Breaking down automaticity: case ambiguity and the shift to reflective approaches in clinical reasoning

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CONTEXT Two modes of case processing have been shown to underlie diagnostic judgements: analytical and non-analytical reasoning. An optimal form of clinical reasoning is suggested to combine both modes. Conditions leading doctors to shift from the usual mode of non-analytical reasoning to reflective reasoning have not been identified. This paper reports a study aimed at exploring these conditions by investigating the effects of ambiguity of clinical cases on clinical reasoning.

METHODS Participants were 16 internal medicine residents in the Brazilian state of Ceará. They were asked to diagnose 20 clinical cases and recall case information. The independent variable was the degree of ambiguity of clinical cases, with 2 levels: straightforward (i.e. non-ambiguous) and ambiguous. Dependent variables were processing time, diagnostic accuracy and proposition per category recalled. Data were analysed using a repeated measures design.

RESULTS Participants processed straightforward cases faster and more accurately than ambiguous ones. The proportion of text propositions recalled was significantly lower ($t[15] = 2.29$, $P = 0.037$) in ambiguous cases, and an interaction effect between case version and proposition category was also found ($F[5, 75] = 4.52$, $P = 0.001$, $d = 0.232$, observed power = 0.962). Furthermore, participants recalled significantly more literal propositions from the ambiguous cases than from the straightforward cases ($t[15] = 2.28$, $P = 0.037$).

CONCLUSIONS Ambiguity of clinical cases was shown to lead residents to switch from automatic to reflective reasoning, as indicated by longer processing time, and more literal propositions recalled in ambiguous cases.

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INTRODUCTION

Judicious judgements and effective decision making define successful clinical problem solving. Two different approaches for processing clinical cases, non-analytical and analytical, have been shown to underlie diagnostic decisions.[1,2] Experienced doctors diagnose routine problems essentially by recognising similarities between the actual case and examples of previous patients.[3] This pattern-recognition, non-analytical, form of clinical reasoning is largely automatic and unconscious.[3,4] In the second, analytical form of case processing, clinicians arrive at a diagnosis by analysing signs and symptoms, relying on biomedical knowledge when necessary.[2,5,6]

It has been suggested that these 2 types of reasoning result from different kinds of knowledge used for diagnosing cases. According to Schmidt and Boshuizen,[3] medical expertise development entails a process of knowledge restructuring. Biomedical knowledge is gradually 'encapsulated' under clinical knowledge and, with clinical experience, scripts of diseases and exemplars of patients, is stored in the longterm memory. Empirical studies have highlighted the role of scripts, examples and encapsulated knowledge in non-analytical processing.[3,7,8]

Overview

What is already known on this subject

Two different approaches for processing clinical cases, non-analytical and analytical, have been shown to underlie diagnostic decisions. It was not previously known, however, what makes doctors shift from the usual automatic reasoning to reflective reasoning.

What this study adds

This study shows that the ambiguity of clinical cases is among the conditions that lead doctors to adopt reflective reasoning approaches for diagnosing clinical problems. It also contributes to understanding of how the 2 modes of reasoning act in case processing.

Suggestions for further research

Further investigation is required to identify other conditions underlying the switch from non-analytical to analytical diagnostic reasoning, and whether and how reflective reasoning might be learned.

These studies have often used the clinical case paradigm, in which participants are requested to:

1 read a clinical case description;
2 provide a diagnosis;
3 recall all case information, and
4 explain case findings.

