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The Role of Patient Management Knowledge in the Development of Medical Expertise

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Propositions belonging to the PhD thesis

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1. Although patient workup consists of diagnosis and management, medical expertise research has almost exclusively focused on diagnostic performance (this thesis).
2. As a result of most medical curricula, an illness script is first tuned towards diagnostic tasks, and then, because of gradual integration of management knowledge in later years, it also becomes capable of accommodating management tasks (this thesis).
3. Becoming a medical expert entails the improvement of management knowledge, beginning with a quantitative growth and later continuing with a qualitative enrichment (this thesis).
4. Medical experts are able to simultaneously provide more accurate diagnoses and management plans in clinical settings than medical students (this thesis).
5. The gap between diagnostic and management knowledge at an intermediate level of expertise, which could lead to inaccurate management plans, should be an area of concern for medical educators as this group will shortly graduate and start practicing independently (this thesis).
6. Theories are nets cast to catch what we call “the world”: to rationalize, to explain, and to master it. We endeavor to make the mesh ever finer and finer (Karl Popper).
7. In medicine, “good is what is useful, even when we don’t know why” (Richard Koch).
8. Although a student-centered education, as opposed to a teacher-centered one, is highly appreciated nowadays, we still should not forget that our students still need to be taught *how* to learn.
9. Web surfing is no longer a harmless leisure, if you know that each click to search the web makes the world slightly warmer.
10. Our modern life has its roots in Enlightenment, simply because in the absence of electricity, our modern civilization, as we know it, could not survive.
11. It is not unlikely that expertise studies started with chess only because the most influential pioneer of the field, Adriaan de Groot, was both a chess master as well as a psychologist.

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The Role of Patient Management Knowledge in the Development of Medical Expertise

De rol van behandelkennis in de ontwikkeling van medische expertise

Thesis
to obtain the degree of Doctor of Philosophy from the
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Alireza Monajemi
born in Dortmund, Germany

Doctoral Committee

Promotor:

Prof.dr. R.M.J.P. Rikers

Other members:

Prof.dr. H.T. van der Molen
Prof.dr. F. Paas
Dr. H.J.M. van de Braak

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To my father, mother, and dear Mahban

CONTENTS

Chapter 1

THE ROLE OF PATIENT MANAGEMENT KNOWLEDGE IN MEDICAL EXPERTISE DEVELOPMENT: EXTENDING THE CONTEMPORARY THEORY[1]

Abstract

Medical expertise research has focused on why experienced physicians display remarkable performance in solving clinical problems and how this competency develops over many years of education and practice. The contemporary theory on the development of expertise in medicine proposes that students progress through different stages of knowledge restructuring (i.e., encapsulation and illness script) in which their knowledge is finely tuned towards practical situations. Although research in clinical case paradigm has provided us with a better understanding of the differences between students and doctors, it has almost exclusively focused on diagnostic performance, and patient management has received substantially less attention. This reflects an incomplete picture of a medical expert, as management is not only a crucial step in patient workup, but it is also highly connected to experience with patients. In their daily practice, doctors always diagnose and manage patients concurrently; hence, after a large number of patient encounters in practical settings, these two types of knowledge become integrated into one another. In order to incorporate management into contemporary theory, it is proposed that it should be considered as a part of the illness script structure. In the way towards expertise, knowledge about patient management becomes more prominent, and so

[1] Monajemi, A., & Rikers, R. M. J. P. (2011). The role of patient management knowledge in medical expertise development: Extending the contemporary theory. *International Journal of Person Centered Medicine*, *1*, 109–114.

an investigation of management knowledge could ultimately enable us to broaden our understanding of medical expertise.

1.1 Introduction

A 55-years old man is brought to the Emergency Room by his wife at 2 am because of acute shortness of breath and retrosternal chest pain. The dyspnea had occurred suddenly at 11 pm and had awakened the patient from sleep. He had felt nauseated and vomited a small amount of bile. His past history included several CCU admissions and heavy smoking. The doctor first examines the patient and orders some lab tests. Upon reviewing the lab results, he decides to start streptokinase infusion in order to dissolve the clot in coronary arteries. A few minutes after the start of infusion, the patient vomits a large amount of blood and his blood pressure suddenly drops, so the doctor decides to discontinue the infusion immediately and add some drugs to the order to manage the situation. A few hours later, the cardiac rhythm of the patient becomes irregular and the patient falls unconscious. The doctor administers CPR and some drugs without delay. After a few minutes the patient regains consciousness and becomes stable.

The above scenario vividly shows that doctors need not only appropriate theoretical knowledge, but also a wealth of practical experience to decide immediately and accurately in urgent and life threatening situations. The research area that attempts to understand how doctors are able to deal with such diverse and complex problems is called medical expertise research. It has focused on why experienced physicians display such remarkable performance and how this competency develops over many years of education and practice (Norman, 2005; Schmidt, Norman, & Boshuizen, 1990; Schmidt & Rikers, 2007). This type of research can have a significant impact on medical education as it can guide medical educators on how to train medical students.

Although research on the development of medical expertise has a long tradition (Ericsson, 2007; Norman, 2005; Schmidt & Rikers, 2007), medicine is obviously not the only domain that expertise research has been carried out on. One of the most dominant and influential domains of expertise research is chess, pioneered by the Dutch psychologist and chess master Adriaan de Groot. In his studies, he presented a chess position for a short period of time to chess players of different levels of expertise and asked them to think about the next move (de Groot, 1965). The strongest players (i.e., chess masters), unlike novices, were able to identify the best next move. Another task given to the participants was that they were asked to reconstruct pieces on the board after they had been removed from the board. This recall task was found to sharply discriminate between masters and non-masters, as non-masters failed to reproduce the position, while masters were able to put the pieces back on the right position. The superiority of chess masters in reproducing the positions can be explained by their ability to perceive the pieces in clusters, and to recognize patterns of positions that they had seen before (de Groot & Gobet, 1996). This superiority of experts in dealing with familiar patterns has been shown in a broad array of domains such as thermal-hydraulics (Vicente, 1992), air traffic control (Morrow, Menard, Stine-Morrow, Teller, & Byrant, 2001), architecture (Akin, 1980), circuit technique (Egan & Schwartz, 1979), sports (Allard, Graham, & Parasalu, 1980; Eisenstaedt & Kareev, 1975), and art (Krampe & Ericsson, 1996). Strongly influenced by the pioneering research in chess, in studies in these domains, participants of different expertise levels were also confronted with a task that could be evaluated (like the accuracy of a chess move) followed by a recall task (Vicente & Wang, 1998). In other words, the paradigm that was introduced with chess studies was translated to many other areas of expertise research. In medicine, for instance, participants had to study a clinical case description (see Table 1.1), provide an accurate diagnosis, and eventually recall (i.e., free recall) and explain the information in the case.

1.2 Contemporary theory of medical expertise

This approach to the study of medical expertise is called the clinical case paradigm (Boshuizen & Schmidt, 1992; Muzzin, Norman, Feightner, & Tugwell, 1983; Norman, Brooks, & Allen, 1989; Patel & Groen, 1986; Rikers, Schmidt, & Boshuizen, 2000, 2002; Schmidt & Boshuizen, 1993a). Examples of pathophysiological protocols provided by a doctor and a medical student are presented in Table 1.2.

As was expected, the results showed that experienced doctors always diagnosed the case more accurately than medical students. The novices' performance was also predictably lower than that of advanced medical students (i.e., intermediate level) and doctors. However, the results from the students at an intermediate level were rather counterintuitive and unlike the findings in similar studies in other domains of expertise. They recalled

Table 1.1

Case description of Congestive Heart Failure (CHF)

A 70-year old female is admitted into the hospital because of increasing shortness of breath. History taking reveals that the patient has been very tired lately and tolerates her food badly. Sometimes she has chest pain, especially after dinner. She has admitted several times in C.C.U. The history of hypertension and hyperlipidemia is positive. Physical examination shows a pale and tired woman. She has an irregular, unequal pulse of 100/min. The blood pressure is 110/70 mmHg and Jugular Venous Pressure (JVP) is elevated. The patient has widespread peripheral edema and positive jugular venous pulsations. The heart is enlarged to all sides, and auscultation reveals a holosystolic murmur at the apex radiating towards the axilla. Lungs auscultation reveals rales at both sides at bases. The thoracic X-ray shows congestion of the lungs and an enlarged heart. Echocardiography shows an enlarged left atrium and ventricle. ECG reveals Atrial Fibrillation (AF).

Table 1.2

Pathophysiological explanation of a fourth-year medical student and an internist (expert doctor)

Pathophysiological explanation of a fourth-year medical student: As a result of increased pressure in pulmonary arteries due to the pressure and volume overload in left atrium and ventricle, the blood flows from left side of the heart and subsequently backs up in the pulmonary circulation. This leads to a congestion of lungs and extravagation of the fluid and causes shortness of breath in the patient.
Pathophysiological explanation of an internist: Both the anemia and atrial fibrillation have worsened the forward and backward heart failure of the patient that leads to pulmonary edema.

more and explained the signs and symptoms more elaborately than both the doctors and novices. The question that arises here is that if doctors know more about everything in medicine than medical students, then why do they recall less than medical students? The analysis of the protocols uncovered the cause of this finding in medicine (see Table 1.2). It showed that doctors and students used different types of knowledge while solving clinical cases. That is, doctors use their clinical knowledge (i.e., the ways in which a disease manifests itself) to understand the problem, whereas, medical students apply their biomedical knowledge (i.e., the basic mechanisms and functioning of the human body and pathological processes underlying the manifestation of diseases).

In the protocol produced by a fourth-year medical student displayed in Table 1.2, he has focused on isolated signs and symptoms (such as edema or dyspnea) and seems to have attempted to understand the case by relating each of these to some pathophysiological mechanisms (i.e., those of edema or pump failure). This is because students acquire extensive biomedical knowledge through courses in the basic sciences at the first stages of their medical training. Therefore, in order to make sense of the information provided in a clinical case, they will use their detailed, elaborate biomedical knowledge and thus, they are more likely to remember the details better than doctors. As a result of this detailed processing as well as a lack of relevant knowledge, the fourth-year student will experience more difficulty in providing an accurate diagnosis. On the other hand, the doctor does not explicitly refer to the biomedical concepts anymore in the protocol (see Table 1.2). An examination of the doctor's protocol shows that a few clinical concepts like forward failure or venous congestion were used to explain the case. These concepts are sufficient to understand all relevant signs and symptoms without the need to engage in a detailed biomedical mode as most students do. This is why the protocols of experts contain hardly any biomedical concepts but mainly clinical concepts. Schmidt and Boshuizen (1993a, 1993b) have called these concepts "encapsulated" because they summarize such biomedical knowledge under diagnostic labels (e.g., forward failure and pulmonary edema), which are simplified causal models that explain signs and symptoms. These encapsulated concepts develop as a result of extensive application of biomedical knowledge and especially through encounter with patient problems in medical diagnostic situations (Rikers et al., 2000, 2002; Schmidt &

Boshuizen, 1993a, 1993b; Schmidt & Rikers, 2007).

However, knowledge encapsulation is not the last stage in the course towards expertise. Having encapsulated concepts such as forward failure is not enough to enable doctors to deal with real patients. Instead of using biomedical knowledge, the features that characterize the clinical presentation of a disease become the anchor points of experts' reasoning. An expert's knowledge is much richer than encapsulated knowledge, and it contains much more information about all different facets of diseases: about how diseases are acquired, how they manifest in patients, and which risk factors predispose them. When doctors would see a patient like the old woman described in Table 1.1, a diagnosis of Congestive Heart Failure (CHF) quickly pops into their mind as they recognize the pattern of the clinical presentation of the disease that has been formed as a result of having seen many similar patients.

All the information about diseases that doctors have is organized in a structure called the illness script. It is an integrated knowledge structure consisting of at least three parts: faults, consequences, and enabling conditions (Feltovich & Barrows, 1984). Faults are pathophysiological malfunctions that constitute the biomedical core of the disease and are usually subsumed under a diagnostic label (e.g., right-sided heart failure, pulmonary edema). Consequences are about the clinical manifestations of a disease such as complaints, signs, and symptoms (e.g., chest pain, dyspnea). Finally, enabling conditions are the patient's background information (e.g., age, sex, medical history, drug history, family history of diseases, occupation, and living environment) that generally makes the occurrence of a certain disease more or less likely (Custers, Boshuizen, & Schmidt, 1996, 1998; Hobus, Hosfstra, Boshuizen, & Schmidt, 1988). For the CHF case, hypertension, previous coronary artery diseases and old age are enabling conditions. Table 1.3 shows the illness script of congestive heart failure.

Illness scripts and encapsulated knowledge are formed during the course of years of training and practice, hence, they differ strongly between students and doctors (Charlin, Boshuizen, Custers, & Feltovich, 2007; Charlin, Tardif, & Boshuizen, 2000; Schmidt & Rikers, 2007). In the early stages of medical expertise development, biomedical knowledge plays an important role in constructing scripts for diseases. As students begin to practice with actual patients, their biomedical knowledge becomes encapsulated and will

Table 1.3

The Illness Script of Congestive Heart Failure (CHF)

Congestive Heart Failure (CHF):

- **Faults**: pulmonary edema, right-sided heart failure, left-sided heart failure
- **Consequences**: dyspnea, chest pain, peripheral edema, raised JVP, indigestion, cardiomegaly
- **Enabling conditions**: old age, previous coronary artery diseases, previous CCU admission, smoking, hypertension, hyperlipidemia

be reorganized into the illness scripts (i.e., fault component of illness script). In this phase, the newly formed illness scripts consist of signs, symptoms, and complaints (i.e., consequences) that are held together by a network of biomedical explanations (Custers et al., 1998). With increasing expertise, the role of biomedical knowledge becomes less important, while simultaneously the role of enabling conditions of diseases becomes more important. The integration of enabling conditions into illness scripts is a consequence of a long period of clinical practice with real patients (Charlin et al., 2007; Custers et al., 1998; Schmidt & Rikers, 2007). Enabling conditions give valuable information on how to quickly recognize diseases in daily practice. In the example mentioned above on congestive heart failure for instance, several risk factors like hypertension, hyperlipidemia, and previous cardiac problems in an old patient with increasing shortness of breath, are crucial to the doctor in picking CHF as the diagnosis, whereas in the absence of the above enabling conditions, in a patient with an increasing shortness of breath, diagnostic hypotheses such asthma attack, pneumonia, pulmonary emboli, or Chronic Obstructive Pulmonary Disease (COPD) become more relevant. As a result of limited experience with actual patients in medical students, their knowledge about enabling conditions is not yet integrated into their still developing illness scripts. Consequently, they cannot benefit

Table 1.4

Management protocol of a patient with Congestive Heart Failure (CHF)

1.	Semi sited position	7.	Digoxin
2.	Low fat/low salt diet	8.	DC shock standby
3.	Nasal O2 3-4 lit/min	9.	Input/Output (I/O) control
4.	Vital sign control	10.	Angiotensin-converting enzyme (ACE) inhibitors
5.	Digitalization if necessary	11.	Diuretics (e.g., Lasix)
6.	Intermittent elastic banding	12.	Anticoagulation

to the same extent as experts from the enabling conditions when diagnosing a case. In sum, the presented theory on the development of expertise in medicine proposes that students progress through different stages towards expertise. The knowledge encapsulation and illness script formation are two major processes of knowledge restructuring in which the medical students' knowledge is finely tuned towards practical situations to deal with real patients (Schmidt & Rikers, 2007).

1.3 Patient management and medical expertise theory

Although research in the clinical case paradigm has provided us with a better understanding of the differences between the case representation in students and doctors, it has almost exclusively focused on diagnostic performance (Boshuizen & Schmidt, 1992; Patel & Groen, 1986; Patel, Groen, & Arocha, 1990; Rikers et al., 2000, 2002; Schmidt & Boshuizen, 1993a). According to some authors (Gruppen & Frohna, 2001; McGuire, 1985; Norman, 2005), this is a limited perspective as patient management has received much less attention. This is in addition to the fact that patient workup consists of not only making a diagnosis, but also putting forward a management plan for the patient (Gruppen & Frohna, 2001; Patel, Groen, & Patel, 1997). Doctors do much more than providing a diagnosis and a large part of their activity consist of figuring out management plans for patients (Gruppen & Frohna, 2001). Table 1.4 shows a management plan for the case provided by one of the expert participants.

