Drivers of Information Needs: A Behavioural Study

Exploring Searcher's Feeling-of-Knowing

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ABSTRACT

The searcher's realisation of Information Need (IN) in Information Retrieval (IR) is triggered by a perception of the knowledge gap the searcher perceives. Introspective epistemic (knowledge) feelings are evoked, describing the state of the user's anomaly. For instance, Feeling-of-Knowing (FOK) refers to a state of a user's temporary unavailability to recall the information in question. The role and the extent to which such epistemic feelings inform the user's cognitive context need further research. Our methodological design followed the Recall-Judgment-Recognition (RJR) paradigm, commonly used as a framework for memory tests. We collected behavioural data from twenty-four participants in a general knowledge Q/A user study to investigate the interplay of users' internal perceptions of knowing based on three metacognitive states (Recall). The results showed significant differences across different metacognitive states and subsequent memory retrieval performance (Recognition), leading to our conclusion of the accuracy of the metacognitive states of knowing. Specifically, we found that FOK was only a relatively accurate predictor of MR. The amount of failures of recognition connected to FOK, thus, suggests that the participants might have misattributed their positive FOK. Participants could not recognise the answer as they thought, giving rise to phenomena such as Illusion of Knowing. Furthermore, our data support the significant effect of task (question) difficulty on participants' metacognitive states. Based on the interactions between Recall and Recognition, our results contribute to the understanding of the graded nature of cognitive functions, supporting the user's cognitive context in information search and expanding such an area to the realm of contextual task difficulty.

CCS CONCEPTS

• **Information systems → Information retrieval**; **Users and interactive retrieval**; *Task models*;

KEYWORDS

Information Retrieval, Information Search, Information Need, Anomalous State of Knowledge, Feeling of Knowing, Metamemory, Illusion of Knowing, Task Difficulty, Question-Answering

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1 INTRODUCTION

Cognitively-oriented research on Information Seeking and Search (IS) and Information Retrieval (IR) literature [20, 21, 23, 28, 48] provides a holistic description of the user at defining their Information Needs (IN) [58]. Kuhlthau [28, 30] drew attention to the search process as the process of sense-making for the user who actively searches for new information to fit what they already know on a particular topic. Following the ASK Model by Belkin et al. [4], knowledge anomaly is a trigger for the searchers' INs to arise. Variability of ASK is hypothesised to exist depending on the level of an individual's knowledge [4, 5]. The anomalies in knowledge were conceptualised on the basis of the problem statement [5]. The internal processes behind the awareness of anomalies in knowledge and formulation of IN in user's mind are rarely described in the IR literature. For instance, Cole [12] adapted the Frame Theory [36] for the user's cognitive context, depicting the knowledge information exchange subserving the user's realisation of INs. In recent years, user-based studies with an interdisciplinary approach, such as *NeuraSearch* [16, 25, 37, 41], emerged.

Motivated by the aim to understand IN on a deeper level, NeuraSearch user-based studies by Moshfeghi et al. [40, 41] and by Moshfeghi and Pollick [39] explored the act of IN realisation in order to analyse the involved underlying neurocognitive processes. The active brain areas revealed functional networks commonly associated with processes supporting metamemory, Feeling of Knowing (FOK) and factual memory search. The findings support the notion of internal processes engaged in epistemic (knowledge) retrieval and notably highlight FOK, an introspective state of knowing [18]. FOK reflects the assessment of one's extent of knowing that, at present, one cannot recall [46]. It results from the engagement of metamemory, defined broadly as the knowledge about one's memory [42].

Such cognitive states of knowledge are mapped along a graded spectrum of cognitive processes [34] aiding the user to appraise their level of knowledge availability in relation to a problem in question. Such graded distribution seems to be in alignment with the character of ASK variants [4]. Work by Arguello et al. [1] reused the Tip-of-Tongue (TOT) phenomenon, generally considered as a stronger instance of FOK [34]. Here, the TOT was used to define the searchers' state of knowing where they cannot express their

INs with the relevant query terms which often causes inefficient retrieval. The study concluded that TOT-based INs express the retrieved memories from the searchers' declarative memory [51, 52], both factual and episodic. The study further brought out an overall need for a redefined support for the users in their varying states of knowledge. Similarly, according to Belkin et al. [4] differentiation of the retrieval mechanisms would be required to support the variants of ASK. The epistemic feelings, as the cognitive states of knowledge, can provide the means to understand the searcher's true IN and maximise the efficiency of IR.

Epistemic introspective feelings, such as TOT and FOK, reflect the searcher's temporary unavailability of knowing and, as such, can provide more insight into the differentiation of drivers of IN from a knowledge perspective. In the context of the quality of the epistemic states, recognition of the insufficient knowledge seem to co-manifest with the feeling of uncertainty [29], feelings of a disagreement with user's beliefs [4], feelings of unease [12] and feelings of dissatisfaction [53]. Searchers were found to naturally exhibit the uncertainty with a varied intensity as the search progresses through the phases of the Information Search Process [29] and as the user's understanding of the problematic situation changes. The strength of one's memories modulates the memory retrieval (MR) and affects the perceptions of uncertainty [59]. FOK, in general, seems to predict whether the searcher will or will not recall/remember the information queried at a later stage of IN realisation [18]. Its prospective character implies the user's uncertainty; therefore, the user's estimation might be underconfident or overconfident [33]. This uncertain nature of metacognitive feelings, then, quite naturally impacts their accuracy. A decrease in accuracy happens to correlate with phenomenons such as Illusion of Knowing [2] when the user cannot recall the memory when supposed to. The Illusion of Knowing was found to occur in all types of metacognitive feelings, but more evidently in judgments of a prospective character, such as FOK [2, 15, 33]. The Illusion of Knowing informs us about a mismatch between what we thought we knew (FOK) and what we actually know. Accuracy of FOK can, thus, be an indicator of a (delayed) knowledge anomaly and later in the process could manifest as IN [3]. Further research is needed to understand how accurate this estimation is and what consequences could a misattributed FOK have on the searcher's behaviour. A broader acceptance of FOK will require a better definition and categorisation within IR. For instance, it is necessary to specify to what extent FOK impacts the MR output and how such impact relates to IR and IN.

