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Expertise in Non-Well-Defined Task Domains: The Case of Reading

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ABSTRACT

In this article, we discuss expertise by considering the activity of reading. Cognitive scientists have traditionally conceptualised reading as a single, well-defined task, namely the decoding of letter sequences into meaningful sequences of speech sounds. This definition captures a core feature of the reading activity at the computational level, but it is an overly narrow model of how reading behaviour occurs in the real world. We propose a more expansive model of expertise. In our view, expertise in general is best conceptualised as a distributed process that takes place within a cultural-cognitive ecosystem. Our model allows for a more inclusive view of expertise in reading. We argue that reading is better understood as a manifold task domain that admits multiple reasonable criteria for evaluating performance. We draw on ethnographic data to show how our model allows for a wider appreciation of what expertise in reading amounts to in educational contexts.

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1. Introduction: Linking Reading and Expertise

In this article we are interested in expertise in non-well-defined domains. Reading has been widely conceptualised as a single, well-defined task (Dehaene 2009). This view, however, depends on a narrow cognitivist definition of reading as the (correct) decoding of letter sequences into corresponding sound sequences with a fixed meaning. On this view, expertise can be evaluated in terms of the speed with which an agent performs such decoding while simultaneously achieving a required level of understanding of the text. But explaining reading expertise simply by reference to a set of basic, universal mechanisms is reductionist and does not fit either empirical evidence or historical-anthropological accounts of how reading has changed and continues to change (Ingold 2022; Saenger 1990). Indeed, reading is interesting, when considered as a domain of expertise, precisely because it is inherently multifaceted. It is, for instance, not straightforward to define a single success criterion that captures what reading is as a task (Wagner and Stanovich 1996).

Following this short introduction, the article is organised in six sections. In section 1 we discuss empirical research on expertise in reading. Drawing on the literature, we will emphasise that reading is not just one kind of linguistic meaning-making activity based on ocular scanning, but is interdependent with the wider context in which it is performed. We end this discussion with a call for further research that challenges mainstream views on expertise, which outlines the implications such rethinking has for investigating expertise in reading. In section 2, we trace expertise models to historical

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advancements in artificial intelligence and cognitive and educational psychology. In section 3, we suggest that reading does not fit well into this traditional AI-based understanding of expertise. Reading is a non-well-defined problem domain. However, we suggest that the expert reader typically makes use of several techniques for reformatting the reading task, turning their reading activity into a (temporarily) well-defined problem. Next, we discuss the implications of this for expertise research more broadly. We propose that expertise should be understood as a feature of a cultural-cognitive ecosystem (section 4). Our model highlights the adaptive dimensions of task emergence and management which develop in accordance with a dynamic context. We suggest that experts are capable of intelligently integrating ways of perceiving (cf. Goodwin 1994). We demonstrate the applicative value of this model with a case study of reading 'in the wild' (section 5), and in section 6 we draw a few conclusions on expertise in non-well-defined task domains.

2. What is Expert Reading?

Shanahan, Shanahan and Misichia (2011) give an excellent description of the diverse forms of expert reading across several scientific disciplines. Their review implicitly invites the reader to consider reading as a manifold task domain where different criteria can be used to judge how well it is being performed in a given context. Let us unfold that argument by turning to the review. First, with reference to Peskin (1998), Shanahan, Shanahan and Misichia (2011) explain how experts in literary reading (English doctoral students) read poetry texts in a significantly different way from how novices (here in terms of high-school students) read poems. The difference is revealed *not* in (lack of) knowledge about poetry discourse, but rather in how novices lack analytical tools to constrain interpretations (discipline-specific interpretive strategies), which – in contrast – allow experts to conduct systematic and coherent interpretations that fuel understanding and motivation.

In science reading, an expert reader is a different kind of actor again. Latour and Woolgar (1979) point to the experiential and social dimensions of reading. They show how scientists' readings are remarkably distinctive depending on whether they read an anonymous academic text or work by a colleague – pointing to reading as more than just objective information retrieval. Bazerman (1985) also emphasizes how physicists often select texts (sourcing) based on an author's authority and recognition, and how – when reading such sourced texts – their readings are remarkably different from other forms of reading. For instance, when physicists search for new data and material they are drawn by surprises and insights in texts, and their cognitive attention is highly constrained by places of significant importance to their knowledge. They skip sections, they go back and forth in the text, and they economize with their engagement. Shanahan, Shanahan and Misichia (2011) conclude that Bazerman's study shows how experimentalists spend time on methods sections whereas theorists are more immersed in conceptual and theoretical parts. While physicists' readings are often characterized by comprehension difficulties,

