# SEMANTIC APPROACH TO SCRIPT CONCORDANCE TEST

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**Abstract**

*Clinical reasoning is a core competence of a physician and therefore a very important part of medical education. Application of the Script Concordance Test (SCT) in the assessment of clinical reasoning is present over the last two decades. Because of its high discriminatory quality, its application increases. With the rise of Semantic Web and ontologies in the fine-grain knowledge management and reasoning, the new possibilities for automatic question generations emerge. Creating a significant number of SCT question with the help of ontologies can reduce the workload of teachers in the construction of the SCT. This paper describes a concrete development of an ontology for the Script Concordance test assessment method, called SCTonto. Ontology testing shows that SCTonto is suitable for the purpose.*

**Keywords:** Semantic Web, Ontology, Script Concordance Test, Medical education

## INTRODUCTION

Clinical reasoning ability is probably the most core characteristic of any physician since it touches all aspects of patient care [1]. It can be said that clinical reasoning is a hypothetical-deductive process characterized by the early generation of hypotheses, oriented data collection, and decision-making judgment, using collected data to confirm or reject hypotheses [2].

Over the last two decades, the Script Concordance Test (SCT) proven to be one of the most appropriate assessment tools to measure clinical reasoning. Its application is spread in the various field of medicine [2-5] and several studies confirmed its feasibility, reliability, and validity [2,6].

Although some studies claim that SCT is relatively easy to construct and administer [2,3] it still needs a panel of at least 10 experts to decide on the different degrees of probability of a certain diagnosis [7]. Since the SCT method is suitable for computer-based assessment [8], there have been attempts to create question database in order to reduce the workload of teachers [9]. However, it still needs a number of experts to create each question in database and that is a time-consuming task. On the other hand, Semantic Web technologies facilitated the emergence of a new trend in question generation that is based on the use of ontologies [10,11]. Consequently, with the usage of Semantic Web, the SCT method can be significantly improved in terms of automatic question generation. Although several studies explored the generation of objective questions over ontologies, they are related to multiple choice question, its variations [10,12,13] and comprehensive integrative questions [14].

Research conducted to date provides no records of adoption of ontologies suitable for automatic generation of SCT assessment method specifically. Thus, the primary goal of this research was the development of SCTonto ontology that will be suitable for automatic generation of questions for the SCT assessment method.

## SCT DESCRIPTION

Script Concordance Test first presents students with a brief clinical scenario (clinical vignette) in which the information provided is insufficient to reach a decision (Figure 1) [8]. Students are then faced with three columns table. In the first column, there are several diagnostic hypotheses (usually, but not necessary, three) concerning the given scenario. The second column presents new

information (e.g. clinical data, an imaging study or a laboratory test result) that might have an effect on the diagnostic hypothesis. The third and final column gives a five-point Likert-type scale (see an illustration of three columns table in Figure 1). By selecting an appropriate number on the scale students judge the change in the likelihood of a diagnostic given a new piece of information. The five-point Likert scale ranges from –2 (the hypothesis is almost eliminated) through 0 (the information has no effect on the hypothesis) to +2 (it can only be this hypothesis) [2].

For each item, the students' response is compared with the composite judgment of a panel of experts, and credit points are assigned in accordance with the proportion of experts selecting the same response when test norms are constructed. If the student selects the same response as the majority of experts, he/she obtains the maximum number of credit points. If the student sides with a minority of experts, points are detracted. Otherwise, no points are awarded at all [15].

Because the clinical scenario presented is ambiguous, script-concordance items may provide insight into clinical judgment in the real world [16].

**Clinical vignette:** A 30-year-old male patient is admitted to the emergency room after a fall from a motorcycle with a direct impact on the pubis. Vital signs are normal. The X-ray reveals a fracture of the pelvis with a disjunction of the pubic symphysis.

| If you were thinking of | And then you find | This hypothesis becomes |
|---|---|---|
| Urethral rupture | Urethral bleeding | -2 -1 0 +1 +2 |
| Retroperitoneal bladder rupture | Bladder distension | -2 -1 0 +1 +2 |
| Intra-peritoneal bladder rupture | Spontaneous micturition after the accident | -2 -1 0 +1 +2 |

Notes: -2 = the hypothesis is almost eliminated
-1 = the hypothesis becomes less probable
0 = the information has no effect on the hypothesis
+1 = the hypothesis is becoming more probable
+2 = it can only be this hypothesis

***Fig. 1:*** *Script Concordance Test adapted from [2]*

## SCTONTO DEVELOPMENT

SCTonto ontology development was conducted following guidelines, given by [17]. The main goal of SCTonto is to support automatic SCT question generation. Users who will benefit from SCTonto are teachers whose workload will be significantly reduced, medical practitioners for self-assessment and researcher for further research purpose.