Furthermore, IN has been recognised as a complex, multifaceted concept, highly context-dependent by numerous publications [6, 23, 49, 50, 58], therefore, one has to consider the surroundings of IN. The situational context is often reliant on the task requiring information to resolve it [50]. For instance, task difficulty is a common factor used as an input parameter in behavioural studies [17]. The searcher's response and derived search parameters, e.g. query, were found to be responsive to task difficulty [31]. FOK itself was a target in several Question-Answering (Q/A) tasks [9, 43] with the question difficulty used as a modality to explore the effects of varying difficulty in relation to the rates of FOK they produced [9]. Assessing the influence of situational contexts (i.e., difficulty) on epistemic feelings would help to draw a more complex picture about the modality of the users' cognitive states of knowing in IR.

The Conceptual Framework and Research Goals. Based on the studies reviewed above, an interplay of users' internal functional processes and manifestations [39] subserves the user's realisation of cognitive states of knowing, which then drives the users' behaviours in information searching. We propose an approach to further explore the graded nature of these cognitive states of knowledge, particularly FOK.

Our Research Goals are connected to the application of a cognitive behavioural framework that combines our key concepts in a single study:

(1) Metamemory levels linked to introspective insights that provide prospective guides to the user in relation to the problem and with task difficulty as the situational context;
(2) Factual MR to assess the validity of prior metamnemonic outcomes, i.e. the user's estimates.

The details of the framework are described in Section 2.

Within the framework, we aim to explore the transition from the initial FOK to the states informed by MR. We will explore if FOK can be used as a predictor of the future needs to search by answering these Research Questions (RQs):

(1) RQ1 - Is FOK an accurate predictor of the user's ability to retrieve the information in question from the memory?
(2) RQ2 - Is FOK affected by the stimuli (task) difficulty in our context of a textual question of general knowledge?

Our study. We addressed our Research Goals by creating a user study where participants interacted with a Q/A system of general knowledge. Our assessment was built on top of established scientific paradigms (see Section 2.1). Our design was aimed at letting the participants experience different states and magnitudes of knowing corresponding to our investigated phenomenons concerning user's knowledge prospect (Meta) and memory retrieval (MR).

Contributions. Our study sheds new light on the transition between the underlying metacognitive processes, which inform the user's knowledge availability or lack thereof with the prospect of expanding the IN continuum and devise an improved IR support. Our study opens up a discussion within the IR research in the areas such as:

- Interactions between fundamental metacognitive (FOK) and cognitive processes linked to IN. Deepening our understanding of such interactions can provide new insights into the drivers of FOK, occasions for IN to rise (Illusion of Knowing) and, in turn, create opportunities for IR to modify them.
- Improved support for the user in different states of knowledge. Exploring the likely scenarios where early metacognitive process accurately inform later cognitive functions (i.e., memory) can help with developing the strategies to maximise the efficacy of the IR outcome.
- Memory cues as part of the IR output to enhance the correct MR, understanding and certainty. Effective memory cues can be devised considering when and under what conditions

FOK could enhance the knowledge retrieval. This would allow for timely support during the information search.

2 BACKGROUND INFORMATION

2.1 Paradigms

To investigate the RQ1, we adapted Recall-Judgment-Recognition (RJR) Paradigm [9] as a framework for our Task (Section 3.5.1). The task was designed as a Q/A scenario with the control over the input (question) attributes, i.e. difficulty, in order to answer RQ2.

RJR framework is used in studies delving into memory monitoring employing a recognition memory task [9, 11]. The typical procedure of RJR starts with presenting subjects with a stimulus cue (that triggers memory remembering processes, e.g. a question) and ask to recall the target information (i.e., the answer) from memory. If they are unable to do so, they are asked to make a FOK judgment, i.e. how likely they feel they might recognise the information later. This is followed by a recognition test using mnemonic cues (e.g., answer choices) to enhance the recall.

In summary, our study combines RJR in the Q/A Task of general knowledge, implementing:

- Evoked epistemic feelings including FOK.
- Factual MR to test the accuracy of FOK.
- Situational context represented by a Q/A system with the input divided by its specific attributes in order to study their effects on participants' evoked perceptions of knowing.

2.2 Metamemory

Metamemory refers to an introspective function of monitoring and controlling one's memory and the strength of one's memories [42]. It is an important part of metacognition, a self-awareness process applied in cognitive demonstrations, e.g. thinking, learning, knowing and experiencing. Ingwersen [20] referred to the IR process as the interactive problem-solving process. Here, individual knowledge structures and the application of perception, memory recall and recognition, learning and decision making are vital instruments to resolve the problem. McAllesse [35] speculated the link between ASK and the underlying metacognitive mechanism. Its self-reflective nature produces an increased awareness of one's state of knowledge and thus could be used to explain the origin of ASK and ASK variants. The attention to cognitive states of knowing was accentuated by Arguello et al. [1] who analysed users' TOT expressions of INs, and concluded the memory-oriented origin of searchers' INs requests.

2.2.1 FOK. FOK is a result of the user's introspect into their internal knowledge and their availability. It is generally a relatively accurate measure [18, 26] and is speculated to be part of a rapid automatic process to assess incoming stimuli [45]. FOK judgments tend to scale with factors such as familiarity cues, e.g. higher FOK are associated with questions containing familiar terms [27, 45]. Its potential prospect for a search context was shown in studies [13, 14] investigating how FOK might be influenced by the user's reliance on the ubiquitous availability of online information as an extension of the user's knowledge capabilities [46].