> they weighed effort against benefit and were more critical when reading work that was related to their own. If they thought the information was not directly applicable to their work, they tended to read relatively uncritically, accepting its accuracy and appropriateness and focusing more on learning the information. This alternation between learning and critiquing was a characteristic observed in each of the physicists as they read, except one, whose broad knowledge of the field allowed for a constant critique. (Shanahan, Shanahan and Misichia 2011, 397)

Historians are yet another species of readers. Shanahan et al. refer to studies conducted by Wineburg (1991) in which both novices (high school students) and experts (historians) are assigned the task of reading several texts about a historical event (the students had studied the topic before whereas the historians had not). The students focused on facts in isolation, trying to apply an objective approach. What made the historians expert readers was the fact that they saw the task very differently:

> In addition to 'learning' the information, [they] engaged in three processes: sourcing, contextualization, and corroboration. That is, they paid attention to the author, what kind of document it was, and where it came from (sourcing), they thought about the time period in which it was written and considered what they knew about the

> political, social, economic, or cultural conditions of that time (contextualization), and they looked for agreements and disagreements across the text and with their own views (corroboration). Unlike the physicists, they did not suspend their critical stance when they read information about which they knew little. (Shanahan, Shanahan and Misichia 2011, 397ff)

Finally, Shanahan, Shanahan and Misichia (2011) present Rouet et al.'s (1997) studies of how students – in psychology and history – engage in different kinds of attention during reading. For instance, psychology students use an accumulative and purposeful strategy trying to build up information, whereas history students use interpretation and critical analysis of evidence. In that sense,

> the history students were better able to connect the information sources to their interpretations, even though there were no apparent differences in their abilities to judge the trustworthiness of the various documents. Of course, disciplines share similarities and differences, so the psychology students may have been applying analogous and workable heuristics drawn from their own field of study. (Shanahan, Shanahan and Misichia 2011, 398)

Overall, the conclusion of this comparative consideration of expert reading in different disciplines is that an expert reader performs differently in different disciplines because they (implicitly or explicitly) perceive reading as different tasks. Further, whether explicit or not, it seems that each discipline has made a manifold and non-well-defined task domain manageable by reducing attention to a set of reading strategies or patterns that fit a given discourse and its judgment criteria. These results are intriguing because a contrary assumption has dominated reading research and Western education practices which have reduced reading to a single task, and thus prioritized the development of a fixed skill set, such as the ability to make correct letter-sound correspondences, reading speed and comprehension, for instance (Dehaene 2009).

While the attention towards discourse is crucial in defining expertise, we argue that it is not sufficient. Reading is not just different across domains and comparisons within the novice-expert paradigm are not sufficient for explaining what counts as an expert reader.

3. A History of Expertise Models

The field of expertise studies, as we know it today, has its origin in the 1950s with Allen Newell and Herbert Simon's developments in artificial intelligence, with advances in educational psychology and with the emergence of cognitive psychology as a rejection of behaviourism. Human thought and human problem-solving were some of the central topics of enquiry leading to these developments.

In 1956, Newell, Shaw and Simon developed the first artificial intelligence program, called Logic Theorist, which was able to prove theorems in predicate calculus in a manner similar to how humans would do it. Among the proofs it found were two novel proofs to theorems in Whitehead and Russell's *Principia Mathematica* (see Newell, Shaw and Simon 1958). In the following years many other problem-solving programs were developed that mimicked specific kinds of human intelligence, the selection of which depended on 'drawing a fairly sharp line between the physical and the intellectual capacities of a man' (Turing 1950, 434) and prioritising the latter. For instance, Samuel's checkers playing program, from 1959, had by 1963 beaten an expert checkers player in the U.S.A., and Gelernter's Geometry Theorem Proving Program, from 1957–1958 (see Buchanan et al. 2018) excelled in its domain. The Logic Theorist program was later generalised into the General Problem Solver to solve problems in different domains (Ernst and Newell 1969). With the assumption that human thought consists of information processing, these programs constituted the first steps towards the idea in psychology that computer programs could model human thought and human problem-solving processes (see Simon and Newell 1964).

However, not all problems faced or formulated by humans are of the same kind: some of them have very clear boundaries, success criteria and rules defining what is 'legal', while other problems have fuzzy borders, multiple possible solutions and uncertainty about the concepts and rules necessary to reach a solution. Simon called the former kind of problems well-structured problems, and the latter kind ill-structured (Simon 1973; see also Jonassen 1997; Reed 2016). Both kinds of problems can in principle be solved through general non-domain-specific methods, like means-ends analyses, but as problems become more and more complex, general methods (also called 'weak methods') are less effective, and specific knowledge of the domain becomes the key to solving them (see Feltovich, Prietula and Ericsson 2018).

