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# Search tactics used in solving everyday how-to technical tasks: Repertoire, selection and tenacity

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ABSTRACT

With greater access to computational resources, people use search to address many everyday challenges in their lives, including solving technology problems. Although there are now many useful 'how-to' resources online (especially videos on YouTube), it can still be difficult to identify, understand, and resolve certain kinds of technical problem. While research tasks have been studied for many years and we know the tactics people use, we know far less about searchers' tactics for how-to technical tasks that involve actually being able to apply found information to resolve a problem. Crucial to our study was developing and studying a highly realistic, how-to technical task, for which there was no single guidance resource: making a phone safe for a child. After providing 39 participants with an actual phone to fix, and a search engine to perform the task, we analysed their search tactics using retrospective cued think aloud interviews. Our primary contribution is a set of 77 tactics used, in three categories, along with detail of how common they were. We conclude that people had a lot of tactics in their repertoire. Although it was not hard for participants to find relevant information, what was hard was for participants to find information they could use; indeed only 23% of participants successfully completed the entire task. Domain knowledge affected the choice of tactics used (although not necessarily towards better task success). We discuss these influences and make design recommendations for how future search systems can support those in resolving how-to technical tasks.

## 1. Introduction

Many everyday problems can be solved by a simple one-shot search, where a person types a query into a search engine, selects one of the top-ranked results, and obtains the information they need to address their problem. There are many useful how-to resources, for helping people complete everyday tasks like cooking and DIY, especially on YouTube (Torrey, Churchill, & McDonald, 2009). Nevertheless, there are problems that require more effort to try and obtain useful and usable information. When we cannot find a simple answer to a technical problem, it can be challenging for even technically minded individuals to solve. We were interested in how people dealt with these more challenging tasks, and the tactics used. This kind of task can involve iterative searching, and also iterations between searching and acting with the results, and so we expected to see additional tactics that lead to task success.

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Notably, success is measured not by the relevance of the information retrieved, but by whether the information retrieved helps a person to actually solve the problem in their subsequent interaction with the technology.

Our objective was to identify search tactics for resolving everyday how-to technical tasks, in order to identify ways in which search systems can help struggling searchers. Through this work, we contribute:

a) A novel characterisation of information-seeking when resolving everyday how-to technical tasks, as opposed to open ended research tasks.
b) An expanded set of tactics that build on prior work.
c) Evidence that everyday users have lots of tactics in their repertoire; they don't necessarily need to be taught 'more tactics'.
d) Evidence that the task type invoked different types of tactics to research tasks in previous literature.
e) Recommendations for how future research, and search systems, can support those resolving everyday how-to technical tasks.

We conclude that to improve people's search skills, we should focus on helping them understand types of tasks, and appropriate tactics for them, rather than on teaching them new ones.

## 2. Related work

### 2.1. Search tactics

Bates (1990) defines a move as the basic unit of analysis – "an identifiable thought or action that is part of information searching". A tactic is "a move or moves made with the purpose of improving or speeding the search in some way" i.e. a tactic is a grouping of moves that may incorporate both thought-moves and action-moves. These definitions continue to be a basis for many subsequent studies. In our study, we are interested in search tasks where the searcher must use the information found to resolve how-to technical problems. A search can only be considered successful if the information found does actually resolve the information problem. We, therefore, extend Bates' (1990) definition of a tactic to "a move or moves made with the purpose of improving or speeding the search in some way *to resolve an information problem*".

The focus of our study and this review is tactics; the "first level at which strategic considerations are primary" (Bates, 1990), as it is here that the cognitive approach taken to search is revealed (Hsieh-Yee, 1993). It should be noted that for many studies the focus is on moves (e.g. Fidel, 1985; Wildemuth, 2004; Zhang, Jansen, & Spink, 2006) . We review these studies too if tactics are also discussed (Table 1). Some studies also try to identify tactics from system logs. He, Qvarfordt, Halvey, and Golovchinsky (2016), for example, attempted to automatically identify tactics in system logs, but had to focus on a small number of (e.g. 6) tactics that had explicitly observable user actions (or 'moves') in them. The broader sense of tactics we are concerned with involve moves or actions that could be attributed to multiple different tactics, and ultimately require a cognitive form of investigation to identify.

In a seminal study, Bates (1979a,b) identified tactics based on her own experience and that of professional information specialists searching subject databases. Bates (1979a,b) identified five groups of tactics (1) Monitoring tactics – keeping the search on track, (2) File structure tactics – ways of locating items in search systems, (3) Search formulation tactics – design of the search query, (4) Term tactics – selection and organisation of query terms, and (5) Idea tactics – ways to resolve search problems. Also examining how professional information specialists search, both Fidel (1985) and Shute and Smith (1993) considered the moves and tactics made in online searching and found that these largely correspond with the tactics identified by Bates (1979a,b) but that while all Bates' tactics are theoretically possible, professional searchers only use some (Fidel, 1985).

Since these studies of professional searchers, the rise of the web has meant that much in the information environment has changed: full text is indexed, content is uncontrolled, results are ranked, and search is an everyday activity for many people, not just professionals (Mlilo & Thatcher, 2014). Subsequent studies have considered the tactics of web users (Savolainen & Kari, 2006; Smith, 2012; Thatcher, 2008; Xie & Joo, 2010). Many of the tactics identified by Bates (1979a,b) have also been observed in these studies (Hsieh-Yee, 1998; Smith, 2012) but some new tactics and tactic groups have also been identified. Most notably both Smith (2012), and Xie and Joo (2010) have extended Bates' groups of tactics to include evaluation of the search results. Although not calling them tactics, Barry and Schamber's (1998) evaluation criteria collected from both university students and staff, as well as occupational users of weather-related information is more extensive. Building on this study, Savolainen and Kari (2006) investigated the use of these criteria in web search by asking their participants to search on a topic related to their own self-development such as a hobby.

It seems likely that there is a universal set of tactics (Savolainen, 2017) but which tactics are employed is dependent on a number of factors including task, perceived knowledge, search system and process (Xie & Joo, 2012). It can be difficult to make comparisons across studies as the approaches taken to identifying tactics differ and tactics are identified at varying levels of granularity. Tactics can either be identified from a person's explanation of the action taken (e.g. Bates, 1979b) or by analysing chronological sequences of moves (e.g. Thatcher, 2006; Wildemuth, 2004). Studies may identify a detailed list of a particular group of tactics / moves (e.g. Fidel, 1985) or just a range of tactics at a high level (e.g. Xie & Joo, 2010). In our study, we are interested in people's explanations of all the actions taken while searching to resolve an information problem. Understanding how people make sense of their own searching activities can help in uncovering additional features that should be taken into account in design interventions, whether that involves designing better interfaces and functionality for search engines or designing better learning experiences to help people search more efficiently and effectively.

**Table 1**
Moves and tactics identified in prior work.

| | Moves and tactics | Identified from |
|---|---|---|
| Bates (1979a,b) | 32 tactics categorised under 5 groups: Monitoring, File structure, Search formulation, Term. Idea. | The author & information professionals |
| Barry and Schamber (1998) | (1) 23 evaluation criteria categorised under 7 groups: Information contents of documents, Sources of documents, Document as a physical entity, Other information or sources within the environment, Users situation, User's beliefs and preferences, User's previous experience or background. | (1) University students and staff |
| | (2) 32 evaluation criteria categorised under 10 groups: Accuracy, Currency, Specificity, Geographic proximity, Reliability, Accessibility, Verifiability, Clarity, Dynamism, Presentation quality | (2) Professional users of weather information |
| Bhavnani (2001) | 5 operators: Find-websites, Scan-websites, Compare, Verify, End-task | (1) Healthcare experts<br>(2) Shopping experts |
| Fidel (1985) | 18 operational moves and 12 conceptual moves | Professional searchers |
| Hsieh-Yee (1993) | 9 tactics grouped under Term selection, Monitoring, and Search formuation | Participants with varying search experience and domain knowledge searching the DIALOG database |
| Hsieh-Yee (1998) | 26 search tactics grouped under: search statements, number of search statements, starting tactics, tactics used when too many items were found, and tactics used when nothing relevant was found | Web users conducting 4 assigned search tasks: 2 known item (1 text, 1 graphic) and 2 subject searches. |
| Navarro-Prieto et al. (1999) | 3 cognitive search strategies: Top-down strategy, Bottom-up strategy, Mixed strategy | Web users with varying knowledge and experience, conducting 4 types of search task: 2 fact-finding (1 dispersed structure, 1 category structure) and 2 exploratory (1 dispersed structure, 1 category structure). |
| Savolainen and Kari (2006) | 18 user-defined relevance criteria | Web searchers self-chosen topic related to self-development |
| Shute and Smith (1993) | 13 knowledge based tactics categorised into 3 groups: Broaden topic scope, Narrow topic scope and Change topic scope | Expert intermediaries conducting literature searches |
| Smith (2012) | 34 Internet search tactics categorised into four groups: Monitor, File structure, Formulation and Term | Internet search tactics identified by author from research literature |
| Thatcher (2006, 2008) | 28 moves categorised into five broad areas: Task initiation behaviours, Search terms, Sustaining search behaviours, Terminating behaviours, and Unusual search behaviours.<br>78 tactics identified from chronological sequences of search moves<br>12 cognitive search strategies identified from search behaviour patterns | Web users with varying experience searching for 2 researcher and 2 participant defined tasks that are either fact-finding or general purpose browsing |
| Vakkari et al. (2003) | 6 search formulation tactics and 4 other tactics | Students with varying IR knowledge conducting searches for 1 work task: a research paper |
| Wildemuth (2004); | 13 moves categorised under 5 groups: Beginning moves, Moves to reduce the size of the set, Moves to increase the size of the set, Moves to increase both precision and recall, Other moves<br>Tactics identified from sequences of moves | University students conducting a database search for clinical problems in microbiology at three time points. |
| Xie and Joo (2010, 2012) | 13 tactics[a]: Identifying search leads to get started, Creating search statement, Modifying search statement, Evaluating an individual item, Evaluating search results, Keeping a record, Accessing forward, Accessing backwards, Learning, Exploring, Organising, Monitoring, Using / Obtaining | Web search general public 1 work related task and 1 personal-related task |
| Xie, Joo, and Bennett-Kapusniak (2017) | | (2) self-generated task (academic and personal) in four systems (online database, search engine, OPAC, digital library) |

[a] Tactics as reported in Xie and Joo (2010).

