ORIGINAL ARTICLE

The Script Concordance Test: A New Tool Assessing Clinical Judgement in Neurology

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ABSTRACT: ***Background:*** Clinical judgment, the ability to make appropriate decisions in uncertain situations, is central to neurological practice, but objective measures of clinical judgment in neurology trainees are lacking. The Script Concordance Test (SCT), based on script theory from cognitive psychology, uses authentic clinical scenarios to compare a trainee's judgment skills with those of experts. The SCT has been validated in several medical disciplines, but has not been investigated in neurology. ***Methods:*** We developed an Internet-based neurology SCT (NSCT) comprising 24 clinical scenarios with three to four questions each. The scenarios were designed to reflect the uncertainty of real-life clinical encounters in adult neurology. The questions explored aspects of the scenario in which several responses might be acceptable; trainees were asked to judge which response they considered to be best. Forty-one PGY1-PGY5 neurology residents and eight medical students from three North American neurology programs (McGill, Calgary, and Mayo Clinic) completed the NSCT. The responses of trainees to each question were compared with the aggregate responses of an expert panel of 16 attending neurologists. ***Results:*** The NSCT demonstrated good reliability (Cronbach alpha = 0.79). Neurology residents scored higher than medical students and lower than attending neurologists, supporting the test's construct validity. Furthermore, NSCT scores discriminated between senior (PGY3-5) and junior residents (PGY1-2). ***Conclusions:*** Our NSCT is a practical and reliable instrument, and our findings support its construct validity for assessing judgment in neurology trainees. The NSCT has potentially widespread applications as an evaluation tool, both in neurology training and for licensing examinations.

RÉSUMÉ: Le test de concordance de script : un nouvel outil pour évaluer le jugement clinique en neurologie. ***Contexte :*** Le jugement clinique, la capacité de prendre des décisions appropriées dans des situations ambiguës, est au cœur de la pratique en neurologie. Cependant, nous manquons de mesures d'évaluation objective du jugement clinique chez les résidents en neurologie. Le test de concordance de script (TCS), qui est fondé sur la théorie du script en psychologie cognitive, utilise des scénarios cliniques authentiques pour comparer les habiletés de jugement d'étudiants en formation à celles d'experts. Le TCS a été validé dans plusieurs disciplines médicales, mais non en neurologie. ***Méthodes :*** Nous avons élaboré un TCS pour la neurologie (TCSN) via Internet de 24 scénarios cliniques comportant 3 ou 4 questions chacun. Les scénarios ont été élaborés de telle sorte qu'ils reflètent l'ambiguïté rencontrée en clinique de neurologie adulte. Les questions explorent des aspects du scénario pour lesquels plusieurs réponses pourraient être acceptables; on demande aux étudiants de juger quelle réponse ils considèrent comme étant la meilleure. Quarante et un étudiants de la première à la cinquième année de résidence en neurologie et 8 étudiants en médecine qui participent à trois programmes de neurologie nord-américains (McGill, Calgary et Mayo Clinic) ont complété le TCSN. Les réponses des participants à chaque question ont été comparées à une agrégation des réponses d'un groupe d'experts composé de 16 neurologues. ***Résultats :*** La fiabilité du TCSN était très bonne (coefficient alpha de Cronbach = 0,79). Les notes des résidents en neurologie étaient meilleures que celles des étudiants en médecine et moins bonnes que celles des neurologues, ce qui est en faveur de la validité de la structure du test. De plus, les scores TCSN ont pu distinguer les résidents seniors (résidents 3-5) des résidents juniors (résidents 1-2). ***Conclusions :*** Notre TCSN est un outil pratique et fiable et nos observations appuient la validité de sa structure pour évaluer le jugement chez les étudiants en neurologie. Le TCSN pourrait avoir des applications étendues comme outil d'évaluation tant dans la formation en neurologie qu'au cours des examens de licence d'exercice.

