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Research Article

### COGNITIVE SCHEMES FOR CLINICAL DIAGNOSTIC REASONING BY MEDICAL STUDENTS

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**Abstract:**

*Cognitive processes that activate clinical reasoning are complicated. These cognitive processes are either analytical (slow) or non-analytical (fast). This research focuses on how thinking cultivates and alters over the course of years spent in medical college and how they are different in high vs borderline medical students.*

**Objective:** *The study aims to explore the cognitive schemes, build up by medical students with different achievement records for clinical diagnostic reasoning, the pathways followed by them for diagnostic reasoning and to explore neurocognitive factors that influence their clinical diagnostic reasoning.* **Methodology:** *The sampling technique was purposively followed by theoretical sampling. The study was conducted from Dec 2016 to May 2017. This was a qualitative study based on the Grounded theory of Constructivist design. In-depth interviews were audio-recorded, transcribed, and analyzed manually.* **Results:** *Using thematic analysis, 8 themes surfaced. Students of high achievement followed pattern recognition (system 1). Hypothetical deductive reasoning (system 2) was followed by borderline students. However, most strategies of reasoning were uniformly distributed among high achievers and borderline students. Sleep deprivation and fatigue were the two most important factors which affected the cognitive schemes of medical students.* **Conclusion:** *Clinical reasoning in medical education is of significance in the development of future doctors. The actual reasoning process includes medical decision-making on one hand and problem-solving on the other hand. Cognitive schemes of high achiever students are based on pattern recognition and borderline students follow hypothetical deductive reasoning.*

**Keywords:** *Cognitive schemes, clinical diagnostic reasoning, system 1, system 2, pattern recognition, hypothetico-deductive reasoning.*

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**INTRODUCTION:**

Health care is fragile and is disposed to diagnostic and management miscalculations<sup>1</sup>. Doctors are challenged to make clinical judgments that affect the lives of patients on a daily basis<sup>2</sup>. Clinical judgment is fundamental in the formulation of diagnosis and safe management of patients<sup>3</sup>. Clinical reasoning may be well-defined as thinking through the different aspects of patient care to choose a rational decision for the prevention, diagnosis, or management of a clinical problem in a particular patient<sup>4</sup>.

Clinical reasoning emphasizes the clinical presentation of a patient. This definite reasoning process comprises decision and problem solving<sup>5</sup>. Training the students with different learning methodologies will help develop cognitive structures that will enable them to process the patient's data in a very refined manner<sup>6</sup>. The characteristic of critical thinking dates back to the days of Socrates (470–399 BC)<sup>7</sup>. The teacher directs the learner towards critical thinking through question and answer procedure<sup>8</sup>. Clinical diagnostic reasoning consists of knowledge, cognitive skills, reflective reasoning, contextual thinking, and mutual decision making<sup>9</sup>.

Cognitive schemes can be defined as questioning the problem, processing information, executing the plan, and an estimation of the results<sup>10</sup>. Earlier research has documented a range of four consecutive approaches for problem-solving in medicine: guessing, scheme induction, hypothetical-deductive reasoning, and pattern recognition<sup>11</sup>. Unlike novices, experts are inclined to use 'problem solving mental schemes'<sup>12</sup>. Clinical reasoning is influenced by more than 40 cognitive and emotional tendencies<sup>13</sup>. Researchers have tested the hypothesis that expertise in clinical diagnostic reasoning is related to the person's knowledge and is captured or interlinked to the amount of knowledge or the type of knowledge a person has<sup>14</sup>.

The dual-process theory was proposed in 1975 by Jonathan Evans. In his theory, there were two distinguishing types of processes: analytical processes and heuristic processes. Stanovich<sup>15</sup> coined the terms *System 1* and *System 2* to mark the two different sets of processes. Daniel Kahneman stipulated further understanding by distinguishing the two processes, *intuition* and *reasoning* in 2003<sup>16</sup>. These systems are often signified as "*System 1*" and "*System 2*," as created by Stanovich and West. The non-analytical is referred to as system 1 and the analytic as system 2 processing.