It is obvious that providing the correct diagnosis, without managing the immediate needs, is not sufficient and may lead to the patient's death. For instance, in the case above, because the patient is in pulmonary edema, it is imperative that a diuretic (e.g., Lasix) be immediately administered to resolve this urgent problem, or else the patient will suffocate. Studies have also highlighted the importance of management in the patient workup. For instance, it has been shown that medical doctors who consistently provide effective management as evidenced by low rates of complication and death, and high rates of recovery and healing are recognized as experts (Ericsson, 2004, 2007). Other studies have indicated that extensive practice with patients appears to be linked to effective patient management (Norcini, Lipner, & Kimball, 2002; Schuwirth et al., 2005). Overall, it could be concluded that patient management is not only an essential component of medical practice, but also highly connected to expertise in medicine. As indicated above, the contemporary theory has treated the concepts of medical expertise and diagnostic expertise as interchangeable, something that reflects an incomplete picture of what it means to be a medical expert. It seems especially important to medical expertise research to have a good understanding of the nature of management knowledge and its organization in doctors' minds. This is because the improved understanding in this area is considered essential in broadening the definition of a medical expert (Albert, Hodges, & Regehr, 2007). Taking the management focus into consideration, raises some new questions that can be addressed. For instance, in what way does management knowledge differ between experienced and less experienced doctors or students? Would a management focus, as opposed to diagnostic focus, lead to a different evaluation of the findings in a clinical case by a doctor? What is the relationship between the diagnostic and the management knowledge during the course of development towards expertise?

Although previous studies in the clinical case paradigm have not focused on the management task, reviewing them may reveal some findings that can be considered as a starting point. Some studies that investigated the structure of illness script already revealed a trace of management knowledge. For example, Boshuizen, Schmidt, Custers, and van de Wiel (1995) asked medical students and family physicians to describe the clinical picture of some diseases. This is not similar to previous clinical case studies because there was no diagnostic situation. Interestingly, about 6.5% of the generated

Table 1.5

The revised version of Congestive Heart Failure (CHF) illness script

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Congestive Heart Failure (CHF):

- **Faults**: pulmonary edema, right-sided heart failure, left-sided heart failure
- **Consequences**: dyspnea, chest pain, peripheral edema, raised JVP, indigestion, cardiomegaly
- **Enabling conditions**: old age, previous coronary artery diseases, previous CCU admission, smoking, hypertension, hyperlipidemia
- **Management**: Digoxin, Diuretics, DC shock, I/O control, ACE, anticoagulation Heparin and Warfarin if necessary, digitalization if necessary

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items referred to patient management. These items were neglected, and were not taken into consideration because they were not assigned to any known component of the illness script.

In the works by Hobus et al. (1988) and Custers et al. (1998), which used the same method as above, the results showed that participants with higher levels of expertise provided more information concerning patient management. That is expected, as experienced doctors obviously possess more knowledge about patient management and this knowledge is part of their clinical knowledge.

If management knowledge is part of the experts' knowledge, then why has it not appeared in most of the clinical case studies? In previous studies when participants were not explicitly asked to provide a diagnosis, management items did appear in the protocols. This is due to the fact that in their daily practice, doctors always diagnose and manage patients concurrently, and after a large number of patient encounters in practical settings, these two types of knowledge become integrated into one another (Bissessur et al., 2009). So, it can be concluded that management is a neglected component of an illness script, and should be incorporated into the illness script structure. A revised version of the illness script theory, therefore, contains information about the clinical presentation (i.e., consequences), the pathophysiological mechanisms (i.e., fault), risk factors (i.e., enabling conditions), and finally the management plan (i.e., management). Table 1.5 shows this revised version of CHF illness script.

The way in which management becomes part of the illness script, is comparable to the described process of integration of enabling conditions into the illness script (Charlin et al., 2007; Custers et al., 1998; Schmidt & Rikers, 2007). That is, management knowledge is not part of the embryonic (newly formed) illness script of medical students, but as a result of extensive practice in patient management situations, it becomes integrated into the illness script structure and knowledge about patient management becomes more prominent. So, it seems that the illness script of medical students is different from that of doctors with respect to their knowledge of patient management. Our overall goal in this thesis is to further explore the nature of this difference.

1.4 Conclusion and implications for further research

Although, as indicated, patient management has received less attention in medical expertise research, the methods of clinical case study could be adapted to study management knowledge acquisition and organization during the course towards expertise. A closer look at clinical case studies reveals that doctors and students, while processing case information, only had to work out what the case's diagnosis was. The ensuing recall and pathophysiological explanation, therefore, reflected how information was processed with a diagnostic focus. Changing this focus to a management focus, could be obtained if participants are asked to read a case while thinking about patient management. Comparing these two case representations (i.e., diagnostic and management) may uncover the contribution of both to the development of medical expertise during education and practice. This thesis aims to shed light on this neglected part of patient workup in order to find out how management becomes part of illness script, and how it influences the way case information is processed.

1.5 Overview of the studies presented in this thesis

The studies described in this thesis were designed with two objectives in mind. First, to further investigate the proposed developmental course of management knowledge (Mx), and second, to elucidate the mutual relationship between the diagnostic knowledge (Dx) and the Mx-knowledge in the path towards expertise

Our starting point in Chapter 2 was to question whether or not the Mx-focus would lead to a different evaluation of the findings in a case in different levels of expertise. In the first step, the traditional method of free recall, which has usually been employed in clinical case studies (Boshuizen & Schmidt, 1992; Norman et al., 1989; Patel & Groen, 1986; Rikers et al., 2000; Schmidt & Boshuizen, 1993a), was used for two purposes. It served as an opportunity to compare the results with the previous studies and it also provided a basis for comparing the developmental trend of the Mx-knowledge with that of the Dx-knowledge. So in our study, doctors, sixth-year and fourth-year medical students were asked to study cases to either diagnose or manage them, and recall afterwards.

In Chapter 3, we will explore the Mx-knowledge more explicitly with a decision-task study. In this study, participants at the same three levels of expertise, doctors, sixth-year and fourth-year medical students, were asked to judge the relevance of Mx-items to a given clinical case description. It was expected that the case information with the provided diagnosis should activate a specific illness script, the contents of which could then be examined by the decision-task. Based on the revised illness script theory, it was assumed that the Mx-knowledge is part of the illness script, and it becomes integrated into the illness script structure as a result of repeated exposure to real patients. We therefore predicted that the number of errors in the Mx-items would gradually decrease as the level of expertise increases.

In Chapter 4, we will deal with two issues arising from the first two studies. One of the issues was that simply demonstrating an association between expertise level and Mx-errors does not provide information on how Mx-knowledge actually contributes to providing patient management. The second point was that, although in Chapter 2 the relationship between diagnosis and management in different levels of expertise was examined, their mutual relationship in more practical and real tasks remained implicit. So, in Chapter 4, the same type of participants, that is doctors, sixth-year and fourth-year medical students, were asked to read clinical cases and to provide a management plan. It was hypothesized that if the Mx-knowledge is associated with medical expertise, the accuracy of the Mx-plan would gradually increase as the level of expertise increases.

In Chapter 5, we will study more deeply the relationship between known components of illness script, that is, fault, enabling conditions, and consequences, and a newly proposed component, management. In this study, fourth-year, and sixth-year medical students, and residents were asked to think aloud while either diagnosing or managing a case, and recall it afterwards. The think-aloud methodology ensured that the participants were in the intended mode of thinking, that is, they were actually thinking about management or diagnosis as instructed. It was hypothesized that if management is an actual component of the illness script structure, then the intermediate and expert participants should be the ones that show sensitivity to focus, by producing more Mx-related items proportional to their expertise level when the focus is on management.

Finally, in Chapter 6, findings of this research will be summarized, the implications for medical education will be discussed, and issues for further research will be suggested.

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Chapter 2

CLINICAL CASE PROCESSING: A DIAGNOSTIC VERSUS A MANAGEMENT FOCUS[2]

Abstract

Introduction: Most studies on medical expertise research have shown that experts process cases in an encapsulated mode in diagnostic situations (Dx), however, it is yet unknown if the same phenomena can be observed in management situations (Mx). The present study aimed at exploring the differences between clinical case processing across two tasks, i.e., Dx versus Mx. Method: The participants were 40 medical students (20 fourth-year and 20 sixth-year) and 20 internists. Participants were asked to study clinical cases with either a diagnostic or a management focus. Subsequently, participants had to write down what they remembered from the case. Results: In both conditions, experts recalled fewer propositions and used more encapsulated concepts. Although, they processed the cases faster and more accurately than medical students, no significant difference between management and diagnosis focus was found for the experts. Fourth-year students showed no significant differences in recall and processing speed between conditions. In contrast, sixth-year students recalled more with a diagnostic focus than a management focus, and processed the case more slowly in the management conditions. Conclusion: In both conditions, findings indicate that experts processed the cases in an encapsulated mode, and fourth-year students in a more elaborated mode. Sixth-year students' recall, with a diagnostic focus, was similar to that of fourth-year students, but with a management focus, these students' recall was more similar to that of experts. In

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contrast to the experts, this finding seems to indicate that sixth-year students' diagnostic knowledge in not fully integrated with their knowledge about management.

2.1 Introduction

In order to investigate differences in knowledge organization between expertise levels, many studies on the development of medical expertise have used the clinical case paradigm (Boshuizen & Schmidt, 1992; Patel & Groen, 1986; Rikers, Schmidt, & Boshuizen, 2000, 2002; Schmidt & Boshuizen, 1993a). In these studies, participants of different levels of expertise were requested to study a clinical case description, to provide a diagnosis, and finally to recall everything they could remember from the text. Although this paradigm has provided us a better understanding of differences between students and physicians' case representation, it almost exclusively focused on diagnostic performance, largely ignoring the important aspect of patient management (Gruppen & Frohna, 2001; McGuire, 1985; Norman, 2005). That is, while processing case information, participants only had to figure out what the patient's problem is. The recall that followed was in a way a reflection of the information that was considered important with a diagnostic focus. However, it is not clear whether or not a change in this focus will also result in a different evaluation of the findings in a case description. That is, it is unclear if a management focus while processing the case information will lead to a different appreciation of the findings than a diagnostic focus (Ericsson, 2004). For instance, suppose a patient with a history of peptic ulcer complains about symptoms completely unrelated to her previous problem (e.g., ankle pain). For diagnosing this new complaint, there is no need to know about her concomitant diseases and drug history. However, from a viewpoint of management, this information is highly relevant. In other words, what is important with a diagnostic focus does not necessarily overlap with what is important with a management focus and vice versa.

Most studies with a diagnostic focus have shown that experts process case information faster and more accurately than medical students (de Bruin, Schmidt, & Rikers, 2005; Rikers et al., 2000; Rikers, Schmidt, & Boshuizen, 2002; Schmidt & Boshuizen, 1993a, 1993b). However, these studies also showed that advanced students outperformed both novices (e.g., first-year students) and medical experts recalling case information. This effect has been called intermediate effect (de Bruin et al., 2005; Schmidt & Boshuizen, 1993a; van de Wiel, Schmidt, & Boshuizen, 1998). This consistent finding was surprising because in other areas of expertise research (e.g., chess), there is a linear relationship between expertise level and performance (Vicente & Wang, 1998). Schmidt and Boshuizen (1993a, 1993b) suggested that the explanation for these intermediate effects lies in the qualitatively different knowledge that students and expert physicians bring to bear on a diagnostic task (Schmidt & Boshuizen, 1993a, 1993b). Medical students mainly use their extended biomedical knowledge to explain case data, leading to elaborate and detailed case processing. In contrast, biomedical knowledge only plays a minor and implicit role in experts' clinical reasoning. According to Schmidt and Boshuizen (1993a, 1993b) the experts' biomedical knowledge has become fully integrated with their clinical knowledge as a result of repeated exposure to a large number of real patients. The integration of both types of knowledge has been dubbed "knowledge encapsulation" and leads to a more holistic approach of case processing, focusing mainly on the sign and symptoms. Consequently, their recall is shorter and contains more encapsulated concepts than that of students.

Shifting from a diagnostic focus to a management focus, the present study investigates differences between diagnostic focus versus management focus in terms of clinical case processing. As has been outlined above, a management focus while processing clinical case information does not necessarily concur with a diagnostic focus. Moreover, the development of diagnostic knowledge is often not completely synchronized with that of management knowledge. In the first years of the students' training (i.e., pre-clinical phase), students acquire knowledge largely from textbooks and lectures without any real patient encounter. There is a strong emphasis on providing the correct diagnosis, which is often not accompanied by the same emphasis on developing a patient management plan (Brater & Nierenberg, 1988). The training in management knowledge often starts considerably later (i.e., during the clinical phase) than that in diagnostic knowledge. Consequently, less advanced students confronted with a management task, will most likely deal with it as if it were a diagnostic task (which is the only mode of processing of a case they have some experience with). More advanced students on the other hand, might already have acquired some clinical experience in hospitals during their clinical rotations, and hence management has become a bit more concrete. However, in contrast to experienced physicians, these advanced students are still in the middle of the process of linking their diagnostic knowledge with their newly acquired management knowledge.

In this study, doctors, sixth-year students, and fourth-year students were asked to study cases with either a diagnostic (Dx) or a management (Mx) focus, and subsequently recall the provided information. Based on the view of knowledge encapsulation (Schmidt & Boshuizen, 1993a, 1993b; Verkoeijen, Rikers, Schmidt, van de Wiel, & Kooman, 2004), the following predictions were made. Internists construct their clinical case representation similarly under both conditions, because their Dx-knowledge and Mx-knowledge has become well-integrated over the years, and, therefore, no differences are expected in terms of diagnostic accuracy, recall, and speed. Students, on the other hand, are expected in both conditions to be less accurate, slower, and more elaborate in their recall than the internists. Furthermore, fourth-year and sixth-year students are expected to show similar results in the Dx-condition concerning recall and processing speed. However, sixth-year students, as a result of more clinical experience, might show a better diagnostic performance than fourth-year students. Finally, in the Mx-condition, sixth-year students will be more elaborate in their recall, and process the case information more slowly than fourth-year students. That is, due to a lack of relevant knowledge, fourth-year students will treat a case with an Mx-focus similarly as a case with a Dx-focus. Sixth-year students who have already acquired some Mx-knowledge will be able to differentiate between both focuses, but are not yet proficient enough to deal with a case in an Mx-focus efficiently, and hence will have to go through the case information very thoroughly, leading to more recall and slower processing times.

2.2 Method

Participants

40 medical students (20 fourth-year and 20 sixth-year) of Isfahan medical school and 20 internists from 5 hospitals in Isfahan (Iran) participated. It takes about seven years (4 preclinical years and 3 clinical years) to finish medical school in Isfahan school of medicine. Fourth-year (preclinical) medical students had no or very limited experience in hospital, and their clinical knowledge was based on textbooks and lectures, whereas sixth-year students were in their hospital training as interns under the supervision of senior residents and attending physicians. The internists were practitioners with an MD degree and at least two years of experience.

Materials

The materials consisted of a booklet containing an instruction about the procedure, four written descriptions of clinical cases, and two blank response sheets after each case (one page for recall and the other for diagnosis). The cases were identical to cases used by Patel and Groen (1986); Rikers et al. (2000); Rikers, Schmidt, and Boshuizen (2002); Verkoeijen et al. (2004). The cases were acute bacterial endocarditis (Patel & Groen, 1986) , two cases of heart failure (Rikers et al., 2000; Rikers, Schmidt, & Boshuizen, 2002), and a case of Addison's disease with tuberculosis (Verkoeijen et al., 2004). The four case descriptions were about one page in length and consisted of 76, 82, 105, and 107 propositions respectively. The order of the cases for each participant was randomized, with the same sets of cases for all expertise levels.

Procedure

Participants were randomly assigned to the Mx-condition or the Dx-condition. In order to familiarize the participants with the procedure, they were first given the opportunity to read an unrelated text of about same length. In the Dx-condition, participants were told that they had maximally 5 minutes to diagnose the case. Subsequently, they were instructed to write down everything they could recall from the case and to write down their diagnosis. In the Mx-condition, participants also read the case, but this time they were instructed to come up with a management plan for this patient. After they studied the case with a management focus, they were also asked to write down what they remembered from the case. However, in order to maximize the contrast between both conditions, they were not asked to provide a diagnosis after the case. The time spent reading a case was registered using a chronometer by the experimenter. Processing time was recorded form the time that participants started to read the case until they had finished reading it. Participants were informed that they could proceed to the next task whenever they were ready with studying the case. However, if they did not finish within 5 minutes, they were instructed to go the next task. During the test, the cases were presented sequentially and were studied individually. After each case had been diagnosed or managed, the next case was handed out to the participant.

Analysis

The correct diagnoses associated with the 4 cases were divided into different diagnostic elements. In line with previous studies, the accuracy of diagnosis was determined by attaching weights to each of the elements based on their relative importance (Rikers et al., 2000; Rikers, Schmidt, & Boshuizen, 2002; Schmidt & Boshuizen, 1993a, 1993b; Verkoeijen et al., 2004). The resulting diagnostic accuracy score, ranged from 0 (completely inaccurate) to 3 (completely accurate). For example, if in the case of acute bacterial endocarditis the diagnosis contained the key concept "endocarditis" 1.5 points were given. The presence of "sepsis/septicemia", "IV drug abuse", or "infection" each contributed 0.5 points. The maximum score is three points.

