



Wilson, Max L. (2017) The Tetris model of resolving information needs within the information seeking process. In: Conference on Human Information Interaction & Retrieval (CHIIR'17), 7-11 March 2017, Oslo, Norway.

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# The Tetris Model of Resolving Information Needs within the Information Seeking Process

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## ABSTRACT

Theoretical abstractions, of many different aspects of search, have played a crucial role in driving research into human information seeking and retrieval forward. From models of the Information Seeking Process, to how we perceive search systems, these models help us to 1) conceptually formalise and separate aspects of the model's focus, 2) communicate more clearly about these aspects, 3) create hypotheses for subsequent research, and 4) produce implications for future systems. Implicit in these four aspects is that models and theories should have a focus and a purpose. After clarifying the relationships between models, theories, and meta-theories, this perspectives paper introduces the Tetris Model of Resolving Information Needs within the Information Seeking Process, the purpose of which is to better represent the behaviours around the Human Computer Interaction with Information Retrieval, which are often confounded within stage-based models of the Information Seeking Process. In particular, the possible sequence of actions performed by a searcher are typically linearly aligned from left-to-right, and thus imply a temporal progression. The differing focus of the Tetris model is to better capture the temporal experience of searching, by removing the implied progression of left-to-right. The aim of this perspectives paper, therefore, is to introduce this new Tetris Model, such that it can be used to formalise people's interactive experiences in a new way, so that we can more clearly communicate about them, create hypotheses from the model, and consider novel design implications based upon it.

## CCS Concepts

•Information systems → Users and interactive retrieval;

## Keywords

Information Seeking Process; Information Need; Theory; Model

## 1. INTRODUCTION

There have been many theories and models of information retrieval, information seeking, and information behaviour (including, in fact, a model of how these three are related [58]). The focus of

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CHIIR '17, March 7–11, 2017, Oslo, Norway.

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DOI: <http://dx.doi.org/10.1145/3020165.3020169>

one book, for example, was purley to catalogue the many theories from Information Science into one publication [17]. These theories and models play a crucial role in research, allowing us to 1) communicate more clearly about search (e.g. [31]), 2) formalise our understanding (e.g. [8]), 3) create hypotheses or explain research findings (as surveyed by Pettigrew & McLechnie [35]), and 4) produce implications for design (e.g. [6, 20, 56]). Many of the theories mentioned in this paper have been produced by people in our community, but its also an acceptable practice to consider whether theories from outside of our research area may also help us to develop new understandings or explanations for observed results (e.g. [6]).

By their vary nature, models are reductionist abstractions of the reality we are observing or recording. We typically categorise possible behaviours into reasonable numbers of major groups [9], such that we can examine them separately, but not have to do so for an infinite number of situations. We might also define typical relationships between categorisations [31], so that systems can expect what users might do next. Whatever the aim of the model or theory, and regardless of what they are trying to communicate, they help us to understand something a little better, but necessarily the level of abstraction means that they cannot encapsulate all of the reality. This also means, however, that having theories and producing models means that we can critique them [22] (although these can lead to some rather interesting and very public debates [7, 23]).

One common (but inevitable) limitation to models of the Information Seeking Process (ISP), is that in defining the possible stages that users can go through, they cannot so easily define the actual process likely to be experienced by the searcher. Perhaps most evident in this is the well known and popular model of the ISP produced by Marchionini [31] in Figure 1. Marchionini's figure is typically cited for the key stages, shown left-to-right, that a user would go through. Most interesting for this paper, about Marchionini's figure however, is the sheer number of back-arrows (its perhaps an interesting challenge to find a pair of boxes that are *not* connected by a back arrow). While Marchionini's ISP model is highly effective at conveying the key stages a searcher *must* progress through, its left-to-right presentation implies a temporal progression that a searcher *will* progress through; the back-arrows are there of course to highlight that its not *normal* to go straight in that order, but that other paths are possible, if not more normal.