By studying cases of expertise in chess playing, it soon became evident that to model expert-level performance, programs needed to include and heavily rely on considerable amounts of specific knowledge of the task-domain: this is the birth of knowledge-based systems, of which expert systems are a subclass (see Buchanan et al. 2018). Unlike general problem solvers that focus on portable methods (i.e. generalizable methods that do not depend on specific knowledge of the problem domain, like 'means-ends analysis' or 'generate and test'), expert systems focus on having vast amounts of information and simple inference methods. This shift of focus from general problem-solving methods to expert systems based on specific domain knowledge was called the knowledge-based paradigm (Goldstein and Papert 1977; see also Buchanan et al. 2018).

Let us emphasize that expert systems in artificial intelligence were developed based on human experts' thought processes, and at least partially with the goal of modelling human problem-solving. We will now focus on one of the main features of expertise derived from studying and modelling expert problem-solving: domain-specificity and task-specificity. Studies with chess masters and experts in physics, medicine, mathematics and other disciplines show that there is an inverse relation between the level of performance of the expert and its transferability into other domains, even when the domains are fairly similar (see Chi, Glaser, and Farr 1988; Ericsson and Lehmann 1996; Reed 2016). As Reimann and Markauskaite (2018) put it, chess masters are not necessarily good generals, and vice versa. The reason why expertise is not transferable across domains is that it is heavily dependent on domain-specific knowledge and when the domain changes, even if some skills are still applicable in the new domain, the knowledge of the new domain is lacking.

Importantly, an assumption that was transparent in the 1960s and 1970s about domain specificity in expertise has become an unexamined truth in many current accounts inspired by the cognitivist paradigm: the assumption that the domain of expertise must be a well-defined domain. This can be seen not only in the concrete treatments of expertise, but also in the wide majority of research on expertise within well-defined domains, like medicine (Ericsson 2007), physics (Collins 2017), mathematics (Butterworth 2018), chemistry (Stull et al. 2012), meteorology (Hegarty, Canham and Fabrikant 2010), chess (Gobet and Charness 2018), sports (Williams et al. 2018) and even Scrabble (Tuffiash, Roring and Ericsson 2007).

In the origin of artificial intelligence, this assumption was accepted as a practical decision to study and model experts' thought processes when faced with well-structured problems, but it was not intended to imply that expertise should be limited to well-structured problems in clearly defined task-domains. Already in 1973 Simon claimed that the difference between well-structured problems and ill-structured problems is one of degree, and there is no reason to think that in principle artificial intelligence or experts could only solve well-structured problems (Simon 1973; see also Reed 2016).

If we uncritically assume that expertise is predicated only to agents solving well-structured problems within well-defined domains, we end up with an unnecessarily restrictive account of what experts can do, and with a limited notion of what counts as expert performance. From the characterization of well-structured problems in well-defined domains follows a picture of success criteria as unitary, objective and fixed – as opposed to criteria being multiple, relative to the community and modifiable according to the values of the community.

However, the very historical development of the notion of expertise shows that it can be attributed and emerge in task-domains with blurry limits. In these cases, the expert is faced with problems that move along the spectrum between ill-structured problems and well-structured problems, and the expert is evaluated according to multiple, modifiable and emergent success criteria, that vary with the values favoured by the specific cultural-cognitive ecosystem.

4. Expertise in Non-Well-Structured Problem Domains

In this article, we are concerned with the possibility of studying expertise in non-well-structured task domains.[1] The domain of reading is an interesting case here. First, it is not straightforward to define what constitutes expert performance in the case of reading. For instance, the reading task can be understood narrowly as the decoding of written word forms, or it can be understood more broadly in terms of successful comprehension of the meaning of the text (Wagner and Stanovich 1996). Second, it is not straightforward to decide how to measure expert performance in the domain of reading. Performance in reading can in principle be measured, for instance, in terms of speed of processing the text, or it can be measured in terms of the rate of errors made during decoding, or in terms of successful responses to comprehension questions or using several other alternative methods. If we wish to develop an empirical program for studying expertise in reading, then we are faced with a difficult problem at the outset: defining what reading is in the first place is itself a problem with multiple degrees of freedom.

When faced with problem domains that lack a clearly defined structure, one strategy that is open to researchers is to adopt an ethnographic approach. Instead of attempting to identify a criterion of success at the outset, the strategy adopted by ethnographic researchers is to simply observe what happens when people engage in the activity in question. For several decades now, researchers have been carrying out such observational work using cognitive ethnographic methods (Hutchins 1995a, 1995b; Ingold 2022; Trasmundi 2020)

Some broad conclusions can be drawn from this body of observational work. One is that, in the real world, people routinely solve problems that do not conform to the well-structured format as defined by Simon (1973). Another conclusion is that, when the problem solver encounters difficulties, often these difficulties are overcome via a reformatting of the problem itself. The problem solver often reconfigures the problem space in a way that turns the problem from an ill-formatted one into a well-formatted one. The reconfiguring of the problem can be temporary, which allows the problem solver to solve parts of the problem before engaging with additional parts. We can identify three broad categories of techniques for reformatting a problem.

