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Clinical Pharmacology and Therapeutics
Teach the Teacher Program

Understanding therapeutic reasoning

A scientific report

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1 Preface

Over the years, considerable effort has been taken at a European level to improve clinical pharmacology and therapeutics (CPT) education and thereby prescribing practice. However, despite this effort, medication errors are still a common phenomenon.

To improve education and daily practice in clinical pharmacology and therapeutics, with the ultimate goal of preventing medication errors, it is essential to gain a better understanding of the reasoning and decision-making processes underlying prescribing. While some insights from cognitive psychology have been applied to diagnostic reasoning, this is not (yet) the case for therapeutic reasoning.

A comprehensive study of this complex process is needed to gain an understanding of our thought processes when prescribing, with a view to improving prescribing skills. By incorporating insights from cognitive psychology, we can shed light on the intricacies inherent to therapeutic decision making. This, in turn, will pave the way for the development of innovative training methods tailored to prescribers, both inexperienced and experienced, ultimately improving daily practice. A profound understanding of the cognitive processes involved in prescribing will enable healthcare professionals to make better-informed decisions, based on their awareness of thinking dispositions, leading to improved patient outcomes and safety.

This report, a result of European collaboration, was written to provide a better understanding of therapeutic reasoning, based on the newest insights, and its implications in practice. It is part of the Clinical Pharmacology and Therapeutics Teach the Teacher (CP4T) program, supported by Erasmus +, grant number 2022-1-NL01-KA220-HED-000088069. A shorter version of this report has also been

published as a research article (1). Although the topic is complex, it is important for improving teaching and training in clinical therapeutics. Next to that, insight into the therapeutic reasoning process can also help to improve artificial intelligence decision support systems in the future. We hope that it will inspire you to incorporate this knowledge in your own education and training programs.

The authors, on behalf of the EACPT education group and CP4T.
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2 Key points

- Upon diagnosing a patient, an initial automatic response arises based on pattern recognition through therapy scripts (type 1 thinking). At some point, this response is evaluated by the reflective mind using metacognition (which plays an important role in type 2a thinking), and if found to be incorrect or incomplete, an alternative response is formulated through a slower, more analytical, and deliberative process, known as type 2b thinking. This process is shown in the European Model of Therapeutic Reasoning.
- Metacognition monitors the reasoning process and helps a person to form new therapy scripts after choosing the right therapy.
- Experienced physicians have more and richer therapy scripts than inexperienced physicians, based not only on their knowledge but also on their expertise and appreciation of the relevance of enabling conditions, such as patient characteristics. Therefore their type 1 response is more often correct.
- There are significant differences between diagnostic and therapeutic reasoning, raising questions about their comparability, and therefore more research is needed.
- It is recommended that all steps of the reasoning process in clinical pharmacology and therapeutics be optimized. This can be done, among other things, by providing structure , stimulating metacognition through reflection, increasing motivation, and providing context-rich education to develop rich therapy scripts early in professional training. However, because these teaching methods are mainly based on diagnostic reasoning, they should be tested in practice for therapeutic reasoning as well, and adjusted if necessary.

3 Problem definition

A professor of Clinical Pharmacology told several generations of students that he once encountered a former student who was now a practicing physician. She said to him that she had forgotten almost all the details she had learned from him, except for the red warning light. This starts to burn whenever she decides to prescribe a medicine. Then the critical questions arise and the process of choosing the best medicine for the individual patient starts. The professor was very pleased with that reply, and often showed a red warning light in his teaching (1). In this report we describe what is now known about the process behind the 'red warning light', and what we can learn from it for education, clinical practice and further research. To clearly describe and understand this complicated cognitive process, we have included a model of the thinking process.

Over the years, considerable effort has been taken to improve clinical pharmacology and therapeutics (CPT) education and assessment (2, 3). These improvements have occurred at local, national, European, and intercontinental levels. Examples include joint assessments conducted both nationally and at a European level, harmonization of education systems, sharing of materials, and teach-the-teacher programs resulting from European and worldwide collaboration (4-10). However, the current collaboration at both national and international levels in the fields of pharmacotherapy education and research highlights that, despite all these efforts, more needs to be done to improve therapeutic reasoning and thereby prescribing. This is because research has shown that residents' still make many errors and their prescribing knowledge and skills do not seem to improve during their first year of clinical practice (11, 12). These errors result in patient harm, decreased quality of life, and increased healthcare costs (13, 14).

It would be expected that if prescribing were based solely on guidelines and knowledge, then improving the use of guidelines would reduce the number of prescribing errors. Yet, this seems not to be the case – prescribing involves more than following guidelines: it is a complex skill that needs to

be developed by training and doing in different clinical scenarios (15). Indeed, a prescriber must be aware of specific patient characteristics such as comorbidities and co-medication, the severity of the disease, drug characteristics and clinical context, and how these influence the choice of medication in order to establish the most appropriate treatment, and also taking patient's preference into account. This requires a high level of the so-called therapeutic reasoning, which is a subset of management reasoning.

Developing therapeutic reasoning requires training and good examples well rooted in a clinical context. However, it is often observed in practice that when residents or students ask their supervisors to explain why they chose a specific treatment, they hear regularly that the supervisor follows current guideline or has used this treatment for this condition for years with success, without being able to provide detailed information about why it is the drug of choice for this specific patient. Because residents and students frequently rely on the examples set by their teachers or supervisors in clinical practice, they may prescribe the same medication for future patients without understanding why, merely repeating what they have seen (16). For example, the supervisor may choose a drug on the basis of specific patient characteristics, but if the resident is not aware of this, he or she may prescribe the drug to patients with the same disease but with other characteristics, potentially leading to prescribing errors. Moreover, the prescribing skills of experienced prescribers may become daily routine instead of an up-to-date skill, especially if they prescribe the same drug for years, even when another (often newer) drug may be more appropriate. So, understanding the therapeutic reasoning process may help to improve the prescribing skills of both experienced and inexperienced prescribers.

While many studies and medical education have mainly focused on diagnostic reasoning as part of clinical reasoning, more needs to be learned about why physicians choose a specific therapy (i.e. therapeutic reasoning) (17). A scoping review about therapeutic reasoning process research showed

that research on therapeutic reasoning rarely builds upon results from previous studies, and aspects such as metacognition are scarcely included (18). Most existing models of therapeutic reasoning are mainly based on diagnostic reasoning, such as the models of Bissessur et al (19), Denig et al (20), and the WHO 6-step (21, 22). However, although diagnostic and therapeutic reasoning are intricately linked, both have its own challenges. Therefore, therapeutic reasoning may deserve a focus of its own. Contemporary insights into cognitive psychology, which emphasize the complex nature of reasoning processes, may improve therapeutic reasoning and vitalize CPT education for both undergraduate and graduate prescribers. Therefore, the aim of this narrative review was to gather insights into the therapeutic reasoning process, identify knowledge gaps and provide a foundation for future research to improve CPT education and prescribing practices in clinical settings (1).

In this review, the most important theories are presented from the perspective of cognitive psychology, because this forms the basis of theories of clinical reasoning. In order to choose the best therapy, a physician must consider whether the standard treatment which immediately comes to mind (via scripts) is suitable and recognize when it is not (with help of metacognition). If it is not appropriate, he/she must come up with an alternative (with analytical thinking as part of the dual-process theory). To understand these theories, it is necessary to gain insight into cognitive psychology processes and their influence on clinical reasoning and decision making and factors that influence this process. An adjusted model for therapeutic reasoning and its implications is proposed (1).

