Using the script concordance test to assess clinical reasoning skills in undergraduate and postgraduate medicine

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ABSTRACT

The script concordance test is a relatively new format of written assessment that is used to assess higher-order clinical reasoning and data interpretation skills in medicine. Candidates are presented with a clinical scenario, followed by the reveal of a new piece of information. The candidates are then asked to assess whether this additional information increases or decreases the probability or likelihood of a particular diagnostic, investigative, or management decision. To score these questions, the candidate’s decision in each question is compared with that of a reference panel of expert clinicians. This review focuses on the development of quality script concordance questions, using expert panellists to score the items and set the passing score standard, and the challenges in the practical implementation (including pitfalls to avoid) of the written assessment.

Introduction

Script concordance test (SCT) is a relatively new format of written assessment to assess higher-order clinical reasoning and data interpretation skills of medical candidates.1

In recent years, universities and postgraduate colleges worldwide have used SCT for both formative and summative assessment of clinical reasoning in various medical disciplines including paediatric medicine, paediatric emergency medicine, neurology, orthopaedics, surgery, and radiology.2-8 In the classic written assessment, multiple-choice questions (MCQ) and short-answer questions (SAQ) usually examine the candidates’ simple knowledge recall at the lowest ‘knows’ level of the Miller’s Pyramid (Fig 1).9,10 Questions in SCT are able to test candidates at the higher order of thinking at the ‘knows how’ and even ‘shows how’ level. It is a unique assessment tool that targets the essential clinical reasoning and data interpretation skills in a very authentic way that reflects the element of ‘uncertainty’ in real-world clinical scenarios prevalent in clinical practice. This is the key aspect of clinical competency that enables medical graduates or fellows in training to link and transfer their mastery of declarative clinical knowledge and skills into clinical practice in a real clinical setting. Recent literature reports the value of using SCT to assess other areas of disciplines where classic questions are difficult to develop, for example, in assessing medical ethical principles and professionalism.11

The structure and format of script concordance test

In SCT, candidates are presented with a clinical vignette/scenario, followed by the reveal of a new piece of information. The candidates are then asked to assess whether this additional information increases or decreases the probability or likelihood of the suggested provisional diagnosis, increases or decreases the usefulness/appropriateness of a proposed investigation or management option. The process reflects everyday real-world decision-making processes where clinicians retrieve their ‘illness scripts’ or network of knowledge (about similar patient problems and presentations stored in their memory) when faced with uncertainty in a clinical presentation. This enables them to determine the follow-on diagnosis and management options most appropriate to the situation. As further clinical encounters are experienced, the scripts are updated...
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A recent study, however, raised concerns about the reference standard and judgement of the expert panel. The study compared 15 emergency medicine consultants’ judgement scores with evidence-based likelihood ratios. The results showed that 73.3% of the mean judgement was significantly different to the corresponding likelihood ratios, with 30% overestimation, 30% underestimation, and 13.3% with diagnostic values in the opposite direction.20 Other studies raised concerns about the possibility of outdated clinical knowledge and cognitive bias in the experts’ decision-making.21,22 Evidence of context specificity has also been highlighted whereby the agreement between SCT scores derived using different scoring keys with expert reference panels from a different context (hospitals and specialty) was poor.23

Implementation of script concordance test in formative and summative assessments

The structure and layout of the SCT questions can easily be implemented in the usual pen and paper-based or online electronic format. Candidates answer each question (with five options) using a standardised answer sheet to facilitate computer scanning and scoring or directly online using the computer.

It is often difficult to get busy clinicians to meet together face-to-face to answer the questions. By uploading the questions online, the panellists can attempt them anytime and make the questions available through a secure online platform. The response data can then be collated and the weighted

### TABLE 1. Sample questions of script concordance test

#### Clinical scenario

**A:** A 22-year-old woman presents to the Emergency Department with severe abdominal pain.

<table>
<thead>
<tr>
<th>If you were thinking of...</th>
<th>and then you find that...</th>
<th>this hypothesis becomes...</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Ruptured ectopic pregnancy</td>
<td>Her serum lH-COG is negative</td>
<td>-2 B C D E</td>
</tr>
<tr>
<td>2 Acute appendicitis</td>
<td>On abdominal examination, there is marked guarding and rigidity</td>
<td>-2 B C D E</td>
</tr>
<tr>
<td>3 Acute cholecystitis</td>
<td>Her temperature is 36.8°C</td>
<td>-2 B C D E</td>
</tr>
</tbody>
</table>

**B:** A 16-year-old girl is brought to the Emergency Department by her parents. She has been vomiting and complains of generalised abdominal pain.