The free-recall protocols were scored based on a propositional analysis method introduced by Patel and Groen (1986). A clinical case can be segmented into several meaningful information units or propositions. Each proposition consists of two concepts connected by a qualifier, such as *causation* (cau.), *negation* (neg.), *location* (loc.), or *specification* (spec.). For instance, the text fragment "a 45-year-old man complains about nausea and vomiting for 3 weeks", consists of four propositions: 1- man-spec. (45-years old), 2- complaints-spec. (nausea), 3- complaints-spec. (vomiting), 4- complaints-temp. (3 weeks). Evidence for encapsulation of case data was explored by counting the number of high-level inferences in the recall protocols. High-level inferences were considered as encapsulated concepts if they could be matched to more than one proposition in protocols. For example, if a case contains, among other things, the following information about a patient: *fatigue*, *abdominal pain*, and *palpitations*, a potential high-level inference might be *adrenal insufficiency*.

For each participant the data from each focus were collapsed to obtain a mean reading time, diagnostic accuracy, free recall, and high-level inferences. The data were analyzed using a 3 (Expertise level) $\times$ 2 (Case focus) analysis of variance with expertise level as and case focus as between-subject factors. The least significant difference test was used to make posthoc comparisons between the different expertise groups. Significance was set at $p < .05$ for all tests.

2.3 Result

2.3.1 Diagnostic accuracy

Table 2.1 depicts the mean diagnostic accuracy as a function of expertise level in Dx-condition (Note that participant in the Mx-conditions did not have to provide a diagnosis). The accuracy of the diagnoses is associated with level of expertise, $F(2, 27) = 9.08$, $MSE = 3.26$, $p < .001$, $\eta^2 = .40$. Pairwise comparison showed that experts provided significantly more accurate diagnoses than fourth-year and sixth-year students. There is no significant difference between sixth-year and fourth-year students.

Table 2.1

Mean diagnostic accuracy and standard errors (SE) as a function of level of expertise in diagnostic (Dx) focus

Level of expertise	**Dx**
Fourth-year students	1.50 (.17)
Sixth-year students	1.62 (.14)
Doctors	2.30 (.16)

2.3.2 Processing time

Table 2.2 depicts the mean processing time as a function of expertise level and case focus. Analysis of variance indicated that the time each participant spent reading the cases was associated with expertise level, $F(2, 54) = 20.53$, $MSE = 2222.70$, $p < .05$, $\eta^2 = .43$. There was no main effect of focus, $F(1, 54) = .01$, $MSE = 2222.70$, $p = .91$, and there was no interaction, $F(2, 54) = .05$, $MSE = 2222.70$, $p = 0.94$, $\eta^2 = 0.02$. Pairwise comparisons indicated that experts were significantly faster than both fourth-year and sixth-year students. Moreover, mean processing time did not differ between fourth-year and sixth-year students. No significant difference in processing time was observed between the Dx-focus and the Mx-focus in medical students as well as in experts.

Table 2.2

Mean processing time in seconds and standard errors (SE) as a function of levels of expertise and case focus

	Focus	
Level of expertise	**Dx**	**Mx**
Fourth-year students	266.80 (9.78)	270.97 (8.19)
Sixth-year students	254.02 (14.95)	249.35 (14.40)
Doctors	180.70 (18.58)	177.07 (19.85)

2.3.3 Free recall

Table 2.3 depicts the mean number of propositions recalled as a function of expertise level and case focus. Analysis showed a main effect of expertise level, $F(2,54) = 9.716$, $MSE = 149.60$, $p < .05$, $\eta^2 = .27$, a marginally significant effect of focus, $F(1,54) = 3.57$, $MSE = 149.59$, $p = .06$, $\eta^2 = .06$, and there was a significant interaction, $F(2,54) = 3.30$, $MSE = 149.59$, $p < .05$, $\eta^2 = .11$.

Pairwise comparisons within each focus showed that in the Mx-condition, doctors and sixth-year students differed significantly from fourth-year students, but not from each other. In the Dx-condition, fourth-year students and sixth-year students did not show significant differences, but both groups did produce significantly more propositions than the experts. Finally, the sixth-year students' recall was significantly higher in the Dx-condition than in the Mx-condition.

Further, the presence of high-level inferences in the recall protocols was also investigated because they are considered as evidence for encapsulated knowledge. Table 2.3 also depicts the mean number of high-level inferences as a function of expertise level and focus. There was main effect of expertise level, $F(2,54) = 4.37$, $MSE = 17.32$, $p < .05$, $\eta^2 = .14$, but there was no main effect of focus, $F(1,54) = 1.55$, $MSE = 17.32$, $p > .05$, $\eta^2 = .03$, and there was no interaction, $F(2,54) = .02$, $MSE = 17.32$, $p > .05$, $\eta^2 = .03$. In addition, pairwise comparisons between expertise levels revealed that experts produced significantly more high-level inferences than sixth-year and

Table 2.3

Mean propositions recalled and high-level inferences and their standard errors (SE) as a function of level of expertise and case focus

Level of expertise	**Focus**			
	Dx		**Mx**	
	Recall	High level Inferences	Recall	High level Inferences
Fourth-year students	44.67 (3.60)	2.5 (.70)	49.12 (2.50)	3.6 (1.33)
Sixth-year students	51.67 (3.89)	2.8 (.82)	36.32 (3.06)	4.10 (.9)
Doctors	34.40 (5.34)	5.8 (1.38)	27.40 (4.16)	7.40 (2.1)

fourth-year students. There was no significant difference between sixth-year and fourth-year students. Furthermore, there was no significant difference between Dx and Mx within expertise levels.

In order to correct recall for differences in time spent studying the cases, Table 2.4 depicts the mean proposition recalled per second (i.e., the total number of propositions recalled divided by the processing time) as a function of expertise level and focus. This measure gives us a purer indication what is remembered from the case description. Analysis showed no main effect of expertise level, $F(2, 54) = .53$, $MSE = .00$, $p > .05$, $\eta^2 = .02$, focus $F(1, 54) = 1.19$, $MSE = .00$, $p > .05$, $\eta^2 = .02$, nor a significant interaction, $F(2, 54) = 1.15$, $MSE = .00$, $p > .05$, $\eta^2 = .04$. Pairwise comparison showed only a significant difference between Dx and Mx for the sixth-year students.

2.4 Discussion

In contrast to previous studies, the present study was concerned with the way the case information was processed while managing clinical problems. Based on the view of knowledge encapsulation (Schmidt & Boshuizen, 1993a, 1993b), it was predicted that expert physicians would process the clinical problems in an encapsulated mode regardless of their focus (i.e., Mx or Dx).

Table 2.4

Mean number of propositions recalled per second and standard errors (SE) as a function of level of expertise and case focus

	Focus	
Level of expertise	**Dx**	**Mx**
Fourth-year students	.17 (.01)	.18 (.01)
Sixth-year students	.21 (.02)	.15 (.01)
Doctors	.21 (.03)	.19 (.04)

Furthermore, it was expected that sixth-year students will shift from a less elaborated processing mode while diagnosing the case to a more elaborate mode while managing the case. Fourth-year students were expected to be insensitive to the manipulation and process the cases in a similar manner.

The results were largely in line with our assumptions, in that medical experts processed cases faster and provided more accurate diagnoses than students in both Dx and Mx-condition. Furthermore, the experts' recall was much lower than that of medical students, whereas their mean number of high-level inferences was significantly higher. There was, as predicted, no difference between experts in Mx and Dx-focus. These data show that experts engaged in an encapsulated processing approach independently of their processing focus. The fact that there was no significant difference in propositions recalled per second between experts and medical students (see Table 2.3), shows that differences in recall between expertise levels are not the result of slower processing speed. These findings are in line with previous studies that demonstrated that experts' performance is relatively insensitive to the nature and circumstances of the task (de Bruin et al., 2005; Rikers et al., 2000; Rikers, Schmidt, & Boshuizen, 2002; Rikers, Loyens, & Schmidt, 2004; Rikers, Schmidt, Boshuizen, Linssen, et al., 2002; Verkoeijen et al., 2004).

Fourth-year students showed, as expected, no significant differences in recall in both Dx-focus and Mx-focus. Interestingly, in both focuses, there were no significant differences in speed and diagnostic accuracy between fourth-year and sixth-year medical students. These findings indicate that sixth-year students did not engage in a more elaborate processing mode than fourth-year students in the Mx-condition. However, there was a significant difference between both student groups in free recall. That is, sixth-year students remembered less than fourth-year students in the Mx-condition, which is not in line with our predictions. Moreover, sixth-year students remembered less in the Mx-condition than in the Dx-condition, which is also not in line with our predictions. As a matter of fact, their recall performance was similar to that of the experts in the Mx-condition. However, even though sixth-year students provided recall protocols quantitatively similar to those of experts in the Mx-focus, this finding does not imply that their recall is also qualitatively similar. This is substantiated by the finding that sixth-year students generated significantly less high-level inferences than experts: Sixth-year students' protocols contained 11% high-level inferences and experts 27%. The observed decrease in sixth-year students' recall with a management focus might be explained in the light of previous studies on knowledge encapsulation. For instance, Schmidt and Boshuizen (1993b) asked participants of different levels of expertise to study a case for 30 seconds, and subsequently participants were asked to write down what they remembered from the case. Their results also showed no significant difference in recall between sixth-year students and experts, but, in line with our study, experts generated significantly more high-level inferences. This finding was explained by assuming that reducing processing time, advanced students did not have sufficient time to process the case deeply and hence lost their advantage in terms of case recall. Similarly, due to insufficient patient management knowledge, sixth-year students in our study were also confronted with a task that interfered with their usual (diagnostic) way of dealing with clinical cases and hence experienced difficulty in building an appropriate and coherent representation. Consequently, they might have experienced difficulty reproducing the case information, which resulted in a poor recall performance (Brater & Nierenberg, 1988; Custers & Boshuizen, 2001; Kwan, 2004; Maxwell, 2003; Pearson, Rolfe, & Smith, 2002; Pearson, Smith, Rolfe, Moulds, & Shenfield, 2000; Prince, van de Wiel, Scherpbier, van der Vleuten, & Boshuizen, 2000). So, although sixth-year students have acquired more expertise in management than fourth-year students, this expertise hinders them in this phase because their Mx-knowledge is still underdeveloped to be used efficiently.

In sum, our study seems to indicate that especially for sixth-year students, there is a clear distinction between a diagnostic focus and a management focus while processing clinical case information. That is, their more recently acquired Mx-knowledge is not yet fully developed and integrated with their Dx-knowledge. In most medical schools Mx-knowledge does not seem to play an important role during the pre-clinical years, and the integration of Dx- and Mx-knowledge will therefore mainly start during the student's clinical years. As a result, the development of Mx-knowledge will lag behind the student's diagnostic competence and will only become fully integrated with Dx-knowledge after many years of clinical experience.

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Chapter 3

EXPERTISE IN PATIENT MANAGEMENT: DIFFERENCES BETWEEN DOCTORS AND MEDICAL STUDENTS IN A RECOGNITION TASK[3]

Abstract

Introduction: Many studies have investigated the structure of an illness script, but the patient management component (Mx) has not received much attention. Based on the illness script theory, it was assumed that the Mx-knowledge is part of the illness script, and it becomes integrated into the illness script structure as a result of treating real patients. The present study aimed at elucidating the role of Mx-knowledge in the development of illness script. Method: In this study, 20 fourth-year and 20 sixth-year students and 18 doctors studied clinical cases, each associated with a specific given diagnosis. Immediately after they had studied a case, target items were displayed to which they had to respond by indicating whether or not the items were related to the presented case. Five types of item were used as targets: faults, consequences, enabling conditions, management, and unrelated filler items. Results: Doctors made fewer mistakes in recognizing relevant Mx-items than both groups of medical students. Sixth-year students were also significantly more accurate than fourth-year students. As for the fault items, doctors made fewer mistakes than both groups of medical students. The error rates in enabling conditions (EC) and consequences (C) did not show any significant difference between levels of expertise. Conclusion: The current study has demonstrated

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a developmental pattern in correctly recognizing the relevance of Mx-items to expertise level, corroborating the assumption that management is part of the illness script. The significantly lower rates of error in inferred medical information (i.e., fault and management items) showed that these items played a more prominent role in the case representation of doctors than information that was literally stated in the case description. A non-significant difference in EC and C might be due to the nature of the recognition task.

3.1 Introduction

If a doctor and a medical student are asked to describe a patient with acute myocardial infarction, the doctor may describe a middle aged man with a previous history of hyperlipidemia and CCU admission who comes to ER with severe new onset retrosternal pain, and in urgent need of medical attention such as drug therapy. A medical student, on the other hand, may describe a patient with nausea, vomiting, anxiety, and palpitation due to the ischemia of heart's muscles. Obviously, the doctor's description is more realistic and accurate than the one the student provided. But how could these differences be explained? The answer to this question lays in the mental structures that are used by doctors to deal with clinical information in diagnostic settings. The clinical knowledge of doctors is supposed to be organized as a large set of illness scripts, which are fully developed and contain wealth of clinical information, including contextual information (i.e., enabling conditions) such as middle age or hyperlipidemia as well as the signs and symptoms of diseases (i.e., consequences) such as chest pain or nausea (Charlin, Tardif, & Boshuizen, 2000; Feltovich & Barrows, 1984; Schmidt & Rikers, 2007). In students and inexperienced doctors, on the other hand, the illness script is not yet fully developed. Their knowledge of the enabling conditions (EC) component is still deficient as their illness scripts are predominantly symptom oriented, i.e., they contain relatively more knowledge about the consequences component of the illness script than anything else, as reflected in the above example (Charlin et al., 2000; Schmidt & Rikers, 2007). However, besides the differences of EC, another component seems to play a crucial role in these expert-novice differences. A closer look at the above scenario reveals that the doctor not only thinks about the risk factors and contextual information, but also about the management plan for the patient. This important aspect was missing in the student's description. In the revised version of illness script theory, proposed by Monajemi and Rikers (2011), was suggested that management (Mx) should also be a component of an illness script. The way in which management becomes part of the illness script is comparable to the described process of integration of enabling conditions into the illness script (Custers, Boshuizen, & Schmidt, 1996, 1998; Schmidt & Rikers, 2007). That is, Mx-knowledge is largely absent from the newly formed illness scripts of medical students, but after extensive practice in patient management situations, it becomes integrated and more prominent in the illness script structure (Monajemi, Rikers, & Schmidt, 2007).

Reviewing what has been known about illness scripts should be the first step in taking patient management into consideration. Some studies that investigated the structure of illness script already revealed a trace of management knowledge. For example, Boshuizen, Schmidt, Custers, and van de Wiel (1995) asked medical students and family physicians to describe the clinical picture of some diseases. Interestingly, about 6.5% of the generated items referred to patient management, despite the fact that the participants were not explicitly asked for it. In the works by Hobus, Boshuizen, and Schmidt (1989) and Custers et al. (1998), which again used the same method, the results also showed that participants with higher levels of expertise provided more information concerning patient management. These items were not taken into consideration because they were not assigned to any known component of the illness script. It was suggested by Custers (1995) that another component called Course and Treatment, should also be included in the illness script. This idea has been followed and a revised version of the illness script theory was presented (Monajemi & Rikers, 2011), which contains information about the clinical presentation (consequences component), the pathophysiological mechanisms (fault component), risk factors (enabling conditions component), and finally the treatment of the patient (management component). To illustrate how this revised illness script theory would play out in a real medical context, consider the following example. Suppose the patient described above, sees a doctor in the emergency room, and is complaining about chest pain. The doctor first recognizes the clinical picture of acute myocardial infarction in the patient, and automatically the related script will become activated in the doctor's mind. The script guides the doctor's history taking, physical examination, and his ordering of additional investigations and tests (Custers et al., 1998; Patel, Groen, & Patel, 1997). When the diagnosis is confirmed, the doctor starts ordering the management plan, which consists of some drugs, and some suggestions for life style modification.

In order to elucidate the role of Mx-knowledge in illness script development, participants of the current study judged the relevance of items to a clinical case description. Fourth-year students, sixth-year students, and doctors studied three clinical cases, each associated with a specific given diagnosis. Immediately after they had studied a case, target items were displayed on a computer display which they had to respond to. In particular, they had to indicate whether or not the presented target was related to the case description. Five types of items were used as targets: faults, consequences, enabling conditions, management, and filler items.

Based on the illness script theory, it was expected that the information within the case description, and the provided diagnosis should activate a specific illness script in the doctors' minds. Consequently, illness script components will become highly activated and hence doctors should make fewer mistakes than both groups of medical students on all item types. In particular, it was expected that the number of errors in the Mx-component would decrease gradually as the level of expertise increases. Fourth-year students, on the other hand, would experience more difficulty in linking case information to the provided diagnosis as a result of underdeveloped illness scripts, which would lead them to make more errors. Finally, as sixth-year students have more clinical experience than fourth-year students, it was predicated that they would make fewer errors than fourth-year students, specifically on Mx-items.