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The evolution from novice to expert is a central process in medical education. Clinical supervisors in neurology training programs must monitor this evolution and determine whether residents have achieved sufficient levels of competence for independent practice. Although clinical judgment - the ability to make appropriate decisions in uncertain or ambiguous situations[1,2] - is an integral part of competence in neurology,

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evaluation of "judgment skills" presents a particular challenge to neurological educators.

Whereas factual knowledge is relatively straightforward to assess using traditional testing methods (such as multiple choice or short-answer examinations), standardized measures of clinical judgment in neurology are lacking. At present, assessment of clinical judgment in most residency training programs involves global ratings by staff who observe residents in the clinical setting over the length of a clinical rotation[3]. Global ratings, however, are subject to bias, and tend to demonstrate limited reproducibility and objectivity[4].

The Script Concordance Test (SCT)[5] is an evaluation tool that aims to assess clinical judgment objectively in medical trainees. The SCT builds on the principles and characteristics of script theory, which emerged from the cognitive psychology literature out of a larger debate about the nature of expertise[6]. Although experts in a field generally possess more knowledge than novices, script theory posits that the real hallmark of an expert is not merely the amount of accumulated knowledge possessed, but also how knowledge is organized in the expert's mind[7]. Applied to medicine, script theory proposes that networks of knowledge, called "illness scripts," begin to form during the very first clinical encounter, and become refined with experience[8]. Each time a physician is faced with a new patient, incoming data (symptoms, signs, laboratory data, etc.) activate relevant pre-existing networks of knowledge (illness scripts) that direct the selection and interpretation of these data[9]. The evolution of illness scripts enables medical experts to make accurate clinical decisions rapidly, efficiently, and often with minimal conscious effort, in the context of ill-defined or incomplete information[6]. This ability is the cornerstone of clinical judgment.

The SCT seeks to monitor the development of illness scripts in trainees during their evolution from novice to expert by comparing their performance on the test to that of a panel of expert clinicians. Although the SCT has been shown to be a valid and reliable instrument for assessing clinical judgment in several medical disciplines[10-14], it has not yet been explored in the field of neurology. Given that decision-making in the face of uncertainty is central to the practice of neurology, we felt that the SCT was promising as a means to assess this essential clinical skill in neurology trainees. Early applications of the SCT were paper-based, but an on-line version has demonstrated feasibility and reliability[15,16]. We felt a web-based SCT would lend itself particularly well to neurology, as this allows easy incorporation of images and video segments, enhancing the authenticity of the test-taking experience, and allowing assessment of clinical judgments involving subtle or ambiguous examination signs upon which decisions in neurology often hinge.

In this paper we describe the development of a web-based neurology SCT (NSCT) using scenarios from clinical practice, and ask: Is the NSCT a valid and practical instrument for assessing clinical judgment in neurology?

Methods

Format of SCT questions

Figure 1 gives examples of the basic format of questions in an SCT. The format is patterned after a standard model of the clinical reasoning process, the "hypothetico-deductive" (HD) model. The HD model proposes that very early on during a clinical encounter, clinicians generate a few hypotheses based on patients' initial verbal and nonverbal cues, and then collect data (i.e., relevant history, physical exam, laboratory results and other investigations, etc.) to confirm or reject these hypotheses[17]. The SCT format parallels the steps of the clinical reasoning process outlined by the HD model. The case description provides early patient cues, and the three columns correspond to the stages of hypothesis generation ("…if you were thinking…"), data collection ("…and then you find…"), and hypothesis evaluation ("…this hypothesis becomes…") (see Figure 2).

Case 1: You are evaluating a 60 year-old man with left hemiparesis in the emergency room.

If you were considering:	And you find:	Your hypothesis becomes:				
1. Cerebral abscess	Patient had dental work 10 days ago	-2	-1	0	+1	+2
2. Ischemic stroke	Symptoms began suddenly, 2 hours ago	-2	-1	0	+1	+2
3. Cerebral metastasis	Normal contrast-enhanced CT head	-2	-1	0	+1	+2

Case 2: A 35 year-old patient has been referred to your clinic for evaluation of severe, episodic right fronto-periorbital headaches associated with nausea.