The aim of this paper is to introduce a the Tetris Model of Resolving Information Needs within the ISP, with the aim of specifically modeling the search process, as experienced by a searcher resolving an information need. This new model does not represent the stages or categorise the possible behaviours, but instead complements these by representing the motivations of a searcher as they move between them. Below, I first set the scene by discussing the exact nature

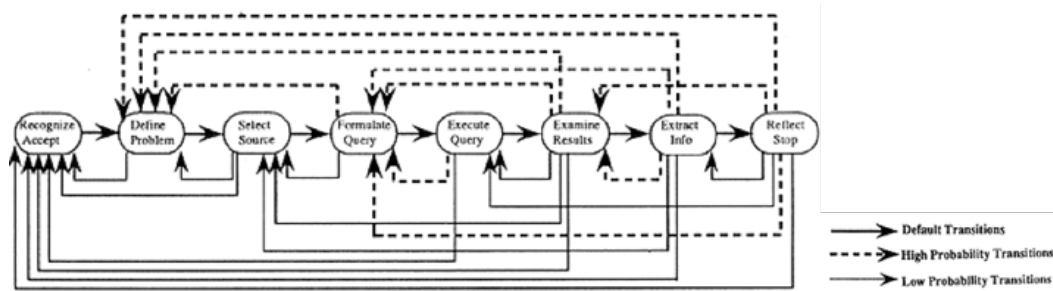


Figure 1: The Information Seeking Process provided by Marchionini, from [31]

of theories, models, and frameworks, before surveying a range of different theories in our research community. I then present the Tetris model, before concluding with a discussion of what it can tell us about search, whilst considering what it cannot tell us.

## 2. RELATED WORK

I have not, so far, been especially clear on the use of *theories* and *models*, or indeed how they relate to *principles*, *metatheories* and *frameworks*, if not many more similar terms. In honesty, nor do I wish to go into these in depth, which could be an academic endeavor of its own. To set a cursory pretext, however, a theory, in general, is a perhaps complex but particular principle that we believe to hold true across many circumstances; Information Theory [44], Activity Theory [28], and Information Foraging Theory [36] are a few examples. Information Foraging Theory, for example, explains how information is found in much the same way that animals forage for food, involving several principles such as an effort vs cost tradeoff. Whether or not the creators of a theory are explicitly aware of it, theories typically come from a certain perspective on interpreting the real world; Hjørland discusses meta-theoretical perspectives in more detail for a reader that would like a philosophical challenge [21]. Models (in our discipline at least), however, are usually smaller specific abstractions used within theories to represent a point. Typically tabular or graphical, models encapsulate an idea into a single metaphor or representation such that they can be portrayed, discussed, and even tested. In more algorithmic parts of Computer Science and Information Retrieval, models are often explicitly implemented to show that they produce more accurate results (e.g. tfidf [46], BM25 [40], language models [37] etc.) In Human-Computer Interaction with Information Retrieval (HCIR), we are more likely to create conceptual models of human behaviours, and create experiments or build systems to support them [9]. Finally, frameworks are typically an application of a theory or model that somebody takes as a guide to frame their work. One might take the principles of Activity Theory as a framework for designing future research (e.g. [28]), or likewise might use Information Foraging Theory to design a new search user interface widget [49]. Similarly, Wilson et al [57] used Belkin’s model of search situations [9] and Bates’ taxonomy of tactics [2] as a framework for predicting user interaction with search user interfaces. In practice, these terminologies are often used informally or incorrectly within literature, and the boundaries between can become arguable; it is not the aim of this perspective paper to discuss these concepts in detail nor the correct use of them.

### 2.1 Models of Interactive Information Retrieval

There are of course both many models and theories that could be discussed, and many ways to approach them. Bigger surveys of

theories [17] and their uses in research [35] have been produced. In this paper, I will review a few that are most relevant to the Tetris Model of the ISP being presented here.