Nature of FOK related to IN. Having FOK, the searcher feels the current unavailability of memory information [43], i.e. knowledge insufficiency, which is, in definition, a premise for IN to arise. According to Taylor [54] searcher's inquiry is based on the underlying "area of doubt", implying the absence of confidence and increased uncertainty. In ASK Model [4] the realisation of anomaly is often accompanied by feelings of doubts and uncertainty, which are hard to express, but paradoxically seem to act as triggers of one's engagement in a search scenario. Following the notion that INs reflect what the user knows [60], FOK represents an estimate of what the user thinks he/she knows or believes to know. FOK is, therefore, sensibly a relevant state of knowing to investigate in relation to IN realisation. However, being an estimate implies its inherent nature of uncertainty and broadly supports the variable cognitive feelings the searcher experiences during a search process [29, 30]. The accuracy of FOK is therefore not guaranteed as it is influenced by uncertainty. Under- or overconfidence of user's FOK contributes to this aspect which might result in the Illusion of Knowing [2] effect, i.e. what we thought we knew was wrong and could be transformed later as IN.

2.3 Recognition based on Mnemonic Cues

Ingwersen [20] analysed the cognitive aspects of IN and stressed the roles of the user's memory recall and recognition capabilities to support the process of IN realisation. Kuhlthau referred to topical knowledge of the user as a "personal frame of reference" ([29], p.361) playing a vital part in the constructive process of problem solution-finding.

In our study, the participants accessed their declarative memory [51] to answer a question of general knowledge requiring a factual memory search. Declarative memory stores facts and events [52, 57]. This type of memory was found to be used to express TOT-type of INs [1]. Recognition according to mnemonic cues serves to i) enhance the correct MR or ii) act in the opposite direction by using distractors (e.g., incorrect answer choices). Depending on the outcome, we can deduce the strength of one's memories, accuracy of their initial metamnemonic feelings, FOK and support the user in reducing knowledge misconceptions, e.g. Illusion of Knowing [2] and assumptions [8].

2.4 Task difficulty

The task difficulty is a common attribute of the context of information search [49, 50]. Such parameters can be manipulated to investigate their effects on the search outputs, such as query difficulty [31]. The difficulty was also used as a target measure when search behaviour patterns were explored to detect the task difficulty [17]. Several behavioural studies using a Q/A format have indicated that question difficulty and metamemory performance are linked [9, 44, 47]. The findings suggest that general knowledge questions evaluated as objectively difficult elicited higher FOKs compared to easy questions. Moreover, participants provided overconfident FOK in answers to difficult questions [44]. Also, in terms of metamemory accuracy, the highest accuracy was reached for the easiest questions, and the lowest for the difficult questions [7]. From the search and IR perspective, the interplay of specific cognitive states of knowledge, such as FOK, MR and the contextual challenges as determined by task difficulty, has not yet been established.

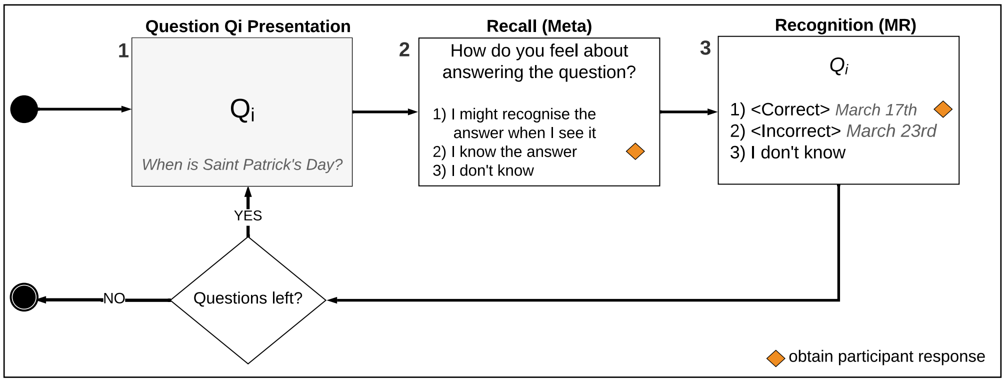

Figure 1: The flowchart diagram diagram of the task structure with a question example.

In our study, we manipulated the difficulty of the questions to explore if the proportions of evoked metacognitive and cognitive responses were moderated by such input attributes.

3 METHODOLOGY

3.1 Factors

We developed an interactive Q/A system of general knowledge graphically presented in 1 that collects the participants' behavioural data. Our experimental study applied a within-subject design. It accounted for a 2x3 factorial design of independent variables constructed to address our research objectives. By limiting the space of available levels in each factor (i.e., the response space) we had control over the categorisation of users. Each response the participant recorded was, thus, assigned to one level from each factor aligning with the participant's perception of knowledge for a given question:

1. Recall - METAMEMORY (Meta)
   A. I recall (KNOW)
   B. I might recognise the answer when I see it (FOK)
   C. I do not know (NKNOW)
2. Recognition - MEMORY RETRIEVAL (MR)
   A. Correct (MR-C)
   B. Incorrect (MR-I)
   C. I do not know (MR-N)

The dependent variable was the proportion of responses each participant generated in a session (one session consisted of 120 trials) for each level of the two factors above.

3.2 Participants

Twenty-four healthy volunteers participated in the study. There were 17 females (71%) and seven males (29%) within an age range between 18 and 39 years and a mean age of 24 years (sd 6). These were students enrolled in different university programmes (66.70 % of Undergraduates, 25% of PhD students and 8.30% of MSc students). Over half of the participants, 54%, studied for a Psychology or Psychology combined degree, followed by 25% of students of Computer and Information Sciences. All participants met the inclusion criteria: 1) age between 18 – 55 years and 2) fluency in English. Each participant received an Information Sheet explaining the experiment procedure. Participants became aware of their rights and were asked to sign an informed consent before participating in the study. Ethical permission to carry out this study was obtained from the University of Strathclyde Ethics Committee.

3.3 Q/A System

The interactive Q/A system which ran the Task (see Section 3.5.1) was developed for this experiment. It used the input of 120 questions of general knowledge which we now proceed to describe.