Expert doctors were shown to recall less information from the case description in a literal format than did advanced students. By contrast, experts generated more high-level inferences (i.e. inferences based on more than 1 finding in the case).[8,9] Experts apparently make shortcuts in their lines of reasoning while processing cases. They easily recognise a set of signs and symptoms as characteristic of a disease, almost automatically infer relevant encapsulated concepts, and generate diagnostic hypotheses, without needing to analyse individual findings and pathophysiological mechanisms.[8,9]

Research on medical expertise has particularly investigated non-analytical case processing. Recently, interest in analytical diagnostic reasoning has risen, stimulated by concerns about medical errors. Despite its effectiveness in routine situations, non-analytical reasoning may lead doctors to fail when they encounter complex or unusual problems.[10,11] Heuristics and experienced doctors' difficulties in reformulating initial hypotheses have been pointed out as potential causes of errors.[12,13] Reflective practice, conceptualised as doctors' ability to critically reflect on their own reasoning and decisions, has been considered crucial for optimal clinical performance.[14,15] A recent study suggested a multi-dimensional structure of reflective practice in medicine.[14] It would imply an elaborate, careful consideration of case findings and critical scrutiny of one's own reasoning. This thoughtful approach is not expected to be used in routine problems, but would be triggered by troublesome situations.[16] The conditions that trigger reflection, however, are not known.

The purpose of this study was to examine factors that lead doctors to switch from their usual non-analytical reasoning to a reflective diagnostic approach.* More specifically, we aimed to investigate whether ambiguity in clinical cases would lead to a breakdown of automaticity. By ambiguous cases, we mean a patient presentation that corresponds to the typical pattern of a disease but also includes features consistent with alternative diagnoses. The present study required residents to read a clinical case, provide a diagnosis and, subsequently, recall the case information. Based on previous studies on reflective practice,[14] we hypothesised that ambiguity in clinical cases would lead doctors to shift from non-analytical to reflective reasoning. According to the knowledge encapsulation view, doctors will largely use encapsulated knowledge when dealing with routine cases,[8,17] when they do not need to evaluate the findings extensively. Reflective reasoning, however, would require more systematic consideration of individual signs and symptoms. Based on these assumptions, we made a set of predictions. Firstly, processing time will be higher for ambiguous cases than for straightforward cases because ambiguous cases lead to reflection. Secondly, recall protocols of ambiguous cases will be more elaborate than protocols of straightforward cases, not only in terms of literal propositions but

*The 2 main forms of case processing have traditionally been designated by the terms 'non-analytical' and 'analytical', the latter conceived and operationalised largely in terms of mental, cognitive processes. Reflective practice in medicine has been conceptualised as a set of behaviours and reasoning processes involving affective dimensions, which would also be expected to play a role in the reflective processing of clinical cases. As this paper is aimed at calling attention to the affective skills required for reflective diagnostic approaches, we have adopted the term 'reflective reasoning', which will be used throughout the text.

also in terms of high-level inferences. That is, an ambiguous case will trigger additional inferences resulting from the doctor's effort to understand this complex case. Finally, diagnostic accuracy will be higher for straightforward cases than for ambiguous cases, which would validate our manipulation.

METHODS

Design

In this experimental study all participants performed under both experimental conditions (i.e. repeated measures). The independent variable was case type (straightforward versus ambiguous). Dependent variables were processing time, diagnostic accuracy and propositions (per category) recalled.

Participants

The participants were 16 second-year internal medicine residents from teaching hospitals in the Brazilian State of Ceará (mean age = 27.06 years; standard deviation [SD] = 1.06 years). A total of 22 eligible residents were invited to participate and informed consent was obtained.

Materials

The materials consisted of 20 written clinical cases, covering common conditions within the domain of internal medicine (Table 1). Case descriptions reported contextual information, complaints, findings from history taking and physical examination, and test results. There were 2 versions of each case. In the straightforward version, the case corresponded to a 'text-book case', exhibiting the set of features encountered in the typical presentation of the disease. The case description strongly suggested only 1 diagnosis. A few features were added to the straightforward version to generate the clinically ambiguous version. These features consisted of information about the patient's context, medical history and/or complaints, which raised the plausibility of an alternative diagnosis. Table 2 presents an example of a case. Items in italics were included in the clinically ambiguous version only. Cases