Studies have shown that medical students and

novices use the system 2 approach because they are less experienced and have seen fewer cases, they have fewer disease scripts in their memory and the clinical presentations could not match the diagnosis of a particular condition<sup>17</sup>. On the other hand, experienced doctors tend to use the system 1 approach, as they have several scripts and clinical scenarios in their memories. Pattern recognition and hypothetico-deduction, which have been widely explained in the medical literature – are the foundation of the intuitive system and the analytical system<sup>18</sup>. The dual-process theory has received enormous encouragement from a variety of sources and has surfaced as the chief model for human decision making.

**METHODS:**

The study duration was from 1<sup>st</sup> December 2016 to 1<sup>st</sup> May 2017. The study was conducted at Foundation University Medical College It was a qualitative study based on the Grounded theory of Constructivist design. This design was used to generate a theory that expounded a process, interaction or action about a topic at a broader level. The research sets out to explore the cognitive schemes of medical students for clinical diagnostic reasoning. A research design using In-depth Interviews was engaged to discover the cognitive schemes of medical students for clinical diagnostic reasoning. Students from the 4<sup>th</sup> and 5<sup>th</sup> year were included in the study according to the sampling criteria. Faculty members of the 4<sup>th</sup> and 5<sup>th</sup> years were interviewed for the triangulation of data. The sampling technique adopted was purposive (maximal variation type) followed by theoretical sampling. Interviews were conducted in a predefined place in a secure, safe and comfortable environment. A total of 20 students of the 4<sup>th</sup> and 5<sup>th</sup> year M.B.B.S class participated in the study. In Phase 1, the 1<sup>st</sup> round of interviews was conducted. Interviews were audio-recorded and then transcribed. For preserving secrecy and confidentiality, study participants were coded before analysis. In Phase 1, the 2<sup>nd</sup> round of interviews was conducted once the point of saturation reached after 1<sup>st</sup> round data analysis. Interview questions were changed to get more information in detail. Memo writing was done after each interview. In Phase 2, an interview was conducted in which faculty members of the 4<sup>th</sup> and 5<sup>th</sup> year were interviewed. This was done to get more info and for the triangulation of data. Thematic analysis was used in qualitative research and emphasizes on probing themes within data. Coding was the main process for emerging themes within the raw data by recognizing important moments in the data and encoding it to interpretation. Triangulation and member checking were the two methods to increase the credibility of

data. A comprehensive description of the site, participants, and procedures was used to collect data for other researchers to evaluate whether the results applied in one study is a good match, and makes sense to generalize. The study described the exact methods of data collection, analysis, and interpretation in detail for dependability.

### RESULTS:

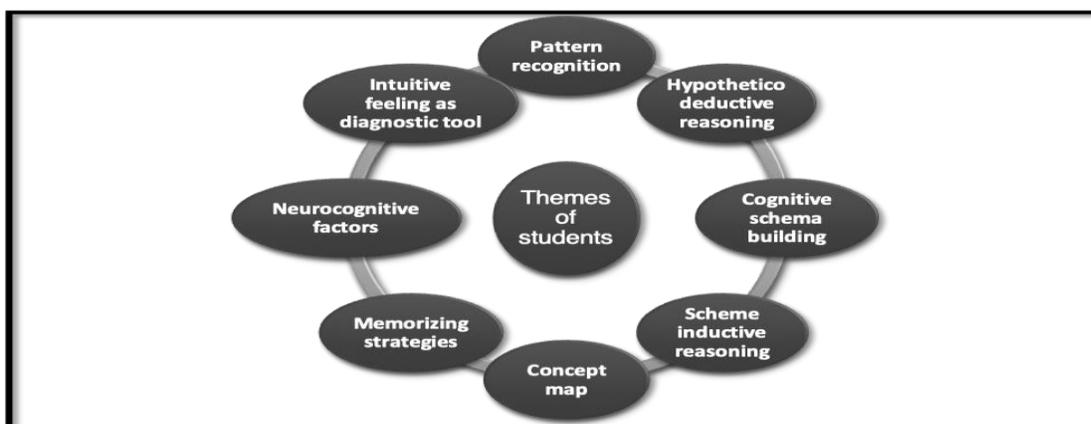
Out of 20 students, 11 were females and 10 were male students. The mean age was 23 years. **59 open codes** appeared by analyzing the whole of the data manually. In **axial coding**, categories were interrelated with their subcategories and tested their associations against data. This resulted

