

Scripts and clinical reasoning

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CONTEXT Each clinical encounter represents an amazing series of psychological events: perceiving the features of the situation; quickly accessing relevant hypotheses; checking for signs and symptoms that confirm or rule out competing hypotheses, and using related knowledge to guide appropriate investigations and treatment.

OBJECTIVE Script theory, issued from cognitive psychology, provides explanations of how these events are mentally processed. This essay is aimed at clinical teachers who are interested in basic sciences of education. It describes the script concept and how it applies in medicine via the concept of the 'illness script'.

METHODS Script theory asserts that, to give meaning to a new situation in our environment, we use goal-directed knowledge structures adapted to perform tasks efficiently. These integrated networks of prior knowledge lead to expectations, as well as to inferences and actions. Expectations and actions embedded in scripts allow subjects to make predictions about features that may or may not be encountered in a situation, to check these features in order to adequately interpret (classify) the situation, and to act appropriately.

CONCLUSIONS Theory raises questions about how illness scripts develop and are refined with clinical

experience. It also provides a framework to assist their acquisition.

KEYWORDS knowledge; education, medical, undergraduate/*methods; teaching/*methods; *clinical competence; review [publication type]; *decision making; *diagnosis.

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INTRODUCTION

An adult patient comes into the outpatient office of a doctor complaining of facial pain and nasal obstruction for 2 days' duration. Instantly, from these 2 signs, knowledge about acute facial pain pops into the clinician's mind, with sinusitis being especially salient because of its frequency of occurrence in this age group. This specific knowledge then orients the questions asked and physical examinations administered. A few minutes later, a new patient comes in with vertigo signs. Instantly, knowledge about sinusitis and facial pain is dismissed from active memory, and knowledge of vertigo takes over. Each clinical encounter engages an amazing assortment of psychological events: perceiving the important features of the situation; quickly accessing relevant hypotheses; checking for signs and symptoms that confirm or rule out these competing hypotheses, and using related knowledge to guide appropriate investigations and treatment. All clinicians experience this mobilisation of organised knowledge relevant to the situations they encounter. Feltovich and Barrows¹ have termed these knowledge structures 'illness scripts', adapting the script concept from cognitive psychology for application in medicine.²

This essay is aimed at clinical teachers who are interested in the basic sciences of education. It will provide an overview of scripts, a concept that well explains research data accumulated on clinical

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Overview

What is already known on this subject

'Script' is a cognitive sciences concept that aims at explaining how humans understand real-world events and why this understanding in most cases occurs almost effortlessly.

What this study adds

Scripts-based clinical reasoning is very efficient because script activation is automatic and almost unconscious, activated scripts are used in a conscious and strategic way to confirm or refute corresponding hypotheses, and activated scripts serve to guide information selection, memorisation and interpretation.

Suggestions for further research

The script theory raises questions about how scripts are acquired, and how their development and refinement can be fostered.

reasoning. For clarity, theories will be summarised and few details will be given on the experimental studies that support them. Research data that support script theory will be cited during the theory description.

SCRIPT THEORY

Script theory aims at explaining how humans understand real-world events and why this understanding in most cases occurs almost effortlessly.³ It assumes that memory functioning involves the use of abstract cognitive structures. Scripts (schemas) arise from repeated experiences with real-world events, as a result of which certain types of information come to be organised in specific ways.³ For example, activities such as travelling by plane or visiting a restaurant consist of a sequence of events. Having experienced such sequences a number of times, people create knowledge structures that capture the activities within such sequences.

The notion of scripts emerged from attempts to enable computers to understand real events. In addition, psychologists and linguists² applied it to the reading process, proposing that understanding

implies knowledge structures that represent what a text is about in a general way and provide expectations to enable the reader to quickly interpret complex events within the text and to make predictions about how these situations will develop. Scripts are also applicable to understanding and acting in the real world. A script is about what is normal and what acceptable variations are, and how these variations hang together. It captures what one can expect in a frequently encountered setting, such as having a meal at a restaurant. Once established, the script then allows one to make sense of different restaurant visits and differences among them, ranging from a fast food snack to a banquet in a select restaurant. Such a structured framework allows the 'understander' to deal expeditiously with a variety of otherwise difficult-to-understand situations.³