In order to define the scope of the SCTonto, several competency questions were identified. Some of them are: "Can each question have more than one clinical vignette?", "Can each question have more than one hypothesis?", "Does every new information item describe exactly one case description item?", "How many possible effects can one new information have on the hypothesis?", "How many responses can each question have?", etc.

Since SCTonto is an application ontology it needs domain ontology in order to be populated. Throughout our research, we have come to the conclusion that the Electronic Health Record (EHR) ontologies are best suited for this purpose. Although different in some elements, EHR ontologies have most of the concept that matches the main concepts in SCTonto ontology i.e. Symptoms and Signs (Case description in SCT), Diagnosis (Hypothesis in SCT), Laboratory and other analysis (New information in SCT), etc.

Based on the conducted analysis, several concepts and relations between them were identified that may be represented as classes and properties in the SCTonto ontology. Main classes are sct:Question, sct:CaseDescription, sct:Hypothesis, sct:NewInformation and sct:Response. Each individual instance of the sct:Question class is in a containment relation

with only one instance of the sct: CaseDesciption class, several instances of the sct:Hypothesis class, several instances of the sct:NewInformation class and several instances of the sct:Response class. In other words, each question consists of one case description, several hypotheses, several new information and several responses. This is modeled with properties sct:hasCaseDescription, sct:hasHypothesis, sct:hasNewInformation and sct:Response classes.

Each instance of sct:CaseDescription class is in containment relation with several instances of sct:NewInformation class. This means that case description can have several important information that are not presented in the clinical vignette. This is modeled with property sct:hasMissingPart. On the other hand, information that is not presented at the beginning belongs to only one clinical vignette. This is way each instance of sct:NewInformation is in a relationship with exactly one instance of the sct: CaseDescription class.

Since each new information may or may not have the effect on exactly one proposed hypothesis, this relationship is modeled with property sct:hasPossibleEffect. And vice versa, property sct:isPossibleEffectedBy represents relation where each instance of the sct:Hypothesis class is in a relationship with exactly one instance of the sct:NewInformation class.

Because students judge each hypothesis by selecting an appropriate number on the Likert scale, this relation is modeled with two properties: sct:hasResponseOfMajority and sct:hasResponseOfMinority. The first property represents the fact that maximum credit points are given if the majority of panel experts chose that same option. Similarly, property sct:hasResponseOfMinority represents the response of a minority of panel experts that chose that particular option. In order to achieve question automation, the response of a panel of experts is represented with a single diagnosis that matches the case description.