#### 2.1.1 Levels of Granularity

Search can be modelled at very tiny levels of Information Retrieval actions, and at very grand levels of process. A key set of theories has been to break categorise and separate the levels being discussed into: Information Behaviour, Information Seeking Behaviour, and Information Search Behaviour [58]. The benefit of separating these levels, is that other models can be specific about which granularity they are concerned with. Jarvelin & Ingwersen used similar levels to describe how each level motivates the levels within, and to specify which evaluation criteria should be used to measure success at each level [25]. Elsweiler et al considered that their model worked only for work contexts and further extended their model to describe the difference between work behaviours at each level and casual behaviours at each level [15]. Overall, its common for theories and models to be focusing on one these levels, if not describing the relationship between them. Research into creating realistic Work Tasks [10], for example, focuses on the need for information retrieval to be motivated by real information seeking tasks, which are in turn realistically motivated by how the result of seeking will be actually used in a Work Task.

#### 2.1.2 Information Behaviour

At a very high level, information seeking is considered as only one of many information behaviours. Godbold [19] produced a model that highlighted that information behaviour also includes creating information, avoiding information, destroying information and much more. A nice example outside of information seeking is information encountering [16], which describes how people might encounter information without trying to find it. Formalisations of the reasons that Information Behaviour exists, include Dervin’s model of the sensemaking gap [12], which highlights a few points including the existence of a gap, the need to take action to cross it, and the cost involved in doing so. Belkin’s formalisation of the Anomalous State of Knowledge [8] further describes the implications of knowledge gaps and the motivations to resolve them as information needs. Another of Wilson’s models encapsulates each of these in a little more detail, highlighting activating mechanisms for e.g. choosing to seek information [58]. Each of these models aim to convey some important aspect of the reasons why we search (or not) for information, to help us make predictions about human behaviour, or to interpret the outcomes of information seeking with more clarity.

#### 2.1.3 Information Search Process

Perhaps most common and well known are three models of the Information Seeking Process (ISP). Marchionini’s model (Figure 1),

for example, highlights the key stages that a user progresses through [31] but using finer-grained language that implies stages of a smaller information retrieval process. In a similar way, Ellis [14] describes some of the key activities that searchers embark on during an ISP, including: Chaining, Browsing, Monitoring, Differentiating, Extracting and Verifying. With a different aim to convey the user motivations and emotions, and describing larger endeavours into researching, Kuhlthau's model highlights a series of major phases that searchers go through [27]: Initiation of project, Selection of topic, Exploration of ideas, Formulation of the key information needs, Collection of results relating to them, and Presentation of what they have found. Her model highlights levels of e.g. anxiety and clarity as they move through these stages. Whether explicitly mentioned or not, knowing such emotions and phases has inspired much subsequent work on estimating frustration in search [34] and to support confidence in the trustworthiness of search results [43].

As mentioned above, without taking away from the value that these well known models provide, they (like all models) have limitations in what they convey. In particular, these examples imply a linear left-to-right progression and the back-arrows in Marchionini's model are an attempt to compensate for this implication. Instead, Spink visualises information seeking as a sequence of information retrieval cycles rather than a linear progression of one retrieval episode [47], where each cycle involves both the use of a search tactic, and the relevant judgement of what is found. Taking the non-linear concept further, Bates' Berrypicking Model is a well known example that specifically highlights that we collect information from many different places as we exploring information, especially when browsing [3]. Bate's model aimed to convey that resolving an information need is often achieved by collecting and piecing together separate bits of information found in those multiple locations. Likewise, Forster's nonlinear model conceptualises this as searcher having a paint palette, using information seeking activities as necessary to achieve the bigger picture they are looking for [18].

Other models focus differently on the type of searching situation that develops these information seeking episodes. Marchionini more recently identified many types of search episode, but broke them down into three major categories: *Lookup*, *Learn*, and *Investigate* [32], with the aim of highlighting that they can be treated differently. Belkin broke down seeking into 16 situations, based on four binary dimensions including problem clarity and knowledge of the target result [9], before using them as a framework to build a system to handle them each differently. It could be said that the left-to-right stages describe a straightforward *lookup*, and that all the back-arrows describe all the deviations that we largely describe as Exploratory Search [52]. In order to model all the types of situations that Exploratory Search tasks might involve, Wildemuth & Freund modeled a strong set of dimensions that can be used as a framework for designing tasks for experiments [54].

