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WEB PAPER

Tacit knowledge and visual expertise in medical diagnostic reasoning: Implications for medical education

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Abstract

Background: Much education—especially at the university level—has been criticized for having primarily dealt with explicit knowledge, i.e. those aspects of mental activities, which are verbal and conscious. Furthermore, research in medical diagnostic reasoning has been criticized for having focused on the specialty of intern medicine, while specialties with other skills, i.e. perceptive skills within pathology and radiology, have been ignored.

Aims: To show that the concept of tacit knowledge is important in medical education—at all levels and in medical diagnostic reasoning.

Methods: Describing how tacit knowledge according to Michael Polany, is experienced and expressed in day-to-day life, it is shown that there is a tacit dimension to all knowledge. Reviewing recent literature on medical diagnostic reasoning, it is shown that tacit knowledge is recognized in connection with concepts such as "non-analytical reasoning" and "dual process of reasoning."

Conclusion: It is important that educators are trained in how explicit and implicit knowledge is attained and that tacit knowledge is included in educational programmes of all medical specialties.

Introduction

Recent reforms in Denmark have cut the time allotted for post-graduate education for surgeons, doctors and practicing physicians. Post-graduate training programmes and the time allowed between internship (*basisuddannelse*) and residency (*introduktionsstilling*) have been greatly accelerated[1].

These reforms have been initiated in Denmark in an attempt to solve logistical problems: there is a growing shortage of physicians and of specialists, particularly in psychiatry and oncology. Thus, the reform is based on the demands of the market rather than on any coherent pedagogical methodology, although it does borrow a few tools from the Can MEDS framework.

It is on this background that vital epistemological questions about the very nature of medical knowledge and its acquisition must be raised. If we are to maintain and improve standards of post-graduate clinical education in Denmark, we need to raise questions about the very nature of clinical learning and knowledge. That is the purpose of this article.

As a post-graduate clinical tutor in the field of pathology, I have been particularly interested in how novices in my field learn to see, to reason and to diagnose. With this in mind, I chose to study current literature in a reappraisal of the work of the late Hungarian-British philosopher Michael Polanyi. Polanyi was a physician as well as a chemist and philosopher, and was interested in the layers of knowledge which presuppose explicit skills, competencies and the ability to reason. He calls these layers of knowledge *the tacit dimension of knowledge*. Indeed, his particular contribution to the field of epistemology, in general, and medical education, in particular, is this very concept of *tacit knowledge*. The concept was introduced in Personal Knowledge (Polanyi 1958a) and in The Tacit Dimension (Polanyi 1966a). When applying his theory to a criticism of clinical education today we find that, generally speaking, the understanding of knowledge today has been reduced to that of epistemic knowledge[2], which has become the ideal for knowledge per se, especially within the sciences (Wackerhausen 1996). However, when focusing only

Practice points

- Reforms in medical schools have cut the time allotted for post-graduate education of all medical specialties and have challenged medical educators in how to attain the requisite competencies within a shorter period of time.
- Michael Polanyis concept of tacit knowledge is an important contribution to the field of epistemology in general, and to medical education in particular. The concept recognized in recent literature concerning medical diagnostic reasoning (non-analytical reasoning) and cognitive psychology (dual process of reasoning).
- Non-analytical reasoning is a central component of medical education at all levels and is a prerequisite for a successful progression from novice to expert.

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on explicit, epistemic knowledge, other aspects of knowledge, particularly the dimension of tacit knowledge, are overlooked. As Polanyi (Polanyi 1966a) writes: "We can know more than we can tell."

In the following, I will first attempt to present a short overview of Polanyi's theory of tacit knowledge in order to relate it to medical diagnostic reasoning and diagnostic skills in the field of pathology. Here, I will compare Polanyi's tacit dimension with complementary types of visual and diagnostic skills. Finally, I will raise questions about the implications of this theory of knowledge upon clinical education in general and post-graduate pathological education in particular.