Table 1 Diagnostics of the cases used in the experiment

1	Community-acquired pneumonia
2	Stomach cancer
3	Acute bacterial endocarditis
4	Rheumatoid arthritis
5	Inflammatory bowel disease
6	Acute pyelonephritis
7	Acute viral hepatitis
8	Acute bacterial meningitis
9	Pseudomembranous colitis
10	Hyperthyroidism
11	Deficiency of vitamin B_{12}
12	Addison's disease
13	Acute alcoholic pancreatitis
14	Nephrotic syndrome
15	Pulmonary thromboembolism
16	Liver cirrhosis
17	Coeliac disease
18	Acute viral pericarditis
19	Acute myeloid leukaemia
20	Acute appendicitis

Table 2 Example of a case used in the experiment. Items in italics were given only in the ambiguous version of the case

The patient is a 27-year-old woman, who complains of pain in the right side of the chest that started suddenly 24 hours ago. The pain becomes worse with inspiring and is associated with dyspnoea. The patient denies cough, expectoration, haemoptysis or wheezing. She describes having felt warm, but did not take her temperature. She denies oedema in the inferior limbs and says she has never had respiratory problems. She has used no medications other than oral contraceptive pills. *She raises various types of birds at home and smokes 20 cigarettes per day.* She does not consume alcohol and has no risk factors for HIV. Her family history is negative for asthma. *Her father had pulmonary emphysema and died from coronary heart disease when he was 62 years old*

Physical examination

The patient is slightly obese. She appears uncomfortable and is in mild respiratory distress

The patient's temperature is 38 °C; pulse is 115 beats/min; blood pressure is 140/80 mmHg; respiration count is 30/min. There is no jugular turgidity. Cardiac examination is normal. Lung examination does not show rhonchus, crepitations or wheeze. Abdomen examination does not show abnormalities. The extremities are normal, without oedema or cyanosis

Tests

Haematocrit: 42%; haemoglobin: 14.5g dl^{-1}

White cell count: 6000/mm^3, with 74% neutrophils and 26% lymphocytes

Chest X-ray: normal cardiac area, small infiltrate in the right lower lobe

Electrocardiogram: sinus tachycardia

Arterial blood gas values: pH: 7.49; pCO_2: 32 mmHg; pO_2: 60 mmHg contained an average of 39.67 (SD = 11.13) propositions (i.e. discrete idea units in the text).[18]

Two expert doctors with a specialty board certification in internal medicine and over 15 years of clinical practice prepared the cases. They were presented in the format of a booklet containing, for each case, a page with the case description and a space to write the diagnostic hypothesis, followed by a blank page for free recall. Each booklet contained 20 cases to be diagnosed, 10 under each experimental condition (i.e. straightforward and ambiguous). Ambiguous and straightforward cases were presented alternately. Half the booklets started with an ambiguous case and half with a straightforward case. The presentation sequence of the 20 cases was also counterbalanced in each booklet to control for order effects.

Procedure

The experiment consisted of a training phase and a test phase. In the training phase, 2 sample cases were presented to familiarise participants with the procedures. There were no time constraints but the experimenter asked participants to strive to provide the most likely diagnoses for the cases as fast as possible. This was in order to prevent participants, as much as possible, from evaluating cases in a more elaborate manner than their usual processing mode. In the test phase, each participant received a booklet containing cases to be solved by the same procedure used in the training phase. The participant was asked to first read the case and provide the most likely diagnosis, and then to turn the page and recall the case information. For each case, the experimenter recorded processing time from the moment the participant started to read the case to the moment he or she wrote down the diagnosis. Participants were tested individually in sessions lasting approximately 60 minutes.

Analysis

The accuracy of the diagnosis provided by participants was independently rated by 2 experts with specialty board certification in internal medicine, and over 18 years of professional practice in teaching hospitals. Diagnoses were rated on a 5-point scale ranging from 0 (completely incorrect diagnosis) to 4 (completely correct diagnosis). For example, 1 point was attributed to a diagnosis that was not the correct main diagnosis for the case but contained at least 1 of its constituents (e.g. *upper gastrointestinal bleeding* in a case of *stomach cancer*). The inter-rater agreement between the 2 experts was 86%. Disagreements between raters were resolved by discussion.