#### 2.1.4 Aspects of the Search Process

A final set of key models break down the different aspects, or factors, that are at play during search. Saracevic identified several key layers involved in searching, from both the user side and the system side [42]. A user has motivations, strategies to use, and actions to achieve them, where as a system has the document collection, the algorithm to retrieve them, and the interface to present them. Bates later broke these down into many more levels [5], having already highlighted that the amount of automation in a system could be studied at each level [4]. Jarvelin and Ingwersen identify 9 key aspects to any searching situation: including the data, the algorithms, the user interface, the dimensions of the searcher themselves, the tasks, and indeed the searchers perceptions of the tasks [25]. Ingwersen

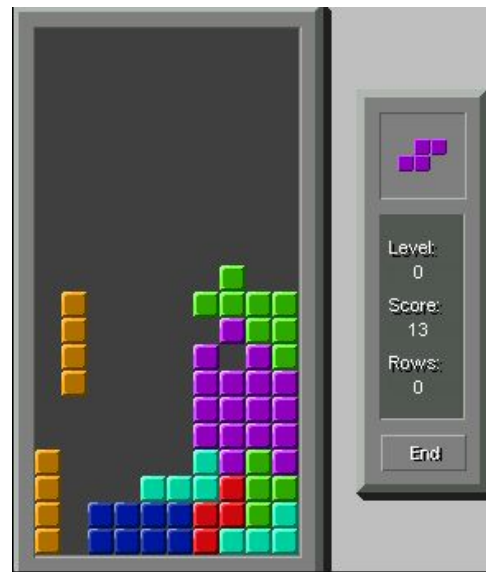


Figure 2: Example Tetris interface. Unedited image ©joefoodie, taken from: <https://flic.kr/p/AQDh2>

also produced a useful cognitive model (perhaps best represented with the clouds in [24]) that focused specifically on this issue of perception, highlighting that information seeking behaviour depends on what they know about the possible results, what they know about how the retrieval algorithm works, what they know about the user interface features, and so on.

## 2.2 Summary

There are many more models and theories that could be described that relate to HCIR, but there are two key takeaways from those noted above: 1) models are created to convey a particular understanding: the factors that affect user behaviour, the aspects of retrieval system, the users perception of those aspects, the levels of searching behaviour, the evaluation criteria for levels of searching behaviour, and so on. 2) that there is a gap in explaining how information needs, the retrieval of both known and unknown information, and the resolution of information needs, all relate to each other through the ISP. The aim of the Tetris Model of ISP, described below, is to model how these issues relate, and help elaborate on why and when e.g. users take the back-arrows in Marcionini's model.

## 3. THE TETRIS MODEL

The aim of this section is to propose that the aim of the game of Tetris, perhaps taken (for now) without the fun-creating aspects of time pressure, is a valuable model for understanding how searchers resolve information needs during the Information Seeking Process (ISP). In particular, the aim is to remove the notion of progressing from left-to-right through stages, in order to tie progress to the resolution of information needs instead.

### 3.1 A Recap of Tetris

The aim of the game, shown in Figure 2, is to fit the descending pieces, of varying shape, together so that they create one or more complete lines across the width of the screen. When a complete line has been created, the line is removed from the game and the score is increased. In order to better fit these pieces together, users are able to rotate the descending objects and move them left and right as necessary. To make this game fun and challenging, the rate at

which pieces descend increases, so that the user has less time to a) work out where to place the piece, and b) move and orientate the piece accordingly.

We are not the first to consider Tetris within academic purposes. Kirsh and Maglio [26], for example, have studied the difference between epistemic and pragmatic actions performed by users, as the speed of the game increases, to learn more about perception and reaction protocols. Further, Veksler and Gray used a Tetris-based task set to measure learning [50].

### 3.2 Introducing the Tetris Model

As an overview of how we use this Tetris analogy, the game window itself is considered to be a working space for an information need. The pieces already at the bottom of the game window, making up incomplete horizontal lines, represent a *current information need* or Anomalous State of Knowledge [8]. The depth of the incomplete horizontal lines represents the depth or complexity of the current information need, and determines the amount of information needed to resolve the information need (perhaps demanding more exploratory learning and investigating). Being aware of these unresolved lines is paralleled to recognising that you have an information need; something captured in many models. Arriving, descending pieces in the game are considered as *new pieces of information* that the user finds from searching, or simply encounters [16]. The user is hoping that these new bits of information found will resolve an information need, fitting into their gaps in knowledge, but may not fit completely (partially resolving the information need), or may not fit at all (perhaps creating new information gaps). Any completed lines of the game are resolved information needs, and thus removed from the working space, and a score value incremented, which represents the cumulative amount of knowledge a searcher has about this topic.