Polanyi's theory of tacit knowledge

Tacit knowledge covers those aspects of human knowledge, skills and competencies, which lie outside the domain of rules and procedures and thus, can be extremely difficult to articulate. Furthermore tacit knowledge refers to the knowledge, which is a pre-condition for any skill or competence that is in focus for its performer.

One of the most convincing examples of tacit knowledge is facial recognition. "We know a person's face, and can recognize it among a thousand, indeed a million. Yet we usually cannot tell how we recognize a face we know, so most of this cannot be put into words." (Polanyi 1966b). When you see a face you are not conscious about your knowledge of the individual features (eye, nose, mouth), but you see and recognize the face as a whole. Other examples of daily activities and tacit knowledge are: riding a bike, playing the piano, driving a car, hitting a nail with a hammer. You may know explicitly how turning of the handle bars or steering wheel change the direction of a bike or car, but you cannot simultaneously focus on this and at the same time orientate yourself in traffic. Similarly, you may know explicitly how to hold the handle of a hammer, but you cannot simultaneously focus on the handle and hit the nail correctly with the hammer. The master pianist can perform brilliantly, but if he begins to concentrate on the movements of his fingers instead of the music, he will not be able to play as a master.

Polanyi says that the physical body is the basis of our knowledge, intellectual as well as practical. "All knowing is personal knowing." (Polanyi 1969b). By this he means that all knowledge is acquired by the knower by means of physical and mental processes. This is not the same as saying that personal knowledge is subjective. However, all knowledge, both intellectual and practical, is always attached to the knower. This is a criticism of the dogma of the separation of profession and person, because, according to Polanyi, to be professionally competent and knowledgeable, we have to act with our physical being, since a part of our professional knowledge is also embodied in our physical being.

No matter what type of activity we are engaged in, we act on the basis of tacit knowledge. It makes no difference whether we employ tangible tools or intangible capabilities, since both of these enable a skilled user to get things done. To learn to use a tool or a skill properly, we need to accommodate and embody it.

Tacit knowledge and medical diagnostic reasoning

If we accept that there is a tacit dimension to all knowledge and that we act on the basis of tacit knowledge, then we must consider how this affects medical education. In their excellent articles, Henry, Goldman and Tsoukas (Goldman 1990; Tsoukas 2002; Stephen Henry 2006) discuss the role of tacit knowledge in medical diagnostic reasoning. Henry argues that evidence-based medicine presupposes an inaccurate and deficient view of medical knowledge and that Michael Polanyi's theory of tacit knowledge both explains this deficiency and suggests remedies for it. According to Goldman, it is a dominant view that clinical judgment is a fully explicit process compared to the relatively neglected view that tacit knowledge plays a substantial role in the clinician's mental operations. Tsoukas argues that tacit knowledge has been greatly misunderstood. Tacit and explicit knowledge are not the two ends of a continuum, but two sides of the same coin. Even the most explicit kind of knowledge is presupposed by tacit knowledge

A most convincing example of tacit knowledge in the field of medicine is Polanyis own description of a student reading an X-ray of a chest: As a beginner, the student is cognitively distant from the diagnostic task, because he only thinks of basic, relevant radiological knowledge. Later "he will gradually forget about the ribs and begin to see the lungs and eventually . . . a rich panorama of significant details will be revealed to him: of physiological variations and pathological changes, of scars, of chronic infections and signs of acute disease. He has entered a new world" (Polanyi 1958c). The student has now interiorized the radiological knowledge and "a new world" has entered him. Polanyi calls this dialectical process "in-dwelling."

Diagnostic skills in pathology

The core skill in the specialty of pathology is the diagnosis of illnesses (macroscopically and/or microscopically) based on morphological changes in tissues and cells. Pathologists have a lot in common with radiologists and dermatologists using vision as the most important diagnostic instrument. Performing visual diagnosis has a lot in common with face recognition: As mentioned above, when you see a face, you are not conscious about your knowledge of individual features—eye, nose, mouth—but you see and recognize the face as a whole. In the same manner when you as a pathologist see cancerous tissue in the microscope, you are not conscious about your knowledge of the individual features (the morphology of the cells, the cytoplasm, nuclei and nucleoli) but you see the cancerous tissue as a whole.