3.2 Method

Participants

The participants were 20 fourth-year and 20 sixth-year medical students of Isfahan university medical school, and 18 internists from Isfahan hospitals. All internists were practitioners with an MD degree and board certified, and all had at least 3 years of clinical experience. The fourth-year students were preclinical students and had therefore no or very limited experience in hospitals. Sixth-year students, on the other hand, were interns and practicing under the supervision of residents and attending physicians in university hospitals.

Materials

The materials consisted of 3 clinical cases presented on the computer screen. All cases were within the domain of internal medicine and contained a complaint, history of present and past illnesses, physical examination, relevant laboratory data, and some additional information such as X-rays or ECGs. One case described a patient with bacterial endocarditis (Patel & Groen, 1986), one case was about heart failure (Rikers, Schmidt, & Boshuizen, 2002), and one was a patient with adrenal insufficiency (Verkoeijen, Rikers, Schmidt, van de Wiel, & Kooman, 2004). The case descriptions were about one page in length. Participants were asked to read a case, and subsequently judge whether or not a target item was related to the presented case. In order to make sure that all participants activated the correct illness script, the diagnosis was provided at the beginning of each case description. Based on the illness script components, fifty items per case were assembled: 10 fault items, 10 consequences, 10 enabling conditions, 10 Mx, and finally 10 filler items that were not related to the clinical cases. For example, the heart failure case contained the following information: a 70-year old woman with previous history of hypertension, hyperlipidemia is admitted because of shortness of breath. The physical examination reveals elevated JVP and peripheral edema. "Shortness of breath", "elevated JVP", and "edema" are items belonging to consequences, whereas "hyperlipidemia" or "hypertension" relate to the enabling conditions component. Concerning other components of the illness script of this case: "pulmonary edema" relates to fault component, whereas "diuretics" and "digitalization" are items related to the management component. Items such as "pemphigus" and "cataract" are possible filler items because they are unrelated to the heart failure case.

Procedure

The experimental setting was identical to the one used by Rikers, Loyens, and Schmidt (2004) study. Participants were instructed to carefully study each case description presented on a computer screen for period of 4 minutes. Subsequently, a row of asterisks appeared in the center of the computer for 500 milliseconds. This was then replaced by a target item, which remained visible until the participant made a response. Participant had to decide as accurately as possible whether the presented item was related to the case or not, by pressing yes or no button on the screen using the computer mouse. The items were considered related if they were literally stated in the case or they were inferences based on the case information. Once a decision was made, the target item disappeared and the screen remained blank for 500 milliseconds, after which the row of asterisks reappeared, indicating the start of the next trial. The computer automatically registered the response after the mouse button was pressed. The presentation order of the case and target items was randomized for each participant. In order to ensure familiarity with experimental procedure, a practice session preceded the experimental phase. All participants were tested individually in a session that lasted approximately 45 minutes.

Analysis

For each participant the data from 3 cases were collapsed to obtain a total error rate of all levels of each item type. The data were analyzed using mixed design analysis of variance (ANOVA); Expertise level (3) $\times$ Item type (4), where expertise level included fourth-year, sixth-year medical students and internists, and item type included fault (F), consequences (C), enabling conditions (EC), and management (Mx), with item type as within participant factor and expertise level as the between-participants factor. Filler items were not analyzed. Bonferroni tests were used to make Pairwise comparison between different levels of expertise. In addition, planned comparisons were made on the effects of item type. Effects were considered significant if $p < 0.05$.

3.3 Results

Table 3.1 shows the total error rate of the participants as a function of expertise level and item type. There was a main effect of expertise, $F(2, 55) = 14.12$, $MSE = 215.56$, $p < .05$, $\eta^2 = .33$, and a main effect of item type, $F(3, 165) = 78.11$, $MSE = 660.84$, $p < .05$, $\eta^2 = .58$. The interaction between item type and expertise level was also significant, $F(6, 165) = 3.91$, $MSE = 33.14$, $p < .05$, $\eta^2 = .12$.

Post-hoc tests showed that doctors had a significantly lower error rate than fourth-year and sixth-year students in both fault and Mx-items. Sixth-year students made fewer mistakes than fourth-year students only in Mx-item. There were not any significant differences in other items between different levels of expertise.

Table 3.1

Total error rates and standard errors as a function of expertise level and item type

Item Type	Level of expertise		
	Fourth-year students	Sixth-year students	Doctors
Fault	8.95 (3.05)	6.8 (4.17)	4.84 (2.85)
Consequences	3.90 (2.26)	3.45 (1.87)	2.57 (1.69)
Enabling conditions	4.95 (2.03)	3.6 (2.34)	3.68 (2.12)
Management	14.25 (5.39)	10.55 (4.77)	7.54 (2.74)
Total	32.05	24.4	18.64

3.4 Discussion

The present study especially investigated the role of Mx-knowledge in the development of illness scripts towards expertise. Based on the illness script theory, it was predicted that doctors would not have any difficulty linking the case information to their illness script that is rich in Mx-knowledge. It was predicted, therefore, that they would make the fewest errors in recognizing relevant Mx-items. Medical students, on the other hand, due to their limited clinical experience, would have more difficulty to link the case information with Mx-knowledge and would make relatively more errors. Our second group of students, the sixth-year students, were expected to be more accurate than fourth-year students, because they already possess some clinical experience, but obviously less than the doctors in our study.

Findings are largely in line with the revised version of the illness script theory (Monajemi & Rikers, 2011), in that doctors made fewer mistakes in judging relevant Mx-items than both groups of medical students. The results also showed a significant difference between the accuracy of Mx-items in sixth-year and fourth-year students, which could indicate that the integration of Mx-knowledge into illness script may have started at the level of sixth-year students. Surprisingly, sixth-year students did not show any significant difference in recognizing relevant Mx-items compared to that of doctors. Obviously, this non-significant difference in accuracy does not mean that in an actual setting, in which they are expected to actually manage patients, there would still be no difference between doctors and advanced medical students. Similar finding have been reported concerning the enabling conditions in doctors, and advanced medical students. For instance, Custers and his colleagues (1998) found that sixth-year students, compared to doctors, do not differ in the number of enabling conditions produced if they are explicitly asked to mention them. However, they cannot utilize it when they are asked to diagnose a case. They suggested that knowledge accessibility, as opposed to knowledge availability, is the critical aspect. It is possible that sixth-year students know quite a lot about the importance of patient management, but they are only able to access this knowledge when it is explicitly cued (e.g., if they have to judge the relevance of an Mx-item). In other circumstances, like in actual management situations, this type of knowledge may suffer from a transfer problem(Gick & Holyoak, 1980), and hence will not be used by students.

The results also show that fourth-year students have a 50% accuracy rate in recognizing relevant Mx-items. So, essentially their performance is at chance level due to their limited Mx-knowledge that was also shown in the other studies (Monajemi et al., 2007; Patel et al., 1997). The results of the other components are also interesting from the perspective of illness script development. Concerning fault item, doctors made fewer mistakes than both groups of medical students. The same result was also found in previous studies (Rikers et al., 2004; Rikers, Loyens, Winkel, Schmidt, & Sins, 2005) in which the accuracy of doctors in recognizing encapsulated items was really higher than the accuracy of fourth-year and sixth-year students. These findings demonstrated that they have not forgotten their biomedical knowledge.

The error rates of enabling conditions (EC) and consequences (C) did not show any difference between levels of expertise, which was not in line with our predictions. In most of the previous studies (e.g., Custers et al., 1996, 1998) experts showed a superior performance in producing C and EC-items. A possible explanation for the results in our study may be our experimental setting, in which the name of the disease associated with case information prevented it from becoming mainly a diagnostic task. The same results were also reported by Custers et al. (1996, 1998). They suggested that the recognition task is not sufficiently sensitive to uncover expert-novice differences in knowledge of EC and C, because participants are required to recognize them against the background of a diagnosis, rather than the other way around.

Furthermore, our findings seem to indicate a gradual change in the role of illness script components as the level of expertise increases. For both fourth-year and sixth-year students, there was no significant difference between enabling conditions and consequences, which indicates that their representation was still very superficial and text-based, as these two components were literally present in the case description. For doctors, however, inferred medical information (i.e., fault and management items) played a more prominent role in their case representation than information that was literally stated in the case description as corroborated by significant lower errors in these items.

The developmental aspects of illness scripts have again been found in this study. Although the focus of our study was on the role of management in illness script development, our results with respect to the other components were also measured, confirm that our method of experimentation is capable of simultaneously detecting the developmental nature of the illness script in other components as well.

Our results also shed a different light on the previous illness script studies. These studies that employed the method of free production task, had mostly focused on diagnosis and paid little attention to management (Boshuizen et al., 1995; Custers et al., 1996, 1998; Hobus et al., 1989). Yet, even in light of this emphasis on diagnosis, traces of management still managed to surface in their findings; so much that their participants often directly asked if they should mention Mx-related information (Custers, 1995). Our study, in which we simply asked the participants to judge the relevance of certain given items to a case, showed that not only does management have a prominent presence in the doctors' and advanced medical students' case representation, it also plays an important role in expertise development.

Our study, in particular its methodology, has some limitations. Asking medical students and doctors to evaluate paper cases with an already given diagnosis, and to decide on the relevance of some items on the screen does not actually resemble those that doctors encounter daily in their practice. It is, therefore, likely that certain differences between doctors and students (specifically advanced medical students) might have not been detected.

Since in this study, the participants were asked neither to diagnose nor to provide a management plan, something that does not occur in actual practice, it would be reasonable to suggest that in our future studies, the role of Mx-knowledge be investigated in a more natural setting such as asking participants to provide management plans for clinical cases. Another way to study the Mx-knowledge more deeply may be to experimentally examine illness script components when shifting focuses from diagnosis to management.

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Chapter 4

ASSESSING PATIENT MANAGEMENT PLANS OF DOCTORS AND MEDICAL STUDENTS: AN ILLNESS SCRIPT PERSPECTIVE[4]

Abstract

Introduction: Illness script theory offers explanations for expert-novice differences in clinical reasoning. However, it has mainly focused on diagnostic (Dx) performance, while patient management (Mx) has been largely ignored. The aim of the present study was to show the role of Mx-knowledge in illness script development and on the way it relates to diagnostic knowledge during the course of development towards expertise. Method: The participants were 10 fourth-year, 10 sixth-year students, and 10 doctors. Participants were asked to study the case description and to provide management plans. The protocols were examined for accuracy and the proportion of Mx- and Dx-items was also analyzed. Results: Providing accurate Mx-plans that pay attention concurrently to diagnosis and management was a characteristic of doctors. The Mx-plans of sixth-year students were as accurate as fourth-year students, but the format and the size of sixth-year students' protocols was like doctors. While 6th-year students generated plans with an Mx-focus, the protocols of fourth-year students were characterized by a Dx-focus. Conclusion: The doctors' accurate plans resulted from the high integration of their Mx and Dx-knowledge. For sixth-year students, the integration of these types of knowledge is still incomplete, and this leads to generic as well as inaccurate Mx-orders. For

[4] Monajemi, A., Schmidt, H. G., & Rikers, R. M. J. P. Assessing patient management plans of doctors and medical students: An illness script perspective. *Journal of Continuing Education for Health Professions(In press)*

fourth-year students, the Mx-focus is lacking, and hence they treat an Mx-task like a Dx-task.

4.1 Introduction

There is always a sense of curiosity about how doctors think when they deal with patients. This becomes the subject of further debate when the differences between medical students and doctors are taken into account. One example may clarify what is meant by these differences. Suppose doctors and medical students see the following patient in the emergency room:

> A 45-year old man complains about increasing tiredness during the past few weeks. In addition, he complains of nausea, vomiting, dizziness, abdominal pain and bloody sputum. During physical examination, he presents as moderately ill, temperature 38.6° C , blood pressure 110/70 mmHg lying down, 85/55 mmHg standing. Crepitation is heard in the left upper lobe of lung. Oral and cutaneous pigmentations are visible.

When doctors see this patient, they diagnose him with adrenal insufficiency without any hesitation, and manage accordingly with urgent fluid therapy and hydrocortisone infusion. Medical students, on the other hand, pay attention to the patient's bloody sputum that has made them suspicious of injury somewhere in the thorax. They think about the pathology in the lungs or the heart that needs more investigation such as thoracic CT- scan or chest X-ray (Schmidt, Norman, & Boshuizen, 1990; Schmidt & Rikers, 2007). This is the point where questions start surfacing, such as: Why are doctors able to provide an accurate diagnosis (Dx) and management (Mx) plan while the students are not? Where do these differences arise from? What is the relationship between diagnosis and management? How are diagnosis and management tuned up to save a patient's life?

Research aimed at understanding the nature of differences between doctors (i.e., experts) and medical students (i.e., novices) has already a long tradition (Ericsson, 2007; Norman, 2005; Schmidt & Rikers, 2007). It has generally focused on the way expertise in medicine develops over the years, and particularly on how medical students actually acquire medical expertise through medical education and practice. Schmidt et al. (1990) have offered an explanation for these expert-novice differences in medicine. They suggested that doctors possess better-organized and more accessible knowledge, which guides them through a patient workup, and also supports them in looking for relevant cues. Feltovich and Barrows (1984) called these knowledge structures that contain information about manifestations and risk factors of diseases illness scripts. In real settings, like the above example, doctors first and foremost have to deal with complaints and symptoms (e.g., fatigue, nausea, abdominal pain, etc), called consequences, as well as patients' background information called enabling conditions (e.g., he is 45 years old). They enable doctors to quickly recognize patterns of diseases, to filter out irrelevant information, and consequently to narrow down the possible diagnoses (Charlin, Tardif, & Boshuizen, 2000; Custers, Boshuizen, & Schmidt, 1996, 1998; Schmidt & Rikers, 2007). An illness script is therefore a structure that is particularly tuned towards use in practical diagnostic situations (Charlin et al., 2000; Custers et al., 1998). Medical students, on the other hand, are not usually able to recognize the pattern of the disease, and consequently fail to provide the correct diagnoses. Although they may already have developed rich biomedical knowledge, which is called the fault in illness script theory, due to limited clinical experience, their illness scripts, in particular the enabling conditions and consequence components are still underdeveloped, and not yet tuned towards practical applications (Custers et al., 1998). So, when students walk the wards, each clinical encounter with a patient adds bits and pieces to the related script, and gradually, rich illness scripts will develop (Charlin et al., 2000; Schmidt & Rikers, 2007).

Despite the fact that the illness script theory sheds light on the diagnostic aspects of expert-novice differences in medicine, it is not comprehensive enough to explain other aspects of expertise development. Illness script theory neither covers patient management nor does it tell us anything about the relationship between diagnosis and management when doctors deal with patients. If an illness scripts is supposed to represent a knowledge structure that is finely tuned towards practical situations, then a management plan for the patient should also be part of it (Charlin, Boshuizen, Custers, & Feltovich, 2007; Gruppen & Frohna, 2001; Monajemi & Rikers, 2011; Patel, Groen, & Patel, 1997). It is especially important to medical expertise research to have a good understanding of the role of management knowledge in the doctors' and the medical students' clinical reasoning, as it could help devise better plans for training medical students and junior doctors (Monajemi & Rikers, 2011; Mylopoloulos & Regehr, 2007).

The goal of the present study was to provide the experimental evidence for the role of management knowledge in medical expertise development within the framework of the illness script theory (Monajemi & Rikers, 2011). More specifically, the present study tries to provide explanations on how the management knowledge relates to diagnostic knowledge during the course of expertise development. In this study, doctors, sixth-year and fourth-year medical students were asked to read clinical cases and to provide a management plan. The protocols were examined for accuracy and the proportion of Mx- and Dx-relevant items.

Based on the revised illness script theory, management knowledge should be part of the illness script, and it gradually becomes integrated into it as a result of repeated exposure to real patients during educational experiences. The development of Mx-knowledge, however, is often not completely synchronized with that of Dx-knowledge. When students begin to practice with actual patients, there is a strong emphasis on providing the correct diagnosis, which is often not accompanied by an equivalent emphasis on developing a patient management plan (Brater & Nierenberg, 1988; Monajemi, Rikers, & Schmidt, 2007). Consequently, less advanced students, when confronted with a management task, would most likely deal with it as if it were a diagnostic task, which is the only mode of case processing they have some experience with. Therefore, in the present study, fourth-year students were expected to give Mx-plans more in accordance with their Dx-knowledge and would have a tendency to produce more items related to diagnosis rather than management. Sixth-year students have acquired more knowledge of management than fourth-year students, therefore, their produced plans were expected to be more centered around the Mx-component and less accurate than doctors. Experienced doctors, on the other hand, have learned through exposure to actual patient problems to take both diagnosis and management into account. It was therefore predicted that experts would provide more accurate Mx-plans than medical students. Moreover, it was predicted that these two types of knowledge would be more evenly present in their protocols than in those of students.