3.3.1 Q/A Dataset. At first, we constructed a raw dataset consisting of 180 questions of general knowledge. The questions were taken from the following sources: (1) TREC-8 and TREC-2001 Q/A Track [1] (50% contribution to whole data set) and (2) B-KNorms Database[2] (remaining 50% of questions). The former is widely applied in in IR studies [38], and the latter has been used in the investigations of cognition and learning studies [9]. The questions were of open domain and closed-ended answer. Each question had assigned a correct answer (MR-C) and an incorrect answer (MR-I) taken from the aforementioned sources. An example of such a question: "When is St. Patrick's Day?" with the correct answer: "March 17th" and the incorrect answer: "March 23rd". They covered a diverse range of categories: History, Science and Technology, Geography, Culture and Art. The questions' Difficulty attribute was assessed by two independent assessors (with Cohen's Kappa measure of inter-rater reliability of 0.61). They were supposed to judge if the question was generally easy or difficult to recall the answer straightaway. The assessors were not given the answer choices for each question. We selected 120 questions where annotators' judgments matched as our final set to the Q/A system. Additional five questions were used for the practice session. The questions were equally distributed between easy (60) and difficult (60). Here is an example of a Difficult question from the dataset: "What is the length of the coastline of the state of Alaska?" and an Easy question "What primary colours do you mix to make orange?". We used the Difficulty attribute to manipulate the distribution of the first

[1] https://trec.nist.gov/data/qamain.html
[2] https://www.mangelslab.org/bknorms

Table 1: Distribution of questions in the Q/A Dataset according to their length

Question Length (Word Count)	3	4	5	6	7	8	9	10	11	12	13
Question Count	13	7	8	9	9	15	17	10	8	14	10

set of responses concerning the metamnemonic states of knowledge (Meta). We expected that different perceptions of knowledge were going to be triggered by different levels of difficulties, such as easy questions triggering more recalled responses (KNOW) and difficult ones, more not-recalled (NKNOW) responses. FOK level is in general more challenging to predict. As FOK was found to be sensitive to input difficulty levels [9, 10], we expected that higher levels of FOK would be observed at the intersection of the two levels of difficulty, for instance, when a strong feeling of a later recollection at the users prevails. Section 4.5 provides the behavioural responses distributed by their assigned Question Difficulty. The difficulty attribute only controlled the distribution of Meta factor. The mnemonic cues (answer choices) in the Recognition part were only used to enhance the retrieval and were not applied to control the distribution of MR factor. We recognise that in each pair of the MR-C and MR-I answer choices, one of the choices might have felt more obvious than the other and influenced the increase of MR-C by guess. The present study did not account for this separation.

The question length was measured by the number of words the question consisted of. The question length ranged from three to thirteen words. Some of the questions taken from source (2) were syntactically modified to fit the question length limit.

Preliminary Analysis of the effect of Question Length. Q/A Dataset was not balanced following the question distribution by Question Length (see Table 1). To balance out different question counts across question length and avoid counter-effects, we divided mean response numbers in each Question Length category by its respective Question Count number (Table 1). Initial analyses of the data using ANOVA did not reveal any significant main effects (F=1.822, p-value=0.12) of Question Length on the mean volume responses categorised by their respective knowledge awareness they produced (see Meta levels in Section 3.1). In addition, Pearson's Chi-squared test was conducted to test the potentials association of the knowledge awareness (Meta levels) with Question lengths, e.g. to see if shorter questions would attract more Know-type responses. The results were however not significant (χ^2 = 24.8, df = 30, p-value=0.7). We, therefore, focused our analyses on the hypothesis concerning the effect of Question Difficulty and, thus, collapsed data across the question lengths.

3.4 Procedures

After signing the consent form, participants completed two questionnaires requesting demographic information, their habits with information searching and search engines. Participants then underwent the practice session, which ensured a general understanding of the procedure and familiarity with the task structure. The practice session resembled the main experimental task (see Section 3.5.1). The practice session consisted of 5 questions, was not limited by time with the option to repeat it until feeling comfortable to proceed to the main session. After the main session, there was a debriefing session and participants were required to fill out a final post-task questionnaire related to their subjective perception of the task. Responses were entered by the participants via a computer keyboard with keys previously allocated to each option. Question order, as well as the answer options on the screen, were randomised across participants. Participants were advised to take 2 breaks (after completion of 1/3 and 2/3 of questions) by a notification on the screen to avoid fatigue. Participants completed the task (without the breaks) on average in 44 min (sd=4.62, med=43.40).

3.5 Overview of Experimental Pipeline

In the following section, we provide an overview of the flow of the Q/A Task, termed as "Main Task", to which the participants were subjected.

3.5.1 Main Task. As was explained in Section 2.1, our study adapts RJR in the Q/A Task of general knowledge. An interactive Q/A system was developed to run the task. Figure 1 illustrates the trial sequence. Each participant was subjected to 120 trials (i.e., 120 questions from Q/A Dataset described in Section 3.3.1). Every trial followed the same order of steps: Step 1 *Question Presentation*, Step 2 *Recall (metamnemonic judgments*, Step 3 *Recognition (memory retrieval)* based on a set of mnemonic cues individual for each question from the Q/A Dataset. Behavioural responses collected in Steps 2 and 3 were assigned to a corresponding level of each factor (Section 3.1).

Trial. The trial started with an on-screen question Q_i randomly selected from the Q/A Dataset (Section 3.3.1). Participants were instructed to make a first response (Screen S2 in Figure 1) by selecting one of the options, in random order, that best described their current ability to answer the question: A. *I recall the answer* (KNOW), B. *I might recognise the answer when I see it* (FOK), C. *I do not know the answer* (NKNOW). Here we captured the responses related to participants' metamemory recall outcomes, including the option FOK as the prospective judgment of future knowledge.

After the response was made, Step S3 followed where participants were requested to choose a correct answer to the question from three on-screen mnemonic cues, which in random order represented A) correct answer to the question (MR-C), B) incorrect answer (MR-I) and C) the default option for the participant to acknowledge they did not know, respectively could not recognise the correct answer (MR-N). The output of each session was a file that stored the sequence of question numbers, the corresponding responses and timestamps. Data were generated automatically whilst the participants performed the task.