One of the essential studies by Crowley et al. (2003) investigated 28 beginners, intermediates and expert pathologists. They were videotaped with "thinking aloud protocols" while diagnosing well-defined histological specimens. Rebecca Crowley points out that microscopic pathology is unusual because the diagnostician's eyes must move around in different slides, from area to area, and look at different regions in different magnifications. This makes the

visual classification slow, at least for the novice. The pictures must be decoded and understood in small pieces. Rebecca Crowley deals with five categories during a microscopic investigation: 1) data examination, 2) data exploration and explanation, 3) data interpretation, 4) control processes and 5) operational processes. The length of time spent on the different categories depends on whether the pathologist is a novice or an expert. She refers to the Dreyfus and Dreyfus model (2002), which describes the general development from novice to expert—from the novice's *perception of parts* to the expert's *recognition of patterns* in any field. Pattern recognition, according to Crowley, consists of converting long sequences of specific features into shorter sequences of non-verbalized pattern recognition. The pathologist's diagnostic speed and accuracy increases, while the features are learned and put down in an ever-growing knowledge bank.

In a study by Krupinsky et al. (2006), an eye-tracking device was used, assessing eye-movements of medical students, pathology residents and practicing pathologists, examining virtual slides on a digital display monitor. According to image processing theory, the extraction of feature details from complex images relies on two processes: *global impression* and *focal search*. Eye position recording data suggests that, as one gains more and more experience, more relevant information is handled during the initial global impression, reducing the extent and search of focal search. The study shows, that enough information is extracted from images in the initial global impression, to reduce the need for examining all tissues with focal search.

The diagnostic process of "global impression" and "focal search" is confirmed by a recent study by Kundell et al. (2007). In this study, they recorded the eye-position of nine radiologists, in the spectrum of novice to expert, who interpreted 20 normal and 20 abnormal mammograms. The results support the hypothesis that a difference exists, in the mechanism of image perception, from relatively slow *search-to-find mode* to a relatively fast *holistic mode*. The holistic mode seems to be more highly developed in the most proficient observers

Crowley, Krupinsky and Kundell describe a dual way of arriving at a visual diagnosis: The novice more often uses "focal search" or "the search-to-find mode" compared to the expert's use of "global expression" or "the holistic mode of search". The expert, however, apparently cross-checks his/her diagnosis by using the "search-to-find-mode". This dual way of visual diagnosis has much in common with the current discussion among cognitive scientists concerning the dual process of reasoning (Kahnemann 2002; Evans 2003; 2008): System 1 is an intuitive mode in which judgments and decisions are made automatically and rapidly, this corresponds to the holistic mode of search. System 2 is a controlled mode, which is deliberate and slower corresponding to the search-to-find mode. In a recent review, Karen Eva (Eva 2004) emphasizes the importance of non-analytical reasoning strategies as well as analytical reasoning strategies in medical diagnostic reasoning. Geoff Norman states that non-analytical reasoning strategies are a central component diagnostic expertise of all levels (Norman 2007).

The authors use different descriptive words concerning the novice's and expert's way of diagnostic resoning. Their theories have all in common the distinction between cognitive processes that are fast, automatic and unconscious and those that are slow, deliberate and conscious. Table 1 shows the key words of explicit and implicit reasoning according to the authors mentioned above.

Educational implications

When novices are learning from experts, it is not enough that the novice is presented to new knowledge through literature, courses and clinical guidelines (i.e. explicit knowledge). If such were the cases, he could learn to be a doctor without leaving the classroom. Clinical knowledge must be experienced and embodied (indwelled) as in Polanyi's description of the student's reading of an *X*-ray or in the pathology students' study of a slide. Only when the novice has entered "the new world" and "a new world" has entered the novice, it is possible for her/him to fully attain the requisite competencies and to become an expert. This double process of indwelling, however, takes time and practice, as Martin Talbot points out (Talbot 2004) in his "critique of accelerated higher specialist training". At what point in the doctor's career does "the new world" become second nature (embodied)? How much time, how much observation and how much practice is "enough"? Is 1 introductory year of a specialty sufficient to assess if a person is suitable for continuing on to 4 years of specialist training in a particular field? Is 4 years of specialist training sufficient to attain the requisite competencies of the field? If specialist training is accelerated too much, it may inhibit the process of indwelling, a prerequisite for progressing from novice to expert.