4 Methods

Because the medical literature is not conclusive and the reasoning process has been widely studied in other disciplines, we decided to take a broad approach, by using a narrative review. The strength of a narrative review is that it seeks to identify what has been accomplished previously, allowing for consolidation, building on previous work and identifying knowledge gaps (23). This method allows us to incorporate knowledge from other fields into the theories of therapeutic reasoning and to perform an additional search for extra information about relevant topics, such was whether theories from cognitive psychology are also incorporated within therapeutic reasoning. The PubMed, MEDLINE, EMBASE, PsycINFO, and CINAHL databases were searched for articles about therapeutic reasoning in English or Dutch, to gain a broad understanding of therapeutic reasoning among various healthcare professionals. The last search was performed on 15 November 2023. In addition, a more general search of studies about reasoning and decision making was performed, because of the profound insights into reasoning in general. The references of relevant articles were screened, using the snowball method. Search terms included (synonyms of) therapeutic reasoning, management reasoning, management decision making, therapy or management scripts, drug choice, and prescribing patterns. Studies involving both experienced and inexperienced prescribers and students of all professions with prescribing authority were included.

5 The cognitive psychology basis of reasoning and decision making

5.1 Theories in cognitive psychology

5.1.1 Dual-process theory

One of the most accepted theories for decision making is the dual-process theory of Kahneman, which states that two types of thinking are involved in decision making (24). Type 1 thinking, also called non-analytical thinking, is rapid, driven by instinct and experience (25). It is associated with bias, particularly belief bias, whereby people tend to defend their type 1 decision if they believe that this answer is correct, rather than assess their decision rationally (26). Type 2 thinking, or analytical thinking, is a slower, step-by-step approach to solving a problem. Unlike type 1 thinking, type 2 thinking is a form of deductive reasoning, in which multiple hypotheses are weighed. This is associated with effort and the use of working memory, which is why type 2 thinking functions less well under non-optimal conditions, such as fatigue or time pressure (27). However, having enough time to reach a decision does not necessarily lead to better decisions (28).Type 1 thinking is always active, whereas type 2 thinking may be inactive. Type 1 thinking can lead to a decision or conclusion, whereas type 2 thinking can be used to evaluate whether this fast decision or conclusion is valid (27).

Example:

When you see the following multiplication: 17x24, you immediately have an idea what the outcome should be approximately and you know how to do the multiplication, but you probably do not know the correct answer. This is your type 1 response. You can choose to calculate it or not. To know the exact answer, type 2 thinking is necessary. This requires cognitive working memory. It is not possible to solve the sum while reading a book or making eye contact because the capacity of working memory is limited (27).

The most important features of type 1 and type 2 thinking are given in table 1 (29). Both develop in early childhood (30). It is not completely clear which type of thinking is used in which situation. In general, most people 'prefer' the cognitive ease of type 1 thinking, due to the brain's limited working memory. Cognitive effort, of any type, stimulates the use of type 2 thinking and prevents the use of a type 1 response, which could potentially prevent bias (27). However, even if we think we have made a rational decision, the decision is often made unconsciously (type 1 decision). In a study in which participants had to decide arbitrary to press a button with their left- or right hand, functional Magnetic Resonance Imaging (fMRI) showed that they decided which hand to use about 7 seconds before the subject indicated that a choice was made (31). It has even been argued that experts, like firefighters, sometimes make better decisions when they rely on their intuitive thoughts instead of analytical reasoning (32, 33).

Type 1 thinking	**Type 2 thinking**
Fast, effortless	Slow, effortful
Independent of cognitive ability	Correlated with cognitive ability
Automatic, unconscious	Controlled, conscious
Does not require working memory	Requires working memory
Autonomous	Cognitive decoupling and mental stimulation
Associative	Rule based
Affective	Logical
Implicit knowledge	Explicit knowledge

Table 1: Characteristics of type 1 and type 2 thinking (29)

Several theories are consistent with the dual-process theory. Stanovich stated that type 2 thinking can also be divided into algorithmic thinking and reflective thinking (34). According to this theory, when a person makes a primary, type 1, response, the reflective mind recognizes when this response is incorrect. If this is the case, the reflective mind activates the algorithmic mind to form a better response, overriding the primary response. This reflective thinking is not only described by Stanovich, but also by Evans and Houdé, who refer to it as type 3 thinking (35, 36). The algorithmic mind, in which intelligence plays an important role, comes up with other solutions by weighing different possibilities in order to find the best response (from now on called type 2b reasoning). The reflective mind serves a higher purpose (long-term goal) and is responsible for why different people make different choices (from now on called type 2a reasoning) (34). People who are curious are more likely to question their primary response and to search for alternatives – they use type 2 thinking more often (37). Metacognitive reasoning skills are an important part of reflective thinking (30). According to Stanovich, there are different categories of thinking disposition, namely (i) default to the autonomous mind (analytical thinking has not been activated); (ii) serial associative cognition with a focal bias (people take something for truth and explain why this should be correct instead of weighing other possibilities); (iii) override failure (this can be due to gaps in education and experience or their incorrect use); (iv) mindware gap (when there is insufficient knowledge); and (v) contaminated mindware (which can occur in different forms, such as lay psychological theory or evaluation-disabling strategies). The most important category is the default to the autonomous mind. The reflective mind mostly recognizes when it is necessary to override the primary response, although this does not always happen (34). In cognitive reflection tests, overconfident participants tend to make more incorrect answers, which are mainly intuitive. They probably do not use to type 2 thinking because of their confidence (38).

Similar theories with minor modifications have also been developed (29, 39, 40). For example, Evans divides the mind into an old and a new one. The old mind, which originated early in human evolution,

acts automatically and is completely separate from intelligence. The old mind is a combination of evolution and experimental learning and is driven by earlier successes. As tasks became more and more complex, it was necessary to solve novel problems by reasoning and to weigh possible outcomes. This involved the new mind, which develops over time, and depends on working memory. The primary response to a problem or situation is based on the past successes of the old mind and it can be difficult to override this response (26, 41, 42). Next to that, Hammond describes reasoning as a continuum between analytical, quasirational and intuitive reasoning instead of distinct types (43).

While the dual-process theory is generally accepted, less is known about how systems 1 and 2 interact. According to the original dual-process theory, there is a sequential relation between the two, whereby system 1 acts autonomously and system 2 monitors this process, overriding it when necessary (27). This is also called the default-interventionist model. Another interpretation is the parallel-competitive model, whereby the two processes are active at the same time. Both systems provide input, whereby system 2 can override system 1, and system 1 can block system 2 if the system 1 response is considered strong enough. In both models, system 2 cannot work without the input of system 1 (44). The default-interventionist model is the most accepted model with regard to decision making (40).

Although there are different variants of the dual-process theory, the basis remains that there is always a primary, intuitive response. This response can be appropriate or not and, if necessary, analytical thinking processes are activated to form a better response.

5.1.2 Probabilistic thinking

Probabilistic thinking is part of the analytical process of type 2 thinking. Probabilistic thinking tries to estimate the likelihood that a specific outcome will occur. There are two different ways to look at this, through frequentist and Bayesian statistics, although these can be used interchangeably. For

frequentist statistics, a null hypothesis will be formulated, which can be accepted or rejected. The basis of Bayesian statistics is the theorem of Bayes, which describes the probability of an event occurring based on previous knowledge of the conditions associated with this event, whereby a hypothesis becomes more or less likely instead of accepted or rejected (45). Bayes theorem states that the pre-test odds of a hypothesis being true multiplied by the weight of new evidence generates post-test odds of the hypothesis being true (46).

Example:

If you think a patient with dyspnea has pneumonia, you expect to see pulmonary infiltrates on the X-ray. If pulmonary infiltrates are not seen, then pneumonia is less likely, but cannot be completely ruled out.

5.1.3 Metacognition

Another important theme in decision making is metacognition, which is part of the reflective mind and necessary for both type 1 and type 2 thinking. Metacognition has been defined as 'thinking about thinking' or as the possibility to monitor and influence cognitive processes (47). Metacognition has five core features, namely, awareness of the requirements of learning processes, recognition of the limitations of memory, ability to appreciate perspective, capacity for self-critique, and the ability to select strategies (48). Metacognition has two aspects (figure 1): metacognitive knowledge, which is a person's awareness of, and knowledge about, their cognitive processes, and metacognitive control, which is about a person's self-regulatory mechanisms, such as planning and adjusting behavior relative to a desired outcome. Making a decision happens on the object level (where cognition happens), which can be raised to a meta-level through meta-knowledge. From there, through meta-control, the decision can be changed at an object level (47). Both of these processes also have executive functions.