If you were considering:	And you find:	Your hypothesis becomes:				
4. Cluster headaches	Patient prefers to lie down in dark room during attacks	-2	-1	0	+1	+2
5. Paroxysmal hemicrania	Nasal congestion during attacks	-2	-1	0	+1	+2
6. Migraine	History of herpes zoster ophthalmicus	-2	-1	0	+1	+2

Figure 1: *Two script concordance test cases with 3 questions each. -2=Ruled out or almost ruled out; -1=Less probable; 0=Neither less nor more probable; +1=More probable; +2=Certain or almost certain*

Scoring

Scoring of the SCT is designed to take into account the real-life variability of responses of experts to particular clinical situations. Rather than trying to define a single "correct" answer to the ambiguous clinical scenario, examinees' responses to each question are compared with the aggregate responses of an expert panel. As trainees evolve towards becoming experts, their responses will resemble more closely those of the expert panel. In other words, the SCT measures how closely the clinical decisions of examinees are in concordance with those of experts.

After an expert panel is selected, each expert completes the test, and the aggregated responses of the experts to each item forms the test's answer grid. Previous work has shown that the reference panel of experts should consist of 15 to 20 members to achieve optimal reliability[18]. The scoring scheme for each question is determined by the frequency with which each response is chosen by the experts, based on a 5-point Likert scale (-2, -1, 0, +1, +2). To ensure that each question in the test is given equal weight, the value assigned to each response in a given question is transformed proportionally to give a maximum

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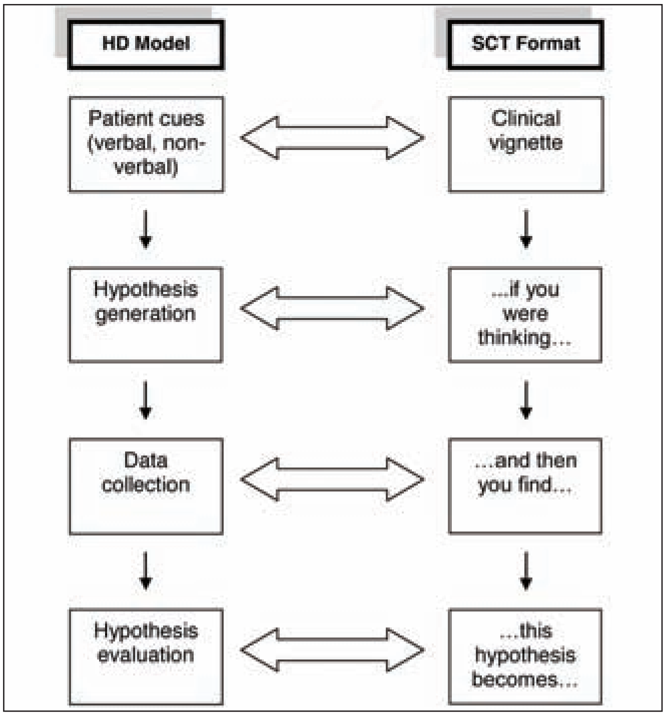

***Figure 2:** Relationship between the hypothetico-deductive model of clinical problem solving and the format of script concordance test questions.*

score of 1 for the response chosen by most of the experts (i.e., the mode); other responses are given fractional scores, depending on the number of experts choosing them. Responses not chosen by experts receive zero. An example of the scoring grid is shown in Figure 3.

Test construction

Previous work has shown that the optimal design for an SCT is three questions per clinical case, and that a total of 60 questions is needed to achieve a reliability coefficient higher than 0.75[19]. More questions than necessary are initially formulated; once the test has been taken by a group of participants, it can then be optimized by an item analysis method described elsewhere[20]. With item analysis, shorter and more reliable tests can be produced. Bearing these principles in mind, we developed 24 cases with 3-4 questions each, for a total of 94

A demo version of the test can be viewed at:

http://www.fpcmed2.umontreal.ca/sctdemo/.