3.6 Analysis

We created a mixed linear model with the parameters mentioned in Section 3.1 analysing the distribution of the participants' behavioural data assigned to the levels from the factorial design. We then performed statistical analysis using ANOVA repeated measures with posthoc tests using Bonferroni corrections and further tests of associations between individual steps of the task.

4 RESULTS

4.1 Q/A Perception

In general, the participants agreed that the Q/A dataset was an appropriate mix of easier and more difficult general knowledge questions. For reference we selected a few of the participants' comments:

"Topics varied widely, which was very interesting as there was quite a mix of things I knew and things I did not."

"Varied, some answers I thought I knew and I was wrong and vice versa."

"A good mix of things which were Easy and there which were hard; even if I got the wrong answer, I could tell it was a question of a low/high calibre."

"Some were hard, some were Easy. I knew the answer to a couple after the answer was given."

4.2 Distribution of Behavioural Responses

Aggregated participant data in Table 2 presents the distribution of responses according to factorial design established in Section 3.1. Starting with the 1st factor, Meta levels, on average, participants recorded most of the FOK responses, 43% (sd 12), followed by 29% (sd 11) of NKNOW. The lowest amount of responses was of KNOW, 28% (sd 15).

Table 2: Distribution of responses (average per participant) per levels of the factors

META Level	*% of Overall Responses*	*MR Level*	*% of Relative Responses*
KNOW	28	MR-C	82
		MR-I	17
		MR-N	1
FOK	43	MR-C	60
		MR-I	30
		MR-N	10
NKNOW	29	MR-C	31
		MR-I	25
		MR-N	44

We visually inspected histogram of Meta levels distribution (see Figure 2) and noted that whilst FOK and NKNOW levels seem to be normally distributed, shape of KNOW is following a bimodal

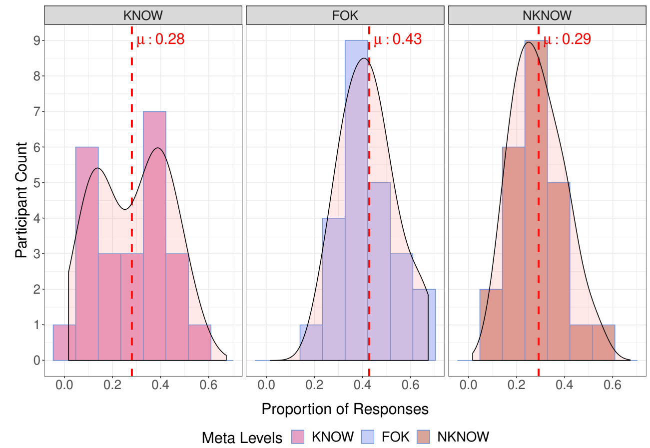

Figure 2: Histogram of responses per Meta levels

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distribution. As a reliable measure we used normality test, Shapiro-Wilk test, prior to deciding upon a test of a significant difference. The results showed that data distribution were not significantly different from the normal distribution.

We ran ANOVA repeated measures over the individual participants' data to statistically evaluate if there was a significant difference between participant volume of responses across the Meta levels. The results proved to be significant (F[2,46]=6.62, p<0.01), and the subsequent post-hoc test revealed that participants, on average, recorded a statistically significant higher amount of FOK responses in comparison to KNOW (p-value<0.01) and NKNOW (p-value<0.01) responses.

The majority of FOK responses were most commonly followed by correct retrieval, MR-C (60%), then by the MR-I responses (30%) and finally by the MR-N responses (10%). KNOW responses provide a similar pattern. The majority of KNOW responses were MR-C (82%), followed by MR-I (17%) and MR-N (1%). As expected, 44% of NKNOW responses were followed by the responses of MR-N level. However, 31% and 25% of the NKNOW responses fell within the MR-C and the MR-I levels, respectively. The question then appears, "What does drive a participant to acknowledge an anomaly in the state of knowledge when later, such knowledge proves available?". This effect is likely related to the impact of mnemonic cues representing a shift from Recall to Recognition, where the cues act as stimuli to the user's recollection. The information contained in the cue impacts the user similarly as the information the user receives and evaluates as part of the IR output.

We now proceed to expand on the outcomes of Table 2 using the correlation analysis.

4.3 Associations

Table 2 indicates some prominent relationships between Meta and MR, such as responses that were recalled (KNOW) seem to attract positive recognition of a correct memory cue (i.e., 82% of MR-C). We also found some less-anticipated results, such as 31% of all, not recalled responses (NKNOW) were correctly recognised (MR-C).