Example:

*A junior doctor has an appointment with a patient who has a suspicion of a metabolic disease at the outpatient clinic. The junior doctor knows that he has difficulties with this topic and has had trouble diagnosing other patients with similar diseases (**metacognitive knowledge**). Therefore, he decides to prepare thoroughly by studying the guidelines and using UpToDate before starting any medication (**metacognitive control**). Based on this positive experience (**metacognitive knowledge**), he decides to prepare for outpatient clinics more diligently in the future (**metacognitive control**).*

Thus recognizing that you have made a mistake and monitoring the reasoning process involves metacognitive knowledge, whereas correcting the mistake, inhibitory control, and resource allocation involves metacognitive control (47). It has been suggested that there are two levels of metacognition. The first one, also called low-level, which is comparable to type 1 thinking, is activated by so-called 'noetic feeling', which stand for subjective, emotional feelings. The second one, also called high-level metacognition, which is comparable to type 2 thinking, is activated when someone thinks that the existing knowledge is incorrect or fictional. High-level metacognition is associated with analytical reasoning and low-level metacognition is associated with experience (49). Better metacognitive abilities are associated with better performance, and individuals with good metacognitive skills recognize when they are not performing well more often than do individuals with poor metacognitive skills (50).

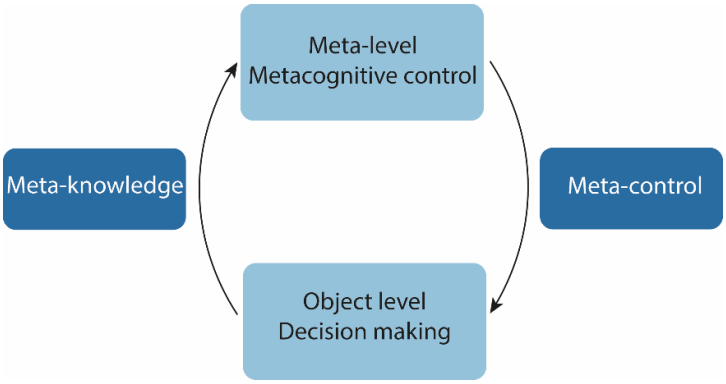

Figure 1: Schematic overview of metacognition in decision making

5.1.4 Scripts

The use of scripts, also called schemes, is widely considered an important part of decision making. Scripts can help us to make decisions quickly and are therefore part of type 1 thinking. A script is automatically formed on the basis of experience and can be activated when a similar situation happens. Pattern recognition is important in this process (27, 51-55).

Example:

When you go to a restaurant, a general script will be activated to understand what will happen next, e.g. that food will be served in exchange for money. Based on the context, more specific scripts will be activated, e.g. if there is a waiter (in a fancy restaurant) or if you have to order at the counter (in a cafeteria) (51).

5.2 Summarizing

The dual-process theory is a widely accepted theory for decision making and can be divided into type 1 thinking, which is intuitive, and type 2 thinking, which is about analytical reasoning. The most common mistake is not recognizing when the type 1 output is incorrect. Probabilistic thinking is an important part of type 2 thinking, while scripts are needed for type 1 thinking. Metacognition plays an important role during the entire reasoning process.

6 Clinical reasoning

6.1 Diagnostic reasoning

The previous section described the cognitive psychology basis for reasoning and decision making. Decision making is inherent to clinical reasoning, which can be divided into diagnostic and therapeutic reasoning. Both are closely related, case influence each other and are necessary for providing good care. At this moment, the majority of research has focused on diagnostic reasoning.

Several models for diagnostic reasoning have been described. One of the oldest models is the hypothetico-deductive model, which is used in the analytical reasoning process (49, 56). According to this model, physicians formulate a limited number of hypotheses (usually three to five) based on the disease etiology and then try to make them more or less likely until one hypothesis is correct, which is a form of backward reasoning (49). This requires probabilistic thinking, based on Bayesian statistics. When interpreting a diagnostic test result or answers to a question as part of the medical history, a hypothesis can become more or less likely, but it is often not possible to reject a hypothesis based solely on test results or answers (46). Another important model is pattern recognition, which is a non-analytical process, whereby a diagnosis is made based on the recognition of symptoms from a previous case (49). Pattern recognition is a form of forward, data-driven, reasoning. Different reasoning skills are involved, which can be divided into basic skills (identifying, describing, comparing, defining, and classifying) and superior skills (analyzing, synthesizing, and evaluating) (57).

Critical thinking is closely linked to clinical reasoning and is needed to prevent errors (58). Critical thinking involves a person's attitude, knowledge, and thinking skills. A correct attitude includes a willingness to plan, being flexible, being persistent, being willing to self-correct, being mindful, and having a desire to reconcile information (58). Without this attitude, it is unlikely that a person will think critically (58). Physicians need to have enough clinical knowledge and knowledge about

evidence-based medicine and clinical epidemiology to create a complete set of hypotheses (56). For hypothesis generation, a physician needs to have sufficient exemplars. Exemplars are clinical examples of a diagnosis, each representing a complex pattern of patient and clinical features (59). In addition, they must have an understanding of cognitive skills and know how to apply them to the reasoning process (58). The dual-process theory is also applicable to diagnostic reasoning, with analytical and non-analytical reasoning often being described as a continuum. Different solutions or hypotheses are typically generated by non-analytical (type 1) reasoning shortly after the presentation of a problem or patient, and these hypotheses are subsequently tested by analytical (type 2) reasoning (60). For example, family doctors tend to use both intuition (non-analytical) and evidence-based medicine (analytical) in their reasoning process (61).

Metacognition is necessary for both type 1 and type 2 reasoning. Metacognition provides feedback on the primary response, strengthening the response if it is correct so that it will be used again in the future (49). Metacognition can also activate type 2 thinking when needed (62), monitor the analytical thinking process and is necessary to validate or reject the final choice (49). Kahneman stated that if a physician sees an immediate effect of his work, the direct feedback following from it will make it easier to create appropriate patterns to recognize in a next similar situation because of this direct feedback (27). Cognitive forcing strategies based on metacognition can help to prevent errors, by identifying scenarios in which error is likely to occur (50).

6.2 Experienced versus inexperienced physicians

A distinction can be made between the thinking process of experienced and inexperienced physicians. However, experience is context dependent, a physician with years of clinical experience may yet be inexperienced when confronted with a new condition. Experienced physicians more frequently use non-analytical (type 1) reasoning processes whereas inexperienced physicians use analytical (type 2) reasoning processes (63-65). In order to generate multiple hypotheses for type 2 thinking, a physician needs to have a number of exemplars at his/her disposal. In order to generate exemplars, inexperienced physicians need to work on case studies during their training (59). Often medical education is analytical and schematic: learning about groups of diseases, criteria for a diagnosis, or using certain steps before prescribing a drug. Students are often discouraged from using pattern recognition (non-analytical reasoning) during their training (63). However, in practice both inexperienced and experienced physicians formulate hypotheses based on pattern recognition, although experienced physicians more often generate a correct primary hypothesis (63). This is in line with the theory of Kahneman (27). Moreover, it is probable that both non-analytical and analytical reasoning contribute to the final decision (60). Furthermore, a study showed that medical students typically use intuitive thinking when they start training, but switch to more analytical thinking as they progress in their studies (66). Inexperienced physicians and students categorize medical problems or patients by their resemblance to a prototype, whereas experienced physicians rely more on the similarity between individual patients (67). Therefore, it is important that students see as many patients with a certain diagnosis as possible, to encounter the different manifestations of the same diagnosis, so as to facilitate appropriate pattern recognition (67). Together with that, feedback and talking about their intuitive feelings help to create better non-analytical reasoning skills (68). In the end, combined non-analytical and analytical reasoning strategies help inexperienced students/physicians to ignore misleading information and to make a correct (differential) diagnosis (69).