4.1. Restructuring the Components of the Problem

A ubiquitous feature of real-world problem solving is that the problem solver will opportunistically make use of properties of the components of the task to simplify the problem. For instance, the problem solver may bring closely related components of the problem into spatial proximity with one another. Kirsh (1995) gives the example of preparing a garden salad. This is a relatively simple task, and it perhaps requires no particular expertise. Nevertheless, anyone who has prepared a salad before is likely to approach the task in a particular way. They are likely to impose a degree of structure on the task space. Probably they will do something like the following. First, gather all the ingredients from the refrigerator and place them next to the sink. Next, wash the ingredients one by one, placing the washed ingredients in a new place on the counter, near the chopping board. Next, chop the washed ingredients and place them in the salad bowl. At each stage, the task is structured spatially around functional places within the physical space of the kitchen.

4.2. Reconfiguring the Rules

Some situations require a more formal structure to function smoothly. A common problem in public behaviour settings, such as deli counters or retail bank branches, is the problem of remembering the order that people arrived so that they can be served in the same order. Hutchins (2014) invokes the cultural practice of queueing as an elegant solution to this problem that again, as in the case of the salad example above, makes intelligent use of physical space:

> The practice of queuing for service is, above all else, a cooperative public means to record and remember the order of arrival of clients. The queue also manages a forgetting function when people leave the line either before or after receiving service. (Hutchins 2014, 39)

The queue is an elegant solution because it imposes a simplified structure onto the group of people who are waiting: it turns them from an ill-structured cluster into a well-structured, one-dimensional array. Hutchins describes this as a reduction of dimensionality: 'A group of people occupying two dimensions of a surface approximates a one-dimensional array when they form a queue' (Hutchins 2014, 40). Such cultural conventions are pervasive in social settings and cultural practices. Some cultural conventions are so familiar as to be almost invisible. The practice of reading relies on certain conventions of this sort. For instance, English text is written from left to right, and from top to bottom on the page (Hutchins 2014, 44). As we have seen, however, real world reading does not necessarily follow this linear structure. In practice, the reader may often find it useful to consult earlier parts of the text, to skip ahead, to reread. Indeed, dictionaries and encyclopaedias are designed to allow for identifying relevant entries without reading the entire volume.

4.3. Replacing the Goal

More drastic, perhaps, than the above two strategies, the problem solver might elect to abandon the original problem goal entirely, and instead pursue a different goal. This will perhaps be likely to occur if the first two strategies have been tried and have failed. In the real world, the resolving of a problem by abandoning one goal in favour of a new one appears to be a fairly common occurrence. Simonsen, Steffensen and Sutton (2023) provide an example from observational work carried out in a nursing home. These authors observed two employees at the nursing home discussing a patient in end-of-life care. The patient in this case had, two days earlier, been in a consultation with a doctor where it was decided that, should the patient go into cardiac arrest, the medical staff should not attempt to resuscitate the patient. However, at the time the two employees are having their conversation, the required paperwork has not been completed. Accordingly, the staff are legally required to attempt resuscitation, but they are ethically obliged to abstain from doing so. Faced with such a dilemma, the two employees resolve the problem by (counterfactually) convincing each other that the patient is not at imminent risk of going into cardiac arrest. The problem is deferred until later, and they redefine their situated goal as one of obtaining the correct medication from the pharmacy.

Overall, the ethnographic work on real-world problem solving that we have discussed here might lead us to the question whether we are still studying human problem solving in the same sense as it was understood by Newell and Simon and the other pioneers of artificial intelligence. For one thing, whereas Newell and Simon took themselves to be studying the individual human problem solver, Hutchins and Kirsh have expanded the scope of investigation to include the environment and other people.

Moreover, Newell and Simon thought of problem solving in terms of logical operations in well-defined problem domains, such as mathematical theorems or chess. These are formal, symbolic problem domains that can be implemented in a computer program. Hutchins, by contrast, advocates the study of problem solving not as a narrowly logical-symbolic phenomenon but as a broadly behavioural phenomenon that takes place within a cultural-cognitive ecosystem. Some work may be required to reconcile the classic vocabulary of research on human problem solving and expert performance with this more expansive, distributed way of studying the phenomenon. One question that arises is over how to define the unit of analysis in ethnographic research. That is, how is it possible for the ethnographic researcher to identify the task being managed, or the task that is being carried out? We turn to this problem next.