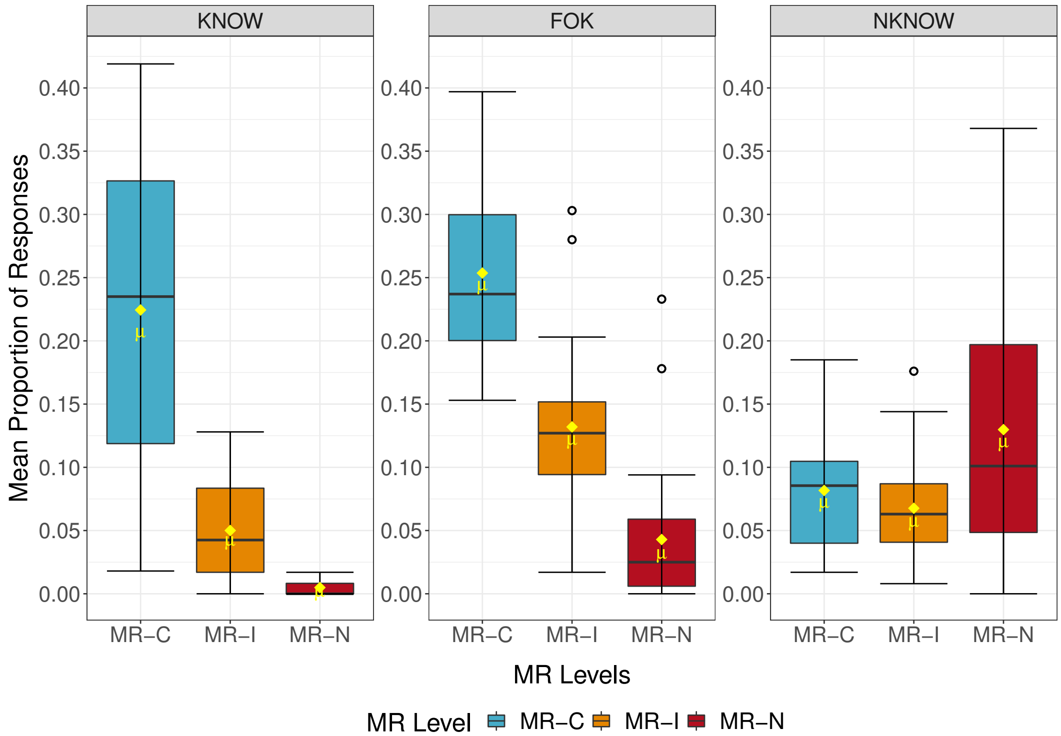

Figure 3: Distribution of responses per Meta and MR levels

To test the statistical significance of the Meta levels and MR associations, we conducted Pearson's Chi-squared test to test the correlation between paired samples based on the significance level of the correlation and the calculated correlation coefficients R. We only report on pairs with statistically significant correlation and with at least "Moderate" correlation ($0.40 < |R| < 0.59$). We account for a "Strong" correlation when $|R|$ is at least 0.65 and "Very Strong" when $|R|$ is over 0.80. As anticipated, the results show a strong positive correlation (R=0.70, p-value<0.001) between KNOW and MR-C responses, meaning the KNOW responses were most likely to be followed by the recognition of a correct memory cue (MR-C). The opposite effect of a moderate negative correlation was found between KNOW and MR-N (R=−0.42, p-value<0.05) when an increase in KNOW was moderately associated with the decrease of MR-N responses. Furthermore, as we would expect, NKNOW was significantly strongly negatively associated with MR-C (R=−0.68, p-value<0.001), meaning more NKNOW responses would be likely associated with less correctly recognised responses, MR-C. On the opposite side, we found a less strong positive correlation with MR-N responses (R=0.61, p-value<0.01), meaning an increase of initial NKNOW responses was associated with an increase in MR-N responses, meaning no recognition.

In relation to FOK, we did not confirm any, at least a moderate, correlation with MR levels. This outcome supports only a relatively accurate character of FOK measure [14] possibly associated with weak or even false memories, which at the time of the recognition test emerged and resulted in a negative prospect of FOK. This reinforces the notion of a conservative approach to knowledge awareness, as having FOK was not found predictive of MR.

We now proceed to expand on the findings to test the statistical significance of differences between participants' responses and the effects of the interaction between pairs of Meta and MR.

Summary. First, the participants were most accurate when providing KNOW or NKNOW answers as the two definite recall states [34]. In the first case, KNOW, participants' initial KNOW recall awareness matched the recognition of the correct answer MR, as given by a high correlation between KNOW + MR-C, which can be translated as a sequence of: I know the answer (NKNOW) - I recognise the correct answer (MR-C). In the second case, NKNOW, participants most likely did not recognise the correct answer as given by a high correlation between NKNOW and not recalled (MR-N) answer, i.e. I do not recall the answer - I do not know (recognise) the answer (MR-N). The accuracy suggest that KNOW and NKNOW are good predictors of current and future knowing and not-knowing, respectively. In the case of NKNOW, this might also explain the reason why do the searchers engage in a search as they believe they do not know something and are likely to be right.

Second, we address the outcomes related to FOK as the intermediate state of recall [34] which implies the temporary unavailability to recall the information with a future prospect to recollect. Here, we did not confirm any, at least a moderate correlation, with MR levels. These outcomes support only a relatively accurate character of FOK measure [14] possibly associated with weak memories [56], which at the time of the recognition test emerged and resulted in a negative prospect of FOK. This reinforces the notion of a conservative approach to knowledge awareness as having FOK was not predictive of MR.

We now proceed to expand on the findings to test the statistical significance of differences between participants responses to test the interaction effects between pairs of Meta and MR.

4.4 Interactions of FOK and Recognition to Determine Accuracy of FOK

To answer our RQ of the accuracy of FOK, we conducted ANOVA repeated measures to test the interaction effects between Meta levels and MR levels. Figure 3 shows the interaction plot contrasting the mean proportions of MR responses in each Meta level.

First, to report on the main effects of two independent variables separately. The results revealed a significant main effect of Meta levels (F[2,207]=10.48, p<0.001). The post-hoc pairwise contrasts specified that the mean proportion of FOK responses was significantly higher than of NKNOW (p<0.001) and of KNOW (p<0.001). Next, the main effect of MR levels was also found to be highly significant (F[2,207]=60.23, p<0.001), with post-hoc analysis specifying that the mean proportion of MR-C was significantly higher in both pairwise contrasts, with MR-I (p<0.001) and MR-N (p<0.001).

We found the interactions of Meta levels and MR levels caused significant differences (F[2,2,4,207] = 30.02, p<0.001) in mean proportions of response with pairwise post-hoc tests specifying the direction.

- First, there were two significant interaction effects for KNOW level. The pair of MR-C and MR-I resulted in a significantly higher (p<0.001) proportion of responses of MR-C (μ=0.22) in contrast to MR-I (μ=0.05). The the same effect (p<0.001) we found between MR-C and MR-N (μ=0.005).
- For the FOK level, we found all MR pairwise contrasts to be significant. Specifically we found statistically significant differences 1) between the pair of MR-C (μ=0.25) and MR-I (μ=0.13) responses, with the former being significantly higher (p<0.001); 2) the same effect (p<0.001) between MR-C and MR-N (μ=0.04) responses; and 3) between the pair of MR-I and MR-N with the former being significantly higher (p<0.001).
- For NKNOW, we found two pairs of MR levels with statistically significant contrasts: 1) pair of MR-C (μ=0.08) and MR-N (μ=0.14) responses, with the mean of MR-N being significantly higher (p<0.01) and 2) pair of MR-I and MR-N caused by statistically significant (p<0.001) lower MR-I proportion (μ=0.06) in contrast to the mean proportion of MR-N.