Experience does not always lead to expertise. Metacognitive feedback helps a person understand which reasoning processes led to the correct diagnosis and which did not (49). Expertise not only requires experience, but also the ability to recognize when a problem needs to be thought through (49, 70). For example, a study found that unexpected patient comments and ambiguous ultrasound images made radiologists slow down and think more deliberatively, shifting, checking, searching, and focusing on available information (71).

6.3 Illness scripts

Scripts are described not only in cognitive psychology, but also in diagnostic reasoning, where they are called illness scripts (72). They enable physicians to compare a patient's clinical presentation with their own mental picture of a disease. Illness scripts have 'slots' that correspond to attributes associated with the disease, such as duration, location, and predisposing conditions. Each slot is associated with the most likely diagnosis in that situation (73). An illness script is activated when the physician recognizes a symptom or pattern of clinical features. Activation, usually a non-analytical response, enables the faster processing of 'classical patient' information (51). Analytical reasoning is activated if two or more illness scripts are activated, if no illness script is activated, or if other signs or symptoms do not support the initial tentative diagnosis (73). Illness scripts consist of three main components, namely, the enabling conditions (the patient and contextual factors), the fault (underlying pathophysiological process, which is basically textbook knowledge), and the consequences (complaints, signs, and symptoms) (51). Students and inexperienced physicians will rely on their knowledge of the fault, whereas experienced physicians rely more on enabling conditions (51). Also the reaction on a therapy can be incorporated into an illness script. Moreover, biomedical knowledge has to become encapsulated and integrated into illness scripts, which is a context-dependent process. For this reason, context must be provided in the medical curriculum (74, 75). Training case-based clinical reasoning will generate rich illness scripts and encourage students

and inexperienced physicians to make more use of information about enabling conditions (the patient in his/her context) and less use of fault-related aspects (that can be learned in a textbook) (76).

6.4 Errors in clinical reasoning

Clinical reasoning is prone to errors. Type 1 thinking uses heuristics. Heuristics are shortcuts in thinking, so that decisions are made quickly and are less effortful, but the decisions may be incorrect because they are based on incomplete information (58). Heuristics also give rise to cognitive bias (77). Bias can occur in different stages of the reasoning process. Before meeting the patient, the physician forms a specific picture based on the first information received (anchoring bias) or on recent similar cases (recent case bias, a subtype of availability bias). During the consultation, the physician tends to create a simple story out of the information (narrative fallacy) and to look for information or symptoms that confirms this story (confirmation bias), while ignoring seemingly contradictory information (78). An example of confirmation bias was found in a study of the diagnosis of pulmonary diseases, in which some physicians chose a plausible but incorrect diagnosis, which implied that auscultation was different in the right and left lung. Subsequently, the physicians heard a difference, even though the lung sounds were identical (79).

Even when type 2 thinking is engaged, bias in diagnostic reasoning can still occur (80). When a person thinks that they have reached a rational decision, they may in fact already have made that decision unconsciously (31). A physician makes a diagnosis after a patient consultation and may be unwilling to change this diagnosis after receiving conflicting information (conservatism), by avoiding negative information (ostrich effect) or believing that negative information does not apply (optimism bias) (78).

6.5 Comparison with theories from the cognitive psychology

Similar to cognitive psychology, the dual-process theory is a widely accepted theory in diagnostic reasoning. Scripts are also used, focused on diagnoses, where differences are described in terms of experience. Type 2 thinking in diagnostic reasoning is mostly described as a hypothetico-deductive process. Metacognition is described in some models, but not everywhere. If it is described, it is seen as important to develop expertise.

7 Therapeutic reasoning

7.1 Theories of therapeutic reasoning

Example:

A 39-week pregnant woman visits the doctor with a urinary tract infection. The doctor initially considers prescribing nitrofurantoin, as he regularly prescribes this medication for such problems (type 1 reasoning). However, he is uncertain if this drug is safe for pregnant patients ("a red warning light"); type 2a reasoning with help of metacognition), which prompts him to use analytical reasoning to evaluate the situation further. He decides to consult the guidelines (type 2b thinking), and based on the recommendations, he opts to prescribe amoxicillin/clavulanic acid instead. From now on, the doctor will prescribe this medication to pregnant women who are over 38 weeks pregnant (forming a new therapy script).

While theories from cognitive psychology have already been adopted in diagnostic reasoning, less is known about their application in therapeutic reasoning, also referred to as management reasoning. It is assumed that this reasoning process is the same as for diagnostic reasoning, although there are some important differences. First of all, the patient is actively involved in therapeutic reasoning, unlike in diagnostic reasoning. Cook and colleagues proposed that diagnostic reasoning is a classification task, with one correct (working) diagnosis at a specific time, operating independently of patient preferences and practical constraints, such as drug availability. In contrast, therapeutic reasoning is more about shared decision making and monitoring, where multiple solutions can be correct, and patient and system preferences can play an important role, making this complex and "situated" and has unavoidable uncertainties (81). While a person has a specific diagnosis, management of the condition necessitates ongoing monitoring and adjustment of the management plan (81). One consequence of these differences is that therapeutic reasoning requires analytical, backward reasoning more often and is therefore more cognitively challenging (81). Because of this,

therapeutic reasoning could be more sensitive to cognitive overload, which may result in inefficiency, errors, and frustration (81).

In 1994, the WHO published the 6-step model for therapeutic reasoning and prescribing. This model was based on a structured observational study in 1984 involving 500 patient consultations in the practices of 50 physicians. This showed, among other things, that almost all doctors had a standard therapy in mind for most conditions (step 3a), where they checked whether it was suitable for the patient in question (3b). The widely used 6-step model in CPT education describes in detail how students can learn these steps, but it does not explain how and why prescribers choose their therapy in step 3. This explanation should be provided when the WHO model is revised (22).

Therapeutic reasoning often starts when the patient is diagnosed, but a physician can also switch between reasoning about the diagnosis and the management, and reflect on this during the reasoning process (82). Bissessur and colleagues published a hypothetical model for therapeutic reasoning, based on the dual-process theory (19). In this model, it is possible to switch between non-analytical (type 1) and analytical (type 2) thinking during the reasoning process. In the model proposed by Mancuso and Rose, physicians assess different facts, called focal points, to reach a composite decision. This assessment is influenced by the physician's knowledge or experience, which can explain differences in therapy choice (83). Walker et al. found that pharmacy students exhibited three different stages of therapeutic reasoning. First, they gather information, then they analyze it, for example, to assess whether the problem matches the management plan, and lastly they articulate management options and make their final decision (84). Students can go back and forth between these different stages. Walker et al. concluded that metacognition, divided into monitoring and controlling functions, is involved in the entire reasoning process, with students monitoring their own reasoning process, controlling information and setting treatment goals (84). Mertens and colleagues have studied cognitive processes in pharmacists, leading to an eight step model - problem

and demand for care consideration, information collection, clinical reasoning, clinical judgment, shared decision-making, implementation, outcomes evaluation, and reflection - each of them coming with their own cognitive processes (85). Cook and colleagues proposed a model of therapeutic reasoning with four steps: instantiation of a management script; identification of options and explanation to the patient; shared decision-making; and ongoing monitoring and adjustment. Moreover, this process occurs between individuals (e.g. physicians and patients) and not only in the physician's mind (86). However, things can go wrong – the physician may fail to encourage patient autonomy, involve the patient in the decision-making process, or include the patient's (underlying) preferences in the final decision (87). In addition, not only physicians, but also patients have cognitive scripts that guide their interactions with theme. These scripts may influence the therapeutic reasoning process and shared decision-making (1, 87).