<table>
<thead>
<tr>
<th>If you were thinking of ordering the following...</th>
<th>and then you find that...</th>
<th>then your plan of action becomes...</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 CT abdomen</td>
<td>Her last menstrual period was 8 weeks ago</td>
<td>-2 B C D E</td>
</tr>
<tr>
<td>5 Laparoscopy</td>
<td>CT abdomen is normal</td>
<td>-2 B C D E</td>
</tr>
<tr>
<td>6 CT abdomen</td>
<td>Her blood glucose level is 32 mmol/L (reference range, 3.5-7.0 mmol/L)</td>
<td>-2 B C D E</td>
</tr>
</tbody>
</table>

**C:** A 55-year-old woman with previous asthma presents with acute shortness of breath. She is afebrile. You find she has a diffuse expiratory wheeze.

<table>
<thead>
<tr>
<th>If you were thinking of ...</th>
<th>and then you find that...</th>
<th>then your plan of action becomes...</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 Giving morphine for her distress</td>
<td>Her PO₂ is 55 mm Hg and her PCO₂ is 60 mm Hg</td>
<td>-2 B C D E</td>
</tr>
<tr>
<td>8 Giving hydrocortisone intravenously</td>
<td>Her blood glucose is 24.2 mmol/L</td>
<td>-2 B C D E</td>
</tr>
<tr>
<td>9 Giving 5 mg salbutamol by nebuliser</td>
<td>Her pulse rate is 120 bpm</td>
<td>-2 B C D E</td>
</tr>
</tbody>
</table>

Abbreviations: bpm = beats per minute; lH-COG = beta–human chorionic gonadotropin; CT = computed tomography; PCO₂ = partial pressure of carbon dioxide; PO₂ = partial pressure of oxygen

### TABLE 2. The formula to calculate the weighted scores

<table>
<thead>
<tr>
<th>Score key</th>
<th>-2</th>
<th>-1</th>
<th>0</th>
<th>+1</th>
<th>+2</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of panellists choosing the answer (out of 10)</td>
<td>7</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Formula</td>
<td>7/7</td>
<td>2/7</td>
<td>1/7</td>
<td>0/7</td>
<td>0/7</td>
</tr>
<tr>
<td>Candidate score</td>
<td>1</td>
<td>0.29</td>
<td>0.14</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
scores for responses on each score scale calculated.3

After capturing the candidates’ responses for all items, scoring of responses for each question can then be performed using the formula described above. This will ensure a rapid turnaround time that will be very effective in the assessment process.

For formative assessment purposes, expert panel consensus scores are provided to the candidates, followed by expert clinicians explaining and discussing the options in each scenario with the candidates for constructive feedback. Script concordance test can also be used to identify borderline students with suboptimal clinical reasoning skills for appropriate remedial measures such as bedside teaching, tutorials, or clinical simulations.24

For summative assessment purposes, particularly where there is not a large pool of SCT items, it is important to avoid constructing irrelevant variance in SCT scores, by not releasing or discussing post-examination, the expected responses (based on expert panel's responses), and the associated score for each of the answer options in SCT items.

Unlike MCQ where there is only one single best answer that candidates could memorise and disseminate after the examination, the partial credit scoring model applied in SCT, where multiple answer options are accepted and each carries a fraction or all of the allocated mark, has to a certain extent rendered sharing of ‘correct’ answers after the examination difficult.

Developing quality script concordance test questions

Each clinical scenario has to be authentic and the presentation represents a realistic clinical encounter that is relevant to the specific discipline, preferably with a certain degree of uncertainty. The new information presented needs to stimulate the candidate to re-consider and re-evaluate how that particular piece of new information will affect the likelihood of the initial diagnosis, or appropriateness of initial planned investigation or management option. This will ensure the content validity in the SCT questions.