4.2 Method

Participants

20 medical students (ten fourth-year and ten sixth-year) from Isfahan (Iran) Medical School and 10 internists from three hospitals in Isfahan participated in this study. It takes seven years (4 preclinical years and 3 clinical years) to finish medical school in Isfahan School of Medicine. Fourth-year (preclinical) medical students had no or very limited hospital experience, and their clinical knowledge was based on textbooks and lectures, whereas sixth-year students were in their hospital training phase as interns under the supervision of senior residents and attending physicians. The internists were practitioners with an MD degree and at least two years of experience.

Materials

The materials consisted of a booklet containing an instruction about the procedure, four written descriptions of clinical cases and two blank response sheets following the text of each case for writing the clinical management plan. The cases were identical to cases used by Patel and Groen (1986); Rikers, Schmidt, and Boshuizen (2000, 2002), and Verkoeijen, Rikers, Schmidt, van de Wiel, and Kooman (2004). The cases were acute bacterial endocarditis, two cases of heart failure, and a case of Addison's disease with tuberculosis. The four case descriptions were about one page in length and consisted of 76, 82, 105, and 107 propositions, respectively. The order of the cases for each participant was randomized, with the same set of cases for all expertise levels.

Procedure

In order to familiarize the participants with the procedure, they were first given the opportunity to read an unrelated case of about the same length. Participants were asked to read the case with the aim to provide a management plan for this patient within a period of 5 minutes. After they studied the case with a management focus, they were asked to write down what they thought about the management plan of the case. There was no time limitation for this task. Participants were informed that they could proceed to the next task whenever they were ready to study the case. During the test, the cases were presented sequentially and they were studied individually. After each case had been managed, the next case was handed out to the participant.

Analysis

The accuracy of management plans were independently assessed by 2 internists on a 5-point scale, ranging from 0 = completely inaccurate, to 4 = completely accurate. The kappa score for the two internists' agreement on the Mx accuracy was .8, indicating a good agreement. Disagreement between experts were resolved by discussion. The analysis of Mx-plans consisted of segmenting the protocols into propositions using a technique based on the work of Patel and Groen (1986). The essential element in propositional analysis is the segmentation of a protocol into individual propositions corresponding to discrete idea units in the test. To score the protocols, three measures were used based on previous clinical case studies (Rikers et al., 2000, 2002). The elaborateness was investigated by counting the total number of propositions. The final two measures were based on the classifications of propositions into Dx or Mx. This distinction was based on the object of the proposition. The Mx and Dx-propositions were counted and were divided by the total number of propositions. Propositions concerning the ways in which the disease can be managed were classified as Mx-propositions. They are phrased in terms of entities such as activity limitation, nursing instructions, diet, intravenous fluids, per-request medication, and medication, whereas Dx-items are represented by any intervention to do something for confirming diagnosis or further investigation, including history taking, physical examination, lab data, or referring to a disease entity or clinical presentation. An example of Dx- and Mx-items is listed in Appendix A. As the classification principle is based on the object of a proposition, often propositions from adjacent protocol fragments must be taken into account. Two raters classified the items and an inter-rater agreement of .95 was obtained. When raters disagreed, inconsistencies were resolved by discussion. All data were analyzed by analysis of variance (ANOVA) and effects were considered significant if $p < .05$.

Table 4.1

Mean of management (Mx) accuracy and standard deviation (SD) as a function of level of expertise

Level of expertise	Mean	SD
Fourth-year students	2.15	.82
Sixth-year students	2.33	.97
Doctors	3.09	1.01

4.3 Results

4.3.1 Mx-Accuracy

Table 4.1 depicts the mean and standard deviations of Mx-accuracy of different levels of expertise. There was an expertise effect, $F(2, 27) = 5.83$, $MSE = 5.21$, $p < .05$, $\eta^2 = .41$. Post-hoc analysis showed that doctors provided significantly more accurate Mx-protocols than both groups of students, but there was no significant difference between the two groups of students.

4.3.2 Total number of items

Table 4.2 shows the mean number of items in Mx-protocols. ANOVA showed that a significant expertise effect, $F(2, 27) = 3.58$, $MSE = 913.90$, $p < .05$, $\eta^2 = .45$. The post-hoc analysis showed only a significant difference between fourth-year students and doctors in terms of total number of generated items.

4.3.3 Dx versus Mx proportion in Mx protocols

Table 4.3 depicts the mean proportion and standard deviations of diagnostic (Dx) and management (Mx) items of different level of expertise.The ANOVA showed that overall differences between levels of expertise in terms of Dx-Mx proportion were statistically significant, $F(2, 57) = 6.25$, $MSE = .15$, $p < .05$, $\eta^2 = .42$. Post-hoc analysis tests showed only significant difference

Table 4.2

Mean of number of items and standard deviation (SD) as a function of level of expertise

Level of expertise	Mean	SD
Fourth-year students	42.00	20.15
Sixth-year students	28.80	12.44
Doctors	24.10	14.23

Table 4.3

Mean proportion and standard deviations of diagnostic (Dx) and management (Mx) items of different level of expertise

Level of expertise	Dx	Mx
Fourth-year students	.61 (.13)	.38 (.13)
Sixth-year students	.44 (.08)	.55 (.08)
Doctors	.54 (.22)	.45 (.22)

between fourth-year and sixth-year students. The planned comparison t-tests showed that fourth-year students generated more Dx- items than Mx-items, $t(9) = 2.61$, $p < .05$. In contrast to fourth-year students, sixth-year students provided more Mx-items, $t(9) = -2.13$, $p < .05$. In addition, there was no significant difference between Dx- and Mx-items in the doctors' protocols, $t(9) = .60$, $p > .05$.

4.4 Discussion

The aim of this study was to investigate the role of Mx-knowledge in the development of illness scripts. It was expected that by asking participants of different levels of expertise to provide Mx-plans, the connection between diagnosis and management could be demonstrated. It was predicted that doctors would produce more accurate protocols with a balance between Dx- and Mx-items, while those produced by sixth-year students were expected to be more centered around the Mx-component and less accurate. Fourth-year students, on the other hand, would focus on isolated signs and symptoms, and attempt to relate each of these to the pathophysilogical mechanism; something that could be corroborated by the Dx-dominant protocols and incorrect Mx-plans.

The results of the present study demonstrated that doctors provided more accurate protocols than medical students, which indicates that Mx-accuracy, like Dx-accuracy, is one of the experts' features. Experience with real patients in a setting that diagnosis and management should be done together, organizes the knowledge in the illness script; a phenomenon that is also reflected in the results. An example of such a pattern is given in Appendix B. The components of the Mx-plan indicate that Dx- and Mx-knowledge have both been properly covered. Experts concurrently thought about more investigative tests to confirm the diagnosis (e.g., item No. 1-5) and provide an Mx-plan (e.g., item No. 6-13) to stabilize the patient as well. Since they provided the management plan based on the most probable diagnosis (i.e., pulmonary edema in Congestive Heart Failure), they were able to better deal with this patient.

On the other hand, sixth-year students, as was expected, provided less accurate protocols. Their protocols were inaccurate and almost exclusively focused on management without any need to provide a diagnosis first. This fact is corroborated by the absence of investigative tests as well as the presence of symptom therapy. Although inaccuracy of Mx-plans produced by the sixth-year students' can obviously be linked to their insufficient Mx-knowledge (Kwan, 2004; Maxwell, 2003; Pearson, Rolfe, & Smith, 2002; Pearson, Smith, Rolfe, Moulds, & Shenfield, 2000; Prince, van de Wiel, Scherpbier, van der Vleuten, & Boshuizen, 2000), it is important to note that incomplete or absence of linkage between the Mx- and Dx-knowledge can also affect the overall accuracy of their Mx-plans. This poor integration of Mx into the illness script is for instance evident in the protocol shown in Appendix C, in which the sixth-year student has failed to maintain a balance between the Dx- and Mx-focuses in her Mx-plan and has ordered inhalers (i.e., item No. 9) to manage the patient's dyspnea; a measure taken as a result of solely focusing on symptom therapy (i.e., a purely Mx-focused action) and failing to take the correct diagnosis (pulmonary edema), which would call for the prescription of a diuretic.

The sixth-year students' Mx-items (components) are more qualitatively, rather than quantitatively, different from those of doctors. They provided their Mx-plan while ignoring cues that could have led to requesting ancillary tests (in order to obtain further evidence of some life-threatening differential diagnoses). Some components were unrelated to the case, and some critical components were missing. This sketchiness of intermediates' knowledge is in line with the results of some of the previous studies (Custers et al., 1996, 1998). As a result of limited Mx-knowledge, sixth-year students frequently used a generic pattern of writing an Mx-order, such as "control vital signs," (CVS) as though they felt no need to link each of its items to the most probable diagnosis. So, even though the accuracy of sixth-year students was similar to that of fourth-year students, the format and the total number of items were similar to that of doctors. It could be concluded that they are still in the middle of the process of linking their Dx-knowledge to their newly acquired Mx-knowledge.

Fourth-year students generated less accurate and Dx-dominant protocols, which show the absence of an Mx-focus in their illness scripts. The unstructured approach in ordering therapeutics and tests without specific reasons appeared to be more prominent in this group. They have written requests that are unrelated to any diagnosis. Moreover, they asked for further information on past medical history and explained the pathophysiology of the disease in their Mx-plan, which reflects in that they had little or no knowledge of patient management. It seems that they were more curious about the underlying mechanisms of diseases rather than being concerned with the patient's life. This is illustrated by the protocol produced by a student as shown in Appendix D.

As has been pointed out in the Introduction, the illness script theory has been shown in previous studies to be successful at explaining the development of medical expertise in diagnostic tasks. The present study was concerned with the role of management knowledge in medical expertise development. It could serve as experimental evidence that the illness script theory could also be successful in explaining the development of medical expertise in Mx-tasks as well, and illustrate how the management and diagnostic knowledge link with one another during the course of development toward expertise. The results showed that providing accurate Mx-plan is one of the features of experts; one that is highly linked to their ability to make an accurate diagnosis. The differences between levels of expertise in terms of accuracy and format of the Mx-protocols indicate that Mx-knowledge gradually integrates into the illness script, such that eventually, diagnostic and management actions are performed together.

Although an accurate management plan has been shown as an important characteristic of medical experts in this study, much further work seems to be necessary to further understand the nature of the Mx-knowledge and its relationship with Dx-knowledge. The amount of work needed to reach a point where such understanding of the Mx-knowledge could lead to a tangible practical application in areas such as medical education still remains substantial.

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Chapter 5

HOW DOES PATIENT MANAGEMENT KNOWLEDGE INTEGRATE INTO AN ILLNESS SCRIPT?[5]

Abstract

Introduction: Illness script research has mostly been focused on understanding how doctors make diagnoses (Dx), while patient management (Mx) has received much less attention. In this study, the relationship between known components of illness script, that is, fault, enabling conditions, and consequences, and a newly proposed component, management will be explored. Method: In this study, 16 fourth-year, 16 sixth-year medical students, and 16 residents (i.e., doctors) were asked to think aloud while either diagnosing or managing a case, and recall it afterwards. The think-aloud methodology ensured that the participants were in the intended mode of thinking, that is, they were actually thinking about management or diagnosis as instructed. Results: Doctors provided significantly more accurate diagnoses than both groups of medical students. Doctors and sixth-year students produced significantly more Mx-items than fourth-year students in the Mx-focus. Doctors and sixth-year students produced significantly fewer enabling conditions (EC) items than fourth-year students in the Mx-focus. Fourth-year students, on the other hand, had the same performance in either focus. Conclusion: This study clearly showed that the integration of Mx-knowledge starts at the level of sixth-year students. As the accuracy of Mx and Dx was examined simultaneously, the higher accuracy of doctors in both focuses compared to medical students could be indicative of the full integration of the Dx- and the Mx-knowledge in the doctors'

[5] Monajemi, A., Rajabi Rostami, E., Savaj, Sh., & Rikers, R. M. J. P. How does patient management knowledge integrate into an illness script? Manuscript submitted for publication (2011).

illness scripts. Furthermore, this study showed a drop in EC-proportion without any change in Dx-accuracy when doctors were thinking about management, which could reflect another developmental aspect of this relationship.

5.1 Introduction

Medical expertise research is concerned with understanding the development of medical proficiency. The process through which doctors deal with patients' problems, i.e., patient workup, has attracted the attention of researchers over the past decades (e.g., Boshuizen & Schmidt, 1992; Eva, Norman, Neville, Wood, & Brooks, 2002; Norman, Brooks, & Allen, 1989; Patel & Groen, 1986; Patel, Groen, & Arocha, 1990; Rikers, Schmidt, & Boshuizen, 2000, 2002; Schmidt & Boshuizen, 1993). The following example shows what is meant by the process of patient workup:

> An eight-year-old child comes with his mother to the doctor complaining about pain in the throat that worsens with swallowing. The doctor uses a lighted instrument to look at the child's throat, ears and nasal passages, gently feeling (palpating) his neck to check for swollen glands, and listens to his breathing with a stethoscope. Then the doctor rubs a sterile swab over the back of the child's throat to get a sample of the secretions. The sample will be checked for streptococcal bacteria, the cause of strep throat. Based on the clinical presentation and the test result, the doctor provides the diagnosis of streptococcal pharyngitis. Then, the doctor asks the mother about the child's body weight as well as any history of allergy to Penicillin, to which the mother provides an affirmative answer. Because of that allergy history, Azithromycin tablets are prescribed for the patient.

This is a typical scenario that makes the fact rather trivial that what doctors do is much more than providing a diagnosis, and that a large part of their activity consists of figuring out a management plan for their patient (Gruppen & Frohna, 2001). However, research interest has mostly been focused on understanding how doctors make diagnoses (Boshuizen & Schmidt, 1992; Patel & Groen, 1986; Patel et al., 1990; Rikers et al., 2000, 2002; Schmidt & Boshuizen, 1993), while patient management has received much less attention than it deserves (Bissessur et al., 2009; Ericsson, 2004; Gruppen & Frohna, 2001; McGuire, 1985; Monajemi & Rikers, 2011; Monajemi, Rikers, & Schmidt, 2007; Norman, 2005; Schmidt & Rikers, 2007). Although the work on diagnostics has taught us many things about the nature of medical expertise, focusing solely on this aspect provides us with only a narrow perspective on it, resulting in what might be an incomplete depiction of medical experts. Understanding the nature of the management knowledge and its organization in the doctors' minds is especially important, as ever since its inception, expertise research in medicine has served a clear educational purpose (Ericsson, 2007; Norman, 2005; Schmidt & Rikers, 2007). Improving our understanding in this area would be essential to bringing more depth to our definition of a medical expert as well as how medical knowledge is developed in such a way that turns novice students into skilled doctors (Albert, Hodges, & Regehr, 2007; Monajemi & Rikers, 2011).

In order to take patient management into consideration, one should first review what has been known about medical expertise. Going back to the roots of medical expertise research, reveals that one of the questions that many studies have tried to address is how doctors acquire expertise. That is, how medical knowledge has developed in such a way that it helps doctors solve patients' problems. Previous studies have shown that in real settings, doctors first and foremost have to deal with complaints and symptoms, like a sore throat in the above case, as well as patients' background information, such as age and history of allergy. Complaints and symptoms, as well as background information, are two components in doctors' knowledge structure that enable them to quickly recognize patterns of diseases (Charlin, Boshuizen, Custers, & Feltovich, 2007; Charlin, Tardif, & Boshuizen, 2000; Custers, Boshuizen, & Schmidt, 1996; Rikers et al., 2000; Schmidt & Rikers, 2007). Feltovich and Barrows (1984) have termed these knowledge structures illness scripts, in which "signs and symptoms" and "background information" have been respectively called "consequences" and "enabling conditions." Illness scripts provide direction and scope for the diagnosis and guide doctors in gathering information from the case and in interpreting findings. These knowledge structures, therefore, are particularly tuned towards use in practical clinical situations. The theory also describes how the illness script develops during the course of medical education from novice to expert. As students begin to practice with actual patients, their limited knowledge about disease manifestations are held together by a larger amount of knowledge about pathophysiological mechanisms of diseases, i.e., biomedical knowledge, and this forms their (initial) illness script (Charlin et al., 2000; Custers, Boshuizen, & Schmidt, 1998; Schmidt & Rikers, 2007). Since the biomedical knowledge, referred to as the fault component within the illness script structure, does not play an important role in practical clinical circumstances, especially in routine diagnostic situations, it gradually becomes less prominent as the student gains more experience, when all the while the role of enabling conditions gradually becomes more pronounced . However, since their knowledge on enabling conditions has not completely integrated into their illness scripts, students are not able to readily use it in diagnostic situations (Boshuizen, Schmidt, Custers, & van de Wiel, 1995). This type of knowledge becomes generally accessible when it fully integrates into their illness scripts as a result of extensive exposure to real patients (Custers et al., 1998; Schmidt & Rikers, 2007).

