

Bringing Psychological, Affective and Motivational Relevance Frameworks to Real Information Retrieval Systems

Oswald Barral

*Helsinki Institute for Information Technology HIIT,
Department of Computer Science, University of Helsinki, Helsinki, Finland*

1 RESEARCH PROBLEM

The concept of relevance has been widely studied in the field of information science and a strong theoretical background has been developed around it. It is recurrent to find distinctions between objective relevance, which is intrinsically dependent on the item to evaluate; and subjective relevance, which is dependent on the perception that the user has of such item. Information systems, namely information retrieval systems, are commonly based on objective, algorithmic relevance metrics. These metrics are especially well suited as they are easily quantifiable measures of relevance. Nevertheless, objective relevance alone is far from indicating the real relevance of an item in a given context. It is evident that subjective relevance assessments play a strong role in the success of an information-seeking task. Subjective relevance has multiple facets, and in the proposed research we aim to address a component that has been defined in the literature as affective, psychological or motivational relevance. It can be understood as the relationship between the user's current emotional and cognitive state and the information item. By studying this component, we tackle directly the information need and its relationship between the user's current emotional, cognitive and affective state. To give a simple example, during a complex information-seeking task, an item can be perceived as relevant when the user is engaged into the search task, but perceived as irrelevant when the user feels overwhelmed, frustrated or bored.

2 OUTLINE OF OBJECTIVES

In the present research we aim to apply state-of-the-art physiological computing techniques in order to model psychological, affective, and motivational relevance. That is, we want to infer the users' cognitive, affective and emotional state while engaged in an information-seeking task by analyzing their psychophysiological responses associated with the pre-

sented information items. Such states will be modeled in the system allowing for an online bio-cybernetic loop between the user and the system (adapting the information space, retrieval engine and user interface accordingly). By doing so, we aim to enhance the performance of current information retrieval systems in complex search scenarios such as exploratory search tasks, while improving user experience.

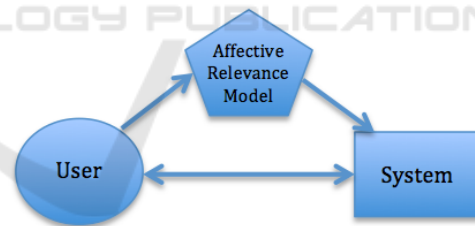


Figure 1: Overview of the proposed ecosystem. The psychophysiological responses of the user while interacting with the system are fed into the affective relevance model, which is inputted to the system. The information presented to the user is therefore influenced by his/her own cognitive, affective and motivational state.

3 STATE OF THE ART

In information science, relevance has been theoretically analyzed in depth over the past forty years. Saracevic (Saracevic, 1975) carried out the first comprehensive review in information science around the concept of relevance back in 1975. He compiled relevant work mainly from the two previous decades, addressing relevance from philosophy all the way to relevance in information retrieval systems. Additionally he aimed at providing a framework to study relevance within the field of information science. Later on, Saracevic updated his review as the field was growing and the discussion was enlarging (Saracevic, 2007a; Saracevic, 2007b). However, Saracevic has not been the only researcher to study the multifaceted aspects of relevance. Schamber (Schamber, 1994) or Mizzaro

(Mizzaro, 1997), are examples of authors that made a substantial contribution during the 90's by writing comprehensive and historical reviews on relevance. We encourage interested readers to go through their work in order to gain a deeper insight in the history of relevance in information science.

A large consensus exists within the community in considering relevance as multifaceted, dynamic and with a high subjective component (Saracevic, 1997; Mizzaro, 1998; Ingwersen, 1996; Cosijn and Ingwersen, 2000; Borlund, 2003; Borlund and Ingwersen, 1998). In the following sections, we will tackle some of the subjective aspects of relevance, leaving out of the analysis objective and algorithmic measures of relevance. Specifically, we will go through three relevance components addressed in the literature by different authors, that are highly related and interconnected, and which we believe can be studied together. These components define the relationship between the user state, the information need and the information item.

3.1 Psychological Relevance

The concept of psychological relevance was first raised in cognitive sciences, in the popular book "Relevance: Communication and Cognition" by Sperber and Wilson (Sperber and Wilson, 1986). In the book, the authors define a framework for relevance in communication and cognition theory, based on the assumption that human cognition only pays attention to potentially relevant information. They argue that relevance is framed in the cognitive system according to comparisons between assumptions and a particular cognitive state. In 1992, based on their theoretical framework, and borrowing some of their theoretical definitions, Harter defined psychological relevance applied to the field of information science (Harter, 1992). He used the concept of *relevance of a phenomena*, elaborated in the above-mentioned book by Sperber and Wilson, as a mainstay for his definition. In plain words, this concept refers to the fact that phenomena have a direct impact on the person's cognitive state, and therefore affect his assumptions by making them stronger or more manifest.