in **20 axial codes**. Finally, **8 themes** appear after **selective coding**.

These 8 themes were pattern recognition, hypothetico-deductive reasoning, cognitive schema building, scheme inductive reasoning, concept map, memorizing strategies, the role of intuitive feeling as a diagnostic tool and neurocognitive factors.

### Figure 1

A pattern of case-based learning was based on “illness script” or “pattern recognition”. Pattern recognition was the primary clinical reasoning strategy. High achieving students believed that cases seen before helped them to recognize the condition.



**Figure 1: Themes of students**

### Table 1

A significant difference between high achievers and borderline students had been seen while asking about the diagnostic strategy they used on encountering a patient.

- Respondent H. A 25<sup>th</sup> said “you become brisker if you have seen such case before”

The borderline respondent didn’t feel confident while reasoning the patient with a pattern recognition strategy. They believed in reasoning protocols to be followed.

Hypothetico-deductive reasoning helped in history taking and physical examination to form detailed knowledge structures of basic scientific understanding and mechanisms.

**Table 1: Theme of Pattern recognition**

Theme	Axial code	Open code	Frequency ( <i>f</i> )	%
Pattern recognition	Confident on seeing cases before	Cases seen before	9	45%
		Quick at diagnosis	6	30%
		Independent to diagnose	3	15%
		Confident to diagnose	7	35%
	Pattern recognition	Register in mind	8	40%

**Figure 2**

Mostly borderline students tried to reason out the cases with help of history, examination, and investigation.

- *Respondent B.L 3 5<sup>th</sup> said, " I concentrate more on history and examination as each of them will help me customize the investigations and treatment plan according to the patient".*

However, if high achiever students came up with the wrong diagnosis via the case-based reasoning method switched over to hypothetico deductive reasoning. Borderline students felt more confident when they reasoned out with hypothetico deductive reasoning.

Learners elaborated on their cognitive schemas by linking newly presented information to the things they already knew. The responses of interviewees explained their schema building and retrieval of these schemas when and where required. They consider long-term memory as an important element for retrieval of these schemas. Both high achievers and borderline believed that new knowledge was built upon previous knowledge base.

- *Respondent B. L 1 4<sup>th</sup> said, " From history to examination, in every step, prior*

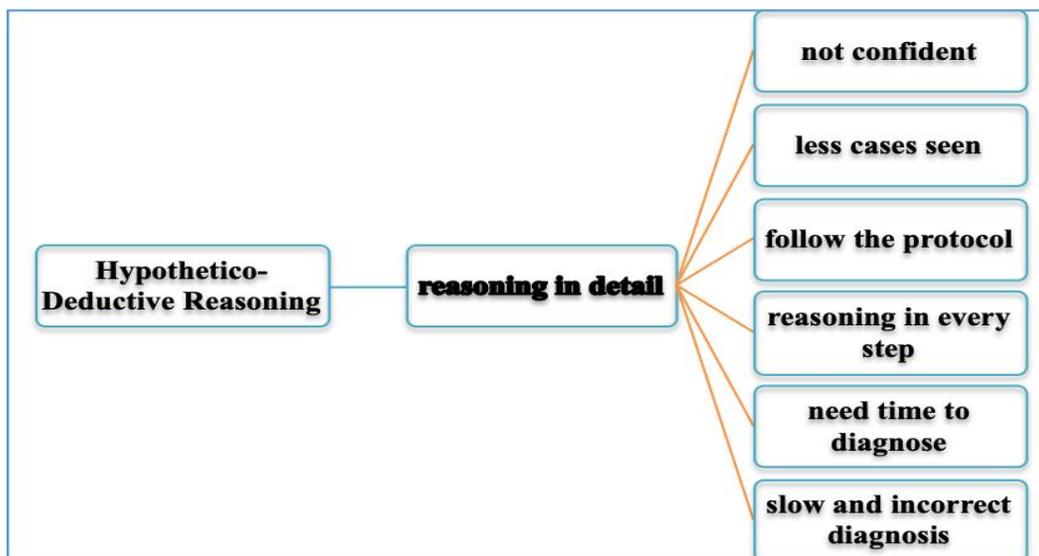
*knowledge is linked to the new one that helps to create a better diagnosis".*