## *2.2. How-to technical tasks*

A task is a goal-based activity (Hackos & Redish, 1998), that may consist of sequences of sub-tasks that need to be performed to achieve an outcome (Toms, 2011). There are both work tasks and search tasks. A work task is "an activity people perform to fulfil their responsibility for their work" (Li, 2009). The concept of a work task is not limited to the work arena and the term can also be used to describe activities within a leisure context (Vakkari, 2003). Many of the studies of tactics have either been for research type work tasks (Bates, 1979a,b; Fidel, 1985; Shute & Smith, 1993; Vakkari, Pennanen, & Serola, 2003; Wildemuth, 2004) and/or for work tasks within particular domains (Bhavnani, 2001; Xie & Joo, 2012). For example, Xie and Joo (2012) compare popular, occupational and scholarly work tasks. It is likely that different types of work task co-exist within each group. In this study we are interested in a particular type of work task: everyday how-to work tasks to fix a technical problem.

Everyday tasks are those that "people employ to orient themselves in daily life or to solve problems not directly connected with the performance of occupational tasks" (Savolainen, 1995, p. 267), although in some circumstances and for some people these tasks may be job related (Savolainen, 1995). How- to tasks are where a person needs to find out how to do or make something. For example, a person may want to know how to bake a cake or make a best man's speech.

When a person lacks information for a work task, this might result in one or more search tasks (Vakkari, 2003). Although search tasks for how-to work tasks may involve many of the same search tactics as a research task (a task that involves finding out about a given topic, and assembling resources deemed relevant), it is likely that there will be differences because of the task characteristics. While for a research task there might be many results that are Topically and Cognitively relevant (Saracevic, 2007), information use in how-to technical tasks means that results have to be Situationally (usable) and Affectively (successful) relevant to the searcher. We suggest that for everyday how-to tasks in the technical domain what counts as domain knowledge and success is different. Furthermore, what information is used for and who searches for this information is different.

For research tasks a person may or may not have domain knowledge ("knowledge of the subject area" – Wildemuth, 2004) depending on their familiarity with a topic. However, for everyday how-to technical tasks a person may be familiar with aspects of the task, regardless of whether they have or do not have technical knowledge. For the task in our study ("make a phone safe for a child"), familiarity with phone safety, the brand of phone used in the study, as well as technical knowledge are all types of domain knowledge. An approach used in many studies to understand how domain knowledge influences tactic use is to compare the searching tactics of those familiar with a domain with those who are unfamiliar (Hsieh-Yee, 1993; Shute & Smith, 1993; Xie & Joo, 2012). Given the inevitably wide variation in elements of subject area knowledge for everyday tasks that are also within a specialist domain we can't easily categorise our participants by subject area knowledge binaries and so we cannot take this comparative approach in our study.

In studies of information-seeking, search success is only rarely linked to whether the searcher can achieve their work task, by resolving the actual problem that led to the use of search systems (Kelly, 2007; Wildemuth, 2004). In studies of research tasks, when success is determined, it is often linked to finding relevant documents and the number of solutions found during the search session (e.g. Vakkari et al., 2003), or task completion speed (Aula & Nordhausen, 2006). While these may be good measures for research-style tasks (Wirth, Sommer, Von Pape, & Karnowski, 2016), for a how-to task information may be relevant but unless the information can resolve the problem it may not be useful. We expect that this will lead to different tactic use.

Many studies of tactics have found that search expertise is a factor in tactic use (Hsieh-Yee, 1993; Navarro-Prieto, Scaife, & Rogers, 1999; Thatcher, 2008; Xie & Joo, 2012). As we are investigating everyday tasks, those undertaking such searches will likely have variable search skill. We could therefore expect a wide variation in tactic deployment for this type of task, depending on the searchers' expertise.

How information is used may also influence the type of tactics employed. For how-to technical tasks, we suggest that information will be used (1) to get instruction – "to find out how to make and do things" and (2) to extend knowledge "to find out about a particular aspect of a topic" (Rutter, Clough, & Toms, 2019). Search task characteristics such as goal specificity have been shown to influence tactic selection in two studies (Navarro-Prieto et al., 1999; Xie & Joo, 2012) although not in two others (Hsieh-Yee, 1993; Thatcher, 2008).

To summarise, most studies of tactics are for research type work tasks or work tasks within a particular domain. In our study, we investigate search tactic use during how-to type work tasks. We anticipate that we will see differences from other studies because of the task characteristics. For everyday how-to tasks (1) searchers may be familiar with a task regardless of their subject knowledge, (2) information found during a search may be topically relevant but unless it can be used may not actually resolve the task problem (3) those conducting such searches will likely have variable search skill and therefore we could expect a wide variation in tactic deployment (4) there will be different information uses (such as to get instruction and to extend knowledge) that will influence tactic use.

With the growth of technologies in our work and home lives, and the growth of how-to technical help available online growing number of people are searchig online for soltions to problems that they are having with their technology use. Whereas in the past, the smaller numbers of people using technology would have called upon designated tech support experts in a work context, across many settings, both work and domestic, people are searching online as part of their help seeking activities. Sometimes this search is fast and unproblematic – the person types in a query and easily identifies a result that is relevant, trustworthy and actionable by them to solve their problem. But what about harder problems, when composing the query is less obvious, where iterated searches are needed, or where the results are harder to assess for relevance, or are simple too confusing for the searcher to make use of? Our aim is to build on established prior work in online searching by people with varying levels of expertise, but try and understand if there are differences in the case of non-trivial tasks involving searching for relevant and actionable how to technical solutions.

## 3. Method

### 3.1. Research design

To identify variation in search tactics, we planned our study to include realistic tasks designed to elicit different search tactics, and recruited participants with varying degrees of search and domain knowledge. Note that this is an exploratory approach, aiming to scope out the range of variation in the things that people do. Consequently, it is not about hypothesis testing or even measuring the relative contribution of different variables. Rather it is about getting an understanding of the range of tactics that should be taken account of in informing future analysis and systems design.

A friend of yours has recently bought a new phone (the one provided here). Sometimes their child uses the phone. Your friend has asked for your help.

1) They do not want to unnecessarily restrict their child from downloading Apps. They do, however, want to ensure that **they do not hear more than mild bad language and they do not see any violence directed towards humans**. Is this possible? What should they do?

2) They would like to set up a **separate profile** for their child but have been unable to do so. Why would your friend find this difficult? Can you do this for them? If not, why not?

3) What else would you **recommend** your friend do to make the phone safe for a child to use?

Please help your friend by searching the Internet (on the laptop provided) to find solutions. When you have found a solution(s) you should implement these on the phone provided.

**Fig. 1.** Task statement provided to participants, including exact use of bold text.

#### *3.1.1. Design of the tasks*

With an emphasis on high ecological validity, and real task consequence (Borlund, 1997), we aimed for a work task that was realistic and seemed plausible that participants would be asked to address it. Our chosen task setting, shown in Fig. 1, was to find out how to make an Android phone safe for a child. This involved three subtasks. To keep the participants focused on actual solutions rather than relevant results, and in line with Borlund's (1997) recommendations for simulated work tasks, we asked our participants to implement changes on a provided phone. These tasks could be credibly assigned by "a friend" – indeed several of our participants stated unprompted that their friends typically ask them to do this type of task or that they typically ask their friends for similar help.

The three tasks within the larger task environment were intended to require participants to generate search tasks and search sub-tasks to complete. This would reveal different tactics, and were designed with different types of information use in mind that are typical for everyday technical problems. For tasks 1 and 2 participants needed to find instructions and for task 3 they had to find further information about phone safety. This meant that the specificity of the search goal varied: for tasks 1 and 2 the goal is specific as there is particular information that must be found whereas for task 3 the goal is open as potentially any information relating to the topic could be used. We also made sure that these tasks were (a) hard for technologically competent people and (b) not solvable with a single 'how-to' video on YouTube. No advanced technical skill was needed to implement solutions on the provided phone. The solution to task 1 is to set up parental controls in Play Store. This information was readily available online but to implement the solution participants needed to locate Play Store on the phone, and determine the appropriate age-rating. Task 2 is easy to resolve on most phones by changing the settings menu. However, it is not possible to set up separate user profiles on the particular version of the phone we provided. At the time of this study, solutions for other phone models appeared in the search results pages – for this reason we anticipated that the solution for the study phone may be hard to find. As a research-style task, there are many solutions to task 3, that we anticipated would be relatively easy to find. We expected that task 1 and task 3 would be easy to accomplish but task 2 more difficult. In our pilot test we found that the tasks were achievable but not too easy.

