Memory and Decision Making: From Basic Cognitive Research to Design Issues

Fabio Del Missier[1,2]

[1] Department of Life Sciences, University of Trieste, Trieste, Italy
[2] Department of Psychology, Stockholm University, Stockholm, Sweden
delmisfa@units.it

Abstract. This abstract summarizes the talk given at the International Workshop on Decision Making and Recommender Systems 2014. The talk discussed ways to bridge cognitive research and recommender system research by focusing, in particular, on human memory and decision-making processes.

Keywords: memory, decision making, recommender systems.

1 Introduction

Recommender systems researchers are becoming more and more aware of the importance of designing user-interaction by relying on cognitive research. They are also becoming more sensitive to the need of designing their systems by taking into account theories and findings on human decision making. However, there is still a large gap between basic research in cognitive psychology and recommender systems research. There are multiple reasons for this state of affairs, including insufficient communication between research fields, fragmentation of cognitive theories, diversity of recommender technologies and aids, and specific difficulties in the empirical evaluation of complex systems also including human components.
A productive interchange between cognitive research and recommender systems research can be fostered by focusing on some empirical generalizations coming from cognitive research, which may be helpful to inform recommender system design. This may involve not only 'traditional' aspects of human-computer interaction and interface design, but also the entire decision-making course. The workshop talk focused, in particular, on empirical generalizations coming from memory and decision-making research, and it was shaped as an introductory lecture for a relatively unskilled audience in psychology and cognition. It ranged from high-level aspects of the choice process to more specific aspects of the interface and user interaction, because research implications encompass different levels of analysis. Some key findings in human memory research relevant for recommender design and their theoretical background were initially discussed, followed by some key findings in the psychology of decision making. After that, some reflections were proposed on how recommender technology

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is changing the way in which we decide. The final part of the talk dealt with opportunities and challenges related to bridging cognitive research and research on recommender systems. Due to space constraints, only a short summary is presented here.

2 Memory and Recommender Systems

In the first part of the talk, two related issues were dealt with: (1) when do we use memory when interacting with recommender systems? (2) how could we support memory during interaction with recommender systems? Answering the first question produces to a rather long list of situations, because different memory processes can contribute to the interaction (see Table 1). These processes have been functionally and neurally dissociated in memory research, but debates are still ongoing on their structural dissociation and, partly, on their neural dissociation [1, 2]. Moreover, significant individual and age-related differences exist in some of these processes, affecting performance in decision making and in other complex cognitive tasks [3, 4, 5].

Table 1. Memory processes in the interaction with recommender systems.

Memory Processes	Examples of interaction with Recommender Systems
Short-term memory Working memory	• Keep in mind sequences of numbers or codes • Keep in mind and integrate information to compare recommended options and their features (e.g. books, movies) • Formulate evaluations based on information integration (i.e., book price, author, delivery time) • Apply rather complex choice strategies to select one option
Episodic memory	• Retrieve specific episodes to decide whether to buy a product from a vendor, trust system recommendations, use a service, or appraise whether a certain product price is cheap or expensive. • Rely on recognition to navigate within a system to find a given product or service, or to understand where you are.
Semantic memory	• Accesses semantic knowledge to understand features of the options, scenario descriptions, option descriptions, and reviews. • Make knowledge-based inferences on options. • Use semantic knowledge to select links and navigate.
Procedural memory	• Navigate and complete tasks effectively after initial learning • Learn to operate on similar systems (but learned procedures may also create problems when switching to a new system with inconsistent situation-response mapping - i.e., negative transfer).

Given that different memory processes seem to have different functional roles in the interaction with recommender system, they may need to be supported in specific ways. Table 2 presents some potential suggestions (see also [3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14]), which cannot be further discussed here due to space limitations.

Table 2. Potential ways to support memory in the interaction with recommender systems

Memory Processes	Potential Support
Short-term memory ***Working memory*** *Don't ask users to keep too many things in mind and do complex computations or information integration*	*Reduce STM load* • Chunk information (visually, spatially, and semantically) • Use easy to remember groups of digits and letters *Reduce working memory load* • Display close together pieces of information that need to be processed sequentially (e.g. features of one option) • Provide results of already-made computations (e.g. unit prices) or computation tools • Provide comparison matrices and external memory tools • Summarize complex information with user-centered information displays and visual representations
Episodic memory *Don't ask users to retrieve, or at least help them to retrieve using appropriate cues*	*Anticipate retrieval attempts by providing their potential targets* • Present factual info where needed (cognitive task analysis and tests with users help to understand what is needed and where) *Transform retrieval in external search* • Provide access to previously visited pages or options (e.g. history, past searches) or transactions (e.g. orders) *Prefer recognition over recall* • Transform a recall task into a recognition one (e.g., autocomplete search forms and preview search results)
Semantic memory *Provide knowledge whenever needed. Users' semantic knowledge can be a design tool*	*Provide knowledge* • Provide knowledge that helps to understand product features or information (wherever user may need it) *Design building on users' semantic knowledge* • Take into account user semantic representation of the domain in planning information architecture (e.g., use cart sorting and knowledge elicitation methods) • Design user-centered links and labels by maximizing the association strength between words in links and labels and keywords in the target content
Procedural memory *Users apply learned procedure; familiar and simple things are easier to learn*	• Be consistent with (good) interface standards and within your system to benefit from positive transfer and learned habits • Remember that what can't be seen or can't be reached can't be used • Test with users, appraise learning and flux experience