5. Expertise as a Feature of a Cultural-Cognitive Ecosystem

In work published in the 1990s, Edwin Hutchins introduces cognitive ethnography as a 'description of the cognitive task world' (Hutchins 1995a, 371). However, Hutchins does not specify exactly what constitutes a 'task', and he uses the term with some ambiguity. On the one hand, he refers to tasks as external facts that exist independent of the actual performance; on the other, he refers to tasks as something an agent performs. The ambiguity is thus between understanding the task as something-to-be-done or as something-done. In Hutchins (1995b) we see the term used in both meanings. For instance, when discussing the 'task environment', the task is defined as part of the milieu, that is, as a condition that faces the agent: 'What are the cognitive tasks facing the pilots?' (Hutchins 1995b, 279). On this view, one can successfully accomplish the task or fail in doing so. Likewise, a task can be simple or complex, easy or difficult. But Hutchins also refers to agents' actual behaviour with the term 'task': 'the performance of tasks' (1995b, 265), 'the cognitive tasks of computing and remembering' (1995b, 266) and 'tasks [that] can be done (or redone) any time' (1995b, 276).

To disambiguate the two, we will distinguish between 'task environment' and 'task performance'. The difference between the two is, we argue, an epistemological difference. Thus, a task environment can be described independently from the agent(s), whereas a task performance can only be deduced from the agents' actual behaviour. Each of the two can be used to define what the task is.

Notice that we do not consider the genesis of the task. We do not propose that the task is somehow issued to an agent in the same way as a labourer is tasked with a specific duty at the assembly line, one at a time. In line with Hutchins's seven 'Conjectures Concerning Local Features of the Cultural Cognitive Ecosystem' (Hutchins 2014, 46), we propose that the task itself 'at any moment depends on the local structure of the ecosystem' (Hutchins 2014, 46). In a cultural-cognitive ecosystem, an agent can face multiple tasks and engage with several at the same time.

Once the task is defined, one can proceed to identify the 'functional system' that performs the task. As Hutchins reminds us, 'what Luria called a functional system (Luria 1979) [. . .] is a constellation of structures, some of them internal to the human actors, some external, involved in the performance of some invariant task' (Hutchins 1995b, 281). Elsewhere, Hutchins refers to these functional systems as *distributed cognitive systems* (Hutchins 1995a, 236).

These comments prompt us to suggest that among the many cultural-cognitive constraints on behaviour – social relations, sociocultural traditions, the behaviour setting, etc. - the task is a key constraint. Accordingly, if one derives the task from the task environment, it allows an observer to gauge the level of expertise with which a functional system solves a task (or fails to solve the task), simply by juxtaposing task environment and task performance. On that view, expertise is a feature of the cultural-cognitive ecosystem. Thus, one can only gauge the level of expertise with which a task has been performed if one has adequately identified (i) the task environment, (ii) the task and (iii) the functional system.

We argue that our understanding of expertise has been misled by an inadequate understanding of these three features. First, whereas an ecological task environment is complex and transitory, cognitive scientists, educational theorists and practitioners have favoured more ordered and stable task environments, such as those found in the classroom. Hence, there has been an inclination to focus on well-structured problems rather than ill-structured problems. Second, while tasks are emergent in ecological task environments, there has been a tendency to focus on tasks that are predefined, for instance by administrators in the educational system or by experimental psychologists – in either case with a predilection for quantified measurements. Third, the cognitive tradition's partiality to methodological individualism has biased the understanding of expertise, as it has traditionally been ascribed to individuals in isolation from their social and material surroundings. In other words, one has focused on the biological being rather than on the entire functional system within which the biological being is embedded.

Obviously, these misidentifications are difficult to counter, if one defines the task from a task performance point of view, for instance with a starting point in ethnomethodology or grounded theory. The reason is that such theories are underdetermined (Stanford 2021): neither the actual behaviour, nor the agents' phenomenological understanding of this behaviour, reveal the larger ecological embeddedness of the task performance vis-à-vis the task environment.

We conclude this section with a short discussion of what this view on expertise as a feature of cultural-cognitive ecosystems means to our understanding of reading as a task. In educational systems, such activities as reading tend to be taught as a single task in isolation from other tasks. However, we will argue that outside of educational contexts, reading always occurs as an aspect of complex tasks: Hutchins's (1995b) pilots read the speed cards in order to plan a sequence of configuring flaps and slats as part of a landing procedure; Trasmundi's (2020) doctors read the patient charts to contextualise the patient's symptoms; and Trasmundi and Cowley's (2020) young reader – in using a children's book to imagine what it would be like to live in a giant pear – prepares himself for a future where the creative and visionary has more options at hand. Superficially speaking, the pilots, the doctors and the children 'do the same', but they are part of very different task environments, and for this reason their reading is part of very different overall activities. Accordingly, the task environment does not include 'reading' as a basic level task, but only reading-as-embedded-in-other-tasks. The difference between treating reading as a task per se and treating it as part of a larger task is particularly important when it comes to the social domain of learning how to read. The educational system has domesticated a complex task environment by isolating interconnected tasks and turning them into independent tasks. In this domesticated task environment, the learner is evaluated from their ability to ignore context and task embeddedness and treat the text and the reading of it as an independent task.