We also considered other aspects of the tasks. We carefully worded the task statement so that keyword terms such as "parental control" and crucial information such as the phone model were missing. We also deliberately sequenced the tasks illogically, as ideally task 2 should be completed first as otherwise parental controls (task 1) will need set again for the new profile. We did this in part because we did not want to discourage participants if they got stuck on task 2, but also because we wanted to see if any participants would evaluate the whole task and then change the task order.

#### *3.1.2. Domain knowledge and search skill*

To identify the variation of search tactics used to resolve a how-to technical tasks, we wished to study participants with differing search skill and domain knowledge. To identify search skill, we asked our participants to rate themselves against two proficiencies relating to online search taken from the EU Digital Competence framework (Ferrari, Neža Brečko, & Punie, 2014). Similarly, we use the same framework to identify technical knowledge by asking our participants to rate themselves against two proficiencies relating to technical competence (see Appendix B). To identify task familiarity, we designed our own questionnaire based on what knowledge we thought participants could use when resolving these tasks (see Appendix B).

### *3.2. Participants*

To recruit participants with varying domain knowledge and search skill, we used self-reported search skill and technical knowledge (see procedures below) in our recruitment strategy. Initially, we recruited participants to: "take part in a study about solving technical problems using a search engine". After determining that our initial sample of participants had mostly self-reported high search skill and high technical knowledge, we later recruited people with posters asking: 'do you **ask other people** to solve your **tech problems**?' as some of our already recruited participants with low search skill and low technical knowledge told us they often

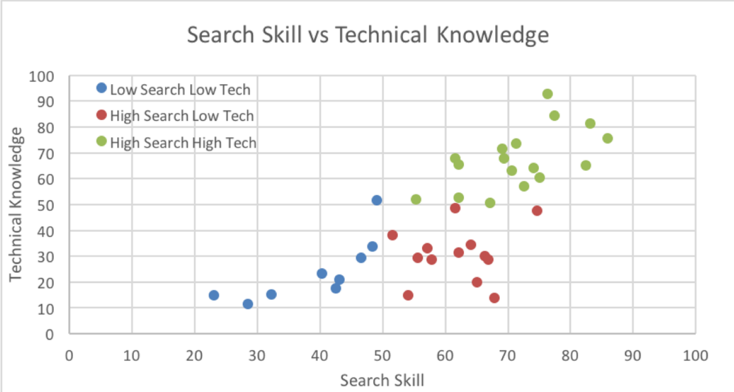


**Fig. 2.** Distribution of participants' search skill (Q1 + Q2) and technical knowledge (Q3 + Q4). Scores up to 100 were calculated from the Digital Competency responses.

asked their friends for help with technical problems. We recruited 39 participants: 17 self-reported as having high search skill and high technical knowledge, 13 had high search skill and low technical knowledge, and 9 had low search skill and low technical knowledge (Fig. 2). Because of the chosen domain, however, we did not have any participants that self-reported as low search skill and high technical knowledge, implying that having good "tech knowledge" came along with higher search skill in our sample.

The participant group consisted mainly of young, well-educated people. 24 were under 25 years of age, eight were between 26–35, three were 36–45, and four were 46 + . 14 were male and 25 were female. 13 participants were undergraduates, 8 were MSc students, 13 were doctoral students, four were employed, and one was unemployed. Most participants were from a range of different academic and non-academic departments in the university, and many participants were from different countries. Although less than half had English as their first language, only two participants thought that language influenced their search process.

### 3.3. Data collection procedures

After gathering informed consent, participants were presented with a pre-task questionnaire: a self-report of search skill and technical knowledge based upon the EU Digital Competence framework (Ferrari et al., 2014). Participants were then given 20 min to make progress on the task. We did not allocate specific time periods to each task, and so participants could work towards the larger of making the phone safe by attempting the subtasks in any order, or indeed in combination. After the time was up, participants completed the task-domain familiarity questionnaire (given post-task so that participants were not primed), before reviewing their task performance, via screen recordings, during a post-task interview. This post-task interview allowed us to capture a reflective cued-retrospective Think Aloud (van Gog, Paas, van Merriënboer, & Witte, 2005) of their search processes and gain insight into their cognitive activities. The study was approved by the School of Computer Science's ethics board at the University of Nottingham, and participants received a £10 Amazon Voucher as remuneration for their time. The browser and phone were reset between participants to remove revisitation indicators for subsequent participants. The web search results (live un-influenced results provided by the search engine of the participants' choice) were likely to be influenced by our academic network address and geographic location, however this location was consistent for all participants.

### 3.4. Analysis

#### 3.4.1. Tactic identification and coding

We used the post-task interview transcripts, supported by screen recordings of the phone and laptop, and video footage of the participant to identify tactics and knowledge used. We analysed all searching behaviour on both devices including the searches participants did to find solutions as well as any search conducted when trying to implement solutions. For each participant their interview was transcribed verbatim. Tactics that participants described were then matched by the first author with (a) the actions taken in the search user interface, and (b) what type of knowledge they were using, if any (Fig. 3).

During the first round of coding, tactics were coded inductively (open coding) based on the participant's explanation of why they searched as they did including their query formulation, results evaluation and how they managed the tasks. In the second comparative deductive phase, the unique tactics in the codebook were primarily cross-referenced against tactics from two well-known sets of tactics produced by Bates (1979b) and Barry and Schamber (1998) (selective coding). Together, these covered a good range of search and evaluation tactics, if a tactic could not be cross-referenced, tactics were linked to other sources where possible. For rigour, this comparative approach was performed in both directions – considering our tactics against those listed in these prior works, and considering each of the tactics in prior works against our own data. As inter-rater reliability can only be carried out using a "simplified coding scheme" (Patton, 2015, p. 667) and the first author had identified 77 tactics, we did not carry out a formal inter-rater reliability assessment. However, at group meetings all authors discussed and refined the coding scheme using example data provided by the first author.

| Device | Action | Interview transcript | Tactics identified | Knowledge used |
|---|---|---|---|---|
| Computer | QUERY "android phone restrict bad language" | Android phone? Yeah, because I've never used an Android phone before and that was just the first thing that came to my mind. And I thought what else have I got? I needed it to be very specific to an Android phone so I knew what to do. I'm seriously not used to that way and that layout, menus and settings, yeah. Bad language, the words were used here [points to task statement]. Yes, in the task statement. And restrict was just a very direct and simple way of saying what I meant. Rather than write a long query, I thought, that'll work better. | C1 EXTRACT C9 PINPOINT C6 REDUCE M24 BACKGROUND | Task familiarity |

**Fig. 3.** Example coding.

This process produced (1) a series of interview transcripts, (2) an accompanying annotated table of tactics used by each participant, and (3) a single codebook of unique tactics, with cross-references to participants. We then considered tactic frequency. We suspected that participant fatigue meant that "new" tactics were described but the repeated use of the same tactic was not. For this reason, we report tactic frequency across our data set (how many participants used a tactic) rather than how many times each participant used each tactic. We report these figures in the appendices in each of the tactics tables. It should be noted that while this method, and analysis, provided very rich and insightful data about tactic use, the focus of the discursive interviews is to identify different types of tactics, not on providing *comprehensive* counts of every time a tactic is used.

#### *3.4.2. Quantifying domain knowledge and search skill*

We expected to see quantifiable differences in tactics between those who self-reported as having technical knowledge, task familiarity and search skill. However, despite extensive analysis we could find no meaningful differences between the different knowledge groups. We also analysed the search logs for differences (number of queries, length of queries, mouse hovers, number of results viewed, use of tabs, and so on), and only found one statistically significant result: those with low tech knowledge inspected web pages listed later in the search results (H: 4.83 (SD:2.23), L: 6.86 (SD:2.76), $t(37) = 2.49, p = 0.02$). We conclude that either self-report data is unreliable (Hargittai, 2005) and/or that knowledge is too complex to quantify for this type of task. Therefore, in this paper, we primarily report our qualitative data and our participants' explanations for the tactics they selected. We plan to report our quantitative data in a related paper.

#### *3.4.3. Task success*

We asked participants to implement the solutions on the phone so that they could test whether the solutions they found worked. We only considered a search successful if the information found could be used to resolve the information problem. No technical skill was required to implement any of the solutions. The tasks were therefore a test of search skill.

As we allowed our participants to complete the tasks in any order, we first identified which of the tasks were started. We then checked (using the phone screen recording) whether participants had successfully resolved and implemented each of the tasks, and whether the solutions were correct or incorrect. We also report participants' explanations of why they stopped working on a task before it was completed.

## 4. Results

### *4.1. Task success*

Task success is reported in Table 2. All 39 participants started task 1. For 3 (8%) participants this was the only task they started, 8 (21%) participants started two tasks, and 28 (72%) attempted all three tasks. Overall 22 (56%) participants felt they did not have enough time to complete all three tasks. Only 9 (23%) of our participants completed all three tasks successfully. A further 21 (54%) found some solutions for task 1 and 3, but were unable to correctly resolve task 2 (although some thought they had). 8 (20%) participants were unable to find any correct solutions. 1 participant found a correct solution for task 1 but could not implement the solution because they were unable to find basic information such as the location of the phone's settings menu. As this participant could not implement the solution, we count this as unsuccessful. For many of our participants these were challenging tasks, particularly because solutions to other phones and models were presented in the search results that did not work for the phone provided in our study.