In this model, we consider *progress* as resolving gaps in knowledge (completing lines), rather than by going through a series of stages. At this point, we are ignoring the time pressure that adds the ‘fun’ to Tetris, but highlight that progress is not going through a series of stages, but in resolving information needs. We are also breaching the randomness of pieces entering a game of Tetris, considering that although users could incidentally encounter information, they might purposefully look for the *right* pieces.

The different stages, captured in other ISP Models, that searches may be in are identified by the state of the game. If a new piece of information arrives into an empty window, then a user has a new information need to resolve (typically the first stage of every ISP model). If the user chooses to begin a new information seeking episode, they are trying to clear that new piece of information from the board. As the user can see what information need they have, they can construct an idea of what remaining pieces they would like to find and encounter. As the user analyses search results, new pieces arrive in the window of the game, and hopefully help to resolve the information need. As the pieces arrive, the user has to analyse how and where they fit into their developing knowledge on the topic. These new pieces, however, may not directly resolve the need, and deepen the number of lines that need resolving, causing the searcher to reformulate their information needs. As the pieces do fit together, however, the user is able to reflect on the state of the game. When the lines have been cleared, the user can consider that they have resolved their information need.

### 3.3 Applications of the Tetris Model

In the following subsections, I further explain the Tetris Model, beginning with three diverse examples that represent different complexities of information needs, taken from the broad categories described by Marchionini [32]: Lookup, Learn, and Investigate.

#### 3.3.1 Lookup Example

A simple lookup has been shown to be a regular part of everyday life, when a simple problem is identified (caused by the arrival of new piece of information), described easily, found quickly, and therefore resolved with ease. This scenario, portrayed in Figure 3.a), can be represented easily by the first three pieces of a game each being made up of simple bits of information. Each block can be laid side by side, horizontally, so that they make up an entire line and the problem is removed. That is, the original problem, the first piece, was simple and, given the empty game window, created a shallow information need. Equally, the searcher came across the appropriate information to resolve the need easily. The newly found information fits simply, without further deepening the information need, and the line (or information need) is resolved. Overall the IS episode was quickly resolved and the screen, until a new problem piece arrives, is entirely empty.

#### 3.3.2 Learning Example

In learning examples, an original information need may appear to be relatively simple, such as needing to buy a camera. The next piece found, however, indicates that more is to be learned before a final camera can be chosen, such as the difference between metering modes and ISO capabilities. The new pieces of information confound the chance of resolving the problem in a single line, and deepen the problem space to a number of Tetris lines (Figure 3.b). Consequently, more information must be sought to resolve any or, hopefully, all of the lines. It is possible, however, for this deepened information need to be completely solved with a single final piece, by clearing several lines at once (Figure 3.c). Alternatively, each of the lines may be resolved one at a time with successive pieces.

#### 3.3.3 Investigate

Investigating is represented by tasks such as planning, analysis, synthesis, and evaluation, where the complexity lies in the initial problem pieces, such as a multi-faceted problem, or a poorly defined information need. If the initial problem piece has a complex shape (Figure 3.d), then the information need can only be resolved by several pieces. The depth of the problem, unlike Learning examples, is controlled by the complexity of the earlier rather than the later pieces. This does not exclude, however, the later pieces from increasing the complexity of the problem, as investigating may often include learning (Figure 3.e).