Participants

Forty-one adult PGY1-PGY5 residents and eight neurology clerkship students from three North American neurology programs (McGill University, University of Calgary, and Mayo Clinic) volunteered to complete the test. The expert panel comprised 16 attending neurologists from McGill teaching hospitals who were at least three years post-certification, who regularly attended on consultation or ward services (at least one month per year), and who were recognized for their clinical expertise and teaching skills. All participants (students, residents, and experts) contributed their responses anonymously; only information regarding their level of training and institutional affiliation was collected. We received approval from the McGill University Institutional Review Board to conduct this study.

Statistical analysis

Reliability of scores was tested using Cronbach's alpha coefficient, and test optimization was achieved by eliminating questions with item-total correlations lower than 0.05. A one-way ANOVA with Dunnett post-hoc test was used to compare SCT scores of the three groups. A linear polynomial contrast was used to test for a significant trend in the data. A Spearman non-parametric correlation was calculated to estimate the strength of the relationship between scores on SCT and level of expertise. All p values were considered significant at $\alpha \leq 0.05$.

Answer	-2	-1	0	+1	+2
Number of experts choosing this answer	0	0	1	5	4
Score	0	0	1/10	5/10	4/10
Transformed score	0	0	1/5	5/5	4/5
Credit per question	0	0	0.2	1.0	0.8

***Figure 3:** An example of the SCT scoring system. Suppose a panel of 10 experts was asked to respond to the first question in the example given in Figure 1, and 5 experts chose response +1, 4 experts chose response +2, and 1 expert chose response 0. The scoring for this item would be: response 0, 0.2 points (1/5); response +1, 1 point (5/5); response +2, 0.8 points (4/5); responses -1 and -2, both 0 points. An examinee's total score for the test is the sum of the credit obtained for each of the items, divided by the total obtainable credit for the test and multiplied by 100 to derive a percentage score.*

Results

All participants completed the test within the allotted 90 minutes. The average time-to-completion of the test was 44.99 minutes (range 22.67 min–71.20 min), with no significant differences between experts, residents, and students. The Cronbach α of the full 94-question test was 0.74. Fifteen questions showed unsatisfactory item/total correlation (<0.05). Exclusion of these 15 questions yielded a 79-question test with a Cronbach α reliability coefficient of 0.79, which would take an estimated average of 40 minutes to complete.

Comparison of groups using the optimized 79-question NSCT yielded statistically significant differences between students (N = 8; mean score 63.6%; SD 6.3) and experts (N = 16; 80.8%; SD 5.2) ($p < 0.05$), and between residents (N = 41; 70.3%; SD 8.8) and experts ($p < 0.05$) (Figure 4). The mean difference between students and residents did not achieve statistical significance (p

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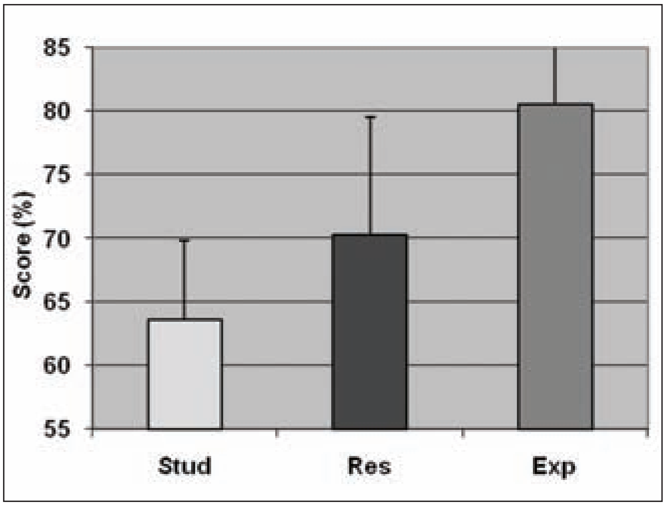