To study the role of management, therefore, it would make sense to elucidate its place within the framework of the illness script theory. It is important to show that management plays a role in the developments towards expertise. The first step in bringing management into medical expertise studies was reported by Monajemi et al. (2007). In this study, when advanced medical students were asked to provide management plans while they were reading a case, they failed to recall elaborately, whereas in contrast, their recalls were quite elaborate when asked to provide diagnoses. The result of this study might suggest that management plays a role in the development of medical expertise. Further, in the next step towards bringing management into the spotlight, an attempt was made to better understand its role in medical expertise by asking people on different levels of expertise to read cases and provide management plans (Monajemi, Schmidt, & Rikers, 2012). The result of this study showed that the management accuracy is an unequivocal indicator of expertise. In addition, the study revealed a developmental pattern in the use of the management knowledge: while management protocols of less advanced students did not resemble an actual management plan, and contained many pathophysiological concepts, and queries for further information on the patient's medical history, more advanced students were able to provide some of the items of an actual management plan. Another important finding in this study was the transitional state of the management knowledge in advanced students, in the sense that although they were able to provide management plans that were superficially similar to that of the experts, the accuracy of their plans was like that of less advanced students, could suggest that their diagnostic and management knowledge had not yet tightly linked to one another. Subsequently, Monajemi and Rikers (2011) proposed to incorporate all these findings into the illness script theory. They suggested that the management knowledge should be part of the illness script, and it gradually becomes integrated into it as a result of repeated exposure to real patients, which is highly linked to their educational and training experiences during the course of their medical education. Furthermore, it was suggested that as education in medical schools puts more emphasis on providing diagnoses than management plans (Brater & Nierenberg, 1988; Monajemi et al., 2007), the initial illness script formed in medical students are tuned more towards diagnostic tasks. In this phase, the students treat a management task like a diagnostic one, which is why their management plans do not resemble an actual one. When students enter the internship phase, they become more familiar with the management task, but their limited experience does not yet allow their newly acquired management knowledge to fully integrate with their priorly established diagnostic knowledge. As a result of extensive experience with real patients in a setting that diagnostic and management should be done concurrently, management knowledge finally becomes fully integrated into the illness script, and this is when they become medical experts.

The goal of the present study was to experimentally determine whether the management knowledge plays a role in the development of illness scripts towards expertise. To elucidate the way the management knowledge integrates into the illness script, a comparison of different levels of expertise was made when they tried to diagnose or manage the cases. Furthermore, fourth-year students, sixth-year students, and residents (i.e., doctors) were instructed to think aloud while reading the case for diagnosis or management. They were also asked to subsequently recall whatever they remembered from the cases. The recall protocol would be examined in terms of illness script components, as well as diagnostic and management accuracy.

Based on the revised illness script theory, it was expected that the proportion of management (i.e., Mx) related items would increase with the level of expertise in Mx-focused tasks. As the integration of Mx-knowledge into illness script begins at the level of sixth-year students, this experimental manipulation, i.e. Dx- (i.e., diagnostic) vs. Mx-focus, would greatly affect the performance of doctors and sixth-year students, whereas the fourth-year students' performance will be largely unaffected. It was predicted that doctors would generate more Mx-items than fourth-year and sixth-year students, and that they would provide more accurate diagnostic and management plans. Sixth-year students have acquired more knowledge of management than fourth-year students; hence their recall protocols should contain more Mx-related items. However, due to the limited links between their diagnostic and management knowledge, they would generate less accurate diagnoses as well as less accurate Mx-plans than doctors. As the Dx-focus is the only mode of case processing available to fourth-year students, they would not be affected by the Dx vs. Mx manipulation, and their performance would remain the same across both focuses.

5.2 Method

Participants

32 medical students (16 fourth-year and 16 sixth-years) from Tehran Medical School and 16 internal medicine residents from three hospitals in Tehran (Iran) participated in this study. It takes about seven years (4 preclinical years and 3 clinical years) to finish medical school at Tehran School of Medicine. Fourth-year (preclinical) medical students had no or very limited hospital experience, and their clinical knowledge was based on textbooks and lectures, whereas sixth-year students were in their hospital training phase as interns under the supervision of senior residents and attending physicians. The internal medicine residents engaged in similar specialty programs in teaching hospitals in Tehran.

Materials

The material consists of two cases in the field of internal medicine. One case was identical to the case used by Patel and Groen (1986) and the other one was constructed by two expert doctors. The cases were acute bacterial endocarditis (Patel & Groen, 1986) and hypoglycemic coma. Both cases were about one page in length. The order of the cases for all participants was similar, with the same set of cases for all expertise levels.

Procedure

Participants were randomly assigned to the Mx-condition or the Dx-condition. In order to familiarize the participants with the procedure, they were first given the opportunity to read an unrelated case of about the same length and to think aloud (van Someren, Barnard, & Sandberg, 1994). In the Dx-condition, participants were told to think aloud for four minutes while they were diagnosing the case. Subsequently, they were instructed to write down whatever they remembered form the case as well as the diagnoses for both cases. In the Mx-condition, participants also thought aloud while trying to devise a management plan for the patient. After they studied the case in the Mx-condition, they were also asked to write down whatever they remembered from the cases and the diagnoses of the two cases. The only reason for imposing a time limit for the thinking-aloud session was to push participants to do the task in a feasible and manageable amount of time. Each participant was tested individually.

Analysis

The accuracy of provided diagnoses was independently scored by two internists ranging from 0 = completely inaccurate, to 100 = completely accurate. The kappa score for the two internists' agreement on the diagnostic accuracy was .9, indicating a good agreement. The accuracy of Mx-items were independently assessed by two internists on a 100-point scale, ranging from 0 = completely inaccurate, to 100 = completely accurate. The kappa score for the two internists' agreement on the Mx-accuracy was .85, indicating a good agreement. Disagreements between the referees were resolved by discussion.

The analysis of recall protocols consisted of segmenting the protocols into propositions using a technique based on the work of Patel and Groen (1986). The essential element in propositional analysis is the segmentation of a protocol into individual propositions corresponding to discrete idea units in the test (Patel & Groen, 1986). To score the protocols, three measures were used based on previous clinical case studies (Rikers et al., 2000, 2002). The elaborateness was measured by counting the total number of concepts. An expert physician, who had experience with the illness-script categories, was consulted in order to establish a sound basis for classification. The propositions in each component were counted and these figures divided by the total number of propositions extracted and reported. The least significant difference test was used to make post-hoc comparisons between the different expertise groups. Significance level was set at $p < .05$ for all tests. The number and proportion of statements in each of the illness script categories were analyzed using a 3 (Levels of expertise) by 2 (Focuses) analysis of variance (ANOVA).

5.3 Results

5.3.1 Diagnostic accuracy

Table 5.1 depicts the mean diagnostic accuracy as a function of expertise level in both focuses. Analysis showed a main effect of expertise, $F(2, 37) = 11.30$, $MSE = 4.16$, $p < .05$, $\eta^2 = .37$, a non-significant effect of focus, $F(1, 37) = .07$, $MSE = 8.33$, $p > .05$, and a non-significant interaction, $F(2, 37) = .97$, $MSE = .36$, $p > .05$, $\eta^2 = .05$. Pairwise comparison indicated that doctors provided significantly more accurate diagnoses than both groups of medical students. There was no significant difference in accuracy between the two groups of students as well as between both focuses in each level. The results support the general validity of the procedure and the selection of the participants.

Table 5.1

Mean diagnostic accuracy and standard deviation (SD) as a function of level of expertise and focus

	Focus	
Level of expertise	**Dx**	**Mx**
Fourth-year students	39 (15.5)	20.0 (20.5)
Sixth-year students	34 (35)	42.5 (34.5)
Doctors	75 (29.5)	85.5 (37.5)

Table 5.2

Mean propositions recalled and standard deviation (SD) as a function of level of expertise and focus

	Focus	
Level of expertise	**Dx**	**Mx**
Fourth-year students	17.75 (3.61)	18.50 (4.34)
Sixth-year students	26.14 (8.00)	38.37 (10.19)
Doctors	26.37 (8.70)	43.37 (14.59)

5.3.2 Total recall

Table 5.2 shows the mean number of propositions recalled as a function of expertise level and focus. Analysis showed a main effect of expertise level, $F(2, 41) = 15.76$, $MSE = 1291.09$, $p < .05$, $\eta^2 = .43$, a significant effect of focus, $F(1, 41) = 14.29$, $MSE = 1170.69$, $p < .05$, $\eta^2 = .25$, and a significant interaction $F(2, 41) = 3.39$, $MSE = 278.40$, $p < .05$, $\eta^2 = .14$.

Pairwise comparison within each focus showed that in the Dx-focus, doctors differed marginally from fourth-year students ($p = .07$), but there was no significant difference between sixth-year and fourth-year students or doctors and sixth-year students. In the Mx-focus, both doctors and sixth-year students produced significantly more propositions than fourth-year students, but there was no significant difference between doctors and sixth-year students. Furthermore, the volume of recall in both doctors and sixth-year students was significantly higher in the Mx-focus than in the Dx-focus, while there was no significant difference in fourth-year students.

5.3.3 The proportion of statements in different illness script categories

Enabling conditions

Analysis showed a significant main effect expertise level, $F(2, 41) = 9.24$, $MSE = .09$, $p < .05$, $\eta^2 = .31$, a significant main effect of focus, $F(1, 41) = 11.25$, $MSE = .11$, $p < .05$, $\eta^2 = .21$, and a significant interaction, $F(2, 41) =$

Table 5.3

Mean Enabling Conditions (EC) proportion and standard deviation (SD) as a function of level of expertise and focus

	Focus	
Level of expertise	**Dx**	**Mx**
Fourth-year students	.45 (.09)	.47 (.07)
Sixth-year students	.40 (.16)	.27 (.08)
Doctors	.41 (.07)	.22 (.13)

4.16, $MSE = .04$, $p < .05$, $\eta^2 = .17$. Table 5.3 shows enabling condition proportion as a function of expertise level and focus. Pairwise comparisons within each focus indicated that while there was no significant difference between levels of expertise in the Dx-focus, doctors and sixth-year students produced significantly fewer enabling conditions (EC) items than fourth-year students in the Mx-focus, but no such difference was observed between doctors and sixth-year students. With respect to differences between Dx- and Mx-focus, the results showed no significant difference in fourth-year students, while there was a borderline ($p = .08$) effect in sixth-year students. There was a significant effect between two focuses in doctors in terms of EC proportion.

Consequences

Table 5.4 shows the proportion of consequences as a function of expertise level and focus. Analysis revealed significant effect of expertise level, $F(2, 41) = 3.82$, $MSE = 0.03$, $p < .05$, $\eta^2 = .15$, but no significant of focus, $F(1, 41) = .76$, $MSE = .007$, $p > .05$, $\eta^2 = .01$, as well as no significant effect of interaction, $F(2, 41) = .95$, $MSE = .009$, $p > .05$, $\eta^2 = .04$. Pairwise comparisons within each focus indicated that while there was no significant difference between levels of expertise in the Mx-focus, there was a mere borderline effect ($p = .08$) in the Dx-focus. The results showed no significant difference in all levels between two focuses.

Table 5.4

Mean Consequences (C) proportion and standard deviation (SD) as a function of level of expertise and focus

	Focus	
Level of expertise	**Dx**	**Mx**
Fourth-year students	.53 (.09)	.47 (.09)
Sixth-year students	.44 (.07)	.39 (.08)
Doctors	.46 (.10)	.44 (.09)

Table 5.5

Mean Enabling Conditions (EC) proportion and standard deviation (SD) as a function of level of expertise and focus

	Focus	
Level of expertise	**Dx**	**Mx**
Fourth-year students	.45 (.09)	.47 (.07)
Sixth-year students	.40 (.16)	.27 (.08)
Doctors	.41 (.07)	.22 (.13)

Management

Table 5.5 shows the proportion of Mx-items as a function of expertise level and focus. Analysis revealed significant effect of expertise level, $F(2, 41) = 14.91$, $MSE = .11$, $p < .05$, $\eta^2 = .42$, significant effect of focus, $F(1, 41) = 54.90$, $MSE = 0.42$, $p < .05$, $\eta^2 = .57$, as well as significant effect of interaction, $F(2, 41) = 13.92$, $MSE = .10$, $p < .05$, $\eta^2 = .40$. Pairwise comparisons within each focus indicated that while there was no significant difference between levels of expertise in the Dx-focus, doctors and sixth-year students produced significantly more Mx-items than fourth-year students in the Mx-focus, but such difference was not observed between doctors and sixth-year students. With respect to differences between Dx- and Mx-focus, the results showed no significant difference in fourth-year students, while there was a significant effect both in doctors and sixth-year students between two focuses.

The Mx-accuracy of the doctors was high ($M = 62.14$; $SD = 24.47$). In contrast the management accuracy of the sixth-year students ($M = 24.47$; $SD = 16.02$) was considerably lower. Analysis revealed significant effect of expertise level, $F(1, 13) = 5.70$, $MSE = 2383.61$, $p < .05$, $\eta^2 = .53$.

5.4 Discussion

The aim of this study was to investigate the role of management knowledge in the development of illness script. In order to demonstrate the gradual integration of Mx-knowledge into the illness script structure, participants from different levels of expertise were asked to think aloud while either diagnosing or managing a case and to recall it afterwards. It was predicted that the proportion of Mx-items would increase monotonically with expertise level. Moreover, both doctors and sixth-year students would be affected by the focus and perform differently by generating more Mx-items, while differing from each other in terms of diagnostic and management accuracy. Fourth-year students, on the other hand, were predicted to perform the same, regardless of the focus, and treat the case with an Mx-focus similarly to one with a Dx-focus.

The results of the present study demonstrated that doctors provided more Mx-items than both groups of medical students in the Mx-focus, which indicates that generating Mx-items could be one of the experts' features. The results of sixth-year students were also in line with our assumptions, as they generated significantly more Mx-items when thinking about management than when they were asked to diagnose. As pointed out earlier, the performance of sixth-year students was superficially similar to that of doctors in terms of Mx-proportion, but with respect to both diagnostic and management accuracy, they resembled less advanced students.

Similar to the previous studies (Higgins & Tully, 2005; Monajemi et al., 2007; Monajemi & Rikers, 2011; Patel, Groen, & Patel, 1997), the results indicate that the Mx items generated by the sixth-year students were generic and blanket, not particularly aimed at managing the specific cases. Furthermore, most of the sixth-year students' Mx-items were about routine tests, diet, etc., which were repeated persistently among different protocols, while some highly important and crucial aspects of patient management plan were missed (e.g., in the comatose patients, they asked for routine test like CBC or serum electrolytes, but ignored ordering blood glucose level and coma cocktail). This highlights the lack of connection between their diagnostic and management knowledge-bases as expected. That is, they are only able to provide a management plan when they are explicitly asked. Therefore, in the present study, when they were asked to provide diagnosis after recalling the case, they provided the diagnosis that they had not taken into account earlier, when they were thinking about the management plan.

Fourth-year students, on the other hand, were very robust and insensitive to the focus as expected. When fourth-year students were asked to deal with an Mx-task, they shifted to a focus that they were familiar with it, providing a mere diagnosis for the case. The absence of Mx-items in the fourth-year students' protocols is explained by the assumption that they processed cases in Dx- and Mx-condition essentially the same way. It seems that they were more curious about the underlying mechanisms of diseases rather than being concerned with the patient's life.

Looking at the rest of the illness script components, shows us other remarkable aspects of Mx integration into the illness script. The results showed a lower proportion of enabling conditions in doctors' protocols in the Mx-focus, while there were no significant differences between consequences across focuses. It seems that when they were trying to make sense of the cases by using their Mx-knowledge, they paid attention to different types of case information, which led to different case representations. That is, when doctors are asked to manage a patient, they have to make up their mind about one or a very limited number of diagnoses in order to focus on managing the patient's problem (Glasziou, Rose, Heneghan, & Ball, 2009; Gruppen & Frohna, 2001; Montgomery, 2006; Oskamp, 1965). As shown in the results, this parsimonious information gathering has not lead to a diminished accuracy of diagnosis, but was useful to narrow down the number of possible diagnoses (e.g., as doctors produced twice as many differential diagnoses in the Dx-focus as in Mx-focus). The connection between the Dx- and the Mx-knowledge in experts' illness scripts is corroborated by this finding as well. The borderline difference in sixth-year students and the absence of any significant difference in stagers, not only indicates the developmental changes of the role of the enabling conditions component in the Mx-focus, but they also highlight the transitory nature of sixth-year students' medical knowledge once again.

In summary, medical expertise can be characterized by the emergence of illness scripts that are rich in terms of management knowledge, demonstrated by an increase in the number of Mx-items proportional to the elevation of expertise level. The present study sheds a different light on the previous studies using illness script as a theoretical framework. That is, although recall and pathophysiological protocols of previous studies do not contain any explicit references to Mx-knowledge, this type of knowledge might play a prominent role in the physician's case representation. In other words, Mx-knowledge might be activated during case processing, even though it does not appear in such Dx-oriented tasks. Consequently, the concept of illness scripts applies more generally to any medical encounter that includes diagnosis and management, and research should be extended to these domains. However, further research is needed to find an answer to the question of how the management and the diagnosis become integrated to one another.