### 3.4 Taking the Model Further

One value of the Tetris Model, is that it can be extended to describe much larger and/or complex sessions. As another example of the versatility of modelling the ISP with a Tetris analogy, life-long learning can even be captured by the Tetris Model. There may be some topics that people spend their entire lives learning about, such as the focus of an academic career, or a personal interest or hobby. During the large period of time, people may engage in lookups, learning exercises and investigations, where each one resolves something they did not understand before, or discovers new pieces of information. Realistically, we process many bits of information as we search, and by resolving one information need, there may always be unresolved blocks that represent information that has not been explained or investigated (Figure 3.f). Here, we can imagine that users pause the game until such time that they wish to engage in information seeking to either resolve new information needs, or the leftover blocks from a previous information seeking session. In Tetris, users’ unresolved lines might be occluded by new pieces of information (e.g. Figure 2 above). The searcher may have to clear several lines and resolve several information seeking problems be-

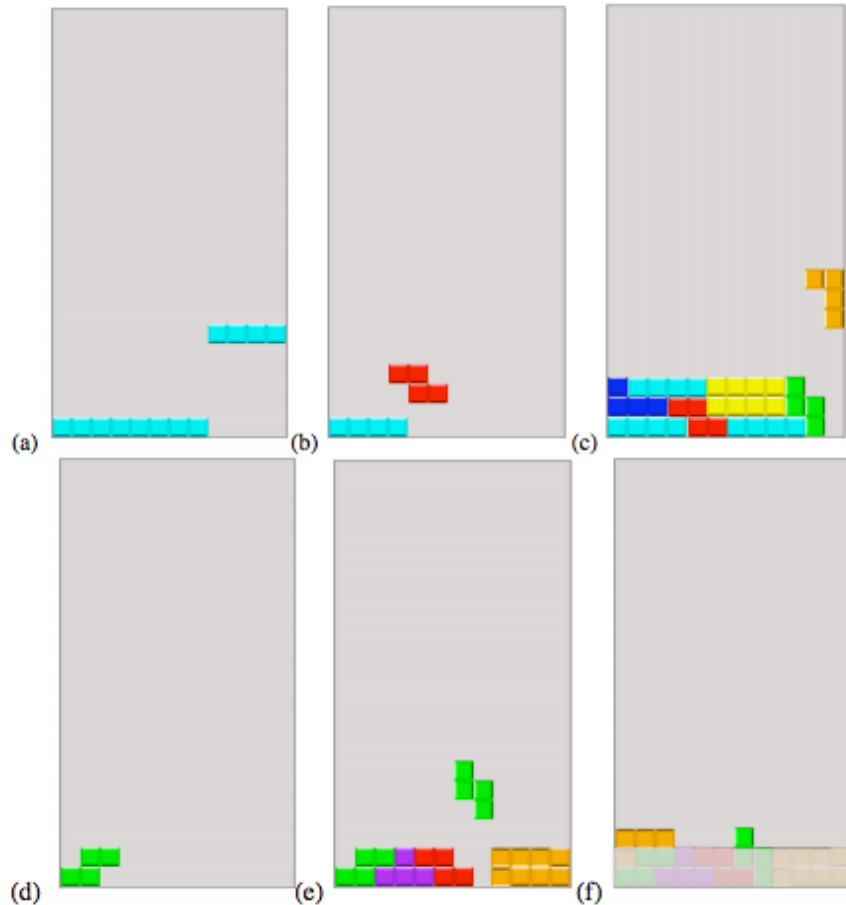


Figure 3: Example information seeking states, where (a) is a simple lookup task resolved easily; (b) is a learning example where the information need was deepened by the second bit of information; (c) presents a deep information need being eventually solved with one piece; (d) shows a more complex initial information need for investigation; (e) shows an investigation need getting even deeper; and (f) represents excess information found that is surplus to solving the information need.

fore one day resolving something that they did not complete before. This may occur when new pieces of information need to be checked, or first understood before the original problem can be resolved.

## 4. DISCUSSION

In this section, I reflect on the advantages, limitations, and possible uses of this model in terms of the four values that models can provide, as noted in the introduction: 1) formalising our understanding of the search process, 2) communicating about the search process, 3) creating hypotheses for future research, and 4) drawing implications for design.