7.2 Therapy scripts

The concept of therapy scripts was introduced by Bissessur and colleagues, who described a therapy script comparable to illness scripts in their hypothetical model (19). A diagnosis activates several therapy scripts, one of which is selected (19, 88). Therapy scripts need to be adapted regularly, because contextual factors, such as comorbidities or patient preferences, could lead to the standard treatment not always being possible (88). Scripts can be changed for example based on earlier treatment, the scripts of colleagues and adapted guidelines. It is hypothesized that unlike illness scripts, therapy scripts often require both type 1 and type 2 thinking, whereby type 1 thinking is involved in script activation and type 2 thinking in script selection and revision, especially when the physician is not familiar with the problem or the problem is complex (89). A premature decision to discard a treatment option (premature closure) may be due to poor scripts, faulty instantiation (misapplying a general rule to a new case), or a lack of relevant knowledge (89). Therapy scripts consist of six key features, namely (i) the problem to be solved; (ii) management options; (iii)

preferences, values, and constraints; (iv) education needs; (v) interpersonal interactions; and (vi) encounter flow (timing and sequence of events such as teaching, additional diagnostic testing and decision making) (89). The script has four attributes, namely, (i) script content (disease-specific knowledge), (ii) a logical sequence, (iii) flexibility (the physician's capacity to tailor the management plan to the unique patient), and (iv) fluency (89). Abdoler and colleagues found that drug knowledge and patient characteristics were important determinants of the choice of which therapy script to use (90). Cook et al. stated that the best scripts seem to have a general framework that can be adapted to a specific illness and patient (86). Mamede and Schmidt assumed that illness scripts contain information about therapy choice, and that physicians activate diagnostic and treatment knowledge at the same time when they see a patient (91). Although illness scripts and therapy scripts may be activated concurrently, they can also be activated separately, for example, during follow-up consultations when the diagnosis is already clear. Students and inexperienced physicians are theorized have simplistic scripts, whereas experienced physicians more often have sophisticated scripts, with greater individual variation, based on their own experience (88, 92, 93). However, this distinction is largely theoretical, as empirical evidence directly observing and measuring these script differences remains limited. A student or inexperienced physician may have a 'starting a medication' script which becomes more specific with experience (89). Novices seem to have a single script for both general and appropriate prescribing, whereas experienced physicians may have a more holistic approach to patient care, which might mean they have separate scripts (92). A study found that while the management plans of sixth-year (clinical) students were incomplete and inaccurate, they were similar in format to those of experienced physicians, which suggests that the students are still learning to combine diagnostic and management knowledge (94). A study showed that when interns and residents were asked to concentrate on patient management, they mentioned more management items than preclinical students did (93). These authors suggested that preclinical students focus more on diagnostic aspects than on patient management, which suggests that they

cannot yet combine the two aspects (94). The differences of the scripts between students and inexperienced physicians and experienced physicians can be seen in table 2.

Scripts of students or inexperienced prescribers	**Scripts of experienced prescribers**
Simplistic scripts	Sophisticated scripts
Rely on their knowledge of the fault	Rely on enabling conditions
Mostly general scripts	More individual variation
Mainly based on textbook knowledge	Mainly based on their own experience

Table 2: Differences in scripts between inexperienced and experienced prescribers

7.3 Factors influencing therapy choice

Several factors influence the choice of therapy, as mentioned in figure 2 (16, 20, 90, 95, 96). These factors can be divided into five categories that are interlinked; for example, the effectiveness of the drugs is interlinked with both evidence in literature and the physician's personal experience with that drug. Weighing these factors depends, among other things, on experience, with 'effectiveness of the drugs' and 'examples from medical teachers' being the most important for students. Experienced physicians mentioned 'clinical experience', 'effectiveness of the drugs', 'side effects of the drugs', 'standard treatment guidelines', and 'scientific literature' as being most important (16). While both students and physicians mention treatment effectiveness as being important, patients and physicians differ in how they describe effectiveness, with patients often mentioning side effects as influencing a treatment's effectiveness (97). Next to experience, the importance of these factors may also differ per situation, for example preventive treatment versus treatment for morbidity or additional treatment. Side-effects are more common accepted when treating morbidity instead of when they occur during preventive treatment. Shared decision making is important for prescribing and potentially influences the choice of therapy. In turn, the emotional context and social factors

concerning the patient (or personomics) influence the decision-making process (98, 99). Drug knowledge and treatment appropriateness are only weakly correlated in medical students, which suggests that acquiring knowledge alone does not guarantee an appropriate treatment choice (100). Having enough knowledge is still important because a lack of knowledge can lead to a mindware gap, which is one of the thinking dispositions according to Stanovich (34).

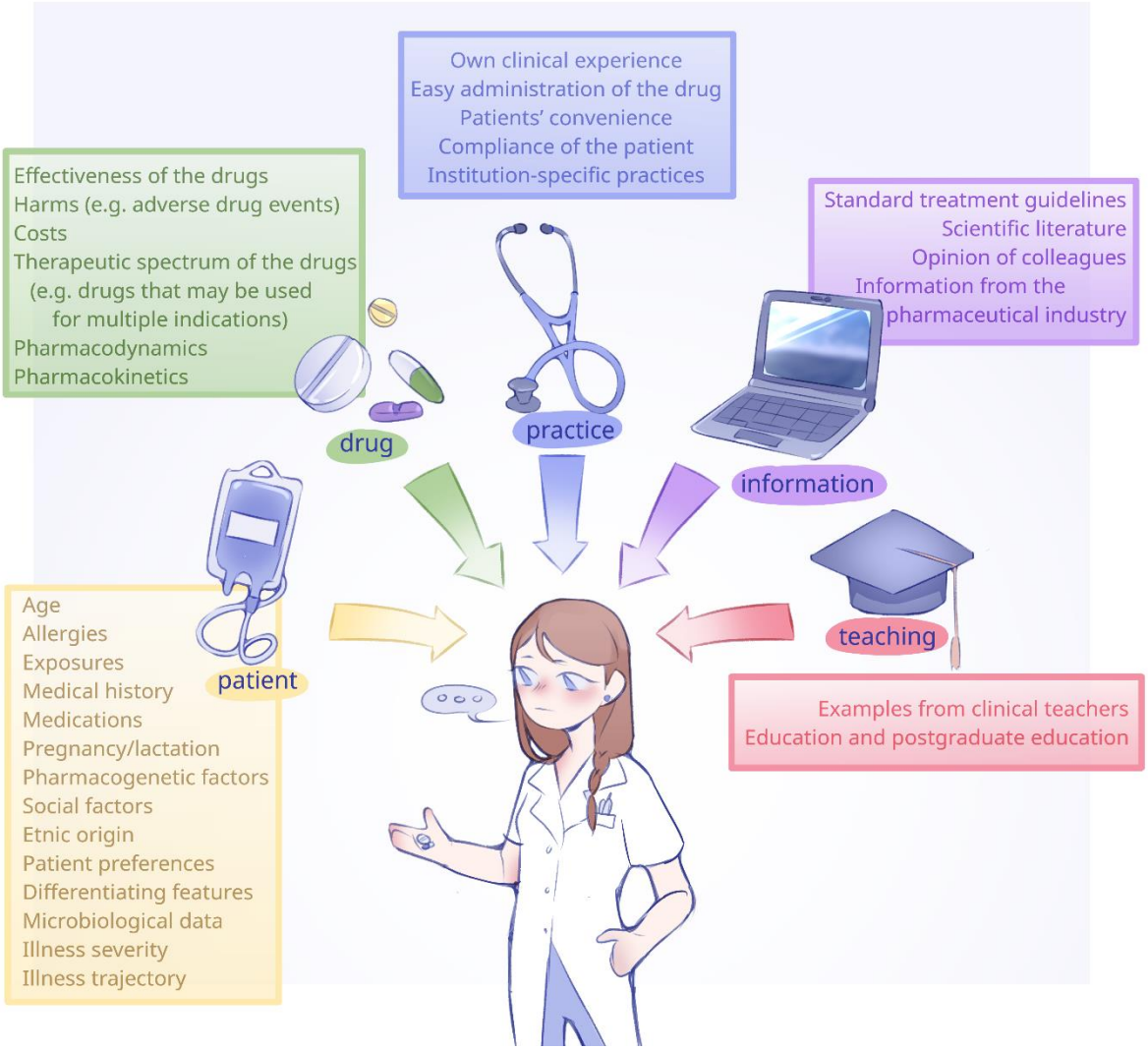

Figure 2: Factors influencing therapeutic reasoning

7.4 Errors and bias in therapeutic decision making

Therapeutic reasoning, like other forms of reasoning, is susceptible to errors. As other models have indicated, type 1 thinking is often prone to bias. Bias is a common occurrence in therapeutic decision making and is manifested in various ways, such as availability bias, impact bias, loss/gain framing effect, commission bias, omission bias, order effects, and relative risk bias. Some of these sources of bias have only been found in hypothetical studies (101). An overview of the most frequently mentioned biases including examples in therapeutic decision making can be found in table 3 (1).