It is important that educators and trainees are aware of the elements of the tacit dimension (associative and holistic,

Table 1. Key words describing the novice's and expert's preferred way of reasoning.

	Novice—explicit reasoning	Expert—implicit reasoning
M. Polanyi	Recognizing a face in parts (ear, nose, mouth)	Recognizing face as a whole
D. Kahneman J St. B T. Evans	S2 mode: slow, serial, effortful, deliberate controlled	S1 mode: fast, automatic, effortless associative, difficult to control or modify
R. S. Crawley	Perception of patterns	Recognition of patterns
E. A. Krupinsky	Search-to-find-mode	Holistic mode
H. L. Kundell	Focal search	Global impression
K. W. Eva G. Norman	Analytic reasoning strategies: Conscious and controlled.	Non-analytical reasoning strategies: Unconscious and automatic.

pattern recognition, non-analytical reasoning strategies) and include this awareness in their educational planning, as suggested by Leron (Leron and Hazzan 2006). It is also important to learn how to use the analytical and non-analytical models of clinical reasoning. It is suggested that clinical teachers should stress the importance of both forms of reasoning, enabling the students to marshal reasoning processes in a flexible and context-specific manner (Eva 2004). Some even emphasizes the importance of explicitly empowering students to utilize multiple diagnostic strategies including non-analytical approaches (Ark et al. 2007). Geoff Norman concludes that teachers should recognize non-analytical reasoning as being a central component of diagnostic expertise at all levels (Norman 2007).

Looking at the spectrum of medical specialties, non-analytical reasoning seems to be more conspicuous in the visual specialties of pathology, radiology and dermatology as compared to the more technical specialties of surgery or anesthesiology. This is due to the fact that pathologists and radiologists rely primarily on their own (embodied) expertise. As a consequence, it is extremely important that novices of visual specialties are given enough time to be able to build up an ever-growing knowledge bank (Crowley et al. 2003). In terms of educational outcomes: if the competencies are not attained, either the level of competencies is too high or the amount of time available is too short. One introductory year in the specialty of pathology may be too little time to assess if a trainee is suitable for continuing on to 4 years of specialist training. How are we to determine how much time is reasonable and feasible, and at the same time allow for individual cognitive differences and learning styles?

Finally, Polanyis identification and description of tacit knowledge is recognized in recent research of medical knowledge and diagnostic reasoning (analytical/non-analytical reasoning strategies) as well as in recent cognitive research (dual process theories of judgment and decision making). There is a level of tacit, experiential learning, which trainees must attain before they can be considered to be competent. (Talbot 2004). However, it can be difficult to formally assess levels of tacit knowledge, as they can be only tested "in action." If the educational reforms do not take these questions into account, the standards of post-graduate medical education may be seriously lowered.

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Notes

1. The duration of post-graduate medical training in Denmark has for several reasons often lasted 8–10 years. In 2003, a reform by the National Board of Health accelerated higher specialist training (Danish ministry of Health 2000): formal post-graduate training programmes have been accelerated and must define learning objectives and assessment methods based on the CanMEDS framework (CanMEDS 2000). Requirements of post-graduate education of today include an 18-month internship (in 2008 it is further reduced to 12 months), a 1-year introductory training in a specialty and a further 4–5-year specialty training as a resident.

2. "Epistemic knowledge." Wackerhausen (1996) bases this concept on Aristotle's concept, where *episteme* is the true, universal and definitive scientific knowledge, *techne* is the skills and crafts, which are connected to the making of things and *phronesis* is connected to ethically correct actions among human beings. According to Aristotle, all three kinds of knowledge are to be considered as a whole and are equally important in understanding the nature of man and his society.

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