For FOK as our main level of interest, we found a significant difference contrasting all following pairwise MR effects. The higher number of responses of type MR-C, significantly different from the rest of MR levels, indicates FOK's relatively good accuracy in predicting recognition of a correct answer. An alternative view provides the analysis from the perspective of MR levels.

The majority of all MR-C responses were preceded by FOK level (μ=0.25) and KNOW level (μ=0.22), without a pairwise significant difference (p=0.5). This could suggest that recognition of the correct stimulus, MR-C, can be initiated equally likely by FOK or KNOW. With respect to FOK, this suggests that FOK can be a predictor of knowing. The difference occurs in the contrast of Meta levels that evoked MR-I level. Here, KNOW responses (μ=0.05) were significantly lower (p<0.001) in contrast to FOK responses (μ=0.13), and the same effect was found contrasting NKNOW (μ=0.06) and FOK, revealing that the proportion of MR-I preceded by FOK was significantly higher (p<0.01). FOK is then most likely to result in Illusion of Knowing [2] reflecting the user's negative estimation of FOK and future recognition. At last, the pairwise contrast between Meta levels that evoked MR-N level revealed two statistically significant differences (p<0.001) driven by the highest mean of NKNOW responses (μ=0.14) in contrast to the mean of KNOW (μ=0.005) and the mean of FOK (μ=0.04). This evidence confirms the findings from earlier, suggesting that the participants whose initially did not recall the answer (NKNOW), were significantly more accurate (MR-N).

4.5 Effect of Question Difficulty on FOK

In this section, we look at the distribution of behavioural data in association with the input (question) attribute, Question Difficulty. We aim to explore how this attribute affected the participant distribution of Meta levels (Recall) as the first trigger to evoke the user's knowledge perceptions with the questions. In particular, we discuss the results in relation to FOK level as our main concern per RQ2. Particularly, we are interested if the variability of Question Difficulty is a significant factor affecting the perception of knowing, as given by Meta levels.

Questions were equally distributed into two levels: Easy and Difficult. Figure 4 presents the mean proportion of responses in a session (i.e., 120 trials) in each Meta level divided by their respective Question Difficulty (E - Easy, D - Difficult) attribute.

The constructed linear model included the main effects of Meta levels and Difficulty attribute and their interaction with the aim to find any significant differences between the mean proportions of Meta levels triggered as the effects of Question Difficulty. ANOVA repeated measures found several effects with variable significance within this data. First, there was no significant difference triggered by the main effects of Difficulty levels (F[1,138]=1.01, p-value=0.32).

Second, similarly, as in previous analyses, we found the recurring effects of Meta levels (F[2,138]=16.8, p<0.001). The questions from our Q/A Dataset attracted significantly more (p<0.00 1) responses of FOK (μ=0.21) than the remaining levels KNOW (μ=0.14) and NKNOW (μ=0.15). In addition, we have found a significant interaction between Meta level and Difficulty level (F=12.95, p<0.001). The pairwise contrasts of the interaction revealed these outcomes:

- Statistically significant difference between the proportions of Easy questions of KNOW (μ=0.19) and Easy questions of NKNOW (μ=0.12), with the former being significantly higher (p-value<0.05).
- Statistically significant difference between a pair of Easy questions resulting in FOK (μ=0.21) and NKNOW (μ=0.12), with the latter's proportion being significantly lower (p-value <0.001).
- Statistically significant difference between the proportions of Difficult questions of KNOW (μ=0.10) and NKNOW (μ= 0.17), with the latter being significantly higher (p-value<0.01).

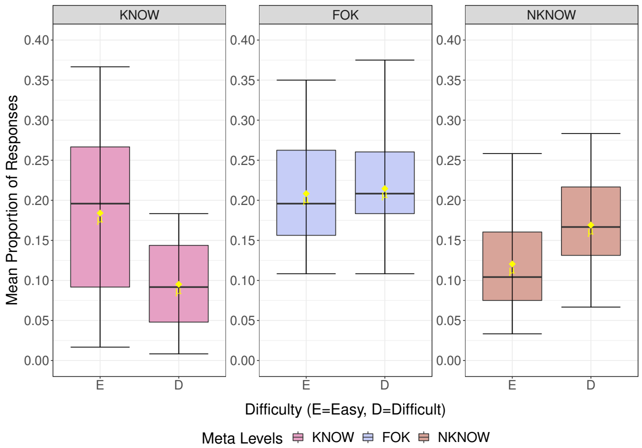

Figure 4: Proportion of responses within a session by Meta levels and their assigned Question Difficulty attribute

- Significant difference between a pair of Difficult questions resulting in FOK (μ=0.22) and KNOW (μ=0.10), with the former proportion being significantly higher (p=0.001).
- Significant difference (p-value<0.001) within KNOW level, where Easy questions (μ=0.19) triggered a significantly higher proportion of KNOW responses than Difficult questions (μ= 0.10) of the same Meta level.
- At last, no significant differences were found (p-value=0.8) between the proportion of Easy (μ=0.21) and Difficult questions (μ=0.22), which resulted in FOK level as well as no significant difference (p-value=0.3) between a proportion of Easy (μ=0.12) and Difficult questions (μ=0.17) which resulted in NKNOW level.

4.6 Summary

The results provide evidence of our initial resolution to create a balanced Q/A dataset in terms of question Difficulty (see Section 3.3.1). The findings affirmed our expectations: 1) Easy questions were associated with higher volumes of participants knowing the answer (KNOW) or feelings they might know the answer (FOK), and 2) Difficult questions were associated with a higher volume of not recalled answers. No significant differences were revealed between the levels for FOK and the levels for NKNOW differentiated by difficulty. This could suggest that if the searcher is uncertain (FOK) or predicts the lack of knowledge (NKNOW), the contextual difficulty seems less relevant. The significant contrast between levels of KNOW suggests that the user perceives the difficulty when having certainty about the output (KNOW).