While bias in type 1 thinking is frequently addressed in reasoning models, it is important to note that bias and errors can occur during other stages of reasoning as well. Type 2 reasoning does not always lead directly to the best treatment plan. Errors can occur for example in type 2a reasoning, where prescribers must recognize the need to switch to type 2b reasoning. Stanovich has described default to the autonomous mind (not activating analytical thinking) as the most significant thinking disposition (34). This can occur through different mechanisms. On one hand, bias, such as premature closure, whereby a physician accepts a treatment recommendation without considering other options, can result in a failure to detect conflict (84). On the other hand, due to limited working memory, our brains tend to prefer cognitive ease, meaning that choices are often based on recognition of an option rather than considering its details (27). For example, when a resident has to make a treatment decision in haste because he needs to see a new patient and because of this, there is only limited working memory – he/she chooses his type 1 'answer' rather than think about what is most appropriate. While this often works well and in some cases the type 1 response (gut feeling or intuition) may be even more sufficient when it aligns with underlying reasons for caution (32, 33). This tendency could partly explain why students frequently base their therapy choice the easy way: on the example set by their teachers (16). Experienced physicians know that a number of treatment possibilities exist for a patient problem and make their final choice heuristically, which often makes it challenging for them to explain their decision-making process to students (16). Because of this,

students may prescribe the same treatment in another situation without knowing how to apply it correctly or appropriately in practice, which could lead to suboptimal treatment choices. Stanovich describes this thinking disposition as an override failure, when a person is willing to reconsider their choices but does not have enough knowledge and experience to do so (34). In case of an override failure, a person is willing to override but is not able to come up with a better alternative, unlike the default to the autonomous mind, where there is no conflict detection at all. An override failure is possible due to so called mindware gaps, for example through a lack of experience and incorrect use of information (34). In addition, residents are often uncertain about their diagnosis or treatment plan, finding it hard to start treatment without a clear diagnosis. They are more worried about giving the wrong treatment than they are about not giving a treatment, which may happen conscious or unconscious (102). Cognitive forcing strategies provide a formal cognitive debiasing approach to deal with pitfalls in clinical reasoning, for example by adding structure. This might help to avoid these biases (50). Examples of potential strategies are described in table 4.

Other pitfalls in therapeutic reasoning which can occur in both type 1 and type 2 reasoning are vague or restricted care plans, failure to ascertain patient preferences, failure to follow cues of the patient, no shared-decision making, and no confirmation of understanding and commitment by the patient (103).

Bias	**Explanation** *Example*
Availability bias (101)	Making a decision based on an example, although it is not the most suitable one in the current case *Prescribing the same drug as for the previous patient with the same condition, although there are other patient characteristics that require a different choice.*
Impact bias (101)	Overestimate and/or underestimate the effect of your choice *If physicians consider antibiotic resistance as an important problem, but indicates that it is caused by physicians of other specialties and that they have to solve it.*
Loss/gain framing effect (101)	Decision based on whether outcomes are presented as potential gains or losses, often favoring risk avoiding when it comes to gains and a willingness to take risks when facing losses. *A physician decides to prescribe a specific drug because 90/100 patients will not have any side effects or to not prescribe that drug because 10/100 patients will experience a side effect that causes them to stop taking the medication.*
Commission bias (104, 105)	Tendency to prefer action over inaction *Concerns about missing an infection outweigh concerns about serious antibiotic harms such as Clostrioides difficle.*
Omission bias (101)	Tendency toward inaction over action *Not treating a patient with antibiotics because of fears of resistance or other antibiotic harms.*
Order effects (101)	Sequence of treatment options in guidelines/formularies has impact on drug choice, i.e. early alphabet options in a ranking are more likely to be chosen *A physician chooses the first drug from a list in alphabetical order, although another drug is more patient friendly.*
Relative risk bias (101)	Bias towards the relative effect – comparing risks between groups – over the absolute effect – the actual difference in risk. *Tendency to look at relative risk reduction (e.g. a 50% reduction in risk) rather than the absolute risk reduction (e.g. a reduction from 2% to 1%) when making a therapy choice.*
Premature closure (84)	Accepting a recommendation without considering other options *Prescribing the first drug that comes to mind instead of considering other drugs.*
Belief bias (26)	Defending the type 1 decision if they believe the answer is correct, instead of analytically reconsidering it *A supervisor coming with arguments to defend his/her choice, instead of reconsidering their choice using analytical processes.*

Table 3: Common biases in therapeutic reasoning

Comparison with theories from the cognitive psychology

There are important differences between diagnostic and therapeutic reasoning. For example, metacognition is barely mentioned in theories of therapeutic reasoning, although it seems to play an important role. In therapeutic reasoning, type 1 or type 2 thinking can be used, while the default-interventionist model involving conflict recognition is the most accepted one in cognitive psychology.

8 Implications for practice

8.1 Model of therapeutic reasoning

The European model of Therapeutic Reasoning (Figure 3), which builds upon the earlier model by Tichelaar et al. (22), illustrates the process of therapeutic reasoning within the context of clinical practice and contextual learning. Our European model of therapeutic reasoning as presented earlier is based on various models as described in this paragraph, while also establishing a connection between clinical practice, therapeutic reasoning, and contextual learning. A unique aspect of this model is that it always begins with some form of type 1 thinking and differentiates between type 2a and 2b thinking, as made in cognitive psychology. This also provides insights for educational approaches.