Both groups believed that long-term memory played a major role in the retrieval of old knowledge which has been stored in the form of schemas for clinical diagnostic reasoning.

Students related new technology with old databases already formed in long term memory. Both groups believed the effectiveness of technology for updating knowledge and relating new knowledge to the older one.

Both the student groups believed that greeting patients helped them to build repo with patients so that it increased the patient's confidence in them for future inquiry. The patient became more acquainted and gave all the information regarding their disease in detail. This helped the students to diagnose the patient.

Surprisingly students had no idea about concept maps and those who heard about it never saw and draw it. Though the concept map was one of the older tools which had been in use for the last 25 years, it had not been implemented in undergraduate teachings.



**Figure 2: Hypothetico-deductive reasoning**

Most of the high achiever students stress upon the importance of memorizing strategies, very few of borderline students mention these strategies. The most important memorizing strategy used by students was reading out loud and making a checklist.

It appeared evident that high achiever and borderline students relied on gut feeling but they thought it might mislead them to reach a correct diagnosis. Students didn't want to support the gut feeling much as they had apprehensions about reaching the wrong diagnosis. One of the high achiever students believed that gut feeling came with experience and with a strong knowledge base. There is no discrepancy between a high achiever and a borderline student's clinical diagnostic reasoning skills due to sleep deprivation and fatigue. Both the groups were affected by it and they consider these responsible for the loss of concentration and diagnosing skills.

Most of the teachers said that high achievers mostly interacted with patients more than borderline. Mostly borderline students were not interested in patients at all. They believed high achievers read a lot, study a lot from books, and are regular in attendance which is why they fell in the category of high achievers.

So, to conclude teachers of 4<sup>th</sup> and 5<sup>th</sup> year were also of the opinion that high achiever students were quicker in diagnosis and borderline were slow. This was consistent with what this study stated.

### DISCUSSION:

The objective of this study was to explore the cognitive schemes of medical students with different achievement records for clinical diagnostic reasoning. In this study students with high achieving records followed the pattern of system 1 that is intuitive and is based on pattern recognition or illness scripts. These illness scripts were already stored in their mind as they already had seen many similar cases before. Timings of diagnosis were immediate and they used significant case features to reach the diagnosis. According to Edward *et al.*<sup>19</sup>, an extremely structured knowledge structure is considered as a core of pattern recognition. In this study, most of the high achieving students follow prototype patterns which are like expert practitioners who have dealt with a lot of cases to diagnose with system 1.

When students enter a medical college, they are encouraged to follow a hypothetico-deductive approach to reason. Hypothetico-deductive reasoning

is slow. It is related to system 2 of the dual-process model which is analytical. In this study, the borderline medical students followed system 2. They reasoned out the diagnosis of cases by asking questions regarding history, examination findings, and finally by various investigations. Literature<sup>20</sup> showed that generally an expert in his field does not use the hypothetico-deductive reasoning approach, but a novice who is struggling to develop a structured knowledge base does rely on analytical approaches<sup>21</sup>. However, high achieving students tried to reason out when their diagnosis came up to be incorrect.