Thus, scripts are goal-directed knowledge structures, adapted to perform tasks efficiently.⁴ They contain attributes, each of which corresponds to some aspect of the domain modelled by the script. Each attribute can be symbolically conceived as a slot that can have different values. The restaurant example helps to illustrate the role scripts play in situation interpretation. When an individual enters a restaurant, a 'restaurant script' will be activated which loads into working memory and arouses a number of expectations about what will happen next. Upon perceiving another person approach, holding documents, some slots in the activated restaurant script will be filled: presumably, the person approaching is a waiter or waitress and the 'documents' are menus. Slots include fixed slots representing what is common in such a setting and pertaining to things that are always true (like restaurants always offering food). Other slots correspond to what has a more incidental nature and pertain to looser expectations that might be filled with various particulars (such as any of a number of different types of service or types of food that might be found across diverse restaurants). It is assumed that individuals possess many hundreds of organising and interpretive scripts, and that combinations of these scripts will be invoked in any reasonably complex situation.³

SCRIPTS AND CLINICAL TASKS

Diseases have an underlying time-based structure, from onset to subsequent stages of development in a host. When confronted with illnesses, doctors take actions that are related to these sequences (e.g. they look for signs, order tests or prescribe). Scripts are knowledge structures associated with time sequences, that is, with developments, events or actions as they

transpire. This makes them particularly well suited to describing clinical disease knowledge.^{1,5}

When doctors see patients, they perceive features – symptoms, signs and context from the patient's environment. Perceptions activate illness scripts that interpret information about the characteristics and features of the situation and that include knowledge about the relationships that link those characteristics and features. Those illness scripts will lead them to make inferences, some of which are used to rule hypotheses in or out in the diagnostic process, whereas others are used for patient management.⁶ In the diagnostic process, every hypothesis is an activated illness script. If only 1 illness script pops up, this is the – most likely – diagnostic hypothesis. On the basis of the activated illness script, the diagnostician will immediately infer – without having to reason deliberately – which symptoms to expect. Theory predicts that deeper reasoning only occurs if 2 or more illness scripts are simultaneously activated for a single patient, or if there are findings that do not fully fit any particular illness script. Empirical findings suggest that in the latter case doctors sometimes ignore these misfits, which may lead to gross diagnostic errors.^{7,8}

Cognitive psychology has provided insights into how scripts function in the diagnostic process.⁹ Illness scripts have 'slots' that correspond to attributes associated with the specific disease they describe, with expectations about values that can or cannot be found for each attribute. For each slot, the attribute value that has the greatest probability of occurrence is the default value. The illness script a doctor might have about bacterial maxillary sinusitis would contain slots (e.g. 'predisposing conditions', 'pain location', 'pain duration', 'nasal obstruction') for which different values are possible (for the slot 'predisposing conditions': viral infection, allergic rhinitis or nasal polyposis; for the slot 'pain location': dull sensation of pressure over the maxilla or infra-orbital pain).

Four other characteristics of illness scripts are important. Firstly, the information belonging to a script is not exclusive. Symptoms and signs (unless pathognomonic) can belong to several scripts. The particular script for an illness is characterised by the set of slots regarding the signs and symptoms expected in the course of the illness and by the relationships that link them, along with its predisposing conditions and actions to take in treatment. Secondly, the activation of one script can automatically lead to the activation of another. This can be the

effect of shared slots, but alarm links are possible as well, such as between diseases that can be easily confused, or a possible disease that must be treated as another until the latter has been positively disconfirmed.¹⁰ Thirdly, scripts are generic structures that can interpret any instance of an illness. Each medical encounter implies a process of finding the actual values of the attributes observed in the patient (script instantiation).^{5,6} This instantiation process also tests if the script that has been invoked is in fact the right script. Fourthly, memory of previous patients is stored in the form of instantiated scripts.¹¹

Typical and non-typical patients

An important characteristic of the script concept is default values.⁹ Among the acceptable values for each attribute, the most common is assumed to be present until an actual value has been verified (the actual value can of course be identical to the default value). In the sinusitis example it would be viral infection for the slot 'predisposing conditions' and infra-orbital pain for the slot 'pain location'. These default values explain why clinicians do not always look for all signs and symptoms.⁶ When they have enough evidence to establish their diagnosis, they often assume that other values are present and do not specifically check them (in the sinusitis example, if a patient has an acute nasal obstruction and pus emanating from the middle meatus, the doctor may not perform percussion over the infra-orbital area, or ask for sinus X-rays). The specific instance of a case in which all slots are occupied by default values represents the prototypical version of the illness. Typical instances are more easily recognised than those that are atypical.¹²