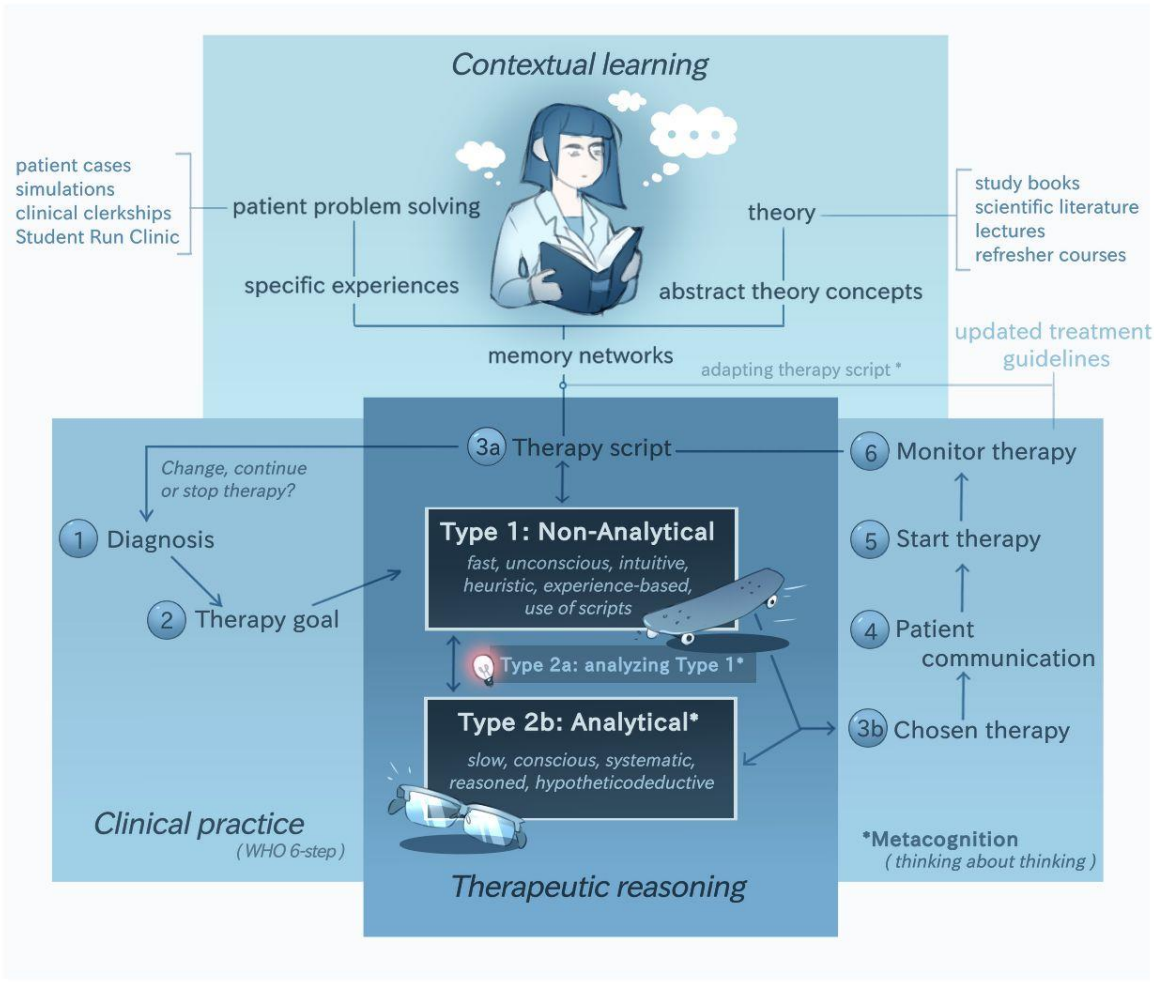

Figure 3: The European Model of Therapeutic reasoning

The aim of **therapeutic reasoning** is establishing a management plan for an individual patient. When a patient problem is presented, type 1 thinking is always used. This type 1 thought can be concrete, which might directly lead to a therapy, or may be more abstract, for example “starting antibiotics”, requiring a type 2 analytical thinking process. The core aspect of this process is the therapy script. Such a script pops up from memory as soon as the therapy is thought about. For experienced physicians, it consists of (1) a small number of therapy options linked to a diagnosis, (2) some relevant patient characteristics and circumstances from previous experiences with similar patients, and (3) the results of previously initiated therapies. The therapy options result from evaluating different medications within and across medication groups, considering their respective advantages and disadvantages. A decision is then made in a fast, intuitive and heuristic manner (type 1 reasoning). Good prescribers then 'automatically' perform a check on that decision (with the help of metacognition; type 2a reasoning). If there is uncertainty about the correctness or completeness of the first decision (the red warning light), then a slower, conscious, more thorough and analytical reasoning follows (type 2b reasoning). On the basis the therapy chosen, therapy scripts can be developed which can be used in new situations. In an uncertain diagnosis the therapy choice can be used as diagnostic tool ,e.g. seeing whether prednisone for presumed polymyalgia rheumatica or furosemide for presumed heart failure reduces symptoms, thus confirming the hypothesis.

This reasoning process belongs to the therapeutic part of a consultation in **clinical practice**. This is represented by the normative and circular WHO 6-step approach, where in step 1 the established (provisional) diagnosis is the starting point, and step 3 is the choice of therapy (3a: therapy script, 3b: the chosen therapy). Step 4, patient communication, which includes shared-decision making could also lead to an adapted therapy if necessary. In step 6, the established therapy for the patient involved is evaluated after some time. On the one hand, the result determines whether the therapy should be continued, adjusted or stopped. On the other hand, the result is (often unconsciously)

added to the other experiences with this therapy, and the therapy script is adjusted if necessary (metacognition). Something similar happens if new treatment guidelines give reason to do so.

Developing therapy scripts starts already during undergraduate training, especially with **contextual learning**. The combination of studying theory and solving patient problems (simulated or in practice) leads to memory networks in the brain that result in illness and therapeutic scripts. Initially, these scripts are still small and insufficient to make a quick decision and therefore, inexperienced prescribers needs to use type 2 analytical reasoning more often.

8.2 Implications for teaching therapeutic reasoning

There are strategies to help students develop clinical reasoning skills, although many of these strategies focus on diagnostic reasoning. These strategies influence one or more of the different steps in the European model of therapeutic reasoning. While there are notable similarities that make these strategies based on diagnostic reasoning applicable, it is important to emphasize that empirical research is needed to determine whether they are equally effective for developing therapeutic reasoning skills. Nevertheless, until further research is available, these teaching strategies can serve as a useful framework. By using these teaching strategies for students, the aim is to provide them guidance to use the learned skills to become better prescribers.

As mentioned before, therapy scripts are an important component of type 1 reasoning. Pre-graduate students often use textbook knowledge in an unstructured way. As they gain more experience, their therapeutic reasoning process may become more structured and informed by contextual knowledge. Because of differences in the scripts of experts and novices, it might be useful to focus more on context within education rather than solely on textbook knowledge (74-76). Seeing patients might

help students develop context-rich therapy scripts at an early stage, instead of relying solely on case-based training (often based on textbook examples). It would also be enriching for students to monitor patient outcomes after the start of their treatment, so that they can reflect on their choices, learning from the appropriateness of their choice and ultimately forming richer scripts (27). Exposing students to more context may not only lead to the development of better therapy scripts, but also make students more open to conflict detection, because they are better able to really understand the necessity of changing their mind in some cases. This helps students to be more critical of their type 1 response and to recognize earlier when it is necessary to switch to type 2 reasoning. In addition, students should be mindful of potential pitfalls in prescribing, such as comorbidities or interactions. Implementing case-based teaching and assessment methods, such as those based on the WHO 6-step approach, can improve students' ability to recognize these pitfalls in their future practice (15, 76, 106).

A person needs to be motivated to detect conflicting information (type 2a reasoning) (58). Therefore, teachers need to create a setting in which students become intrinsically motivated. According to Deci's self-determination theory, autonomy, competence, and relatedness are important for intrinsic motivation (107). Moreover, intrinsic motivation might lead to better memory formation because of different neural processes, such as stimulation of the dopaminergic systems and activity in brain networks for salience detection, attentional control and self-referential cognition (108, 109). Therefore, a teacher should strive to incorporate these elements into their teaching. For example, participation in student-run clinics, where undergraduate students in the pre-clinical phase can treat real patients, or in case-based discussions during undergraduate clinical clerkships can foster high intrinsic motivation to learn how to prescribe effectively (110). This is because students gain autonomy for treating real patients in a practical setting, and they work collaboratively in a team. Additionally, involvement in student-run clinics provides exposure to a variety of cases, leading to more exemplars (59, 110). However, it is important to keep the zone of proximal development in

mind (111), which means that the task should be challenging but doable with help from others, otherwise it could diminish motivation. Working in groups taps different levels of knowledge and experience. Also, acknowledging that uncertainty is to be accepted in medicine and several therapeutic options may be appropriate are key aspects for learners and must be considered by medical educators in organizing their teaching (112). Therefore, appropriate assessment methods, such as case-based assessments like observed structured clinical examination (OSCEs), are more applicable to assesses therapeutic reasoning, where choices can be explained, rather than multiple-choice exam questions with only one correct answer (113). Additionally, an important aspect that distinguishes an experienced prescriber as an expert is the ability to recognize when to slow down and switch to type 2 thinking. Experts should aim to comprehend this when seeking to improve the therapeutic reasoning of students. Understanding their own thinking process will enable experienced prescribers to assess whether their treatment remains the best available option. Additionally, experienced prescribers should explicitly explain their reasoning to check their own thinking and help less experienced learners develop more detailed scripts while avoiding cognitive biases.