3 Decision Making and Recommender Systems

Starting from theories of decision-making competence and recent neuropsychological research [15, 16, 17, 18], the second part of the talk traced a distinction between different decision-making processes. These processes are decision structuring, information integration, and information evaluation. We also considered post-choice processes, for their influence on future decisions. Illustrative examples of suboptimal decision behaviors related to these processes have been described (Table 3), as well as some proposed workarounds, even if research on debiasing is rather scarce due to the historical focus on biases or anomalies rather than on ways to avoid them [16, 19].

Table 3. Decision processes and related problems in the interaction with recommender systems

Decision Processes	Potential Problems	Potential Workarounds
Decision structuring *Define objectives and alternatives, estimate uncertain quantities, collect information, …*	Too narrow representation and search (e.g., availability, focusing) and estimation biases (e.g., anchoring)	• Suggest good options or important attributes missed • Support representation with external memories • Help users to estimate uncertain quantities
Information integration *Process and integrate information about options and attributes to reach a decision (comparisons, computations, weighting, integration)*	Unintentional misweighting of evidence (e.g., order effects, frequency-related biases, salience effects)	• Decrease time costs of external information access. • Summarize search and navigation results using external memories and aggregation tools
Information evaluation *Evaluate options and their features according to personal preferences, criteria, and values*	Biases in valuation processes or emotion-related biases (e.g., framing, sunk cost, improper influence of incidental affect)	• Teach users to recognize specific situations potentially biasing and provide concrete examples of actions to take • Present information using bias preventing formats or displays
Post-choice processes	Distortion/reconstruction, selective retrieval, reappraisal processes (e.g. hindsight and positivity biases)	• Bias-specific interventions (as before) • Provide an external history of past choices and related information

4 The Impact of Recommender Systems on Decision Making

A fundamental way in which recommender technology can shape decision processes is through the provision of potentially good and interesting options (e.g., books, movies, songs, etc.). After all, this is exactly what recommenders are made for, and considering that the users' representation of the decision problem is usually rather narrow (e.g., [20, 21]), especially if the problem is ill-structured and the domain complex and not very familiar, recommender technology has the potential to overcome a potential weakness. However, providing more options and attributes may imply placing a greater burden on integration and evaluation processes. Thus, also these processes may need to be properly supported, via external memories, interaction design, and decision aids that can ease information integration and evaluation (e.g., [6, 14, 22]). In this regard, several (still largely unresolved) design issues may need to be considered in order to provide tools that are, at the same time, prescriptively defensible, easy to use, and effortless for the user. These problems may be also exacerbated by the diffusion of mobile devices, which introduces rather tight screen constraints.

Moreover, considering that users are generally able to figure out some good options in reasonably familiar domains, recommended options need to be clearly better (and perceived as such) in order to make a difference. Thus, in order to be appreciated, recommendation technologies should increase significantly choice quality and users' satisfaction, but keep low the information integration and evaluation load.

Another way in which recommender technology can change our choices is through the provision of knowledge about options, attributes, and the decision domain. For instance, providing knowledge on the reasons why a given attribute is important for a choice and helping users to make sense of attribute values is an important aspect, especially for nonexperts in the domain. This can contribute to more aware choices.

Recommender technology can also change the way in which we use episodic memory, by replacing memory retrieval with external browsing (assuming that the access cost of external information is lower and accuracy higher than retrieval) or turning retrieval into recognition. Thus, new memory problems may not reside no more in retrieving information, but in filtering and combining it, and in handling interference.

Recommender technologies may also have a potential 'dark side' when deployed as commercial services. Besides the important issue of personal data protection and user rights, these technologies have the potential to affect user behavior in rather subtle ways, ranking options according to sponsors' contributions (without providing a bold warning), enabling by default fast shortcuts to purchase, or influencing users' preferences even outside their awareness via mere exposure, priming, framing, or anchoring. In this regard, it is always worth remembering that decision technology should ideally help the users to choose with full awareness and in their best interests.

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