**Table 2**
Task success.

| | Solution found | No. participants ($n$ = 39) |
|---|---|---|
| Task 1 | Correct solution (changes Play Store setting) | 17 |
| | Incorrect or poor solution (installs App) | 14 |
| | No solution implemented | 8 |
| | Task not started | 0 |
| Task 2 | Correct solution (finds out there is no solution) | 10 |
| | An incorrect solution (installs app / changes a setting that does not solve the task) | 22 |
| | No solution implemented | 4 |
| | Task not started | 3 |
| Task 3 | One or more correct solutions | 21 |
| | One or more incorrect solutions | 0 |
| | No solution implemented | 0 |
| | Task not started | 18 |

Part of the reason why the success rate is so low is that 11 (28%) participants considered tasks complete even though they were aware that there was more they should or could do. These participants felt that they could stop doing the task when they had provided a partial solution. 2 (5%) participants reported that they gave up on tasks because they didn't understand them. 17 (44%) participants described not completing tasks because under time pressure when they couldn't find information, they swapped to other tasks.

### *4.2. Search tactics for resolving how-to technical tasks*

All bar one participant started the assigned tasks by searching for information. The only participant that started by directly trying to configure the phone was not able to successfully achieve the desired result this way, and so all participants did search for solutions. Our analysis found three main types of search tactics:

1) 24 tactics to CONTROL the search – to direct what information is received and to manage information across multiple devices,
2) 29 tactics to SELECT and USE information to select which search results to visit, and what information is used in problem resolution,
3) 24 tactics to MANAGE the task and process – to answer the tasks and manage the search process, at a level that coordinated both the use of CONTROL tactics, and the use of SELECT and USE tactics.

These tactics, which are a primary contribution of the article, are extensively and comprehensively reported in Appendix A. In each table, we show how many of the participants reported using each tactic. In Table 3, we summarise tactic use. Individual participants used between 21 and 36 different tactics (mean = 28.6), out of a total of 77 tactics identified. This suggests a large repertoire of tactics that people can draw upon. More tactics were identified to SELECT and USE information (29) and MANAGE the task and process (24) than CONTROL the search (24). However, participants applied more control tactics (mean = 11.4) than SELECT and USE (mean = 9) and MANAGE (mean = 6.7) tactics.

#### *4.2.1. Frequent CONTROL tactics*

We next describe the CONTROL tactics that more than half of the participants used. For a full list of CONTROL tactics see Table 6, Appendix A.

35 (90%) participants described how they found terms to use in query formulation. This was an assigned task so not surprisingly 24 (62%) of these participants extracted terms from the task statement (C1). However, we had carefully worded the statement to avoid key terms: 28 (72%) participants realised that they needed additional information from another source (C5) and so looked for the model and operating system of the phone (either on the phone or on the laptop by searching for information about the phone) to use in query formulation and results examination. Participants also became aware of the importance of the model and operating system of the phone while searching. This influenced what terms they used in query formulation. After finding information about the phone, 32 (82%) participants used terms relating to the phone model and operating system in query formulation (C9) in an attempt to restrict (unsuccessfully) the results to the type of phone. 20 (51%) participants described varying query terms (C12) because (a) they

**Table 3**
Tactics summary table.

| Tactic type | No. of tactics identified | Total no. of tactics used by all participants ($n$ = 39) | Average no. of tactics per participant |
|---|---|---|---|
| CONTROL | 24 | 445 | 11.4 |
| SELECT & USE | 29 | 348 | 9 |
| MANAGE | 24 | 260 | 6.7 |
| **Total** | **77** | **1053** | **27** |

could not find relevant information in the search results and (b) as a technique to find additional sources of information that could be used to confirm previous sources. However, much to our participants' frustration this tactic did not change the results much. Another common query formulation tactic used by 25 (64%) participants was to use exact terms (C10). This was because they sometimes needed to re-find information on the other device, and so what was being looked for was already known.

Another set of tactics was to locate terms on the phone / computer interface (C15 & C16). 33 (85%) participants needed to locate known terms on either the phone or laptop interface. Mostly this tactic was used to locate menus on the phone that had been described in the solutions found on the computer but it was also used to scan lengthy web pages. 27 (69%) participants also searched for what they thought could be alternative menu names (C16). They needed to do this because for task 2, the solution that many participants found described a menu that did not exist on the particular phone provided in this study.

All 39 participants used both devices simultaneously (C19) whereby they implemented solutions on the phone while viewing instructions on the laptop. This tactic is likely linked to this being an instruction-based task. When participants were unable to use this tactic, for example, when they found instruction on the phone and then had to move to a different screen to implement the solution they were frustrated. 30 (77%) participants also kept information available for future use (C17) by either opening new tabs or by taking notes.

Because the solutions were not easy to find and particularly for task 2 where incorrect solutions were readily available, all 39 participants needed to re-examine search results and web pages to try and find additional solutions (C23). For task 2, 21 (54%) of participants also tried to search for an entirely different type of solution (for example, some swapped from searching for how to change settings to looking for an App) (C24).

#### *4.2.2. Frequent SELECT and USE tactics*

We next describe the SELECT and USE tactics that more than half of the participants used. For a full list of SELECT and USE tactics see Table 7, Appendix A.

23 (59%) participants selected and used information objects for their visual clarity (SU1). For instruction type tasks, pictures and lists were considered particularly clear and easy to use. 37 (95%) participants described selecting and using information objects because it matched their information requirements in some way. 27 (69%) participants selected and used information objects because they were broadly relevant to the topic (SU8). This tactic was also used to avoid information objects that were not on topic. 21 (54%) of participants described selecting and using exactly what they were looking for (SU9). This tactic was used to re-find information on the phone that had been found on the computer. Visual cues, such as icons, were often used to help relocation. The most frequently used match tactic was to use related information (SU11). 28 (72%) participants had to use this tactic because despite making their queries specific (C9) to the phone provided, the search system returned results for other phone models. For many this was deeply frustrating. As well, 22 (56%) participants described needing to select and use alternative solutions (SU28). This was particularly employed when participants were unable to resolve task 2 with the solution frequently presented in the search results. Use of this tactic is indicative of the complexity of the task and also of participants trying hard and not giving up.

#### *4.2.3. Frequent MANAGE task tactics*

We next describe the MANAGE tactics that more than half of the participants used. For a full list of MANAGE tactics see Table 8, Appendix A.

Because the task is externally assigned, to ensure that they were on track (M1), all 39 participants checked that the solutions they found matched the requirements in the task statement.21 (54%) participants considered the likely solution prior to searching (M7). We discuss this further under 4.2.4 Knowledge use. As the tasks were all based on the same broad topic (phone safety), 22 (56%) participants described searching for all three tasks simultaneously (M10). One participant described searching for a single solution that could resolve all three tasks.

All 39 participants decomposed the tasks into smaller sub-tasks (M22). The two most frequent sub-tasks were (1) to find information about the phone (model, operating system, version of operating system etc.) because we did not supply all the information they needed in the task statements. (2) To find the location of menu items and apps on the phone. In part, participants needed to do this because they were swapping between devices and also because many of the search results included solutions for other phones with different menu structures.

Although 4 (10%) participants described taking a break and swapping to different tasks (M12), as this study had to be completed in a single search episode, participants could not take a break and return a different time. This was particularly problematic for one participant who feeling frustrated would rather have taken a complete break and come back to the task later.

#### *4.2.4. Knowledge use*

17 (44%) participants reported as having technical knowledge and 30 (77%) as skilled searchers. All our participants owned smart phones. 11 (28%) owned an android device but 13 (33%) of our participants had never used an Android operating system (operating system of supplied phone). Only one participant reported that they had previously tried to change phone safety settings, but 24 (62%) had read about or discussed phone restrictions for child safety. We could find no numerical relationships between having any of these types of knowledge and search tactics used. Participants did describe though how technical knowledge and task familiarity influenced their tactic use. For some tactics, knowledge is integral to the tactic and so we report frequency of use for this type of tactic (e.g. SU27 INTERNAL VERIFICATION: Comparing information sources with what is already known). For other tactics, participants describe using this tactic because they have or do not have domain knowledge but there could be other reasons for using this tactic so we provide illustrative quotes only (e.g. SU8 TOPICAL: Selecting and using information that broadly matches the task topic).

Surprisingly only 3 (8%) participants described finding terms from their own knowledge for query formulation (C2). However, it may be that participants did not verbalise this rather than it did not happen. Participants did describe how lack of knowledge meant that they looked for terms in the results and web pages that they could then use to formulate queries (C3).

*"I just don't know how to start the phrase to search. … Because maybe I don't know the terms for this kind of thing so I am not familiar with it. So I need to try a lot of times and figure out. I will also see the website and see the keywords people usually use." (P38)*

They also used autocomplete and other search system query suggestions (C4): "Sometimes it gives me more accurate things because sometimes I don't know how to type the correct things on the search engine, and this help me get more close to what I want to see" (P27).

Knowledge influenced the use of SELECT and USE tactics. Participants who did not have domain knowledge described selecting results that broadly matched the topic (SU8) – "Just to get a situation awareness of what is going on rather than trying to do one specific problem." (P17). Although inf*ormation* objects were selected for their visual clarity (SU1) because these were instruction type tasks, they were also selected by those who were unfamiliar with the phone because "*I really like the pictures because it is something at least for me who know nothing about the technology, they are very easy*" (P26).