Harter defined psychological relevance in information science as follows: "*Psychological relevance allows us to talk about an 'information need' as the current context –the cognitive state at a given time– of an individual who consults an information system*" (Harter, 1992). In his work, he illustrates through examples how the cognitive state of an individual has a direct impact on the perceived relevance of information items. Moreover, he makes a distinction be-

tween relevance and "*weak relevance*". In Harter's view, relevance occurs when the fact of accessing an information item implies a direct modification of the user's cognitive state. However, *weak relevance* occurs when the user anticipates a change on his cognitive state, even though accessing the information item does not imply a direct modification of the cognitive state. Other variants of the concept of psychological relevance are well illustrated by Harter through well-elaborated examples.

Harter's definition has been present in the work of other researchers, mainly when reviewing the literature, but it has not had so far a direct implication in the implementation of information retrieval systems. In the following paragraph, we would like to cite other authors when rephrasing Harter's definition of psychological relevance. By doing so, we hope the reader will gain a clearer understanding of the concept.

In her review, Schamber (Schamber, 1994) rephrased Harter's concept of psychological relevance as follows: "*Psychological relevance assumes that users are actively seeking information that will change their internal context or store of knowledge, and that if an information item does this, users will perceive it to be relevant*". Saracevic (Saracevic, 1996) pointed at Harter's definition in the following terms: "*Psychological relevance is viewed as a dynamic, ever changing interpretation of information need in relation to presented texts. It is based on an assumption (stated as fact) that the 'searcher's cognitive state changes and evolves with the discovery of each relevant citation'.*" In fact, Saracevic proposed the term "*cognitive relevance*" for the concept, as he argued that the focus was on cognition, rather than on psychology. Finally, to summarize, it is pertinent to cite Mizzaro's reference to Harter's work (Mizzaro, 1997): "*Harter (1992) applies the theory of psychological relevance, proposed by Sperber and Wilson, to the concept of relevance in information science. He obtains an elegant framework and draws some very interesting conclusions for IR and bibliometrics.*"

3.2 Affective and Motivational Relevance

As we just discussed, psychological relevance describes the relationship between the users' prior knowledge and cognitive state, and the information item. Instead, affective or motivational relevance is defined as the relationship between the users' intents goals and motivations, and the information item (Saracevic, 1996; Cosijn and Ingwersen, 2000). Therefore, affective or motivational relevance is goal oriented, and is dependent on the user's current cogni-

tive context (Borlund and Ingwersen, 1998). Saracevic (Saracevic, 1996; Saracevic, 1997) first adapted this term from Schutz's concept of relevance in philosophy (Schutz and Zaner, 1970). Schutz named "*motivational relevance*" as one of the three basic types of relevance, together with "*topical relevance*" and "*interpretational relevance*", that he defined when studying human relationships in the social world. According to Schutz, this kind of relevance is the one that defines the course of action, the action to be executed, the selection of a specific alternative. Saracevic extends and applies the notion to the field of information science. Moreover, he couples it with the notion of *affective relevance*, resulting in the following definition: "*Motivational or affective relevance is the relation between the intents, goals, and motivations of a user, and texts retrieved by a system or in the file of a system, or even in existence. Satisfaction, success, accomplishment, and the like are criteria for inferring motivational relevance.*"

Having said that, Saracevic's definition of affective relevance has not had an unanimous acceptance by the community. Researchers such as Cosijn and Ingwersen (Cosijn and Ingwersen, 2000) or Borlund (Borlund, 2003) have argued that the concept does not refer to a specific type or kind of relevance but, instead, should be seen as an attribute of relevance that influences all other types of relevance. For instance, Cosijn and Ingwersen argue that affective relevance might act as an additional dimension, influencing other subjective relevance types (such as situational relevance, utility, etc.). Following Borlund's point of view, which is in the same direction, motivational or affective relevance is actually the cause for users to search. Therefore, according to her, intent, goals and motivations have to be seen as a characteristic of all the types of relevance: "*Thus, the 'drive' to want information is not an independent, specific type of relevance, but an inherent characteristic of relevance behavior in general*" (Borlund, 2003).

Interestingly, Cosijn and Ingwersen (Cosijn and Ingwersen, 2000) discuss the fact that affective and motivational relevance should be considered as two different types of relevance. In their view, motivational relevance is indeed defining the goals and motivations of the user, hence is seen as an independent characteristic influencing all the other kinds of relevance. Affective relevance, instead, is related to the affects and emotions a user experience when in an information-seeking task. Namely, they link their understanding of affective relevance with Barry's empirical investigation (Barry, 1994), and her types of relevance identified as "*criteria pertaining to the user's beliefs and preferences*". Specifically, Cosijn and In-

gwersen link affective relevance to Barry's *affectiveness*, that she defines as any kind of emotional responses to any aspect of a given document.