### 4.1 Formalising and Communicating

An important concern for any new model is what is its focus and thus what novel insight does it provide. The main insight provided by the Tetris model is in tying the progression of a search episode, and the complexity of the behaviour in the search episode, to the depth and complexity of an information need, rather than in the progression through certain behaviours. This is particularly important because, as a community, we are grappling with the Exploratory Search agenda, to design support for more complex searching to resolve more complex information needs. In particular, research into Exploratory Search in our community often conflates

various scenarios and task factors [54], where one study might set a task involving comparison, and another simply sets a task focused on multi-part problem, but both call them ‘an exploratory search task’. The Tetris Model may help to facilitate the discussion of these different types of tasks more clearly in a way that would be harder to do with stage-based models.

There is a general consensus within research that the ISP involves a start goal, whether it be broad or focused, and an endpoint where all or part of the goal has been achieved. Unlike most models of the ISP, the Tetris Model tries to integrate information need into the process of searching. Further, search is often considered to occur within one IS episode [9], or across multiple search episodes [30]. In the Tetris model, the start and completion of an ISP is not represented by an axis or a direction. Instead, the status of the Tetris working space, the complexity of the unresolved lines (the information need), and the value of newly arriving pieces of information, all determine which of the stages of Marchionini’s model, for example, the searcher is in and which (back-)arrows they follow. Unlike stage-based models, the Tetris Model can accommodate these across multiple sessions. The Tetris Model, therefore connects ISP models with information need models and behavioural models together in a new way that helps us to understand the search process in more detail, and communicate more effectively about how they relate.

## 4.2 Opportunities for Future Research

In contrast to the life-long learning example, there are topics that individuals have learned about in the past, but have many blocks still to resolve. If the user is not actively seeking, one way or another, in those topic areas, then these games can be considered on pause. Unpausing may, therefore, occur as new information arrived through passive information encountering [16], or if the searcher actively engages in a new search episode. There is opportunity, based on this model, to further explore research questions about a) activation causes, b) search resumption, and c) multi-session searching.

Conversely, one open research question for the Tetris model is to decide if users are able to fail ISP-Tetris for certain information problems, as they reach maxima in their understanding of topics. In Tetris, failing is indicated by the stack of unresolved, incomplete, lines filling the available vertical space allocated to the game. Although a maximum vertical space doesn't have a direct parallel in our understanding of the cognitive aspects of search, we can draw parallels with when searchers give up on their task, because it seems unresolvable. Perhaps individuals who fail to understand hard problems have reached their vertical limit on reasonable effort to resolve complex gaps in their knowledge, despite having resolved some set of lines in the past. This gives us an opportunity to, again, consider surprise discovery of information that does suddenly resolve a knowledge gap and make a complex information need seem achievable [11]. Similarly, the model gives us opportunity to further consider the role of effort and satisficing during search [51].

One interesting area of research into information seeking is the role that existing knowledge plays on search formulation [53] and on relevance judgements and the correctness of found information [41]. The interesting research questions lie around the impact that incomplete prior knowledge has on assessing whether new information correctly resolves an information need. Answer correctness, or a measure of an answer's strength, is often used in studies of searching behaviour, whilst also trying to measure pre- and post-search knowledge on a topic [55]. The Tetris Model may help to draw new finer-grained questions about the sequence in which information is found during search.

One final element of the Tetris game that is not covered by this model, is that of the increasing speed at which pieces descend as time progresses. This element of speed is added to the game to introduce both challenge and enjoyment. In real life, however, information seeking is often performed under time pressures such as deadlines or medical emergencies. Similarly, many user studies impose an element of time on their information seeking tasks. Users are often timed as they carry out the tasks, and most analyses assume that improvements in task completion time make their system better. In some respects this is true, if the system in question is producing pieces that will fit together nicely to resolve a problem, then they have supported the users by not accidentally deepening the information need. If the original challenge is more exploratory or investigative, however, then time pressure may make it harder for searchers to fit new pieces in with the unresolved lines. Indeed, many studies involving exploratory search tasks explicitly remove time pressure in order to measure value gain from the system, and are even investigating the benefits of slower search response times providing better and more relevant information to fill information needs [48]. Consequently, time and effort tradeoffs are a current concern in information retrieval research [45, 1], and aspects like hover time and dwell time are examined for what they imply about relevance of results [29]. So although, in general, we have not included time pressure in the Tetris Model, there are interesting questions about the implications of time that can be explored in future research.