Those who self-reported as having high technical knowledge described selecting up-to-date information (SU15), as they realised that technology changes and thus the solution would change too. "I am seeing pages that are old and probably not relevant to this version of the operating system" (P14). They selected results based on rank position (SU22), because, in their experience, Google's ranking is good for this domain and they therefore trusted the order of the results. "What I think is the first result always could give me what I want. So just go to the first one" (P20). They also used their knowledge to select the best solution (SU3). "So ideally things like parental control you want to have built into the operating system itself" (P19). Those with self-reported low tech knowledge described applying a cost/benefit to selecting information. They selected solutions because they thought it would be quick (SU5): "I thought it would be a quicker fix than downloading an app but I couldn't do it so I spent a while looking at the phone trying to …" (P24). Solutions were also selected because they were easier to understand (SU7). Seeing code and technical jargon was often particularly off-putting for those with low tech knowledge, who were concerned that the solutions would be too difficult for them to implement.

11 (28%) participants selected information because the solutions verified what they thought they already knew (SU27). *"I think it can be done because I have a Samsung tablet and I have two profiles."* (P13). This was not always a successful strategy because the solution for task 2 was different for the phone provided in this study. 22 (56%) participants also described using their own knowledge (SU14) to resolve sub-tasks. For part of task 2, participants needed to select the correct PEGI rating (www.pegi.info/page/pegi-age-ratings). 20 (out of 22) based the rating on what they thought was best, rather than the one that best matched the task requirements. This is not simply a matter of least effort as many of the participants went on to extend task 2 (M14) and restrict the films and books that could be downloaded too.

"*Under 5 because I was thinking about my niece."* (P25)

*"The age of the child here wasn't mentioned so I just go for 7 years old because it seemed to be quite relevant with the description. I tried to sort out violence with videos and any other source related to that. Bad language. So I just assumed it was for someone who was already able to read. So not three years old. 12 it matters less because we know how they speak at this age. I just deduce 7 I guess." (P23)*

Knowledge particularly influenced the MANAGE task tactics. Logically task 2 should be completed before task 1. Only 6 (15%) participants considered the logic of the task (M9), and they did this because they were already familiar with phone profiles.

*"So I went directly to look for the restricted options. Because I already knew that with a restricted profile you can do all the task over here and maybe answer this question because maybe the restricted profile have other things more than just restrict apps."* (P13)

*"Because if you can set up a profile then you can select what can be accessed"* (P12)

21 (54%) participants thought about likely solutions prior to searching (M7). This tactic worked well for those with technical knowledge but less well for those without. Those with a good understanding of phone technology looked for a solution that is central to the phone and rejected apps as a solution. Some of those less technically oriented started by looking for an app and never considered other solutions.

*"Because I don't think there is an option to restrict content from the phone. I'm not sure about that I should have searched in the beginning is there an option in the settings. I just thought straightaway that I needed an app."* (P18)

3 (8%) participants changed the task to fit what they already knew on this topic or what they had found (M19). For example, P21 knows that there are dangers in YouTube and adapted the task to this.

*"Because in my family we have a nephew and when he was younger we used to give him a tab so he always watched YouTube. But suddenly we started seeing that he was watching some video games that are violent and we think it is a dangerous thing and we should try to control it and we told that to his family. To his parents, sorry. That is why I always link it to YouTube.*"
(P21)

Participants unfamiliar with the task needed to further decompose tasks (M22) than those who were familiar as they also needed to search for the meaning of terms, concepts and objects, and find the settings menu on the phone. For some participants this was a crucial stage.

*"It was about telling me, go to the setting and then user on how to control the app downloading. But the problem was, yeah from here I was trying to go to the user setting. I couldn't find it quite easily. I am not familiar with Android."* (P25)

Those unfamiliar with the task were aware of the need to adapt tactics to what for them is an unfamiliar domain (M17). 22 (56%) participants reflected on their familiarity with aspects of the task and how this inhibited performance (M24).

*"It is the first time I'm using Android. I'm not familiar with it."* (P12)

*"It was hard because I've never had to be in the mindset of child safety thing because it was a bit foreign to me like. I've never had to think about making my phone child safe. I actually didn't know where to start with it. Which I felt bad about. Yeah. I should know."* (P35)

## 5. Discussion

### *5.1. People had a lot of tactics in their repertoire, allowing them to cope with lack of success*

All participants had a large range of tactics in their repertoire and there was considerable diversity in tactic repertoires across participants. We could not identify any relationship between self-reported search skill and tactic use.

What we saw was that our participants were tenacious searchers and this meant that they used a wide range of tactics. When solutions did not work, they did not give up, they kept on searching, and kept on changing tactics. We think there are three reasons for this. Firstly, the tasks were designed to resonate with the participants. People recognised themselves in the task either as the friend or the person who would ask the problem. Many of the participants seemed genuinely interested in the topic of the task, and indeed when we asked participants to stop searching one participant did not want to finish, a second carried on searching using their own mobile phone and a third asked if we could email a list of websites on the topic. Secondly, our participants were challenged. They wanted to resolve the tasks and were frustrated when they could not. Thirdly, our participants did not believe that there could be no solution to task 2, and so carried on searching. While it could be that some participants assumed that we would not set a task that was not achievable, the reason for persisting given by our participants was that they feel protective towards children. They could not believe that it was not possible to set up profiles on the phone provided and considered the phone company irresponsible.

### *5.2. Universal tactics but application is task specific*

Our study supports the idea of a universal set of tactics (Savolainen, 2017), as many of the tactics for the how-to task in this study have been seen in other studies; most notably those identified by Bates (1979b) and Barry and Schamber (1998). However, some tactics common to other studies were either not described or only infrequently described in this study. This is likely linked to the type of task and a limitation of our study design.

An example of a tactic not seen in our study that is linked to the type of task, is accuracy of information seen in both (Barry & Schamber, 1998; Savolainen & Kari, 2006) studies. As our tasks were instruction-based, participants were not concerned with accuracy while selecting information, instead they looked for good solutions and then tested the accuracy of information when implementing solutions on the phone. Similarly, the most commonly used selection criteria in this study were selecting/using exactly what is looked for (SU9) and selecting/using information that is different from but related to what is looked for (SU11), whereas in Savolainen and Kari's (2006) study specificity, topicality, familiarity, and variety were used most frequently. We suggest that this shows the influence of task and information retrieval system performance: in our study the search results were poor and participants had to select related information, furthermore because they were using two devices they needed to search for exactly the same information again. In Savolainen and Kari's (2006) study, participants are searching for self-development, these are likely open-ended topics which may have been searched before and which will have a range of appropriate information.

### *5.3. Frequently applied tactics linked to the task and search system response*

Prior to conducting this study, we had anticipated that tactic use would be particular to the type of task because information must be used to implement solutions on the phone, and a task would only be successful if the information searched for could resolve the information problem. In Table 4, we summarise the reasons participants gave for the frequently used tactics.

Four of the reasons given are related to the task: it is assigned, it is instruction-based, the solution must be implemented on another device, the task is complex. Although the assignment is a product of a lab-based study, search is social (Evans & Chi, 2010) and when an obvious answer is not available, many people turn to 'techy friends' to help fix a computer problem. Participants used the information given to them "by their friend" to formulate queries (C1) but because crucial information was missing they also needed to find additional information (C5). They also needed to check that the solutions they were implementing matched the task requirements (M1). That the tasks had an instruction information use that needed to be applied to a different device influenced tactic selection. Our participants needed to find solutions that were specific to the phone model and operating system (C9), locate items on the phone (C10, C15, C16, SU9) and they wanted to use information efficiently (C19, SU1). Four tactics (C17, C23, SU28, M22) are likely linked to the complexity of the task. Search task complexity is based on three dimensions: number of subtasks, number of facets and indeterminability (Wildemuth, Freund, & Toms, 2014). It is primarily the indeterminability of our task that makes it complex. The complexity is possibly further compounded because our participants did not expect the tasks to be hard. To deal with the

**Table 4**
Reason for frequent tactic use.

| Frequent tactics (used by more than 50% of participants) | Reason for use |
|---|---|
| C1 EXTRACT: Finding terms in the task statement<br>C5 OTHER SOURCE: Finds terms from another source (i.e. a source other than C1-C4)<br>M1 CHECK: Checking solutions and potential solutions against the task statement | The task is assigned |
| C10 SPECIFY: An exact term is selected because a specific item is searched for<br>SU9 EXACT: Selecting exactly what was looked for | Two devices |
| C9 PINPOINT: A term is selected that restricts the results to the topic / an aspect of a topic<br>C15 LOCATE TERM: Locating a known term on the interface<br>C16 LOCATE ALTERNATIVE: Locating alternative term(s) on the interface<br>C19 SIMULTANEOUS: Viewing information on one device while implementing solution on another<br>SU1 VISUAL CLARITY: The presentation and format of the information makes it easy to use | Instruction based task |
| C12 VARY: A term is selected to replace another term to change the results<br>C17 RECORD: Keeping evaluated information available for later use either by opening new tabs or taking notes<br>C23 REEXAMINE: Returning to search results and / or websites that have already been examined to find additional information<br>SU28 ALTERNATIVE: Finding a new solution to replace previous solution<br>M22 SELECT: Break the task into sub-tasks and work on one sub-task at a time | Task complexity |
| C12 VARY: A term is selected to replace another term to change the results<br>SU11 STRETCH RELATED: Selecting information that is different but related to what was looked for<br>C24 REROUTE: Use an entirely different approach to find additional information sources | Solutions are highly specific but the search results are general |
| SU8 TOPICAL: Selecting information that broadly matches the task topic | Working in an unfamiliar domain |
| M7 LIKELY SOLUTION: What solutions are likely<br>M10 COMBINE: Searches for all tasks at the same time | "Short cuts" |

indeterminability our participants needed to keep their options open (C17) and find alternative solutions (C12, C23, SU28). Our participants also need to decompose the tasks (M22) into a number of subtasks; a second aspect of complexity. They needed to do this because we did not give them enough information in the task statement and they had to implement the solution on another device that they were also unfamiliar with.

