			x			x			
5				x			x		
6	x	x					x		
7				x			x		
8					x		x		
9		x			x				x
10				x					x
11				x					x
12				x				x	
13				x			x		
14		x			x		x		
15	x	x				x			
16	x	x	x			x			
17					x		x		
18	x	x	x			x			
19		x				x			
20	x		x			x			
21				x			x		
22						x			
23			x				x		
24			x					x	
25				x			x		
26	x						x		
27	x						x		
Total	9	7	8	8	4	7	14	3	3

Table 3. Topics and age group addressed in the 27 clinical scenarios

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Smirnov test revealed that the results to the script concordance test were normally distributed (second-year students $p = 0.53$; fourth-year students $p = 0.72$). The Levene's test showed that variances in the two groups were equal ($p = 0.578$). The group comparison (Figure 1) shows that the second-year students' scores were statistically lower (n = 23; mean score = 66.4 ± 7.86 per cent) than those of the fourth-year students (n = 19; mean score = 75.5 ± 5.97 per cent; $t = -4.141$; $p < 0.001$).

DISCUSSION

The goal of this study was to develop and validate a script concordance test for the field of optometry. A valid script concordance test must be able to discriminate along levels of experience. As expected, the fourth-year students of optometry obtained significantly higher scores than did the second-year students. Because length of training and program structure vary between health science professions and educational institutions, it is difficult to compare these results with those obtained in other fields. Many studies in medicine compare script concordance test scores between medical students and residents. For example, Kania and colleagues[9] found a significant difference in otorhinolaryngological script concordance test scores between fourth to sixth-year medical students (n = 21; score = 58.3 per cent) and residents in otorhinolaryngology (n = 22; score = 69.1 per cent), as did Sibert and colleagues[8] in urology between medical students (n = 23; score = 51.45 per cent) and urology residents (n = 25; score = 62.27 per cent) and Boulouffe and colleagues,[24] who compared clinical reasoning related to electrocardiographic readings between medical students (n = 21; score = 59 per cent) and residents in emergency medicine or internal medicine (n = 19; score = 69.5 per cent). The script concordance test has also discriminated between junior residents and senior residents, as demonstrated by Carrière and colleagues[12] in paediatric emergency medicine with first-year junior residents (n = 21; score = 66.5 per cent) and senior residents (n = 11; score = 75.9 per cent), as well as by Nouh and colleagues,[25] who administered a surgical script concordance test to junior residents (n = 96; score = 66.8 per cent) and senior residents (n = 106; score = 70.0 per cent) from nine general surgical programs across Canada. Although these studies were conducted with participants from various fields and levels of training, they all demonstrated that learners with low clinical experience score less well than do more experienced clinicians and that the difference between their scores is often around 10 per cent, like the results of the present study.

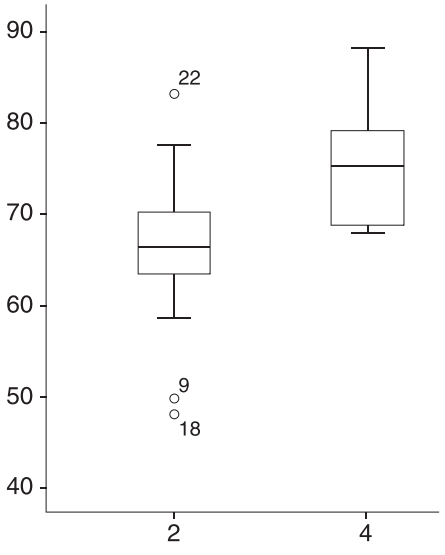

Figure 1. Boxplot of scores on the 77-question script concordance test, by level of training, namely 2 and 4 years

The student body in the school of optometry, where this study was conducted, consisted of only 42 to 46 students per level, so recruiting a large number of volunteers proved difficult. In 2015, the low participation rate by the fourth-year students can be explained by the fact that many students in this class had already taken a script concordance test previously and this disqualified them from participating in the present study. The lower participation rate by second-year students in 2014 can be explained by the fact that this study took place during their examination period. It is plausible to imagine that those second-year students agreeing to participate in the study had more confidence in themselves or had acquired better time-management strategies than those who refused. This would have allowed participants to devote time to this study in spite of the attention they needed to pay to their examinations. Since efficient time management is often associated with better academic performance,[26,27] the script concordance test results for some of the second-year students may be overestimated. If so, this did not prevent researchers from discriminating between the two student groups' performances.

Another factor to consider is the provenance of participants in this study. Student scores tend to be higher if members of the reference panel come from the same milieu as these students, or if they had mentored the students in some way.[28] Therefore, the students' results at both levels might have been lower had the members of the reference panel not been practising at the clinic of the school of optometry. Similarly, optometric students from other institutions might be expected to score differently on this same script concordance test with this same reference panel. These differences in provenance of participants with regard to that of the reference panel would not affect the discriminative capacity of the script concordance test.[28] Thus, we are aware that the sample was not representative of the second or fourth year students from any school of optometry.