In addition, we found that the frequency of FOK is higher than of KNOW for difficult questions, whereas, for easy questions, the frequency of FOK is higher than the frequency of NKNOW responses. First, the contrast of FOK and KNOW for difficult questions suggests that participants were less certain in their knowledge, causing FOK with implied uncertainty to emerge (FOK > KNOW). Participants decided (FOK) believing that a further stage, i.e. recognition (MR), confirms their FOK, i.e. they will recollect the answer and, thus, reduce the uncertainty. Second, having easy stimuli, participants chose to be more optimistic. Even though they felt they did not know the answer right away (NKNOW), they felt positive about their recognition (FOK > NKNOW). For IR, this could imply an expansion of the research of users' interactions with queries, as the representations of what the user needs to know, e.g. recognition of user's knowledge awareness differentiated by a query quality or query reformulation strategies.

5 DISCUSSION AND CONCLUSION

The present study supplies IR research with a functional framework of underlying processes determining the user's realisation of the state of knowledge as a response to a question of general knowledge. We now proceed to conclude the major finding and discuss their impact on IR.

5.1 Research Question 1

FOK was the most commonly perceived metamnemonic state, significantly more frequent than the remaining two. Our data suggest that FOK is a relatively good predictor of the correct cue retrieval. Knowing (MR-C) was found to be equally likely evoked by KNOW as well as FOK levels. Our data (30% of FOK responses were followed by MR-I) also confirm the Illusion of Knowing effect [2] which could potentially increase the chance for (delayed) INs to rise in the future, i.e. to reevaluate one's perception of whether they know or not know the information in question. This idea opens up a discussion for IR research on how to i) incorporate novel cognitive states [1], e.g. TOT-type of IN, FOK-type of IN, into the user-system model and ii) address improved support for the users in these states. IR system should support propagating a strong positive sense of FOK in users [32] and increase the confidence. IR has, in a sense, a subconscious effect on the user, including their affective and cognitive feelings, such as uncertainty [29]. Orientation to reducing uncertainty and increasing users' confidence in the IR process should be further investigated as part of the users' cognitive indicators of INs and satisfaction with IR performance.

In addition, the effects of metamemory and cognitive states of knowledge can further help to expand on the idea of variants of anomalies in ASK [4]. The magnitude of FOK rates [24] can be considered as an extension of this study in relation to IN and, thus, create a more granular spectrum of states of knowledge awareness.

Furthermore, the findings suggest that mnemonic cues positively affected the participants' recognition and contradicted, thus, some of their initial epistemic feelings. We saw these effects were significant for NKNOW, where mnemonic cues enhanced the factual retrieval (56% of the cases) or in the case of FOK, 10% and 30% of these were either not recognised (MR-N) or, respectively, recognised wrongly (MR-I). Our findings revealed that the significantly highest amount of FOK responses was followed by correct responses (MR-C). However, this pair was not found to be significantly associated.

The quality of the mnemonic cues might affect IR. Mnemonic cues can be interpreted in the IR context as keywords, document snippets or metadata. IR process should utilise them in the retrieval process to enhance the efficiency of the retrieval and its output.

The IR process could, thus, contribute to several areas of user's information search experience: 1) support the factual MR of IR users where the retrieved information contributes to what they already know [29]; 2) active learning [19] focusing on the user's document-interaction journey to generate new knowledge and aiming to reduce the user effort to find the relevant documents whilst increasing the retrieval accuracy [55, 61]; and 3) avoid misattribution of information which might then negatively impact the knowledge generation, e.g. by validating the mnemonic cues and documents annotations.

5.2 Research Question 2

We have found numerous significant differences in pairwise contrasts of Difficulty and Meta level, which were reported and discussed in Section 4.5. In conclusion, the searcher's knowledge awareness (Meta levels) seems to be affected by the Questions' Difficulty to a different extent, most prominent between KNOW and NKNOW, where Easy questions are likely to trigger KNOW and Difficult questions, on the other hand, more of NKNOW. Question Difficulty seems to be a driver of knowing and (un)certainty and, thus, differentiating between KNOW or FOK (difficult questions) with participants being more conservative (FOK > KNOW) and between NKNOW and FOK (easy questions) where participants were more optimistic (FOK > NKNOW). To answer the RQ2 concerning FOK level, we did not find any significant differences between the volumes of FOK separated by the Question Difficulty. Also to note, the proportions of FOK responses for both Easy and Difficult questions were the highest out of all remaining Meta levels. Future studies could, similarly to other works [7, 18] expand on the grades of FOK (low - high) to observe the associations on a larger scale.

5.3 Conclusion

In conclusion, this work investigated the role of metacognition in the realisation of users' states of knowledge and how informative they can be as an input to the user information seeking/search process. Particularly, we focused on the concept of FOK and its informativeness as part of the user's cognitive context. To do so, we analogised the idea of memory cues to the retrieved information since they are meant to evoke cognitive mechanisms of information processing, e.g. remembering and encoding. We devised a user study where twenty-four participants engaged in a Q/A task of general knowledge. Our findings show a high correlation between the prior Recall state (metamemory) and the Recognition (memory retrieval), providing insight into the accuracy of metamnemonic states of knowing. We also observed that memory cues significantly helped the participants to select correct answer choices even for the scenarios where they have identified they do not have the prior knowledge. These findings have important implications for IR since they show the effects of memory cues in enhancing memory retrieval and, in turn, satisfying different ASK states. We understand that the user needs different support to find the right information depending on many contextual factors. The cognitive context [22, 23] was the one that was investigated in this paper. This decision was made due to its inherently subjective nature, which makes it challenging to be specified to an IR system. The information about the user's cognitive context in a given search scenario would positively contribute to the user-centric adaptable IR systems and improve user search satisfaction.

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