That the search system returned results that were general rather than specific to the task accounts for three frequently occurring tactics. Participants reformulated their queries by changing terms (C12) or approach (C24). They used related information (SU11) when they could not find exactly what they were looking for. Searcher persistence (noted at the start of this section) accounts for why people kept using these tactics when earlier approaches were unsuccessful (see Section 5.1).

Two tactics are best described as "short cuts". To reduce searching participants tried to combine the tasks (M10), and if participants could avoid searching for information by using what they thought were likely solutions (M7), they did.

Selecting information that broadly matches the task topic (SU8) is linked to many participants working in what is for then an unfamiliar domain, either because the task is unfamiliar or they do not have much technical experience. We discuss this further in Section 5.4 Influence of domain knowledge.

### 5.4. Influence of domain knowledge

We consider how domain knowledge influenced tactic use next. As the number of participants were too few and what constitutes domain knowledge (technical knowledge and task familiarity) too messy for us to group by frequency of use, in Table 5, we group tactics according to whether participants stated that they used this tactic either because they had or did not have domain knowledge.

**Table 5**
Tactic use influenced by knowledge.

| Tactics | Reason for selection |
|---|---|
| SU3 BEST SOLUTION: Selecting an object because it is known to be the most effective solution<br>SU15 CURRENCY: Selecting information objects that are up-to-date<br>SU22 TRUST: Selects information at the top of a ranked list based on trust<br>M9 LOGIC: Logically makes sense to change the task order<br>SU27 INTERNAL VERIFICATION: Comparing information sources with what is already known | Task is familiar / has technical knowledge |
| C3 TRACE: Examining results page and web sites for terms<br>C4 SUPPORT: Using search system functionality (autocomplete, people also ask, related links) to find terms<br>SU1 VISUAL CLARITY: The presentation and format of the information makes it easy to use<br>SU5 TIME CONSTRAINTS: Selecting an information object based on time available e.g. it will be quicker<br>SU7 ABILITY TO UNDERSTAND: Selecting an information object that can be easily understood<br>SU8 TOPICAL: Selecting information that broadly matches the task topic<br>M17 DOMAIN: Adapting tactics to the task domain<br>M22 SELECT: Break the task into sub-tasks and work on one sub-task at a time | Task is unfamiliar/has no technical knowledge |
| SU14 OWN SOLUTION: Use own knowledge instead of searching | Finds way to use own knowledge |

We had expected that those with high technical knowledge would have access to more search tactics when resolving a how-to technical tasks than those with little technical knowledge even if they were familiar with the task. However, participants only described four tactics that used domain knowledge, and what constitutes domain knowledge varies for the different tactics. Those with high technical knowledge described selecting results because they are up-to-date (SU15) as they recognised that the recentness of published information is important in the technical domain. Those experienced at searching in the technical domain also selected results at the top of a ranked list because they trusted Google's ranking for this domain (SU22). Those familiar with the task selected solutions that matched what they thought they already knew (SU27), and as Bhavnani (2001) found those who were familiar were more adept at sequencing the task (M9). Those more technically experienced were able to choose between solutions (an app vs changing the phone setting) presented in the results based on what they already know to be more effective (SU3).

Participants described 8 tactics that they used to compensate for not having domain knowledge. Lack of familiarity with the task meant participants need to find query terms (C3, C4), gain a general understanding of the topic (SU8), and breakdown the tasks (M22). Lack of familiarity with the domain meant that participants need to find solutions they could understand (SU7), information that was easy to use (SU1). They were also aware that they needed to adapt their usual search patterns (M17). Participants without domain knowledge were also more aware of time constraints and selected solutions because they thought they would be quick to implement. This again highlights the influence of Saracevic's (2007) Situational and Affective forms of relevance, where results had to be ones that they could themselves use, given their technical knowledge and device experience.

We had expected that knowledge would very strongly correlate with success, but it did not. Knowledge was often not used well. Like many real-life issues, there are a variety of approaches to resolving this task, and what participants did was often coloured by what they already knew or thought they knew (M7, SU27, SU14). In general those who used an emergent strategy (develops during search) as opposed to a deliberate (existed prior to search) (Savolainen, 2016), and adapted their tactics to the situation, fared better than those who planned ahead. We also observed that participants tended to use their own knowledge (SU14) if they could, that went beyond the immediate task. Although we collected what we thought were a wide range of familiarity data relating to the task (see Appendix B), participants used knowledge that we did not anticipate. For example, they used their knowledge of children (often based on experiences of family members) and what they considered appropriate for children. This re-application of knowledge (SU14) to bridge their knowledge gap may be a good clear example of ‘Create Information’ from Godbold's (2006) Navigating Gap diagram.

### 5.5. Realistic tasks add their own kind of complexity for both searchers and researchers

Although the assigned task was not entirely achievable (in that the correct solution to task 2 is that there is no solution), no participants exhibited signs of distress at being unable to complete it. In fact, most participants were enthusiastically engaged such that some did not want to stop searching; these participants expressed that child safety was so important that the information *should* be clearly available, and if anything, were surprised that it was not.

We set a task that was challenging but still we were surprised by how difficult to achieve it was for many of our participants. As no technical knowledge was required to implement the solutions on the phone, our tasks were a test of search skill (rather than technical ability). However, it was not that participants found it difficult to find solutions per se i.e. it was not difficult to find relevant information. What participants found difficult was finding solutions that worked. That so few studies consider whether search resolves the problem that led to the use of search systems (Kelly, 2007; Wildemuth, 2004) is a concern.

Many research studies aim to test a particular hypothesis, or focus on the impact of particular variables. To achieve such aims it makes perfect sense to design laboratory studies that try to control other confounding variables. By contrast we were committed to trying to design a realistic how-to technical task in order to see what people actually do. Our findings, as outlined above, surprised us, and this was caused at least in part by a series of complexities that sneak in when you deliberately do not try to control for certain real-world complexities. In particular, we found it revealing how additional issues arise when you do not stop at the point of people finding relevant information, but watch what happens when people try to put that information to use, hit a problem and have to do additional searching.

### 5.6. Design implications

Search systems should be designed to respond to users’ tasks (Toms, 2011). We next make suggestions for how search systems could be designed to support how-to technical tasks.

#### 5.6.1. Help with specificity and key terms

In part, these tasks were difficult because people did not know what they needed to know to resolve them. Many participants felt that Google could support them more by guiding them to be more specific in their queries. Suggestions included (1) prompts of “which device” while entering queries, (2) prompts of information to include running in a background browser tab, (3) a list of all phone models that could be filtered on the results page, and (4) support the C3 TRACE tactic better by identifying ‘key domain terms’ in the search engine results pages, rather than just those terms highlighted in snippets that are from the query. While these ideas have so far been technology-search specific, the idea can easily translate into other domains like medical queries, where the technical detail of the queries really matters.

*5.6.2. Query terms more clearly reflected in search results*

Even when participants made their queries specific to the phone model and operating system, this was often not reflected in the search results. Varying key terms in queries did not diversify the results much either. Clustering similar results may give searchers confidence but for this type of task where the solution is specific (and not general to all phones) and where there are both good and bad solutions, our participants wanted search systems that are more responsive to key terms and changes in query terms.

*5.6.3. Providing major directions, overviews and visual information*

Although participants found auto-complete helpful, the recommendations are only continuations of what has been entered, and use of this functionality did not noticeably improve task success. What participants would like is for Google to suggest alternate words that guide them towards more fruitful ‘sets of terminology’. *“If those give the good kind of completion, a semantic idea of: if I'm typing in ‘child safety’ that it would immediately potentially suggest ‘parental controls’ or something like that.” (P14)*. Although search engines do typically provide query suggestions, this particular focus is more in line with the use of idea tactics for search suggestions (Kelly, 2009), to correct or direct the higher-level search approach to related or more successful pursuits. Some participants commented on the usefulness of the information box for this kind of overview guidance. An opportunity is to expand the use of information boxes to establish overviews, especially in relation to large and evolving information areas like child safety online. Participants also wanted more visual information e.g. list, videos and pictures.

*5.6.4. Quality and recentness of results*

For these search tasks, participants questioned the quality of the results in terms of authority and recentness. Forum discussion sites were often at the top of the results list. Even though lots of the most useful information was in forums, several participants wanted to be directed to sites owned by Android and the phone brand. They considered these sites more authoritative and were frustrated that often when searching for information about Android and the phone brand, these sites did not appear in the results list.

Although the recentness of published information is important in the technical domain, recentness was rarely used because while Google does incorporate the date of publication in snippets, many of the results did not have this information.