The free-recall protocols were scored by means of a propositional analysis method introduced by Patel and Groen.[18] Each protocol was segmented into propositions. A proposition consists of 2 concepts linked by a qualifier, such as *causation*, *specification*, *temporal information* or *location*. For instance, the protocol fragment in Table 2, 'The patient is a 27-year-old woman, with complaints of pain in the right side of the chest that started suddenly 24 hours ago' consists of 6 propositions:

1 patient *specification* (woman);
2 patient *specification* (27-year-old);
3 complaints *specification* (pain);
4 pain *location* (in the right side of the chest);
5 starting *specification* (suddenly), and
6 complaints *temporal information* (24 hours ago).

Each proposition in the recall protocol was matched against the propositions in the text of the case description. Based on their relationships with the propositions in the text, the recalled propositions were classified into 6 categories: literal (or paraphrased) propositions; low-level inferred propositions; high-level inferred propositions; non-significant mistakes; significant mistakes, and non-existing propositions. Low-level inferred propositions are inferences based on only 1 proposition in the text, whereas high-level inferences are propositions that can be matched with a number of propositions in the case description. In Table 2, *Fever* or *tachycardia* are examples of low-level inferences. *Pleuritic pain* and *respiratory alkalosis* are possible high-level inferences.

High-level inferences have been considered to be evidence of the use of encapsulated knowledge.[17,19] The total number of propositions in the recall protocol was obtained by summing the number of literal propositions, low-level inferences and high-level inferences. When 2 researchers independently scored a subset of protocols, an inter-rater agreement of 0.92 ($P < 0.05$) was found. Differences were resolved by discussion and, as the procedure turned out to be reliable, scoring of the remaining protocols proceeded with 1 judge.

Data from cases solved in each condition were collapsed for each participant. Descriptive statistics were obtained for each experimental condition (straightforward versus ambiguous), and paired sample *t*-tests were performed for comparing processing time, diagnostic accuracy and propositions recalled in both conditions. We controlled for case length by calculating processing time per proposition and proportion of propositions recalled. Repeated measures analysis of variance, with case type and proposition category as within-subject factors, was used for comparison of the number of propositions recalled in the 6 categories of propositions in the 2 experimental conditions. Posthoc paired *t*-tests were performed for comparison across the levels of the proposition category. Effects size (partial η^2) and observed power (OP) were calculated when indicated.

RESULTS

Processing time

Table 3 shows the mean total processing time and the mean time per proposition for both conditions. Paired *t*-tests revealed a significant difference between straightforward cases and ambiguous cases, both for total time ($t[15] = 5.03$, $P < 0.001$, partial $\eta^2 = 0.628$, OP = 0.997) and time per proposition ($t[15] = 4.19$, $P = 0.001$, partial $\eta^2 = 0.539$, OP = 0.974).

Free recall

Table 4 presents proportions of propositions recalled from the text in both conditions. They were lower in the ambiguous cases than in the straightforward ones and this difference was significant ($t[15] = 2.29$, $P = 0.037$, partial $\eta^2 = 0.259$, OP = 0.573). The proportion of straightforward propositions (i.e. propositions that constituted the description of straightforward cases) recalled was significantly lower in ambiguous cases than in straightforward cases ($t[15] = 6.14$, $P < 0.001$, partial $\eta^2 = 0.715$, OP = 1.0).

Table 5 presents the mean number of propositions recalled in the 6 categories. Analysis of variance showed a large significant effect of category of proposition on the number of propositions recalled ($F[5, 75] = 46.54$, $P < 0.001$, partial $\eta^2 = 0.756$, OP = 1.00). There was no significant main effect of case type ($F[1, 15] = 1.53$, $P = 0.23$, partial $\eta^2 = 0.093$, OP = 0.212), but a large interaction between case type and proposition category was found ($F[5, 75] = 4.52$, $P = 0.001$, partial $\eta^2 = 0.232$, OP = 0.962). Posthoc *t*-tests showed a significant difference between the mean number of literal propositions recalled in straightforward cases versus ambiguous cases ($t[15] = 2.28$, $P = 0.037$). Comparisons of the mean numbers of propositions recalled for the other categories did not show significant differences.