Particular care should be taken to develop options that will attract the full range of the five options available for the candidate to choose from. In other words, the additional pieces of new information should result in the consideration of -2 and +2 as well as -1, 0, and +1 options. A test-wise candidate might choose to consider only the options of -1, 0 and +1 if they notice that most panel consensus answers with a full score of 1 mark usually fall within these three options rather than also covering the -2 and +2.25 As a result, developing good-quality SCT questions is not easy. Care should be taken to develop clinical scenarios that do not focus solely on factual recall but involve a reasoning process with elements of uncertainty that will likely attract responses that spread across the 5-point Likert scale.26

Reliability and validity of script concordance test as an assessment tool

The reliability of SCT as an assessment tool has been investigated.2,6 A 60- to 90-minute examination will produce a Cronbach’s alpha of 0.70 to 0.85.2,25,27,28 There are concerns, however, about inter-panellist errors in SCT; the use of Cronbach's alpha in measuring the reliability of the test where partial credit model of scoring is used, ie multiple options/responses are awarded either a full or fraction of allocated mark; and case scenarios that could create inconsistencies among items.

As an assessment tool, SCT has been shown to be valid in assessing clinical reasoning.13,14,19,28 Studies have shown that SCT scores correlate well with other assessment scores from the clinical years of the candidates.2

The construct validity of SCT questions can be examined by correlating the scores with the level of training to predict future performance on clinical reasoning. A recent study has compared the progression of clinical reasoning skills of medical students with those of a group of practising GPs who are also their Problem Based Learning group tutors.29 Another study showed that there was a statistically significant gain in SCT performance over a 2-year period in two different cohorts of medical students using the same set of 75-item SCT.26 There was significant progression of clinical reasoning skills from medical students at the novice level through to practising GP clinicians, reflected by the higher scores in the GP group attempting the SCT questions. Empirical evidence supporting the construct validity based on progression of SCT scores with clinical experience from undergraduate students to postgraduate training has also been reported.2,5,24,30,31 The construct validity of SCT has been questioned because of the logical inconsistencies as a result of partial credit scoring methodology making it possible for a hypothesis to be simultaneously more likely and less likely.32 Nonetheless, a certain degree of variability in panel scores has been shown to be a key determinant of the discriminatory power of the test and allows richness of thinking about clinical cases.3,34 Another study found that 27% of residents in one SCT administration scored above the expert panel's mean, which may indicate issues with the construct validity, particularly in the credibility and validity of the scoring key and hence the resulting SCT scores interpretation.33

Test-wise candidates would select the answers to be around ‘0’ rather than ‘-2’ or ‘+2’ if they noticed
that most panellist scores did not fall in the ‘extreme’ (-2 or +2) range due to the construct of the SCT questions and options. This could be avoided by first using the option descriptor of “much less likely (-2)” and “much more likely (+2) rather than “ruling out the diagnosis” and “almost certain/definite diagnosis” as described in the format of SCT section above.\(^3\) Second, when collating the SCT questions into an examination paper, one could select a relatively equal number of items with both ‘extreme’ answers as well as median answers. Recent data have shown that by employing the above strategies in developing the paper, candidate who chose ‘0’ for all the questions would score only around 25% in the SCT examination and would gain no advantage (unpublished data). This is in contrast to the finding of another study wherein candidates who chose the midpoint scale (‘0’) performed better than the average candidate.\(^3\)

The correlation of SCT scores with other modalities of assessment would be expected to be low as SCT is designed to measure clinical reasoning rather than factual or knowledge recall. The correlation coefficient between SCT and MCQ is poor \((r=0.22)\); SCT with extended matching questions (EMQ) was \(r=0.46\).\(^3\)

**Collating and moderating the expert reference panellist responses**

In collating the SCT questions for use in a summative examination, appropriate clinical scenarios/ vignettes with the related diagnoses, investigations, and management should be selected according to the blueprint of the assessment. The clinical topics should have a good spread and represent core areas of learning that are relevant to the curriculum and appropriate to the level of training of the candidates.