Although this study shows that the Mx-knowledge could be involved in identifying and describing differences between expertise levels, determining the way Mx-knowledge can be effectively passed on to medical students will be a major challenge for future research. It is important to note that requesting medical students and doctors to read paper cases, as is customary in medical expertise studies, is a different process from what is entailed in diagnosing and managing real patients. However based on the present and previous studies, it seems that students might benefit further from being more exposed to the management side of the medical practice.

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Chapter 6

DISCUSSION AND CONCLUSION

6.1 Introduction

We will start this chapter by presenting a concise summary of the main results of the studies described in chapters 2 through 5. In the subsequent sections, a number of suggestions for future research will be presented, and finally, some recommendations for the development of management (Mx) knowledge in medical education will be discussed.

6.2 Summary of the present results

In the previous chapters, four studies were described that aimed at investigating the development and structure of clinical medical knowledge, with a particular emphasis on Mx-knowledge. In the first chapter, it was argued that this kind of knowledge can be incorporated into the structure of an illness script. This structure is supposed to organize the clinical medical knowledge of doctors and medical students (Feltovich & Barrows, 1984). The difference between illness scripts of medical students and doctors is that doctors' illness scripts are more tuned towards practical situations in diagnostic (Dx) settings (Charlin, Tardif, & Boshuizen, 2000; Custers, Boshuizen, & Schmidt, 1996, 1998). In other words, with doctors having seen many signs and symptoms (i.e., consequences) of different patients as well as their background information (i.e., enabling conditions), their illness scripts are strongly shaped by these components. Medical students, however, have less clinical experience, and so their illness scripts typically consist mostly of mechanisms of diseases (i.e., fault) rather than enabling conditions. During the course of development towards expertise, knowledge of fault becomes less prominent while knowledge of enabling conditions will gradually become more pronounced (Boshuizen, Schmidt, Custers, & van de Wiel, 1995; Custers et al., 1996, 1998).

In the first chapter, it was proposed that if an illness script is a structure that is tuned towards practical situations in medicine, Mx should also be incorporated into the illness script. This is because patient management is not only an essential component of medical practice, but it is also highly connected to expertise in medicine (Ericsson, 2004; Norcini, Lipner, & Kimball, 2002; Schuwirth et al., 2005). So, the illness script was extended by assuming Mx to be yet another one of its components. In order to show that Mx is a component of the illness script, we not only had to show its developmental acquisition during the course of medical education and practice, but also its integration with the Dx-knowledge.

The studies described in this thesis were designed with two objectives in mind. First, to further investigate the proposed developmental course of Mx-knowledge, and second, to elucidate the mutual relationship between the Dx- and the Mx-knowledge on the path towards expertise.

Our starting point was to question whether or not the Mx-focus would lead to a different evaluation of the findings in a case in different levels of expertise. In the first step, the traditional method of free recall, usually employed in clinical case studies (Boshuizen & Schmidt, 1992; Patel & Groen, 1986; Rikers, Schmidt, & Boshuizen, 2000; Schmidt & Boshuizen, 1993), was used for two purposes. First, it enabled us to compare the results with the previous studies. It also provided a basis for comparing the developmental trend of the Mx-knowledge with that of the Dx-knowledge. Second, previous clinical case studies only revealed case information processing in doctors and students, when asked to work out the case's diagnosis. The recall that followed, therefore, reflected how information was processed with a Dx-focus. However, it was unclear whether changing the focus by asking participants to read a case while thinking about patient management would lead to a different processing mode. So, in our study, doctors, sixth-year, and fourth-year students were asked to study cases to either diagnose or manage them, and recall afterwards.

Although there were significant differences between expertise levels, the results showed that both doctors and fourth-year students showed no significant differences in recall with a Dx or an Mx-focus. These data showed that experts engaged in an encapsulated processing approach independently of their processing focus, as they constructed their clinical case representation similarly under both conditions. Fourth-year students, on the other hand, treated a case with an Mx-focus similarly to a case with a Dx-focus (i.e., in elaborated mode).

In this study, two pieces of evidence on the developmental trend of Mx-knowledge acquisition were obtained. First, we observed a change in the performance of sixth-year students (i.e., interns) when switching from diagnosis to management. They remembered less and processed the case more slowly in the Mx-condition than they did in the Dx-condition. The second piece of evidence is the transitory nature of their knowledge as corroborated by their recall protocols. Their protocols contained as many propositions as that of the experts in the Mx-condition, but they contained significantly less high-level inferences. So, although sixth-year students have acquired more expertise in management than fourth-year students, this expertise does not help them in this phase because their management knowledge is still too underdeveloped to be used effectively.

The study presented in Chapter 2 revealed developmental aspects of the Mx-knowledge. However, some findings were implicit and needed more clarification. In Chapter 3, we therefore explored Mx-knowledge more explicitly with a decision-task study. In this study, participants at the same three levels of doctors, sixth-year, and fourth-year students were asked to judge the relevance of Mx-items to a given clinical case description. It was expected that the case information with the provided diagnosis should activate a specific illness script, the contents of which could then be examined by the decision-task. Based on the revised illness script theory (Monajemi & Rikers, 2011), it was assumed that the Mx-knowledge is part of the illness script and it becomes integrated into the illness script structure as a result of repeated exposure to real patients. We therefore predicted that the number of errors in the Mx-component would gradually decrease as the level of expertise increases.

The results showed that doctors made fewer mistakes in recognizing relevant Mx-items than both groups of medical students, which demonstrated a developmental pattern in correctly recognizing the relevance of Mx-items. The results also showed that fourth-year students have a 50% accuracy rate in recognizing relevant Mx-items, suggesting that their performance is at chance level. This is in line with our findings in the previous chapter that this group of students had an extremely limited Mx-knowledge. Sixth-year students were also significantly more accurate than fourth-year students, which showed that the integration of Mx-knowledge starts at the level of sixth-year students (i.e., interns). However, there was also a non-significant difference in accuracy between doctors and sixth-year medical students. This non-significant difference in accuracy between sixth-year students and doctors, does not obviously mean that in an actual setting, in which they are expected to actually manage patients, there would still be no difference between doctors and advanced medical students. This transitory nature of intermediates is one of developmental characteristics of the Mx-knowledge that was explored in the next study.

In Chapter 3, the issues arising from the first two studies were explored. One of the issues was that simply demonstrating an association between expertise level and Mx-errors does not provide information on how Mx-knowledge actually contributes to providing patient management. The second point was that, although in Chapter 2 the relationship between diagnosis and management in different levels of expertise was examined, their mutual relationship in more practical and real tasks remained implicit. In the study presented in Chapter 4, the same type of participants, that is doctors, sixth-year and fourth-year medical students, were asked to read clinical cases and to provide a management plan. It was hypothesized that if the Mx-knowledge is associated with medical expertise, the accuracy of the Mx-plan would gradually increase as the level of expertise increases.

The developmental pattern of Mx-knowledge acquisition was reflected in two findings. First, we found that providing accurate Mx-plans was a characteristic of doctors. The low accuracies of the two groups of students have different origins. In fourth-year students this low accuracy stems from a mere absence of the Mx-knowledge, but in sixth-year students, it is more due to their inability to take both diagnosis and management into consideration when providing Mx-plans. The second finding that corroborates the developmental nature of management was that the sixth-year students were as accurate as fourth-year students, but the format and the size of their protocols was like doctors, which again shows the transitory nature of the sixth-year students' knowledge.

This study experimentally showed the lag between diagnosis and management development. It was shown that when fourth-year students were asked to manage a case, they were more curious about the underlying mechanisms of the disease, which is the only knowledge they had. Interns, on the other hand, were so much preoccupied in managing the case that they forgot to take the diagnosis into consideration; this was corroborated by their low accurate and Mx-dominant plans (e.g., symptom therapy). This study also indicates that the doctors' management plans showed no preference between Dx-focus or Mx-focus, which may be one of the reasons behind their high accurate plans.

The studies reported in the previous chapters each served to highlight certain properties of the Mx-knowledge with respect to expertise within the context of certain types of task. For instance, its developmental connection with the Dx-knowledge in a classical recall task was described in Chapter 2, its developmental accuracy in a recognition task in Chapter 3, and its relative developmental accuracy and mutual relationship with diagnosis when asked to provide a management plan in Chapter 4. In Chapter 5, we studied more deeply the relationship between known components of illness script, that is, fault, enabling conditions, consequences, and a newly proposed component, patient management. In this study, fourth-year and sixth-year medical students, and doctors were asked to think aloud while either diagnosing or managing a case and recall it afterwards. The think-aloud methodology is a useful probe as it might prevent experts and students from output editing (Ericsson, 1998; Ericsson & Simon, 1984). That is, also, it ensured that the participants were in the intended mode of thinking, they were actually thinking about management or diagnosis as instructed. It was hypothesized that if management is an actual component of the illness script structure, then the intermediate and expert participants should be the ones that show sensitivity to focus, by producing more Mx-related items proportional to their expertise level when the focus is on management.

In this study, the accuracy of Mx and Dx was examined simultaneously, which indicates that doctors were more accurate in both than medical students. This finding highlights the full integration of the Dx- and the Mx-knowledge in the doctors' illness scripts. Furthermore, this study showed a drop in enabling conditions (EC) proportion without any change in Dx-accuracy when doctors were thinking about management, which could reflect another developmental aspect of this relationship.

This study clearly showed that the integration of Mx-knowledge starts at the level of sixth-year students, which was implicitly found in our previous studies. This is because both doctors and sixth-year students were sensitive to the focus and generated significantly more Mx-items when thinking about management than when they were asked to diagnose a clinical case. Although, both the 50% accuracy in Chapter 3 and the Dx-dominant protocols in Chapter 4, were enough to conclude that fourth-year students do not have substantial Mx-knowledge.

6.3 Conclusions

A first conclusion that could be drawn from the findings of the present studies is that they fit well with the theory of illness script. As an illness script is a knowledge structure that finely tunes towards practical situations, it is capable of explaining how doctors think when they face patients. In a real setting, doctors think about diagnosis and management concurrently, and illness script theory provides a good basis to put both of them in one theory framework. A closer look at the findings of the present thesis reveals that illness script could not only explain how people at different levels of expertise deal with a patient management problem, but it also clarifies how Mx-knowledge integrates into medical students' and doctors' medical knowledge.

The second conclusion that could be drawn is the developmental nature of the Mx-knowledge on the road towards expertise. In contrast to other components of illness script, management neither gradually becomes less prominent like the fault, nor is it similar to the consequences, in which the differences between expertise level are small. Management like enabling conditions, increases monotonically with expertise level. Our studies show that, on the road towards expertise, it is first the number of Mx-items that increases, and then, with extended experience with patients, it will be the richness of these items that improves. Therefore, while education might be beneficial in the early phases, in the advanced stages of Mx-knowledge development, practice and experience play a major role, a fact that was also proposed for the development of enabling conditions (Schmidt & Rikers, 2007).

The third conclusion that could be drawn from this thesis is that the

Mx-knowledge not only grows, but also integrates with the Dx-knowledge into the illness script. That is, in every patient workup these two tasks (Dx and Mx) should usually be done together. So, in experts' illness scripts, these two types of knowledge become highly integrated and balanced. The mutual relationship between Dx and Mx-knowledge is crucial for a successful and efficient patient encounter.

As pointed out in Chapter 1, medical expertise research has treated the concepts of medical expert and diagnostician as the same; something that would reflect an incomplete picture of what it means to be a medical expert. This thesis aims at improving our understanding of medical expertise by introducing the Mx-focus into this field of research. Taking all the findings into consideration, it could be concluded that a medical expert is someone who possesses rich knowledge of management that is highly accessible, and available in all practical settings, which guides doctors in providing highly accurate and more efficient patient management plans.

6.4 Suggestions for further research

In the discussion sections of Chapters 2 through 5, a number of recommendations and suggestions for further research have already been proposed. In this part these are summarized.

In our studies, it can be seen that the Mx-accuracy of the experts was not very high (about 60-70% of maximum score), albeit significantly higher than both sixth-year and fourth-year students. In addition, as shown in Chapter 3, the error rate of Mx-items was significantly higher than the other components of the illness script. This could raise a number of questions about the nature of the Mx-knowledge: Is it more prone to error than the Dx-knowledge? Do doctors provide more accurate diagnoses than management plans? These issues remained to be addressed in the future.

Our studies indicate that sixth-year students (i.e., interns) do not score well in terms of accuracy of Mx-items, even though it is expected to reach an acceptable level through the rest of their education. However, it is unclear how much time is needed for their Mx-knowledge to become integrated into their illness scripts, and thus for the accuracy of their management to improve. It is important, because after about 1.5 to 2 years, they graduate from medical schools and practice independently without supervision. So, in future studies of this type, it might be good to include junior doctors as a separate level of expertise.

Our studies also explored the relationship between the Dx- and the Mx-knowledge on the road towards expertise. In Chapter 5, it was shown that specifically in expert doctors, switching from the Dx to the Mx-focus led this group to pay less attention to EC. In other words, when doctors were thinking about the Mx-plan, they ignored some pieces of EC information. This finding is very interesting in light of some other studies. For example, Ross (2000) showed that even though the participants were already trained to classify patients into disease categories (Dx-task), when given the additional knowledge of their treatment, their judgment on disease classification (Dx-knowledge) was also affected. The patient data that were relevant to treatment came to be viewed as more central to the disease than the other data that were not relevant to the treatment. In fact, both types of data were equally relevant to the disease and were presented equally often. Hence, learning management might lead to a change in the weighing of features, or a change in the number of features learned, or to a new relationship being encoded among features. Further research is necessary to investigate this issue.

In the structure of illness script what is called Dx-items, consists of at least three components: fault, consequences, and enabling conditions. Analogous to Dx-items, what is called an Mx-item here may again be categorized under various components, some of which might play a more prominent role in expertise development than others. For example, the concept of prognosis could be one of the candidates. The prognosis predicts the outcome of a disease and therefore the fate of the patient with respect to that disease. Statements such as 'about half of the patients with severe septic shock will die within one month' or 'common cold is a self-limited disease and patients recover in about one week' are examples of prognoses. It seems that besides knowing about the diagnosis of the illness and the way it should be managed, knowledge concerning the course of the illness could be one of the experts' features; something that future research may shed further light on.

6.5 Implication for medical education

Translation of findings from such a basic research to applications in medical education is not so trivial. Showing the way experts and students deal with written cases does not directly guide us on how to train medical students. However, some recommendations could still be put forward for medical education.

First, it is true that the Dx-education should precede Mx-education, simply because in order to learn how to manage an illness, one should first know about its clinical presentation and underlying mechanism. However, it seems that these two types of knowledge are separated from each other in a way that medical students, who already know something about diseases, know too little about their management, something that just might not have to be inevitable.

Second, this unfamiliarity with patient management causes a kind of shock, called shock of practice that happens to interns when they start managing real patients (Custers & Boshuizen, 2001; Prince, van de Wiel, Scherpbier, van der Vleuten, & Boshuizen, 2000). The gap between the Dx-knowledge and the Mx-knowledge, that our studies uncovered, might be a source of worry for medical educators. It seems reasonable to start Mx-education earlier in the course of medical education, by asking students to do these two tasks concurrently. In other words, if medical students are to be involved in diagnosing and managing real patient, it might be possible to train them with a more balanced knowledge that is tuned to practical situations.

Complex phenomena are by definition multi-faceted, and medical expertise is, in this regard, no exception. To better understand any phenomenon as such, should therefore include exploration of its as yet unexplored aspects. Our attempt in this thesis was just that; a first step in exploring a formerly unchartered terrain in the medical expertise landscape, that is, patient management.

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Chapter 7

SAMENVATTING

In dit proefschrift worden vier studies beschreven, die gericht zijn op de ontwikkeling en structuur van klinische kennis in de geneeskunde, met de nadruk op kennis over de behandeling van ziektes.

In Hoofdstuk 1 werd verondersteld dat kennis over de behandeling van een bepaalde ziekte gentegreerd kan worden in de structuur van een ziektescript ("Illness script"). Van dit type script wordt verondersteld dat het de klinische kennis van artsen of studenten organiseert (Feltovich & Barrows, 1984). Het verschil tussen ziektescripts van studenten en artsen is dat het script van artsen meer gericht is op praktische situaties (Charlin, Tardif, & Boshuizen, 2000; Custers, Boshuizen, & Schmidt, 1996, 1998). Met andere woorden, artsen hebben veel meer manifestaties van ziektes gezien ("consequences") en zijn ook meer vertrouwd met het interpreteren van achtergrondinformatie van patiënten ("enabling conditions"), zodat het script zich hierdoor in een bepaalde richting heeft ontwikkeld. Studenten geneeskunde daarentegen, hebben amper klinische ervaring en hun ziektescript is hierdoor meer gericht op theoretische kennis betreffende processen die in het lichaam verstoord zijn ("fault"). Tijdens de ontwikkeling van hun expertise wordt deze "fault"-component minder belangrijk en het belang van de "enabling conditions" steeds belangrijker (Boshuizen, Schmidt, Custers, & van de Wiel, 1995; Custers et al., 1996, 1998).