For type 2 reasoning, it might be helpful to structure students' thinking processes, by using the WHO 6-step or a management script template to help them to optimize this process. The first steps of the WHO 6-step can also help to activate a therapy script (type 1), whereby the suitability for the patient can be considered in the next steps (as part of type 2 thinking). Structures such as the WHO 6-step can be used as cognitive forcing strategy, which can help to avoid bias (50). Students need to have enough knowledge to weigh the different options, so there still need to be enough opportunity to gain this knowledge. Next to that, students must also know how to critically weight different options, for example by getting informed about the correct use of guidelines and evidence based medicine. Research showed that difficulties finding and using information from clinical guidelines contribute to medication errors (114).

Other strategies have been developed for use in case-based teaching to stimulate critical thinking and metacognition in general, but these strategies have barely been studied in the context of therapeutic reasoning. Potentially relevant strategies are listed in table 4 along with their primary area of impact, but some of them still need to be tested and, if necessary, adjusted for therapeutic reasoning (56, 62, 115-122). The strategies can aid in adding structure (type 2), slowing down the reasoning process (switching from type 1 to type 2), and assisting students to reflect on their reasoning process (improving metacognition). CPT teachers must be cognizant of these various steps and should consider incorporating all of them in their educational approach to help students develop a comprehensive understanding of successful therapeutic reasoning strategies. This is crucial because each step is essential and should therefore be cultivated through education (1).

Strategy	Short explanation
In general	
Case-based teaching	For example, by solving written clinical cases or engaging in role play (with or without actors portraying patients). Case-based teaching forms the foundation of other teaching strategies. Case-based teaching enables students to apply their knowledge in (simulated) clinical practice. This approach can help them develop richer, context-based therapy scripts and potentially lead to greater motivation compared with traditional lectures.
Case-based assessment (i.e. Objective Structured Clinical Examination (OSCE))	Assessing case-based situations, for example with observations during role plays. Stimulates students to use their knowledge in (simulated) clinical practice, which might facilitate conflict detection. In addition, it provides students with feedback that might stimulate their metacognitive skills.
Mechanism maps	Making visual maps, based on causality between concepts.
Student-run clinic	Train prescribing skills grounded in a real-life context to provide students with early clinical experience and responsibility. This may result in a high level of intrinsic motivation and richer therapy scripts.
Stimulating metacognition	
Time-out (i.e., diagnostic time-out or management pause)	Time-out during reasoning process (reflection-in-action) stimulates type 2 thinking and metacognition. Specific questions during this pause are: (i) why are we choosing this intervention for this patient?; (ii) what are the potential downsides?; (iii) what are potential alternatives and why are we not choosing them?; (iv) have we asked the patient for their perspective?
TWED	Treat (What are the threatening conditions in this patient?) Wrong (What if I am wrong? What else could it be?) Evidence (Do I have sufficient evidence for or to exclude this diagnosis?) Dispositional factors (What are the environmental and emotional dispositions influencing my decision?)
Deliberate reflection	Approach to review a clinical case systematically (read the case, what are pro's and con's, are there any other possibilities)
Guided reflection	Real-time feedback on reasoning during a discussion, i.e. Why? What can also cause this?
Reflective writing	Stimulates metacognition by stepping back, reviewing thoughts, goals and actions and recognizing how your perspectives, motives, and emotions affect your conduct (reflection-on-action).

Equity reflection	Reflection based on two main questions and follow-up questions. 1) Are we deviating in any way from the standard of care in this situation? In what ways, why, and can we do something differently? 2) If you were being discharged in the same situation as this patient, is there anything you would want to be done differently than our present plan?
Stimulating structure	
One Minute Preceptor	1. Summarize the case; 2. Get a commitment; 3. Probe underlying understanding; 4. Reinforce what was done well; 5. Teach General Rules; 6. Correct errors.
SNAPPS	1. Summarize relevant patient history and findings; 2. Narrow the differential diagnosis; 3. Analyze the differential diagnosis; 4. Probe the preceptor about uncertainties; 5. Plan management; 6. Select case-related issues for self-study.
WHO 6-step	1. Define the patient's problem; 2. Specify the therapeutic objective; 3. Choose your standard treatment and verify the suitability of your treatment; 4. Start treatment; 5. Give information, instructions and warnings; 6. Monitor (and stop?) treatment.

Table 4: Clinical reasoning teaching strategies

8.3 Future perspectives

Our revised, European model for therapeutic reasoning is based on models for diagnostic reasoning and on theories from cognitive psychology. It still needs to be tested in practice because there are important differences between diagnostic and therapeutic reasoning. In addition, it would be interesting to know whether the therapeutic reasoning of different prescribers, such as physicians, physician assistants, dentists, pharmacists, and advanced nurse practitioners, is similar and, if not, how differences should be handled, if appropriate. While there have been individual studies on the thinking process of different prescribers or specific situations (85, 123), comparative studies examining their cognitive processes are still lacking.

Recognizing when to adopt type 2 thinking is a crucial principle of therapeutic reasoning and should be integrated in CPT education and supervision. Do experienced physicians use type 1 reasoning and inexperienced physicians use type 2 reasoning more often for therapeutic reasoning, as they do for diagnostic reasoning? The complexity of therapeutic reasoning may mean that type 2 reasoning is used more often than type 1 reasoning by both inexperienced and experienced prescribers. It is assumed that therapy scripts are formed and used in almost the same way as illness scripts, but it is unclear how therapy scripts work exactly and how rich therapy scripts can be created as rapidly and efficiently as possible. Next to that, understanding formal models may also contribute to the development of therapeutic scripts by clarifying which information is used and how it is weighted.

More research is needed into whether strategies to teach clinical reasoning are applicable to therapeutic reasoning and how this can be optimized for both pre-graduate students and non-experienced doctors. Because of differences between experienced and inexperienced prescribers, we need to optimize the interaction between them to stimulate the therapeutic reasoning process, for example during supervision moments. Research must show how this can be optimized. Failure to recognize a conflict between a type 1 response and available clinical information is an important

source of error, and so more needs to be learned about how to recognize the need to switch to type 2 thinking. Next to that, teachers must be able to recognize when their students' type 1 reactions are inadequate so that they can provide useful feedback. Given the increasing prominence of artificial intelligence, it is pertinent to examine how it can facilitate therapeutic decision-making, both in clinical practice and as an educational tool (1).

9 Conclusion

Most theories of clinical reasoning have been adopted from cognitive psychology. However, because of differences between diagnostic and therapeutic reasoning, it is not certain whether these theories can be applied to therapeutic reasoning as well (81). One of the most important models for clinical reasoning is the dual-process theory. This theory distinguishes between type 1 thinking, which is non-analytical and based on pattern recognition with the use of scripts, and type 2 thinking, which is analytical and takes more effort. Because type 2 thinking uses working memory, people tend to make type 1 decisions most of the time, especially when they are busy or tired. Type 2a thinking monitors the primary reaction and can activate type 2b thinking if necessary. There always seems to be input from type 1 thinking, which may or may not be recognized by type 2 thinking. As Stanovich described, the most important thinking disposition is default to the autonomous mind – type 2 thinking is not activated if there is no conflict (discrepancy) between the type 1 response and other patient information/findings. There must be some awareness and/or motivation for conflict detection, otherwise this will not happen. Metacognition, by which the reasoning process is monitored, is generally not included in the earlier models of therapeutic reasoning (19, 83, 84). This suggests that metacognitive skills and knowing when and how to switch between type 1 and 2 thinking are necessary to develop therapeutic reasoning skills. An European model of therapeutic reasoning has been developed, but further research is required to fully comprehend and optimize the therapeutic reasoning process. By advancing our understanding of therapeutic reasoning processes, we can also improve algorithms and create optimized decision support systems, which, given the advances in artificial intelligence, are poised to play an increasingly pivotal role in prescribing in the future (1).

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