## 6. Methodological issues and limitations

This was a study of an assigned task conducted in a laboratory setting, and this had some influence on the tactics used. To make the assignment realistic we simulated an assigned task “your friend has asked you […]”. Several participants commented on the ecological validity of the task, particularly those who self-reported as being technically competent. For others, the task was also ecologically valid but they considered themselves “the friend”. Nevertheless, our study did have ecological validity weaknesses. To manage our study, we set a time limit to complete the tasks whereas in real-life people can carry on searching till they resolve the problem. When we asked our participants if they had enough time, almost half felt they didn't. The limitations that participants told us unprompted was that they would like to have taken a break and come back later, and that all searching had to be done online. That was a problem for many, as participants noted that under normal circumstances they would also consult an expert or speak to family and friends.

Our approach to identifying tactics was reliant on participant descriptions. Although this provides the deep and rich insights into tactic use to meet our objectives, there are also limitations. Firstly, participants can inadvertently overlook details, particularly those that are routine and that for the participant are obvious. For example, only 35 (90%) participants describe how they found terms to use in query formulation, yet they all clearly found terms from somewhere. Secondly, there are so many tactics that it is difficult for participants to describe everything. Our reported results are the superset of tactics discussed by all participants, but we cannot, using this approach, either objectively log or comprehensively identify every tactic used, when so many involve internalised actions. Nor can we report how frequently each participants’ used each tactic. While we report the frequency of occurrence of tactics across the dataset (i.e. how many participants used this tactic), some caution is required in interpretation and so we do not test for statistical significance.

Our study aimed to try and understand more about how people dealt with *everyday how-to technical tasks*. We found that, for our participant sample and the tasks given, people used a substantial number of different search tactics. Our participants were well educated and comfortable with technologies, even though they did not all identify as experts. This may be representative of a growing percentage of the wider population, but there is always the risk of a sampling bias. Future work could check if it is indeed widespread in many settings.

We did not rotate tasks, and participants were free to resolve the tasks in any order. This meant that we could see how our participants’ tackled the whole work task. However, because participant fatigue meant that they tended to describe tactics the first time they occur (rather than each time) it was not possible to distinguish tactic use between the three tasks in our analysis.

We were unable to identify any numerical differences between use of tactics and task familiarity and technical knowledge. We argue that this is because what constitutes domain knowledge for this type of task is complex. However, our tactic identification is fine-grained (77 tactics); such schemes are not suitable for statistical analysis (Wildemuth, 2004). This also means that our scheme will be of limited value to those wishing to analyse sequences of tactics. However, the large list of tactics that we and others have identified is an important reminder of the complexity of searching, particularly in open-ended more realistic tasks as done by people rather familiar with online searching. We believe that the rich and deep insights that fine-grained schemes afford are useful for system designers when considering the functionality that search systems should offer and the sheer variety of tactics that people may employ while using such systems. Optimising for a small number of tactics is unlikely to be useful.

## 7. Future work

Only 23% of participants successfully completed all three tasks. The success rate was much lower than we had anticipated. Whether we had designed a task that was unusually difficult or whether people do find these types of tasks difficult is unclear. We suspect both are true – some how-to tasks will be simple but others more complex. In future work, we intend to investigate tactic use for how-to tasks with varying complexity.

Our how-to task was in the technical domain. We could expect that the domain and not just the type of task influenced tactic selection (Wildemuth, Kelly, Boettcher, Moore, & Dimitrova, 2018). And indeed in our study, those familiar with the domain selected some tactics (e.g. SU15 CURRENCY) because of they were thought particularly applicable for this domain. In future work we would like to compare tactics for how-to tasks in different domains.

In our study, we only considered a search successful if the information found could be used to resolve the information problem (i.e. participants needed to be able to implement the solutions on the phone provided). For an everyday how-to task, we could do this because (a) what counts as successful resolution is more definite for how-to tasks (i.e. typically it works or it doesn't) whereas for example with research tasks what counts as successful resolution is more of a judgement call (b) implementation did not require any technical skill – search skill was need because finding the correct solution was difficult. This meant we could interpret successful implementation as “search success”. In future work we intend to investigate how success can be measured for other types of task and for tasks where the solutions are difficult to implement.

Technical how-to tasks (especially when the searcher fails to find the desired result in a single shot interaction) have many parallels with Search as Learning (Hansen & Rieh, 2016). There is an ongoing process of assessment and discovery, and ideally some reflection on what is an is not working. We want to further investigate these parallels by e.g. including measures of learning over time.

## 8. Conclusions

Although most search tasks may be accomplished by a single query and selection of the most relevant result, there are many real-life tasks that are somewhat more complex, requiring iterated and integrated exploratory searching. It used to be that only information professionals were experienced searchers, and in the early days of the web they had more search tactics than the general population. Nowadays a lot of people are experienced web users (Thatcher, 2008) and our participants had a lot of tactics in their repertoire regardless of technical knowledge. However, that does not mean that finding easy to understand how-to solutions to technical problems is now rendered trivial. Certain tasks, like ours, remain challenging, even for people with considerable domain knowledge and a wide repertoire of search tactics. Indeed, only 23% of our participants were able to *successfully* complete the whole task.

We conclude that having a range of tactics, although highly desirable, does not on its own ensure task success; it is knowing when and how best to employ these tactics for the task at hand that makes a difference. Domain knowledge affected the choice of tactics used (although not necessarily towards better task success), and the most frequently used tactics were linked to the type of task and system response. In our study, searching also required the assessment of the applicability of results to the underlying work task at hand. One of our key conclusions is that this difference between finding information and being able to use it affected activity including relevance judgements and, therefore, the tactics used. It was not hard for participants to find information, what was hard was for participants to find information they could use. It is important to continue to develop our understanding of these more complex information needs in order to develop resources and advice on how to address them.

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## Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ipm.2019.02.008.

## Appendix A. Tables of tactics

Presented in the tables below are all the tactics identified in resolving a how-to technical task. Tactics are cross-referenced to six sources (indicated by superscript numbers), when relevant: Sutcliffe and Ennis (1998)[1], Bates (1979b)[2], Thatcher (2008)[3], Barry and Schamber (1998)[4], Savolainen and Kari (2006)[5], and Bhavnani (2001)[6].

*CONTROL tactics*

Control tactics, shown in Table 6, capture the moves that participants make to direct what information they receive and to manage information across multiple devices.

**Table 6**
Tactics used to control the flow of the search; counts in the right-hand columns show number of participants rather than number of times.

| CONTROL tactics | No. of participants ($n$ = 39) |
|---|---|
| Finding terms to use in query formulation | 35 |
| C1 EXTRACT[1]: Finding terms in the task statement | 24 (62%) |
| C2 OWN KNOWLEDGE: Finding terms from own knowledge | 3 (8%) |
| C3 TRACE[2]: Examining results page and web sites for terms | 14 (36%) |
| C4 SUPPORT: Using search systemfunctionality (autocomplete, people also ask, related links) to find terms | 13 (33%) |
| C5 OTHER SOURCE: Finds terms from another source (i.e. a source other than C1-C4) | 28 (72%) |
| Selecting which of all available terms to use in query formulation | 39 |
| C6 REDUCE[2]: Selects only some of all available terms | 7 (18%) |
| C7 EXHAUST[2]: Selects many or all available terms | 5 (13%) |
| C8 COMPROMISE: Selects the terms that are available even if they are not the best terms | 2 (5%) |
| C9 PINPOINT[2]: A term is selected that restricts the results to the topic / an aspect of a topic | 32 (82%) |
| C10 SPECIFY[2]: An exact term is selected because a specific item is searched for | 25 (64%) |
| C11 PARALLEL[2]: A term is selected to broaden the range of results | 15 (38%) |
| C12 VARY[2]: A term is selected to replace another term to change the results | 20 (51%) |
| C13 CORRECT[2]: A term or terms are selected to correct errors in query formulation | 13 (33%) |
| C14 INFO TYPE: A term is selected to restrict results to a particular answer type, format, media or domain. | 14 (36%) |
| Locating terms on an interface (e.g. computer / phone) | 34 |
| C15 LOCATE TERM: Locating a known term on the interface | 33 (85%) |
| C16 LOCATE ALTERNATIVE: Locating alternative term(s) on the interface | 27 (69%) |
| Maintaining information sources | 39 |
| C17 RECORD[2]: Keeping evaluated information available for later use either by opening new tabs or taking notes | 30 (77%) |
| C18 PARALLEL HUB & SPOKE[3]: Opening multiple results in new tabs and thereby making unevaluated information available for later use | 15 (38%) |
| C19 SIMULTANEOUS: Viewing information on one device while implementing solution on another. If information and implementation on same device then notes used. | 39 (100%) |
| C20 CLOSING: Closing down recorded information sources to make information space more efficient | 5 (13%) |
| Refinding information sources | 17 |
| C21 RUN AGAIN: Repeating a process exactly as was to double check | 12 (31%) |
| C22 FIND AGAIN: Repeating a process to refind information | 9 (23%) |
| Finding additional information sources | 39 |
| C23 REEXAMINE: Returning to search results and / or websites that have already been examined to find additional information | 39 (100%) |
| C24 REROUTE: Use an entirely different approach to find addittional information sources | 21 (54%) |

*SELECT and USE tactics*

Select and use tactics involved those that participants use to select objects; that is selecting which search results to visit, and what information is used in problem resolution. This group of tactics (Table 7) is used when examining results, and also when implementing solutions on the phone.