One may also question the fact that the participants were not under supervision while answering the script concordance test. Participants were asked to do the test on an individual basis, without consulting any document or other resource but this was not controlled. The participants would not benefit from divulging the contents of the script concordance test to their classmates or from consulting any other sources of information because their test results were anonymous and therefore, could not influence their summative evaluations. To our knowledge, no study has compared 'open-book' script concordance test scores to 'closed-book' scores but, considering that script concordance test clinical scenarios and questions involve ill-defined problems requiring clinical judgments and decisions going beyond theories learned in textbooks, it is unlikely that an open-book script concordance test would significantly influence student performance.

The Cronbach's alpha of 0.80 shows that this first script concordance test developed for optometry displays very good internal consistency. A value of 0.80 or higher is generally considered to be satisfactory for moderate-stakes tests, such as major year-end examinations in medicine, while a coefficient of 0.70 to 0.79 is acceptable for low-stakes tests, such as formative or summative assessments administered mid-course.[29] Therefore, the script concordance test is a relevant, reliable tool for assessing clinical reasoning in optometry. Several studies in other fields have demonstrated that it is possible to use script concordance tests for formative purposes, such as self-evaluation[30] or for certification,[25,31] whether as part of initial training,[32] continuing education[33] or for identifying 'poorly performing' professionals.[34] As this is

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the first study done on the use of a script concordance test in optometry, such possibilities remain to be explored. The 77-question test produced for this study could be used to assess different student or optometrist populations at various levels of expertise.

Previous studies have demonstrated that script concordance test results correlate fairly well with clinical performance,[35] while they correlate poorly with multiple-choice questionnaires.[35,36] It might have been useful to compare the results of the script concordance test with those obtained by students during their clinical internships. This facet was deliberately omitted to preserve the confidentiality of the answers and to reassure participants that their performance would not be viewed judgmentally. In fact, the Web platform options retained prevented tracking of participants' answers, for either students or the reference panel. This made it impossible for the researchers to discover whether students with higher script concordance test scores also had better academic or clinical performances. If the script concordance test were to be placed within a credited academic activity, verification of this aspect would become feasible.

Developing a script concordance test is an exacting task that calls upon the skills of a number of people. The writers should be familiar with the purpose, target audience and content domain of the test.[18] Teams of two test writers optimise creativity and productivity.[16] The scenarios and questions are then revised and adapted to provide the best possible reflection of clinical reality.[18] Recruiting a reference panel may at first seem to be a hindrance to developing a script concordance test, as answering questions on a script concordance test that has not been optimised (before the least-useful items are discarded) takes time. In practice, because the clinical situations proposed closely resemble the clinicians' own daily realities, and therefore they have no need to prepare,[37] it was relatively easy to recruit members of the reference panel for this study. Once a script concordance test has been drawn up, it is an easy tool to administer and manage, especially once it is online. Numerous options are possible, depending on how the test is to be used: time limits, data de-identification, immediate or later feedback and so forth. For example, it might be possible to construct a script concordance test that allows learners to see how many members of the reference panel have answered every option on the Likert scale or a script concordance test might allow learners to view the comments made by the reference panel, if such comments had been collected, while the panel was answering the script concordance test. This would allow learners to compare their own reasoning processes with those of experienced professionals and it would encourage learners to reflect on their own capacities and learning processes.

Sound evidence supports the validity, reliability and feasibility of script concordance tests.[28,37] The script concordance test's scoring system accounts for the variability of responses of experienced health professionals to clinical situations; however, some authors have criticised the aggregate scoring method[38,39] and have suggested that members of a reference panel completing a script concordance test should also discuss their responses, clarify their rationales, and reach consensus on the correct answers.[39] This goes against previous work that has shown that response variability among the members of a reference panel is a key determinant of a script concordance test's discriminatory power.[40] It has also been suggested that the avoidance of extreme responses (-2 or +2 on the Likert scale) could raise examinees' test scores[38,41] and that increasing the proportion of questions with extreme modal answers to 50 per cent would contribute to overcoming this problem.[41] Because the script concordance test is not yet known in optometry, it is unlikely that the participants in this study have intentionally exploited this potential weakness. Moreover, the distribution of answers was similar between the students and the members of the reference panel (Table 4), so this is unlikely to have had much effect on the results of this study. Research investigating optimal methods for selecting scoring and standard setting for script concordance tests is on-going.[42–44]

Since this first experience with a script concordance test in optometry has been shown to be conclusive, the next step will be expanding the bank of clinical scenarios. This means, among others, contemplating the creation of more scenarios with visual content (visual field, topography, imaging, photographs, videos). This is because interpreting such data requires perceptual and interpretative skills that are hard to assess using conventional methods.[7] In conclusion, this study has demonstrated the reliability and validity of the script concordance test in optometry. The script concordance test is an assessment and learning tool that is well worth considering as a complement to the pedagogical tools already available.

Likert scale	Distribution of answers		
	Reference panel	Second- year students	Fourth-year students
- 2	15 %	12 %	12 %
- 1	19 %	23 %	23 %
0	24 %	19 %	20 %
+1	27 %	32 %	30 %
+2	15 %	14 %	15 %

Table 4. The distribution of the answers given by the members of the reference panel and by the students

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