Table 3 Mean processing time and mean time per proposition (in seconds) as a function of case version

	Straightforward cases			Clinically ambiguous cases		
	n	*Mean*	*SD*	*n*	*Mean*	*SD*
Processing time	16	548.50	166.74	16	687.81	218.06
Processing time per proposition	16	1.47	0.43	16	1.64	0.51

Table 4 Means for propositions recalled as a function of case version

	Straightforward cases			Clinically ambiguous cases		
	n	*Mean*	*SD*	*n*	*Mean*	*SD*
Number of propositions recalled	16	9.94	4.46	16	10.36	5.19
Proportion of propositions recalled	16	0.27	0.12	16	0.25	0.12
Proportion of straightforward propositions recalled	16	0.27	0.12	16	0.21	0.11

Table 5 Mean number of propositions recalled in each category as a function of case version

	Straightforward cases			Clinically ambiguous cases		
	n	*Mean*	*SD*	*n*	*Mean*	*SD*
Number of literal propositions recalled	16	77.00	40.84	16	84.43	49.93
Number of low-level inferences recalled	16	12.31	7.15	16	10.75	5.92
Number of high-level inferences recalled	16	10.06	7.37	16	8.37	4.27
Number of non-significant mistakes	16	2.75	2.49	16	2.62	3.07
Number of significant mistakes	16	0.75	1.61	16	0.81	1.05
Number of non-existing propositions	16	1.44	1.63	16	2.56	3.40

SD = standard deviation

Diagnostic accuracy

Mean diagnostic accuracy was higher for straightforward cases (mean = 3.09, SD = 0.45) than for ambiguous cases (mean = 2.61, SD = 0.51). A paired *t*-test showed that this difference was significant ($t[15] = 2.41$, $P = 0.029$, partial $\eta^2 = 0.279$, OP = 0.616), which indicates that our ambiguous cases were more complex (i.e. our manipulation was valid).

DISCUSSION

This study was concerned with conditions that lead doctors to shift from non-analytical to reflective reasoning when solving clinical cases. Based on previous studies on reflective practice in medicine,[14] it was hypothesised that 1 of these conditions was ambiguity of a clinical problem. In this experiment, features in case presentation were manipulated to create either a straightforward or an ambiguous case. It was hypothesised that ambiguity would lead participants to engage in elaborate, reflective case processing, and, therefore, spend more time on diagnosing ambiguous cases than straightforward ones. Furthermore, based on the notion of reflective practice in medicine,[14,15] it was predicted that reflective reasoning would be expressed by more elaborate recall protocols (i.e. more literal propositions and inferences) of ambiguous cases. Results showed that participants processed straightforward cases faster than ambiguous ones. Surprisingly, the proportion of total propositions recalled was *lower* and qualitatively different in the ambiguous condition than in the straightforward condition. By contrast, participants also recalled more literal propositions from the ambiguous cases than from the straightforward cases. Differences in the number of inferences generated in the 2 conditions were not significant.

Findings are largely consistent with the hypothesis put forward in this study. Doctors spent more time processing ambiguous cases than straightforward cases. Furthermore, differences in the literal propositions recalled suggest that these propositions were more highly activated in their case representation of the ambiguous cases. Apparently, doctors realised that the ambiguous cases required more elaborate exploration of the findings, which is characteristic of reflective practice in medicine.[14] A recent study exploring question format, task difficulty and reasoning strategies also suggested that case difficulty triggers reflection.[20]

Reflective practice also entails promptness to explore features in a case that do not fit with initial hypotheses.[14] Participants indeed seem to have engaged in such exploration when faced with contradictory clinical findings. The lower proportion of straightforward propositions recalled in ambiguous cases indicates that doctors' attention was directed to the atypical features that were added in this experimental condition. This could also explain the lower total proportion of propositions recalled in ambiguous cases.