3.3 Physiological Computing in Information Retrieval

Physiological computing has gained importance in the recent years. Researchers have studied how measuring psychophysiological measures can enhance information systems, by making the system aware of the user's cognitive, emotional and affective state (Allanson and Wilson, 2002; Fairclough, 2009; Fairclough and Gilleade, 2014). Eye tracking, pupillometry, electroencephalography, cardiovascular measures, electro-dermal activity or facial electromyography are some of the techniques used to measure and infer user emotional and cognitive state (Cacioppo et al., 2007). For example, recent research have shown how it is possible through different physiological channels (electro-dermal activity and pressure sensors, among others) to detect frustration (Kapoor et al., 2007). Electroencephalography has been studied to detect cognitive workload (Gevins and Smith, 2003) or motivational intensity and fatigue (Lorist et al., 2009), for instance. We believe that some of these metrics and computational techniques can be useful in order to address psychological, affective, and motivational relevance in the scope of a complex information retrieval system.

Studies have approached relevance prediction through psychophysiological signals, namely using eye gaze data (Puolamäki et al., 2005; Ajanki et al., 2009; Loboda et al., 2011). Others have used pupil size (Oliveira et al., 2009; Barral et al.,) and even recent studies have tried to predict perceived relevance of text items using EEG (Eugster et al., 2014) or EDA and fEMG (Barral et al., 2015). We would like to stress that in the present research, we are not so much interested in predicting relevance directly from psychophysiological data but focus instead on studying the relationship between cognitive states and perceived relevance, in order to model affective, psychological, and motivational relevance. This will indirectly allow for relevance prediction through psychophysiological data, but in a more informed way, as we will study which are the cognitive and affective states that have an impact on perceived relevance (Barral and Jacucci, 2014).

4 METHODOLOGY

The concepts of affective, psychological and motivational relevance have remained in the theoretical frameworks of information science as they have never been applied to information retrieval systems. In order to address this challenge, and in light of the broad literature regarding physiological computing and the strong theoretical background regarding relevance in information science, we base our research around the research questions stated below. We propose a methodology to answer each of these research questions, which are essential to address the above-mentioned research problem. These questions are presented in chronological order as, prior to solving each of the questions, the previous ones need to be addressed.

Q1. Which physiological measures and which cognitive states are best suited to indicate psychological, affective, and motivational relevance? We plan to thoroughly review the literature on physiological measures used to infer cognitive states in order to comprehensively identify which are the cognitive states that might potentially influence perception of relevance, and which are the physiological measures that are able to indicate them.

Q2. Which are the information-seeking scenarios where the modeling of psychological, affective, and motivational relevance is more pertinent in order to enhance current information retrieval solutions? We hypothesize that complex search tasks are best suited for taking advantage of psychological, affective, and motivational relevance metrics. Through user studies, we will measure different cognitive states such as level of frustration, motivation/engagement, confusion, etc. and their relationship with perceived relevance in different search scenarios in order to identify the search-tasks where the modeling of psychological, affective, and motivational relevance is more pertinent.

Q3. How to model psychological, affective, and motivational relevance? Once the information-search tasks and the cognitive states have been identified, we will define, implement and test several user models based on psychological, affective, and motivational relevance in order to discuss how these models can be applied to currently available information retrieval systems.

Q4. To what extent modeling and implementing psychological, affective, and motivational relevance in an information-seeking system enhances current information retrieval solutions? Once the scenarios and measures have been identified, and the models have been implemented, we plan to merge everything

together into a real information retrieval system that will make use of psychological, affective, and motivational relevance measures. We will test such system against current I.R systems in order to study whether the users' performance in the previously identified information-seeking tasks (Q2) improves.

5 EXPECTED OUTCOME

The main outcome of this research will be an information retrieval system especially designed to address complex information-seeking tasks. This system will make use of the users' cognitive state detected through physiological computing techniques in order to feed its psychological, affective, and motivational relevance model. The research will lead to a system that will outperform current information-seeking solutions by making use of such relevance model.

Additionally, several outcomes will arise from the research process while addressing Q1-Q4; namely, a comprehensive understanding of the different cognitive states suitable to model psychological, affective, and motivational relevance in order to better support users and enhance their performance while undertaking information seeking tasks in real scenarios.

6 STAGE OF THE RESEARCH

We have recently explored how relevance of information items can be inferred through electroencephalography (Eugster et al., 2014) and through electrodermal activity and facial electromyography (Barral et al., 2015). The outcomes of this research shows that, even if such physiological measures carry information regarding perception of relevance, their predictive power is still relatively low. We believe that one way to enhance the applicability of such techniques is, as exposed above, to study how the relevance of information items is perceived in relation to the cognitive, emotional, and affective states of the users. Thereof, the current research is focused in this direction.

Firstly, we are defining and designing a review of the literature regarding psychophysiological inference of cognitive states in HCI, in order to address Q1. Also, we are studying how motivational intensity affects the cognitive processing abilities when presenting text items in different layouts (eg. list, clusters, etc.), and how it is reflected in the physiology, by measuring electroencephalography, eye movements and pupillometry, electrocardiography and electrodermal activity. Next steps, and based on the outcomes

of the literature review, we will conduct further studies regarding users' cognitive states while engaged in information seeking tasks, that might be related with affective, psychological and motivational relevance such as arousal, frustration, confusion, etc.

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