Script activation

How scripts are activated is a key issue. Early hypothesis generation (i.e. quickly finding hypotheses relevant to the situation, with their related networks of knowledge) is an important feature of expert behaviour in medicine: if experts take into consideration the correct diagnosis during the first 5 minutes of a consultation, this hypothesis becomes definite in 95% of cases; if the proper diagnosis has not yet been considered by this time-point, there is a 95% probability that it will be missed.¹³ However, the information available in the earlier part of a clinical encounter is a rather amorphous mix of clinically relevant and irrelevant information, which is available rather than actively collected, and picked up through diverse perceptual pathways. Hobus and colleagues¹⁴ have shown clear

differences between experts and novices in this regard. Experienced doctors appeared more able than inexperienced doctors to extract relevant information from such data and to generate fruitful hypotheses. Much of this information pertains to conditions that may contribute to or protect against acquisition of a specific disease, rather than its resulting signs and symptoms. Feltovich and Barrows called this class of script slots 'enabling conditions'.¹

In many situations, script activation occurs automatically, without conscious awareness. This activation, called non-analytic,^{15,16} is based on recognition of either an instance or a pattern. The former mechanism rests on the vast repertoire of previous cases stored as instantiated illness scripts, which experienced clinicians possess; the identification of possible diagnoses occurs by recognition of similar prior examples.¹⁷ In other situations, the configuration of data elements is so familiar that the solution leaps into mind almost instantly. This mechanism is named 'pattern recognition'.¹⁸ Here, instead of prior examples or images, it is a configuration of salient clinical features that activates an illness script and fills the relevant slots.¹⁹

Non-analytic reasoning probably represents the main method of script activation.²⁰ For non-routine situations, deliberate script induction occurs.²¹ Depending on the situation, involved mental mechanisms may be inductive reasoning, explanation-based reasoning, case-based reasoning, causal biomedical reasoning, analogy, or access to external resources (consultation, electronic databases, textbooks).

Illness script processing and assessment of fit

The set of hypotheses considered by a doctor in a given clinical situation guides the doctor's interview and examination of the patient.^{22,23} It represents the initial possibilities that he or she feels need to be pursued. Whether doctors are aware or not, observation of their reasoning shows that the questions they ask and the items of physical examination they perform are, for the most part, specifically chosen to rule in or rule out, or at least strengthen or weaken, the likelihood of the hypotheses they are considering.²³

The activation of a script provides access to a set of attributes and expectations and allows an active search to find appropriate values for slots.²⁴ There is no fixed order for checking script attributes. Individual clinicians proceed in different orders. This accounts for the variability in data collection

observed among clinicians. Different clinicians rarely use the same set of questions to solve any single clinical problem.^{22,25} Experienced doctors ask questions and carry out physical examinations that are most efficient according to their own activated scripts. This processing phase of scripts, the search for evidence, to confirm hypotheses or to rule them out, is controlled and deliberate.^{6,24}

Stopping the process of diagnosis at the first hypothesis or script activated, without testing it (further), would be considered risky practice. Doctors are systematically educated to test their hypotheses by an assessment of the fit with collected data. In routine cases, on the basis of the available cues, a single relevant illness script is activated; in non-routine cases, there is a set of competing illness scripts. In both cases, the doctor tries to find if the activated script, or any of the activated scripts, adequately fits the clinical findings.

According to theory, this verification requires that values be assigned to the different attributes. For each attribute slot,⁹ there are acceptable and unacceptable values. If unacceptable values are found, the script is rejected (e.g. the maxillary sinusitis script would be rejected if a history of bloody rhinorrhoea were discovered), and other scripts that accept that value are activated or reinforced (e.g. maxillary sinus cancer). Among acceptable values for an attribute, some bring more weight to a hypothesis than others. The diagnostic process aims at decreasing the likelihood of all activated illness scripts except 1. This then becomes the working diagnosis. If the doctor cannot adequately fit an activated script to the findings, he rejects it and begins to verify another.