While educational institutions rely on narrow performance evaluations (e.g. those that translate seamlessly into a seven-step grading scale), we suggest a conceptualisation of expertise as a feature of a cultural-cognitive ecosystem. On that view, expertise is ascribed to a functional system – which is 'animated by human beings' (Steffensen 2013, 202) – when an observer embedded in a cultural-cognitive ecosystem values those functional differentiations that align with what the system (say, a person) does well. Using this model to account for expertise in reading allows for a much wider view on what reading is; indeed, reading ceases to be a uniform activity. Rather, it is part of a complex task environment that allows for multiple reasonable criteria for evaluating performance. Comprehension and fluency are merely possible criteria, and while they have taken preference in most educational systems, they do not exhaust the field of possible evaluation criteria.

6. What Expertise Looks Like in the Wild

In the remainder of this article, we demonstrate how reading occurs in different task environments with varying implications for what expertise in reading is. We show how reading is always embedded in a larger system as described above. If expertise, as we have argued, is a feature of the cultural-cognitive ecosystem, then the reader constantly adapts to and exploits the emergent changes of the reading task in the reading environment. Such flexible, adaptive performance entails that the reader avoids engaging in simple repetitive behaviour (such as re-enacting automatic skill) in situations when an impasse is reached. As the repetitive approach is mechanical it often leads to fixation. Expertise is particularly salient when a system is stressed, that is, when tensions emerge because the problem solver encounters difficulties and needs to reformat the problem in order to 'move on'. Such moments sometimes occur in reading. In our own ethnographic work, we have observed cases where readers successfully engage in the processes described in section 3, namely: *restructuring the components of the problem; reconfiguring the rules* and *replacing the goal*. In this section, we give examples of each of these strategies taken from our observations of reading practices as they evolved in their natural settings.

Our examples stem from a cognitive ethnographic study of Danish university students who were reading Goethe's *Faust*, a text first published in the 1770s. The students were required to read the text before class.[2] The text is in German and is to be discussed in German, which is also the students' subject of study.[3] Our underlying assumption is that these university students are skilled readers, but not yet 'expert' readers in German, which is a second language for them. We expect their task performances to differ when they encounter challenges in the task environment. Some skilled readers are able to act in expert-like ways when they are capable of adapting flexibly to the task at hand, whereas others are unable to get beyond the predictable mode of reading. That said, expert performance is far from identical but can be compared by how well they balance the overall task with other emergent sub-tasks. We present here a few examples of how different strategies are used to deal with the emergent challenges.

The preparatory reading is conceived by the teacher as an invariant task, in which the students mechanically decode and memorise the text. The students all read the text as a preparation for the same class, and they all articulate the purpose (that is the task) of the reading as being able to understand, remember and reflect on the text using analytical tools from the curriculum. The underlying assumption is that this form of reading constructs the basis for subsequent analysis and elaborate discussions in class. However, we observe that the preparatory reading involves more than reading-as-embedded-in-an-educational-system. Reading as a basic level task is one concern, but the students' readings also imply that the task is embedded in their personal life contexts. Most importantly, we observe that reading is not only a matter of fluent reading and word-by-word comprehension, as the pre-defined task implies. More creative strategies are applied to generate detours that lead to successful task performance as we will show, yet some of these detours are rather non-functional or off-task in their local manifestation and they take on an aesthetic, artistic and emotional form. We show this by reference to the three categories of techniques for reformatting the problem, as mentioned in section 3.

6.1. Restructuring the Components of the Problem

In the ethnographic data, one observation that drew into question the simple conception of reading as linear decoding was the intelligent use of the cultural-cognitive ecosystem (the reading space). The setting was of great importance for the students' reading and they turned several text-external components into tools to simplify the problem. Their initial organisation of the setting differed and impacted their strategies for how well they engaged with the reading. Below is a small gallery that illustrates a personalised selection of multiple reading aids (such as additional textbooks, pens, rulers, etc. (Figure 1)) that the students prefer to have at hand when situations require changes in task performance. In the gallery we see how the actual location matters for the students. One student reads in a lecture room at the university, another at home lying on the floor and a third at home sitting at her desk (Figure 2).

If reading were only a matter of ocular scanning and symbolic comprehension, the system in which it is being performed should not be of great importance. However, the students describe how it is almost impossible for them to read in specific locations that did not match their style and personality.

The properties of the components of the task, including tools and other aids, were important for how well transitions between activities were managed (e.g. scanning and writing as in Figure 3).