In this study students of both categories believed in schema building but only high achieving students retrieve their schemas to diagnose correctly. Literature showed that experts are likely better at formulating and applying schemas in situations with which they are familiar. Thus, in this study, high achiever students displayed greater skill with regards to knowledge retrieval and application. On the contrary, borderline students had schemas but they were not able to retrieve those schemas.

In this study, both groups believed that long-term memory played a great part in the retrieval of schemas which was consistent with the literature.

Scheme inductive reasoning or forward reasoning is characteristic of experts. Brett K Hayes and E Heit<sup>22</sup> showed that although not all of the experts solely used forward reasoning. However, those whose reasoning process was mostly in a forward manner attained an accurate diagnosis more rapidly than those using a mixture of forward and backward reasoning. Forward reasoning is used by experts and novices in many situations. In this study, both high achievers and borderline students tried to reason out via the forward reasoning in daily routine either in wards or in the OPD which is also consistent with the literature.

There are very few learning strategies used by students to memorize and retrieve important information to achieve good grades in their medical colleges<sup>23</sup>. However, chunking, recalling, revising, enlisting has been mentioned in the literature. In this study, high achievers mentioned strategies like recalling, enlisting, and revising for memorizing the information. Borderline students didn't mention about memorizing strategies except writing.

Erik Stolper<sup>24</sup> mentioned that practitioners recognize the feeling of agitation that sometimes appears during a consultation. In the case of medical students, this gut feeling comes up with good baseline knowledge

and experience. Deborah<sup>25</sup> emphasizes that there is a 95 percent chance of reaching the correct diagnosis when a correct hypothesis is considered in the first five minutes. In this study high achiever medical students believed in the gut feeling while diagnosing patients and they believed that these feelings come with experience. However, borderline believe in gut feelings but not for the patient's clinical diagnosis. They reason out the diagnosis with hypothetico-deductive reasoning.

Sleep deprivation results in negative mood situations, especially reduced orientation, fatigue, confusion and sleepiness<sup>26</sup>. In this study, both high achievers and borderline students considered sleep deprivation and fatigue as factors that influenced them

According to Norman and Eva<sup>28</sup>, non-analytic reasoning is responsible for diagnostic errors and analytic reasoning strategy is superior in decision-making. Researchers were interested to explore the cognitive schemes of students and the system they follow to reach the diagnosis.

However, this study concluded that high achiever students reached their diagnosis by system 1 mostly. This was due to pattern recognition. At end of the study, a framework was developed on basis of findings of the study. This framework explained the cognitive schemes of both groups of medical students, neurocognitive factors which affected the pathways and role of gut feeling and memory. The framework clearly defined the pathways followed by both of the groups.