**Table 7**
Tactics used to select results and use information to solve the task; counts in the right-hand columns show number of participants rather than number of times.

| SELECT and USE tactics | No. of participants ($n$ = 39) |
|---|---|
| Clarity of information | 23 |
| SU1 VISUAL CLARITY[4]: Selecting and using an object because the presentation and formatmakes it easy to use | 23 (59%) |
| Effectiveness[5] of solution | 30 |
| SU2 A SOLUTION: Selecting an object because it provides a solution | 18 (46%) |
| SU3 BEST SOLUTION: Selecting an object because it is known to be the most effective solution | 13 (33%) |
| SU4 ACCOMMODATION SOLUTION: Selecting an object because it is a good solution given the situtation | 6 (15%) |
| Accessibility[5] of information – applies a cost benefit (weigh[2]) to selection and use | 22 |
| SU5 TIME CONSTRAINTS[5]: Selecting and using an information object based on time available e.g. it will be quicker | 14 (36%) |
| SU6 AFFORDABILITY[4, 5]: Selecting and using an information object based on financial cost | 4(10%) |
| SU7 ABILITY TO UNDERSTAND[5]: Selecting and using an information object that can be easily understood | 16 (41%) |
| Selecting and using an information object because it matches information requirements | 37 |
| SU8 TOPICAL[5]: Selecting and using information that broadly matches the task topic | 27 (69%) |
| SU9 EXACT: Selecting and using exactly what was looked for | 21 (54%) |
| SU10 CONTRARY[2]: Selecting and using information that is opposite to what was looked for | 4 (10%) |
| SU11 STRETCH[2] RELATED: Selecting and using information that is different from but related to what was looked for | 28 (72%) |
| Selecting and using information because it is available[5] | 26 |
| SU12 BEST: Selecting and using the best solution that is available in the results (but there may be better solutions) | 3 (8%) |
| SU13 OFFERED: Selecting and using what is offered (without evaluating first) | 3 (8%) |
| SU14 OWN SOLUTION: Selecting and using own knowledge instead of searching | 22 (56%) |

(*continued on next page*)

**Table 7** (*continued*)

| SELECT and USE tactics | No. of participants ($n$ = 39) |
|---|---|
| Selecting and using information based on time[5] | 6 |
| SU15 CURRENCY[4, 5]: Selecting and using information objects that are up-to-date | 6 (15%) |
| Selecting and using new information | 10 |
| SU16 NOVELTY[5]: Selecting and using information objects because they are new to the user. Also avoiding objects that are not new | 9 (23%) |
| SU17 FAMILIARISE: Selecting and using a range of information sources to get familiar in unfamiliar landscape | 5 (13%) |
| Selecting and using information based on its qualiity[5] | 23 |
| SU18 REPUTATION[5] KNOWN: Selecting and using information from a known resource | 7 (18%) |
| SU19 REPUTATION[5] OFFICIAL: Selecting and using information because it is from official organisations | 11 (28%) |
| SU20 TRIAL: Selecting and using any information, and then testing for quality | 13 (33%) |
| SU21 GENERAL PUBLIC: Selecting and using information posted by others having similar experience | 10 (26%) |
| Selecting and using information based on position | 11 |
| SU22 TRUST: Selecting and using information at the top of a ranked list based on trust | 9 (23%) |
| SU23 ORDER: Selecting and using information according to position in ordered list based on own rules | 2 (5%) |
| Selecting and using information to verify[6] | 28 |
| SU24 DISCRIMINATE: Comparing information sources to determine which one is better | 6 (15%) |
| SU25 CONSENSUS[4]: Comparing information across multiple sources so as to determine a consensus | 12 (31%) |
| SU26 JUXTAPOSTION Verifying appropriateness of solution by comparing information across devices | 18 (46%) |
| SU27 INTERNAL VERIFICATION: Comparing information sources with what is already known | 11 (28%) |
| Selecting and using muliple solutions | 25 |
| SU28 ALTERNATIVE: Finding a new solution to replace previous solution | 22 (56%) |
| SU29 ADDITIONAL: Finding comlementary solutions to add to previous solutions | 5 (13%) |

**Table 8**
Tactics used to manage the overall resolution of the task; counts in the right-hand columns show number of participants rather than number of times.

| MANAGE task tactics | No. of participants ($n$ = 39) |
|---|---|
| Keeping track of the task | 39 |
| M1 CHECK[2]: Checking solutions in the search results against the task statement | 39 (100%) |
| Evaluating the task prior and during search | 17 |
| M2 TASK EASE: Assessing how easy or difficult the task will be. | 9 (23%) |
| M3 TASK CLARITY: Assessing the clarity of the task statement | 5 (13%) |
| M4 TASK TYPE: Assessing the type of task | 3 (8%) |
| M5 TASK COMPREHENSIVENESS: Assessing the comprehensiveness of the task | 4 (10%) |
| Solution: Thinking about the solution prior to search | 22 |
| M6 POSSIBILITY OF SOLUTION: Thinking whether the task is possible | 3 (8%) |
| M7 LIKELY SOLUTION: Thinking what solutions are likely | 21 (54%) |
| Task sequencing[6]: Ordering the tasks | 25 |
| M8 EASE: Ordering easy task first | 3 (8%) |
| M9 LOGIC: Ordering tasks logically | 6 (15%) |
| M10 COMBINE: Searching for all tasks at the same time | 22 (56%) |
| M11 SHIFT: Swapping tasks before original task is completed | 7 (18%) |
| M12 BREAK: Taking a break from a task while planning to return later | 4 (10%) |
| Adapt task: Altering the task | 14 |
| M13 CHANGE TASK: Changing the task to fit what is already known / been found | 4 (10%) |
| M14 EXTEND TASK: Extending the task beyond what is required | 11 (28%) |
| Break pattern[2]: Changing usual tactics | 27 |
| M15 ORIGINATION: Adapting tactics based on who the task is for | 4 (10%) |
| M16 TIME: Changing tactics to fit the time available | 14 (36%) |
| M17 DOMAIN: Adapting tactics to the task domain | 9 (23%) |
| M18 TOPIC: Needing to adapt tactics because of lack of topic familiarity | 13 (33%) |
| M19 LANGUAGE: Adapting to working in a non-native language | 2 (5%) |
| M20 EFFECTIVENESS: Changing tactics when usual tactics fail | 2 (5%) |
| Keep pattern[2]: Using tactics routinely | 4 |
| M21 HABIT: Using usual tactics | 4 (10%) |
| Decompose: Breaking the task into manageable parts | 39 |
| M22 SELECT[2]: Breaking the task into sub-tasks to work on one sub-task at a time | 39 (100%) |
| Reflection: Reflecting on task success | 26 |
| M23 SOLUTION: Reflecting on why task solution does not work | 10 (26%) |
| M24 BACKGROUND:Reflecting on how lack of familiarity makes it difficult to do the task | 22 (56%) |

*MANAGE task tactics*

These tactics (Table 8), were primarily used to answer the tasks and manage the search process, at a level that coordinated both the use of CONTROL tactics, and SELECT and USE tactics.

## Appendix B. Participant questionnaires

*Participant task familiarity*

Please answer the following questions by circling a response

1 Do you own a smart phone? Yes/No

If you answered yes, what type of mobile phone do you own (make & version number)?
___________________________________

1 Have you previously searched the Internet for information about making your mobile phone / computer safe?

(a) Mobile Never / When I get a new device / Periodically
(b) Computer Never / When I get a new device / Periodically

1 How familiar are you with the Android operating system?

I've never used Android before / I occasionally use Android / I use Android often

1 Prior to today, were you aware that you could restrict what Apps can be downloaded from Play Store based on their content?

Yes / No

1 Have you previously restricted the download of Apps through Play Store.

Yes / No

1 Were you aware that you could setup profiles for more than one user on mobiles / computers.

Yes / No

1 Have you previously set up a profile for more than one user on a

(a) Mobile Yes / No
(b) Computer Yes / No

1 Did you already have an idea of what could be done to make a phone safe for a child?

Yes / No If you answered yes, briefly state what you already knew _______________________________________________

1 Have you previously tried to make a phone safe for a child?

Yes / No If you answered yes, what did you do __________________________________________________
**Participant self-report of technical competence and search skill**
For each question, please indicate in the scale box which of the following statements best describes you

**1. Browsing, searching and filtering data, information and digital content;**

| | | |
|---|---|---|
| I can do some online searches through search engines. I know that different search engines can provide different results. | I can browse the internet for information and I can search for information online. I can articulate my information needs. I can select the appropriate information I find. | I can use a wide range of search strategies when searching for information and browsing on the Internet. I can filter and monitor the information I receive. I know whom to follow in online information sharing places (e.g. micro-blogging). |

**2. Evaluating data, information and digital content;**

| | | |
|---|---|---|
| I know that not all online information is reliable. | I can compare different information sources. | I am critical about the information I find and I can cross-check and assess its validity and credibility. |
| | | |
| **3. Solving technical problems** | | |
| I can ask for targeted support and assistance when technologies do not work or when using a new device, programme or application. | I can solve easy problems that arise when technologies do not work. | I can solve a wide-range of problems that arise from the use of technology. |
| | | |
| **4. Identifying needs and technological responses** | | |
| I can use some technologies to solve problems, but for limited tasks. I can make decisions when choosing a digital tool for a routine practice. | I understand what technology can do for me and what it cannot. I can solve a non-routine task by exploring technological possibilities. I can select appropriate tool according to the purpose and I can evaluate the effectiveness of the tool. | I can make informed decisions when choosing a tool, device, application, software or service for the task I am not familiar with. I am aware of new technological developments. I understand how new tools work and operate. I can critically evaluate which tool serves my purposes best. |
| | | |

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