Figure 4: *Comparison of scores by level of training. Mean scores and standard deviations are shown.*

= 0.08). When junior level residents (PGY1-2, n = 16) were compared with senior level residents (PGY3-5, n = 25), significant differences between their mean scores were found (65.6%, SD 9.4 vs. 73.3%, SD 7.0; p = 0.05) (Figure 5). The performance of the participants from the three training programs was similar (mean scores: McGill = 70.5%, SD 10.5 (n = 17) vs. Mayo = 72.2%, SD 7.3 (n =17) vs. Calgary = 65.3%, SD 6.4 (n = 7); p = 0.22).

Discussion

Large-scale accreditation bodies in Canada and the U.S. have highlighted the importance for residency programs to appraise elements of physician competency beyond factual knowledge in their medical trainees. In 1996, the Royal College of Physicians and Surgeons of Canada introduced CanMEDS, a framework for medical education that articulates the full range of competencies expected of skilled physicians upon completion of their training. The American Accreditation Council for Graduate Medical Education has recently undertaken an initiative to promote the use of standardized, reliable, and valid methods to assess higher clinical competencies in residency education programs[23]. For maintenance of accreditation, the American Board of Medical Specialties employs educational and self-assessment instruments that seek to ensure that physicians "have the fundamental, practice-related and practice environment–related knowledge to provide quality care in their respective specialty[24]."

To date, however, many existing assessment tools, such as multiple-choice questionnaires, short- or long-answer written exams, and OSCEs, are often resource-intensive, cumbersome to administer or score, difficult to standardize, or limited to probing pure factual knowledge. The Script Concordance Test seeks to provide a practical, objective method for evaluating clinical judgment, a critical higher level competency that is currently assessed subjectively and rather informally in most training programs[3].

The aim of this study was to develop and validate a new SCT for use in neurology. In a valid test of clinical judgment, a group of residents would be expected, on average, to outperform a group of medical students, while a group of attending neurologists should achieve the highest mean scores. A test that cannot distinguish between groups of increasing level of training and expertise would be of little practical use. In fact, some fact-based methods of evaluation have been criticized for eliciting an "intermediate effect," whereby trainees at intermediate levels of expertise outperform both novices and experts[25]. On our NSCT, residents scored higher than students but lower than staff neurologists, supporting the construct validity of the test. Furthermore, senior-level residents scored almost 10% higher than junior-level residents, demonstrating an important potential discriminatory power of the NSCT. The test also demonstrated good internal consistency, with a Cronbach α coefficient of 0.79.

The NSCT questions were created by two of the authors (SL and CC) over approximately two months. The test's website, built from scratch by a third author (DK), was functional four months from the onset of the study. The 16 panel members submitted their responses on-line during a two-week period, and most of the residents completed the test during two dedicated 90-minute group sessions. Students and residents unable to attend the dedicated sessions took the exam independently via the internet at any time of the day or night. The NSCT therefore proved to be feasible to implement, and future iterations are expected to be even more practical to organize now that the web template for the test is in place.

The web-based design of the test facilitated its administration and scoring. The incorporation of videos, a feature not previously used in script concordance tests in other disciplines,