Figure 3

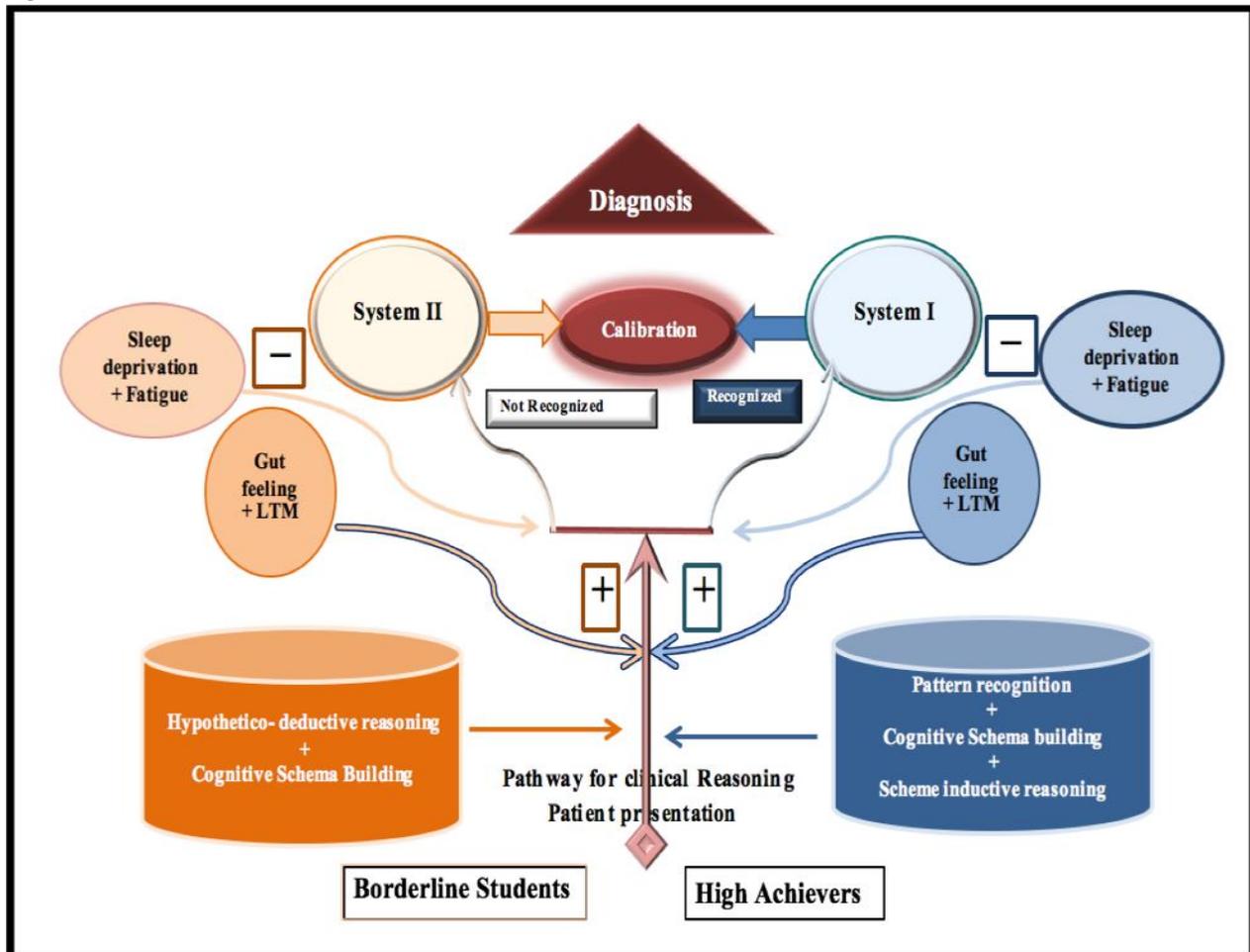


Figure 3: Cognitive framework of diagnostic reasoning

**CONCLUSION:**

Doctors are challenged to make clinical judgments that affect the lives of patients on a daily basis. Clinical reasoning is unquestionably complex and multilayered in nature and can be considered specific to each individual health profession. Hypothetico deduction reasoning is considered to be slow. It is related to system 2 of the dual-process model which is analytical and based on reasoning. However, pattern recognition is related to system 1 of the dual process.

This study showed that high achiever students follow the pattern recognition approach also known as system 1. Borderline students, on other hand, follow system 2 which is slow. To reach the diagnosis, they follow these 2 systems. Different cognitive schemes were used by both groups of students. These schemes include case-based reasoning, hypothetico-deductive reasoning, scheme inductive reasoning, cognitive schema building, and making concept maps. There is also a role of gut feeling and long-term memory which affects the diagnostic abilities of the students.

The study will be a great help for the policymakers of the education department to improve their teaching strategies so that borderline students will learn the skill of clinical diagnostic reasoning in a better way.

**Limitations:**

The intermediate (achievement) group of students were not involved in this study to clearly distinguish the group from high achiever and borderline. Do intermediate students use pattern recognition or hypothetico-deductive reasoning for clinical diagnosis?

This study was a single institute-based study. More studies must be conducted in other medical institutes with different rankings to see the response of their high achiever and borderline students for diagnostic reasoning.

**Declaration of interest:**

The authors whose names are listed above certify that they have NO affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

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