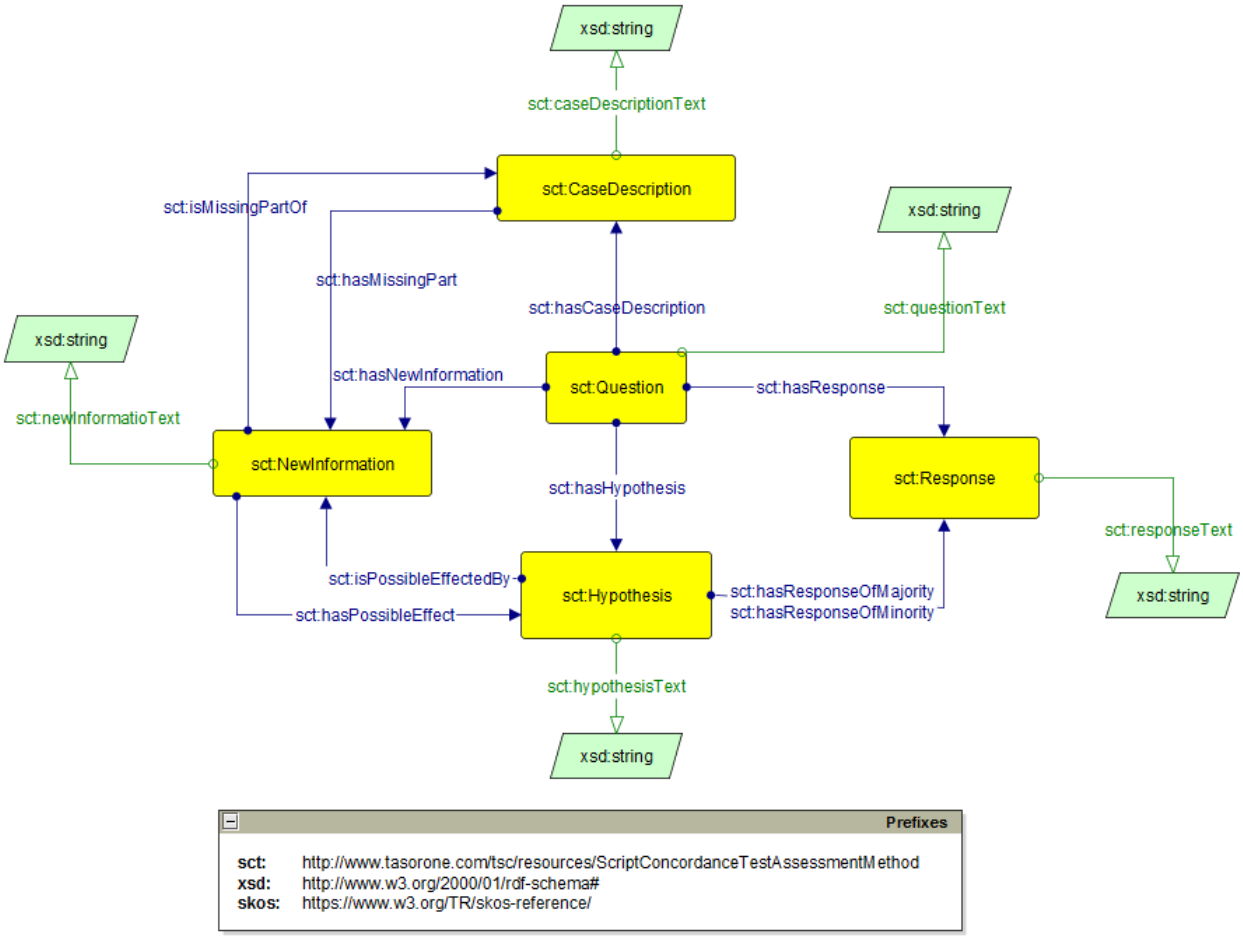


***Figure 2:*** *SCTonto ontology*

## ONTOLOGY TESTING

Ontology testing consists of the dynamic evaluation (through running code) of the behavior of an ontology on a finite set of test cases, against the expected behavior regarding the competency questions [17]. The following is the example of testing regarding competency question: ”Does every new information item describe exactly one case description item?“

```
 PREFIX rdf:
<http://www.w3.org/1999/02/22-rdf-syntax-
ns#>
 PREFIX rdfs:
<http://www.w3.org/2000/01/rdf-schema#>
PREFIX sct:
<http://www.tasorone.com/tsc/resources/Script
CorcondanceTestAssessmentMethod/>
 # single_case_describtion_rule: returns true
if broken ASK {
 FILTER (?number_of_new_information>
1)
 {
 SELECT ?q (count(?s) as
?number_of_new_information) WHERE {
 ?s rdf:type sct:NewInformation.
 ?q rdf:type sct:CaseDescription .
 ?q sct:isMissingPartOf ?s .
 }
 GROUP BY ?q
 }
 }
```

This query checks if the single caseDescription rule is broken (we use ASK type of SPARQL query that returns TRUE if query body returns a result). Since inspection of the query, as well as its test run, proven that query is efficient and simple enough, the conclusion can be made that using SCTonto for development of user-friendly and effective automatic assessment generation process is a promising approach. It should be noted that comprehensive evaluation followed by FOCA [18] methodology is one of the main tasks in future.

## CONCLUSION

The Script Concordance Test (SCT) assessment method has been proven to have high feasibility, reliability, and validity for clinical reasoning [7]. The wide adoption of this assessment method in different fields of medical education highlights the importance of its automatic generation. We have presented the process of developing ontology (SCTonto) for Script Concordance Test method, which supports automatic question generation. The in-depth analysis of concepts and relations in SCT assessment method is performed thus enabling the creation of ontology. Ontology testing was performed by SPARQL queries, which demonstrate that SCTonto is suitable for the development of user-friendly and effective automatic assessment generation process.

The future work will be focused on a software application that implements the automatic question generation process and measures the software complexity together with the application usability.

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