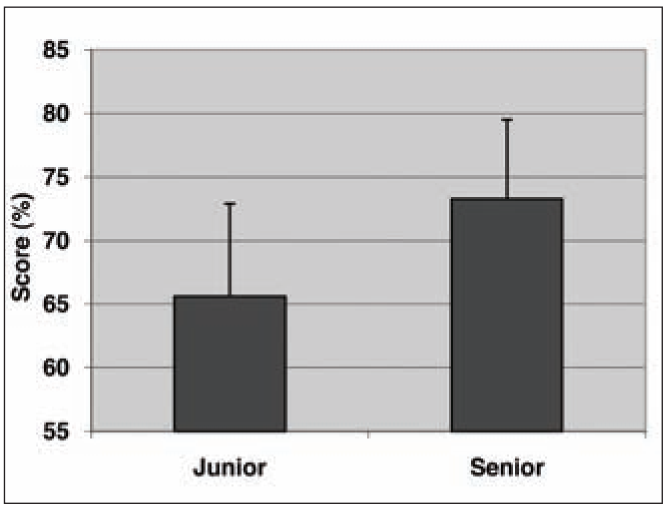

Figure 5: *Comparison of scores by residency level. Mean scores and standard deviations are shown.*

heightened the authenticity of the test-taking experience, and permitted assessment of clinical judgments relating to physical examination signs. Our NSCT also has the capability to provide examinees with instant feedback about the expert responses to each question. We did not use this function in the present study, but we think it may allow the NSCT to be used as a formative as well as a summative assessment tool for trainees in neurology.

The NSCT has broad potential applications in neurological education, from the undergraduate level to specialist certification and maintenance of competence evaluations. Based on our results, we think the NSCT may be particularly useful in the middle of residency training, where it may detect trainees who are not suitable for promotion from a junior to a senior level at a time when opportunities for remediation still exist. The NSCT may also be useful for providing objective feedback to trainees noted to exhibit “poor judgment” during their routine clinical activities, but whose substandard performance is not reflected in scores obtained on in-training tests of pure factual knowledge.

Some participants feel uncomfortable taking a test in which there are no single correct answers. Trainees instructed under a predominantly biomedical educational model may be accustomed to a certain form of examsmanship that promotes right-or-wrong thinking, which is inconsistent with the type of interpretation that occurs during most encounters with patients. The NSCT seeks to identify trainees who demonstrate a flair for choosing the best course of action, under conditions of uncertainty, from among several possible alternatives, rather than relying on black-and-white reasoning.

A limitation of the script concordance approach is that it offers little insight into an examinee’s reasoning process, the “why” behind each response. However, previous work has shown that when doctors are faced with a particular problem, their strategies for solving it may vastly diverge[26]. According to script theory, since no two physicians will have an identical repertoire of scripts, they may ask different questions and examine patients differently, even in similar clinical contexts. This observation renders assessment of the reasoning process for the purpose of standardized evaluation difficult. Nevertheless, despite their divergent lines of reasoning, experts in medicine tend to arrive at conclusions that are similar – i.e., that are largely concordant[26]. Our findings are consistent with this hypothesis: the standard deviation was lowest among the expert group, indicating the least variability in distribution of responses to the questions.

Another challenge to the validity of the script concordance paradigm is the presumption of expertise among the members of the expert panel. For the purpose of this study, we defined an “expert” as a physician with formal credentials in neurology (i.e., one who has obtained specialty certification in neurology from a national licensing body), and who is experienced in the practice of general neurology (i.e., one who is at least three years post-certification, and attends regularly on consultation or ward services). In addition, we chose panelists based on their reputation for sound clinical judgment, presuming that they possessed illness scripts with sufficient breadth and organization to render them legitimate experts in clinical neurology. Though little consensus about adequate measures of expertise exists in the medical education literature[27], we feel that our selected members reflect acceptable community standards of expertise in neurology. Our finding that the standard deviation of error was lowest among the expert group lends credence to the legitimacy of our expert selection process. It would be of interest in the future to compare the performance of expert panels from different institutions on the NSCT.

Our study shows that the NSCT is a valid and reliable tool for assessing clinical judgment in neurology. It also appears to be practical, authentic, and versatile. The NSCT has potential as a valuable adjunct to other traditional standardized methods of evaluation of neurology trainees, both in neurology training programs and for certification examinations. Its implementation in Canadian neurology programs could become a useful strategy to support the CanMEDS thrust to train medical experts who “demonstrate effective clinical problem solving and judgment to address patient problems, interpret available data and integrate information[28].”

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