Als een ziektescript een structuur is die gericht is op praktische situaties in de geneeskunde, dan zou behandelkennis als een belangrijk onderdeel ervan beschouwd moeten worden. Behandelkennis is immers niet alleen een essentieel onderdeel is van het medisch handelen, maar ook sterk gerelateerd met expertise in de geneeskunde (Ericsson, 2004; Norcini, Lipner, & Kimball, 2002; Schuwirth et al., 2005). Het ziektescript werd voor de studies van dit proefschrift derhalve uitgebreid met een nieuwe component die betrekking had op behandelkennis. Om aan te tonen dat behandelkennis een component is van een script, moesten we niet alleen laten zien hoe deze component zich ontwikkelt tijdens de medische opleiding, maar ook hoe deze kennis zich verhoudt tot diagnostische kennis.

De studies beschreven in dit proefschrift zijn ontwikkeld met twee doelstellingen in gedachten. Op de eerste plaats wilden we verder onderzoeken hoe behandelkennis zich ontwikkelt en op de twee plaats een beter inzicht verkrijgen in de onderlinge relatie tussen diagnostische kennis en behandelkennis in de ontwikkeling van expertise.

Ons startpunt zoals beschreven in Hoofdstuk 2, was de vraag of een focus op behandeling bij studenten of artsen zou leiden tot andere evaluatie van casusinformatie. Daarvoor gebruikten we eerst, zoals gebruikelijk in medische expertisestudies, de traditionele maat van “free recall”. De redenen hiervoor waren tweeledig. Enerzijds gaf het de mogelijkheid de resultaten te vergelijken met eerdere studies en anderzijds bood het de mogelijkheid het ontwikkelingspatroon van behandelkennis te vergelijken met dat van diagnostische kennis. Eerder onderzoek op dit terrein liet artsen en studenten zich alleen richten op het stellen van een diagnose, terwijl ze casusinformatie verwerkten. De herinningstaak (“free recall”) die hierop volgde, was derhalve met name een afspiegeling van hoe de informatie werd verwerkt met een diagnostische focus. Het was echter nog onduidelijk of het veranderen van focus, door proefpersonen te vragen na te denken tijdens het lezen van de casus over de behandeling van de patiënt, ook daadwerkelijk leidde tot een andere verwerkingsmodus.

In onze studie werd aan artsen, zesde- en vierdejaars geneeskundestudenten gevraagd om een casus te bestuderen met een diagnostische focus of met een behandelfocus, gevolgd door een herinneringstaak. De resultaten lieten zien dat hoewel er significante verschillen waren tussen de verschillende proefpersoongroepen, zowel artsen als vierdejaarsstudenten hetzelfde presteerden met een diagnostische focus als met een behandelfocus. Verder bleek dat artsen de informatie geëncapusuleerd verwerkten, ongeacht hun focus, omdat hun casusrepresentatie vergelijkbaar was in beide condities. Vierdejaarsstudenten daarentegen, verwerkten een casus met een behandelfocus vergelijkbaar met een casus met een diagnostische focus (dat wil zeggen in een geëlaboreerde modus).

In deze studie werden twee aanwijzingen gevonden voor de ontwikkeling van behandelkennis. De verandering in prestatie van zesdejaarsstudenten wanneer ze moesten switchen van diagnose naar behandeling vormde een eerste aanwijzing. Zesdejaarsstudenten herinnerden zich immers minder en verwerkten de casus langzamer in de behandelconditie dan in de diagnostische conditie. Een tweede aanwijzing was de verandering in de aard van hun kennis, wat tot uitdrukking kwam door vergelijkbare prestaties als de artsen in de behandelconditie op de herinneringstaak. Maar ze maakten minder inferenties vergeleken met artsen. Hoewel zesdejaarsstudenten meer expertise hebben vergaard met betrekking tot behandeling dan vierdejaarsstudenten, bleek deze expertise hen in deze fase nog onvoldoende te helpen, omdat deze kennis nog niet optimaal ontwikkeld is om efficiënt te worden ingezet.

De studie beschreven in Hoofdstuk 2 liet de ontwikkelingsaspecten van behandelkennis zien. Sommige bevindingen waren echter impliciet en dienden verder onderzocht te worden. In Hoofdstuk 3 werd derhalve behandelkennis verder onderzocht door middel van een decisietaak. In deze studie werden proefpersonen van drie expertiseniveaus (d.i., artsen, zesdejaars- en vierdejaarsstudenten) gevraagd de relevantie van behandelconcepten aan te geven in een klinische casus. Er werd verwacht dat de casusinformatie samen met een gegeven diagnose een specifiek ziektescript zou activeren. De informatie van dat script zou dan vervolgens door de decisietaak onderzocht worden. Uitgaande van de herziene versie van de ziektescripttheorie (Monajemi & Rikers, 2011), werd er verondersteld dat behandelkennis onderdeel is van het ziektescript als gevolg van het zien van veel patiënten. Er werd voorspeld dat het aantal fouten dat proefpersonen zouden maken, lager was bij een hoger expertiseniveau.

De resultaten lieten inderdaad zien dat artsen minder fouten maakten in het herkennen van behandelconcepten dan beide groepen geneeskundestudenten, die een ontwikkelingspatroon lieten zien in het correct identificeren van relevante behandelconcepten. De resultaten lieten ook zien dat vierdejaarstudenten een accuratesse hadden van 50% in het herkennen van relevante behandelconcepten, hetgeen op kansniveau is. Dit was in overeenstemming met onze bevindingen in Hoofdstuk 2 dat deze groep nog maar zeer beperkte kennis heeft over behandeling. Zesdejaarsstudenten waren significant accurater dan vierdejaarsstudenten. Dit suggereert dat de integratie van behandelkennis op dit niveau van start gaat. Er was overigens geen significant verschil in accuratesse tussen zesdejaarsstudenten en artsen. Dit impliceert echter niet dat er in een klinische setting geen verschil zal zijn tussen artsen en gevorderde geneeskundestudenten.

In Hoofdstuk 4 werden de issues die voortvloeiden uit de eerste twee studies verder onderzocht. En van deze issues was dat het simpelweg laten zien van een associatie tussen expertiseniveau en het maken van fouten, geen aanwijzingen geeft over hoe behandelkennis in feite bijdraagt aan de behandeling van een patiënt. Een tweede punt was dat hoewel in Hoofdstuk 2 de relatie tussen diagnose en behandeling voor verschillende expertiseniveaus was onderzocht, hun onderlinge relatie in meer praktische en realistische taken impliciet bleef. In deze studie werden wederom dezelfde expertiseniveaus gebruikt (dat wil zeggen, artsen, zesdejaars- en vierdejaarsstudenten) en hen werd gevraagd een casus te bestuderen en vervolgens een behandelplan op te stellen. Er werd verondersteld dat als behandelkennis gelinkt is met medische expertise, de accuratesse van het plan geleidelijk zal toenemen met het expertiseniveau.

Het ontwikkelingstraject van behandelkennis werd zichtbaar door twee bevindingen. Op de eerste plaats omdat voornamelijk artsen een accuraat behandelplan opstelden. De verklaring voor de lage accuratesse van de twee groepen studenten was echter verschillend. Bij vierdejaarsstudenten was de lage accuratesse het gevolg van de grotendeels afwezige behandelkennis. Bij zesdejaars daarentegen, was het probleem dat ze nog niet in staat bleken zowel diagnose als therapie gelijktijdig in overweging te nemen, wanneer ze een behandelplan moesten opstellen. De tweede bevinding die het ontwikkelingstraject van behandelkennis ondersteunde, was het gegeven dat zesdejaarsstudenten beter presteerden dan vierdejaarsstudenten. De protocollen van zesdejaars toonden bovendien veel gelijkenis met die van artsen in termen van omvang en structuur.

Deze studie liet dus zien dat er een gat zit tussen de ontwikkeling van diagnostische kennis en behandelkennis. Er werd aangetoond dat wanneer vierdejaarsstudenten gevraagd werd een behandelplan op te stellen, ze zich meer richtten op de onderliggende mechanismen van de aandoening. Dit is immers de enige kennis die ze bezitten). Zesdejaarsstudenten daarentegen waren al veel meer gericht op het behandelen van een patiënt, maar vergaten soms de diagnose erbij te betrekken. Dit werd duidelijk door hun relatief lage accuratesse en het feit dat hun therapie vooral gericht was op het bestrijden van symptomen. Deze studie toonde ook aan dat artsen geen verschillen lieten zien tussen een diagnostische en behandelingsfocus, hetgeen een verklaring kan zijn voor hun beter geintegreerde behandelplannen.

De gerapporteerde studies in de vorige hoofdstukken hadden als doel bepaalde eigenschappen van behandelkennis te belichten met betrekking tot expertiseniveau en verschillende typen taken. In Hoofdstuk 2 werd bijvoorbeeld de ontwikkelingsrelatie met diagnostische kennis onderzocht door middel van een herinneringstaak. De toename in accuratesse met niveau werd in Hoofdstuk 3 onderzocht door een decisietaak en in Hoofdstuk 4 werd de accuratesse en de onderlinge relatie met diagnose onderzocht bij het uitwerken van een behandelplan.

In Hoofdstuk 5 werd tenslotte de relatie tussen de verschillende ziektescriptcomponenten (d.i. "fault, enabling conditions, consequences, patient management") dieper onderzocht. In deze studie werd wederom aan drie proefpersoongroepen (d.i. vierdejaars- en zesdejaarsstudenten en artsen) gevraagd hardop te denken tijdens het diagnosticeren of behandelen van een casus. Vervolgens dienden ze alle informatie die ze zich nog konden herinneren van de casus, op te schrijven. Hardop denken is een adequate methodologie die het moeilijk maakt voor proefpersonen informatie achter te houden ("output editing"), (Ericsson, 1998; Ericsson & Simon, 1984). Bovendien kan door deze methode gecontroleerd worden of proefpersonen daadwerkelijk nadenken over behandeling of diagnose (afhankelijk in welke conditie ze zaten). Er werd verondersteld dat als behandeling daadwerkelijk een component is van een ziektescript, dat met name vierdejaarsstudenten en artsen gevoelig zouden zijn voor een verschil in focus. Met andere woorden, als er sprake is van een focus op behandeling, zouden er meer behandelconcepten genoemd moeten worden naarmate het expertiseniveau stijgt.

De accuratesse van het behandelplan en de diagnose werden in deze studie gelijktijdig onderzocht. De resultaten toonden aan dat artsen meer accuraat waren dan studenten. Deze bevinding gaf evidentie voor de integratie van diagnostische en behandelkennis in het ziektescript van artsen. Bovendien kon bij artsen in de behandelconditie een afname in de "enabling conditions"waargenomen worden, zonder dat dit invloed had op de diagnostische prestatie.

Deze studie liet verder zien dat de integratie van behandelkennis begint op het niveau van zesdejaarsstudenten, wat in overeenstemming is met voorgaande studies. Zowel artsen als zesdejaarsstudenten werden benvloed door de focus en produceerden significant meer behandelconcepten wanneer ze dachten aan een behandelplan vergeleken met het denken aan een diagnose. Vierdejaarsstudenten daarentegen bleken weinig tot geen behandelkennis te hebben, zoals duidelijk werd uit hun lage accuratesse (50%) in Hoofdstuk 3 en de protocollen van Hoofdstuk 4, waarin met name diagnostische concepten werden gebruikt.

7.1 Conclusies

Een belangrijke conclusie die getrokken kan worden op basis van de studies van dit proefschrift is dat de ziektescripttheorie ondersteund wordt. Een ziektescript is een georganiseerd semantisch netwerk dat gericht is op praktische situaties en dat in staat is te verklaren hoe artsen denken als ze met patiënten geconfronteerd worden. In realistische situaties denken artsen niet alleen aan een diagnose, maar tegelijkertijd ook over de behandeling. De ziektescripttheorie biedt de mogelijkheid om deze twee belangrijke elementen te incorporeren. Een nadere beschouwing van de bevindingen van dit proefschrift, laat zien dat ziektescripts niet alleen in staat zijn te verduidelijken hoe mensen met verschillende expertiseniveaus omgaan met behandelproblemen, maar dat ze ook verduidelijken hoe behandelkennis onderdeel wordt van het kennisbestand van geneeskundestudenten en artsen.

Een andere belangrijke conclusie die getrokken kan worden is dat de behandelkennis een ontwikkeling doormaakt wanneer men medische expertise vergaart. In tegenstelling tot andere componenten in een ziektescript, zoals de “fault” of “consequences”, neemt behandelkennis langzaam maar zeker een steeds prominentere plaats in in het script. Behandelkennis is in dat opzicht vergelijkbaar met “enabling conditions”, omdat beide componenten geleidelijk in omvang en complexiteit toenemen naarmate het expertiseniveau stijgt. De studies van dit proefschrift laten zien dat op weg naar expertise, eerst het aantal behandelconcepten toeneemt en pas later, door het zien van veel patiënten, neemt ook de complexiteit van deze concepten toe. In de eerste fase speelt onderwijs dus een belangrijke rol in de ontwikkeling van behandelkennis. In de latere fasen wordt praktische ervaring essentieel. Dit proces is vergelijkbaar met de ontwikkeling van “enabling conditions"(Schmidt & Rikers, 2007).

Een laatste belangrijke conclusie is dat behandelkennis niet alleen toeneemt maar ook gentegreerd raakt met diagnostische kennis in een ziektescript. Hierdoor maken ervaren artsen altijd gebruik van beide typen kennis wanneer zij patiënten moeten behandelen. Beide zijn essentieel geworden voor het succesvol en efficiënt kunnen behandelen van patiënten.

Zoals al naar voren gekomen is in Hoofdstuk 1, heeft het onderzoek naar medische expertise altijd de nadruk gelegd op de rol van arts als diagnosticus. Dit impliceert een incompleet beeld van een arts. In dit proefschrift is een poging gedaan ons inzicht met betrekking tot medische expertise te vergroten door het betrekken van behandelkennis. Wanneer we alle bevindingen van dit proefschrift in ogenschouw nemen, kan geconcludeerd worden dat een medisch expert iemand is die weliswaar veel diagnostische kennis heeft, maar vooral ook veel verstand heeft van het behandelen van patiënten. De expert weet bovendien hoe deze kennis in te zetten in praktische situaties, wat hen helpt om patiënten sneller te genezen.

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APPENDICES

Appendix A

Examples of diagnostic (Dx) and management (Mx) items

Dx	Mx
Sepsis workup	Empirical antibiotic therapy
PPD	Hydration
Cardiac enzymes	Digitalization
Smear and culture of sputum for BK	Life style modification
ABG	Diuretics (e.g., Lasix)
CBC	Semi sitting position
TFT	Nasal O2

Appendix B

Mx-protocol of an expert (E2)

1. Echocardiography
2. Thyroid Function Test
3. ECG
4. Control of cardiac enzyme
5. Semi sitting position
6. Intermittent elastic banding
7. I/O control
8. Daily weighting
9. ACE inhibitors
10. Diuretics
11. Anticoagulation, Heparin and Warfarin if necessary
12. Digitalization
13. Conversion of AF rhythm

Appendix C

Mx-protocol of a sixth-year student (I17)

1. CVS (Vital Signs Control)
2. NPO
3. Normal Saline 1/lit every 8 hours
4. Nasal O2 4lit/min
5. Pulse oximetry
6. Heparin
7. Beta blocker
8. Complete bed rest
9. Atrovent spray/Salbutamol spray
10. PT/PTT/INR

Appendix D

Mx-protocol of a fourth-year student (N18)

Because the O2-saturation of the patient is normal, there is no need to put an airway.
First of all, we need CXR in order to rule out emboli.
For edema, protein electrophoresis should also be checked.
The major problem of the patient is increase of respiratory rate, so first CXR is needed and then Doppler sonogarphy of lung vasculature should be done.
Asking the patient past medical history concerning gastrointestinal, liver, and kidney diseases such as hematemasis, diarrhea, abdominal pain, head trauma, kidney stone and itching.

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CURRICULUM VITA

Alireza Monajemi was born on July 1, 1974 in Germany. He received his medical degree in 2000 from Medical University of Isfahan (MUI) in Iran. From 2002 till 2008, he worked at the department of introduction to clinical medicine at MUI, where he was in charge of devising curricula for undergraduate medical education specifically in clinical reasoning education and assessment. Since 2008, he has been a faculty member of the Institute for Humanities and Cultural Studies in Tehran, Iran, where he has continued his research in medical expertise. He has also been an exam designer and director of the National Olympiad on Clinical Reasoning of Iranian medical students since 2007. His work and studies have been mainly focused on medical expertise and clinical reasoning. In 2005, he started his Ph.D. research on the development of medical expertise at Erasmus University Rotterdam.