The assessment of each value in the activated scripts explains the fluid status of the set of hypotheses in clinical encounters. Hypotheses can be reinforced, or be attenuated, or disappear, whereas others are activated.²³ The accumulation of acceptable values within a script raises the level of activation of that script, and at a particular moment the clinician decides that there is enough evidence to bring closure to the diagnostic process. He or she then settles on a definitive or working diagnosis, depending on the situation. Research²⁶ suggests that referral rate is also affected by enabling conditions and consequences interpretation, not only as an independent effect but also as mediated by age, gender and practice characteristics. Age and experience also affect the process of weighing evidence pro and con a certain script. Less experienced doctors take counter-evidence more seriously than older doctors.²⁷

The place of basic science knowledge, the acquisition of scripts

Medical diagnosis, in its contemporary conception, is an explanation of a pattern of symptoms made on the basis of an underpinning biomedical knowledge.⁵ Medical curricula devote a great amount of time to the acquisition of biomedical knowledge. Yet research data^{28,29} have shown that experts use less basic sciences in their explanations than novices. Schmidt and Boshuizen¹¹ postulate that their knowledge is encapsulated (i.e. accessible but remaining quiescent until needed) for reasoning, teaching, patient communication, etc.

According to theory, illness scripts develop as students are exposed to real patients. In their first encounters, they apply both biomedical and clinical knowledge.³⁰ They consciously relate symptoms to concepts in the relevant knowledge networks they possess. However, explicit reasoning and thinking causally to carry out a diagnosis is tenuous, error-prone, elaborate and time-consuming.⁵ It is more efficient to use known associations between clinical features and illnesses (scripts), and each encounter with a patient with a specific disease will add bits and pieces to the related illness script. Biomedical knowledge remains, nevertheless, present and accessible. In its encapsulated form,¹ it constitutes the anatomy of the illness script. It places constraints on the acceptable values for the different attributes of scripts and on their relationships.^{6,10} It also alerts clinicians when they find abnormal findings or events that violate physiological expectations that are normally found in that specific type of disease, serving as a coherence criterion for hypotheses about the patient.¹⁰ Biomedical knowledge can also be used in situations where no available scripts are adequate. In such cases, clinicians use their biomedical knowledge to understand the situation and to find pertinent hypotheses through a chain of causal reasoning.^{7,10} If this process also fails, the clinician may revert to more general procedures, such as further referral, doing nothing (recommending the patient to return if complaints do not diminish or get worse), or treatment of individual symptoms without establishing a diagnosis.

Script acquisition is of utmost importance at the beginning of a medical career. Illness scripts require continuous updating as a result of changes in the diseases themselves and the population a doctor deals with. Both explicit and implicit learning processes can contribute to these changes. This process will start immediately, as soon as a student

or doctor experiences contact with patients. The process of incorporating new theoretical knowledge into illness scripts demands active study. Analysis of health care indicators³¹ suggests that for most doctors the knowledge they gathered in medical school remains the basis for medication and treatment.

CONCLUSIONS

Script theory raises educational issues concerning the instructional methods that foster their construction and refinement and their implications for the assessment of clinical competence. Because illness scripts develop from the application of biomedical and clinical sciences knowledge to real cases, and are themselves the key to further development, scripts should be a focus of attention in education. As typical cases represent the default values of an illness script, script building should start from there, taking care of the deliberate application of biomedical and clinical knowledge to the case at hand. Having formed a well established image of the typical representation of the disease,³² attention should also be drawn to natural variations and atypical representations. In this way the slots in the illness script will develop a realistic range of values.

The implications of illness script theory and empirical findings indicate that both problem-based and experience-based learning³³ facilitate the learning and adapting of enabling conditions and consequences knowledge in early career training. However, the acquisition of theoretical knowledge deserves renewed attention, not only because it places constraints on acceptable values within scripts but also because it is this type of knowledge that should enable present students to learn new scientific knowledge and incorporate it into their scripts over 20 years from now. Although the integrating of new knowledge in old has been well investigated in medical students,^{7,34} this learning process at the later stages of someone's career needs more attention. We also need to rethink continuous medical education, collaborative work forms, and support and feedback structures that can help experienced doctors to stay sharp.

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