## 4.3 Possible Implications for Design

This concept of depth for an information need, rather than sequential stages, is a fairly novel way of thinking about the ISP, and so may immediately have consequences for new designs of search systems. For example, the model poses the question of whether, instead of tracking the stage at which a user is currently at, a system could track the level of depth and detail that the user is currently at. There is very little need, for example, to provide a growing overview of a domain if the user simply performs a short look-up. A space for synthesising information, however, would be very useful as the user's information need deepens. Marchionini and White [33] report on previous research that has shown, for example, that automatically trying to create a synthesised view of a domain allowed users to perform Learning and Investigative tasks significantly faster, but provided no significant benefit for look-up tasks. Research has also shown, however, that shown at the wrong time, search user interface features can actually impede straight forward searching [13]. Google appears to share this sentiment, by typically placing recommended query refinements *after* the first ten results rather than upfront in the search process. Some interfaces exist that support different depths of search, however they have typically been designed from the progressive models. We have yet to see, to the authors' knowledge, a system designed specifically from the view of depth or complexity of information need, rather than progression through stages. One research opportunity above is to examine the consequence of finding information before earlier information gaps are resolved. Early research, for example, has examined showing you what you've seen already [38], what new information can be found [49], and whether information can be presented in order of need rather than relevance [39]. Each of these are interesting approaches that could be developed further by considering the design of a search user interface from the point of view of the information need, depth and complexity.

## 4.4 Limitations of the Model

There are, as with any model, limitations to what the Tetris Model captures and represent. As noted above, it does not capture the activities that searchers may perform like ISP models from Marchionini and Ellis, just the reason for trying to find information and effect of having found information. This is of particular importance, because in real life, new information does not arrive to us randomly, but we take actions (captured in other ISP models) to influence the information we encounter. We aim, as it were, to find a square piece when we have a square hole in our knowledge. Further, when we search, or encounter information, we are likely to come across information we already know. The description of the model above implies that arriving, descending pieces are *new* pieces of information; the model therefore does not capture or represent what happens when we encounter information that we already know. We may also encounter information that we do not need, and these do not necessarily deepen our Information Need. Together, these aspects mean that the random allocation of incoming pieces in the game does not clearly represent what determines the information we encounter, but it is true that we may not find the information we hoped for, and will likely encounter many other pieces of information along the way. The Tetris analogy also implies that we have to resolve higher lines before we can resolve lower information needs, but this is not enforced in real life.

## 5. CONCLUSIONS

This perspectives paper has introduced the Tetris Model that describes how the process of Information Seeking relates to and is affected by the depth and complexity of an information need, and

the relevance and utility of the information found or encountered to resolve it. Unlike most models of Information Seeking, which usually try to reduce the process to a single progression across stages, the Tetris model describes a progression separately from spatial presentation, implying that progression is instead temporal and about resolving gaps in knowledge. This means that the Tetris Model directly captures the freeflowing movement between defining an information need, searching for more information, and integrating this into existing knowledge. Further, by making the depth of the problem analogous to the current depth of the unresolved lines in the game, the model allows for any new information in the process to both resolve and/or deepen the problem. The examples of lookup, learning, and investigating above have shown the versatility of the Tetris model for describing diverse searching scenarios. Further, the discussion has identified its potential strengths, as well as how these strengths might be used to direct future research and support the design of future search interfaces.

As identified in the introduction, the purpose of any model is to help us structure what we do know, communicate effectively, hypothesise about research, and draw new implications for, in this case, how people resolve information needs within the Information Seeking Process. In turn these new avenues of research can support or strengthen our models, through identifying and resolving limitations, so that they may again inform new ideas. My hope is that the Tetris Model described above helps to formalise our communities understanding of the search process, especially in regards to Human-Computer Interaction with Information Retrieval (HCIR) around dynamic Exploratory Search conditions.

## 6. ACKNOWLEDGEMENTS

Thank you to everyone that over time has given me comments on this idea, and encouraged me to submit this paper.

**Data access statement:** There is no dataset underlying this model.

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