Our findings call attention to the role of clinical features in diagnostic processes. Several studies demonstrated the significance of encapsulated knowledge in experts' reasoning, but also suggested the potential importance of individual features.[8,17,19] These studies usually explored differences in case processing associated with expertise level. The stimuli, therefore, were frequently the same, whereas participants' levels of expertise varied. The present study investigated whether differences in case characteristics would affect the diagnostic reasoning of participants with similar levels of expertise. Results suggest that individual features in fact play an important role in case representation, and that doctors' reliance on analysis of signs and symptoms increases with the ambiguity of clinical problems. Recognition of ambiguity may only happen if doctors analyse to some extent individual features in their process of identifying a pattern in a set of signs and symptoms. In the course of this process, ambiguous findings may then break down the usual automatic reasoning and lead doctors to engage in reflection.

Contrary to our predictions, there were no significant differences between conditions in high-level inferences. It was expected that reflection would also manifest itself by generating more inferences to account for ambiguous data. A possible explanation for this finding may be that the straightforward cases were more complex to resolve than expected, resulting in similar performances on both types of case. This explanation is substantiated by the participants' diagnostic performance on the straightforward cases, which resulted in about 75% of the maximum possible score (i.e. rather low for the straightforward cases). Alternatively, we might argue that the ambiguous cases were not complex enough to generate extra inferences to deal with the problem. This interpretation is also, to some extent, substantiated by the participants' diagnostic performance on this type of case. They scored 65% of the maximum score, which is not much lower than their score on the straightforward cases. It is important to note that previous studies argued that, unlike diagnostic performance and processing speed, the measure of free recall, and, in particular, high-level inferences, is often not sensitive enough to reveal small differences between doctors in different experimental conditions.[17,21]

It has been suggested that clinical teaching should aim to provide students with multiple reasoning strategies that could enable them to work through problems in different situations.[1,2,22] This requires recognising when more reflection is required. By indicating that ambiguity in a clinical case apparently acts as a cue for reflection, our findings might facilitate teaching of a combined, integrated clinical reasoning. However, how this might be done is still to be explored. Findings also highlighted the role of individual features in doctors' reasoning, which reaffirms the value attributed to teaching the importance of systematic analysis of clinical cases.

Some questions remain for future investigation. Firstly, ambiguity in clinical presentation was shown to break down automaticity, but other conditions that generate a sense of complexity and are still to be identified might have a similar effect. Secondly, light was shed on the role of individual features in diagnostic reasoning, but there is much more to be discovered about how reflection manifests itself in case processing. Finally, some doctors seem to recognise, more than others, when a problem requires an elaborate mode of processing. As far as conditions leading to reflective reasoning become known, the possibility of teaching doctors to recognise and adopt reflective approaches increases. How these reflective practices might be learned remains a question yet to be answered.

The present study has some limitations. As we have outlined above, the clinical case paradigm assumes that case representation can be probed by case recall. However, we cannot exclude the notion that concepts activated during case processing in both conditions did not appear in the protocols or that inferences in the protocols were not generated during case processing, but during the recall task.[19,21] Another limitation is inherent to the laboratory environment. Participants solved written clinical cases under experimental conditions, which restricts the generalisability of findings to performance in clinical settings.

Contributors: all authors participated in the conception and design of the study. SM provided contributions to acquisition, analysis and interpretation of data, drafted the manuscript and is the guarantor. HGS supervised the whole study and contributed to the analysis and interpretation of data, and to the critical revision of the manuscript. RMJPR participated in the data analysis and interpretation, and contributed to the critical revision of the manuscript. JCP and JMC-F participated in the analysis and interpretation of data, particularly with regard to judgement of diagnostic accuracy, and contributed to the revision of the manuscript.

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