In reviewing the expert panel responses to each question, bi-modal and uniform divergence responses should trigger a detailed scrutiny of the clinical vignette and the options. In the case of bi-modal response (Fig 2a), the panel has an equal split of the best option between -2 and +2. This usually results from an error in the question or a controversial investigation or management option with discordant ‘expert opinions’. A modification of the question and re-scoring will usually solve this issue. If re-scoring results in the same bi-modal response, the question should be discarded for scoring in the examination. In the case of uniform divergence responses (Fig 2b), there is an equal spread in the number of members choosing all the five options. This usually signifies a non-discriminating question and the item should again be discarded. A discrete outlier response (Fig 2c) usually represents an error in the particular panellist’s decision or ‘clicking the wrong answer accidentally’ when the member should have answered -2 instead of +2. The ideal pattern would be relatively close convergence with some variation (Fig 2d).\(^3\)

As mentioned previously, the set of questions in the SCT examination should be selected in such a way that there are similar numbers of full marks in each option across the five options. This will avoid the test-wise candidates being advantaged by selecting only the -1, 0, or +1 options and avoiding the extreme options of -2 and +2.\(^3\) By employing this strategy to select questions that cover the full 5-point Likert scale, test-wise students will only score 25% in the SCT examination if they choose the response of ‘0’ for all questions (unpublished data) compared with 57.6% in another cohort sitting a SCT test without the specific question selection process.\(^3\)

**Standard setting the pass/fail cutoff score**

In setting the pass/fail cutoff score of the SCT questions, the expert panels’ mean scores and standard deviations are chosen to guide the process. This is calculated by asking all the members of the panel to attempt the same set of SCT questions and their responses are then scored accordingly. The borderline score of the undergraduate students is usually set at 3 to 4 standard deviations below the expert panel’s mean score.\(^3,35\) Studies have shown that using recent graduates or fellows in training might result in a mean score that is closer to the students’ mean and therefore a smaller number of standard deviations would be more appropriate.\(^3\)

Other methods of standard setting include using the single correct answer method.\(^29,36\) Standard setting of a pass/fail cutoff score is an area that warrants ongoing research to inform and improve the practice of using SCT as a summative assessment tool for clinical data interpretation and decision-making skills.

**The use of script concordance test in the Asia-Pacific region and its limitations**

Examinations using SCT have been successfully implemented in the school-entry medical schools in Indonesia, Singapore, Taiwan, and Australia;\(^5,7,36,37\); and in graduate-entry medical schools in Australia.\(^29,38\) Such test has the potential to supplement MCQ and SAQ to test the higher-order thinking of medical candidates to allow a more robust overall written assessment in the assessment programme. In fact, SCT is one of the few currently available assessment tools for clinical reasoning in a written format.\(^28\) It can be implemented relatively easily in the paper-based format or online. Initial
pilot examinations can be set as a formative exercise to enhance candidates' feedback and learning. Further collaboration with other institutions to develop, score, and share question items can ensure effective and efficient delivery of such examinations.

Limitations to the widespread usage of SCT could be due to: difficulties in developing good-quality SCT clinical scenarios, concerns about the validity of the test, recruiting a sufficient number of appropriate expert clinicians for the reference panel, lack of a general consensus in setting the borderline pass mark, and the candidates' familiarity with the question format.

Conclusions
This article attempts to review the current use of SCT in assessing clinical reasoning and data interpretation skills in undergraduate and postgraduate medicine. The empirical evidence reported for the reliability and validity of SCT scores from existing literature seems encouraging. Approaches to develop quality items, moderation of expert panel scoring and these post-hoc quality assurance measures, and optimisation of scoring scale will to a certain extent mitigate the threat to the validity of SCT score interpretation and its use for summative examination purposes. Combining SCT (testing the clinical reasoning and data interpretation skills with authentic written simulations of ill-defined clinical problems set at the 'knows how' level) with MCQ/SAQ/EMQ (testing the 'knows' and 'knows how'), objective structured clinical examination (testing 'shows how'), and workplace-based assessment (testing the 'does') in the medical curriculum will enhance the robustness and the credibility of the assessment programme.

Further research into the use of SCT in both undergraduate and postgraduate medical education is warranted, particularly on standard setting for the pass/fail cutoff score and best practices that may help reduce the threat to the validity of SCT scores.

References