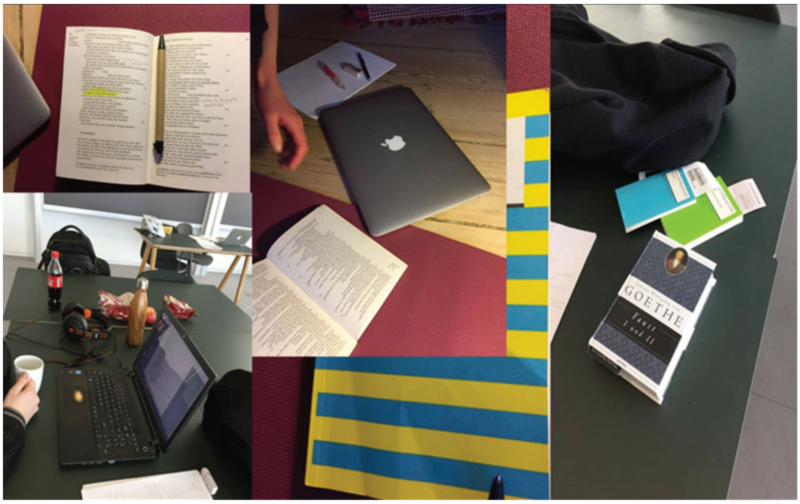

Figure 1. Reading components from three students' preparatory reading of Goethe's 'Faust'.

Figure 2. The three students' preferred reading locations.

6.2. *Reconfiguring the Rules*

Sometimes the readers would change the formal structures to 'move on'. For instance, one student's linear, fluent reading did not allow her to engage selectively with the text. As she moved on in the text, she realised that something intrigued her and that she had to go back, comment in the margin, pause, reflect, leaf through parts and re-read others. She reconfigured the rules for achieving fluency by applying a mix of multiple alternative strategies beyond fluent reading and decoding. Thus, her reading is characterised as highly ruptured and non-linear, and she spends much time on 'not reading'. Her reading is further characterised by insights which were enabled by an individual non-linear approach. In the interview, she revealed that she knew the story very well, and she was particularly interested in one sequence that took up much of her attention and left other areas mostly unaddressed.

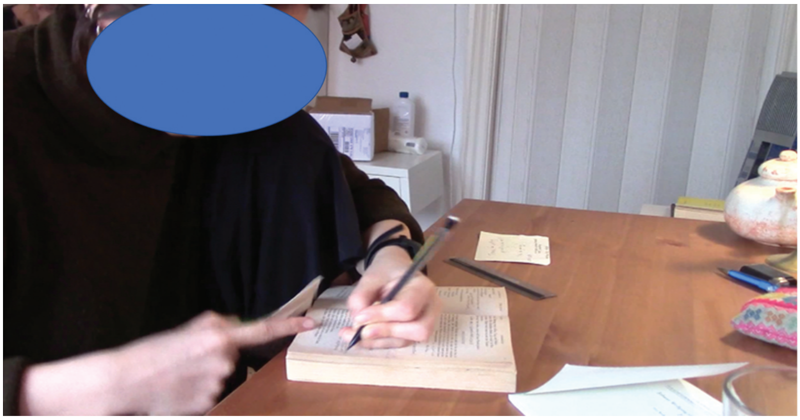

Figure 3. Student 1's transitions between sub-tasks such as reading-writing.

6.3. Replacing the Goal

In another example, we observe how a student *replaces* the present goal. Postponing the goal and pursuing another one allows her to get back to the overall goal in the end, not in spite of but precisely because of her valuable detours. This strategy (replacing the goal) was described as the most drastic strategy above. In our ethnographic material, the strategy is applied as the task performance is about to break down. In one example, a student reads a passage from *Faust* and is perfectly capable of decoding the graphic representations. Comprehension, however, suffers crucially at this point, which she articulates in a post-session interview. We observed a pattern where her silent reading suddenly transformed into vocal articulations (in forms of whispering), and then shortly after she resumed her silent reading. This pattern would repeat several times during her reading. When we asked her about why she would read aloud, she came up with two explanations: a functional and an aesthetic one:

> The fact that I hear it – the case that it is not just a voice inside my head, but I actually also hear it, allows me to focus my attention; that my thoughts so to speak are moved in the background [. . .] I like to use multiple senses in some way too [. . .] I think German is awesome, I enjoy speaking it, so therefore it also . . . it is just cool I think to read it out loud and hear it, and at the same time feel it in the mouth, how the words kind of feel. (Student 2)

This passage suggests the existence of several cognitively interesting processes. First, by reading the text out loud, the participant is reproducing the text in a format that she can not only see but also hear. The participant's explanation suggests that the process of reading aloud is a process that implements a specific cognitive function: it constrains her attention. She elaborates that she sometimes hears meanings that are more invisible in graphic signs. A theoretical explanation is also that understanding language emerges from experience with vocalising, that is, understanding emerges from use. Vocalisation can be an intelligent way of linking experiential development and understanding. Second, the student's interview also highlights how reading is personal and again part of a more complex task environment. This reader is motivated by the aesthetics of the German language. She uses that motivation to move on in the text. By allowing herself to engage with an emotional kind of reading she manages to get through the text when it is boring, difficult or when she is being distracted. Reading is not just functional or hedonic – here the sensational and cognitive mesh into a strategy of moving on.

Ultimately, the student mentions that reading aloud enables her to 'read through' the comprehension problem, so to speak. When the words made no 'sense' to her (i.e. when she encounters translation problems from German to Danish), the reading aloud created another path than decoding (listening to sound). Listening to her own voice gave the problem

Figure 4. Student 3's embodied frustration when an impasse is reached.

a different characteristic. The empirical feature of voice is different from scanning text. Further, she also allowed herself a moment of being 'task off-road'. To be comfortable in being task off-road requires that one has faith that the local detour eventually will bring one back on track. In this case, the student's detour might be more intelligent than trying to solve the problem locally. Eventually, the student proclaimed, the meaning would sediment when she progressed in the text. Not necessarily in the sense that she would comprehend the exact meaning of every word but enough to enjoy the narrative and move on in the text.

What we observe is not a complete *goal replacement* but more a temporary goal replacement that relies on a pausing mechanism. The task is not solved instantly, though comprehension is not necessarily a step-by-step activity. A reader can read and comprehend, get confused and continue reading without comprehension, for instance by reconfiguring the rules as she starts reading out loud, or in another case where a student reads in a textbook about Faust to explore the narrative event around a passage that causes problems. She can momentarily suspend the comprehension goal as she just reads to get through the comprehension impasse, and maybe at a later point in time she understands what she earlier did not. Interestingly, the readers' manipulation (reconstruction) of both components in the system (the aids available, including books, rulers, pens, music, tables, lights), as well as multimodal resources such as gesturing, voicing and gaze enable them to manage problems that emerge during task performance as they reconfigure the rules and temporarily swap a task for another, only to be able to manage the first task. Detours are a feature of the cultural-cognitive ecosystem because it requires that the reader reformats the system, which involves adding complexity. In Berthoz' (2009) terms, problems are presented in new ways when one changes reference frame, points of view, etc.

The students above seem to accept that the problem must be reformatted. However, the third student we discuss is less flexible in his approach. He gets stuck in a similar comprehension (translation) problem and does not try to replace the goal. His frustration is visible in his gestures. He sighs, nods his head, bites his lips and spreads his arms to the side in frustration (see Figure 4).

He later reveals in the interview that he was unable to comprehend specific words, and that the dictionary was of little use, then what else could he do? He followed the rules but did not reformat or reconfigure them. His reading from then on was characterised by emotional frustration, and his analytical, rule-following approach did not help him in overcoming the problem.

7. Conclusion

We have discussed reading as a domain of expertise. We suggested that reading is an interesting problem domain, in terms of expertise, because reading does not conform to the format of tasks that are traditionally considered within research on expert performance. Expertise research has traditionally focused on domains where the performer is presented with what Simon (1973) described as a well-structured problem. Reading can be understood narrowly as the decoding of written symbols into sound forms, but a broader understanding of expertise in reading requires an appreciation of the cultural-cognitive setting within which the activity of reading is being performed.

We have suggested that, in real-world instances of reading, the reader is constrained to continually discover new task goals during the performance itself. An expert reader deals more flexibly with the task environment than the novice when challenges emerge. The expert finds ways to simplify complexity. Above we have described this idea by reference to how expertise is used to restructure, reconfigure and replace task/goal-problems (section 3), and also how expertise is a feature of the cultural-cognitive ecosystem (section 4). That is, expertise involves accrued complexity that enables the person to deal with the task as embedded in a complex open-ended environment. Our discussion suggests that research on expert performance has been unnecessarily narrow in scope. It is possible to study expert performance in non-well-defined problem domains such as reading. Ethnographic observation should be central to a programme of research on expert performance in such domains.

Notes

1. We choose the term 'non-well-structured' here in favour of Simon's (1973) 'ill-structured'. Simon's term implies that the problem has already been identified, albeit badly. 'Non-well structured' does not imply that the problem has already been identified.
2. Johann Wolfgang von Goethe's *Faust* is a touchstone of modern literature. While *Faust* is a drama, and the verse lines are allocated to individual speakers who are then realised by actors on the stage it is - today - mostly read by pupils and students in German literature.
3. The university students are all part of the same study program, and they attend the same course in modern German literature.

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Data Availability Statement

The datasets generated for this study are available on request to the corresponding author.

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