

# Decision-Making in Recommender Systems: The Role of User's Goals and Bounded Resources

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## ABSTRACT

Many factors that influence users' decision making processes in Recommender Systems (RSs) have been investigated by a relatively vast research of empirical and theoretical nature, mostly in the field of e-commerce. In this paper, we discuss some aspects of the user experience with RSs that may affect the decision making process and outcome, and have been marginally addressed by prior research. These include the nature of *users' goals* and the *dynamic characteristics of the resources space* (e.g., *availability* during the search process). We argue that these subjective and objective factors of the user experience with a RS call for a rethinking of the decision making process as it is normally assumed in traditional RSs, and raise a number of research challenges. These concepts are exemplified in the application domain of on-line *services*, specifically, *hotel booking*- a field where we are carrying on a number of activities in cooperation with a large stakeholder (*Venere.com* – a company of *Expedia Inc.*). Still, most of the arguments discussed in the paper can be extended to other domains, and have general implications for RS design and evaluation.

## Categories and Subject Descriptors

H.5.2 [Information Interfaces and Presentation]: Multimedia Systems, User Interfaces. H.3.3 [Information Storage and Retrieval]: Information Search and Retrieval.

## General Terms

Design, Empirical Study, Experimentation, Human Factors.

## Keywords

Recommender System, decision making, Soft Goal, Bounded Resources, design, evaluation, e-tourism, e-booking

## 1. INTRODUCTION

Recommender Systems (RSs) help users search large amounts of digital contents and identify more effectively the items – products or services - that are likely to be more attractive or useful. As such, RSs can be characterized as tools that help people making decisions, i.e., make a choice across a vast set of alternatives [12]. A vast amount of research has addressed the problem of how RSs influence users' decision making processes and outcomes. A

systematic review of the literature about this topic, focused on e-commerce, is reported by Xiao and Benbasat in [18]. These authors pinpoint that when we regard RSs as decision support tools, the design and evaluation of these systems should take into account other aspects beyond the algorithms that influence users' decision-making processes and outcomes. These aspects are related to individuals' subjective factors as well as the design characteristics of the user experience with the RS. While several theoretical arguments and empirical studies exist that support the positive effects of RA use on decision making quality, research in this field is still inconclusive, highlighting the need for further research.

This paper provides some novel contribution to this research area. Most prior work on RSs for decision support focused on e-commerce domains where users buy on-line products or movies [1]. Our work has instead explore decision making processes in the wide application domain of on-line *services*, specifically, *hotel booking*. We are carrying on a number of activities in close cooperation with a key stakeholder in this field, *Venere.com* ([www.venere.com](http://www.venere.com)). This is a company of the *Expedia Inc.* group which is leader in online hotel reservations market featuring more than 120,000 hotels, Bed and Breakfasts and vacation rentals in 30,000 destinations worldwide. In this domain, we investigate some subjective aspects of the user experience with RSs - the type of *users' goals*, and some objective, i.e., design related, attributes of RSs – the nature of the *resources space* (e.g., the availability of items along the time in general, and specifically during the search process) that may affect the decision making processes supported by RS. Still, most of our considerations can be extended to other domains, and have implications for research and practice in RS design and evaluation in general.

## 2. USER GOALS AND “BOUNDED” RESOURCES

### 2.1 Scenarios

Let us consider the following scenarios, in which the user is engaged with an online hotel reservation system.

*Scenario 1.* You have to come to Milan and work with your business partners from August 6 to August 10, 2012. You want to reserve a room in a hotel in Milan for that week.

*Scenario 2.* You will spend a holiday in Milan from September 19 to September 25, 2012, and want to reserve a room.

*Scenario 3.* You have to attend a business meeting in Milan from September 19 to September 20, 2012, and you need to reserve a room in a hotel in Milan on that dates, for one night

*Scenario 4.* You are planning a holiday in Central Italy in mid September 2012, and will visit Rome for few days. You need a hotel in that period.

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**Figure 1: Bounded resources and task goal**

How do the above scenarios differ?

In all of them, the user is doing a similar operational task: buying a service, specifically, reserving hotel rooms. Still, there are some significant differences that may influence the decision making processes, and are induced by i) the different nature of the user's goal; ii) the dynamic nature of the services offered by the system the user is interacting with (Figure 1).

In scenarios 1,2 and 3, user's goals are sharp, users' preferences are well defined and have clear-cut criteria for their optimal satisfaction. In scenario 4, the user has less strict preferences – her dates are “flexible”, and we may not exclude that she is flexible also with respect to other criteria, or may not know all her preferences beforehand. Preferences are likely to be shaped and changed throughout a session in the specific decision environment. Using the terminology of goal oriented requirements engineering [15], scenario 4 depicts a situation that is characterized by *soft goals* [20], i.e., *open-ended* needs that are progressively elaborated during the interaction with an environment and the decision process, and may be somehow supported by one or more combinations of solutions and decisions<sup>1</sup>.

Further differences in the above scenarios are related to the intrinsic nature of resources, in particular, to the *dynamic, time dependent characteristic* of the items in terms of their *availability*.

In scenario 1, the user is making a decision in the context of a *very vast set of stable alternatives*: in the second week of August, hotel availability in Milan is huge, as most people and companies or institutions are on holiday. No matter when and how you reserve a hotel, it is very likely that you will find one that matches your preferences.

In contrast, in scenarios 2, 3, and 4, the user is taking decision in the context of *limited or very limited resources*, or of resources that *become* limited, or even fully *unavailable*, as the decision process proceeds. In scenario 2, the user is looking for hotels in a period - from September 19 to September 25, 2012 – when Milan will host one of the most important international events in the fashion world, the Milan Fashion Week, attracting thousands of

<sup>1</sup> It is worth noticing that soft goals often occur also in entertainment-related domains, such as video-on-demand and interactive TV. For instance, a user may wish to watch a relaxing TV program, without expressing any other requirement

people from all over the world. Most hotels are booked one year in advance for that event. Hence, we can reasonably expect that, when searching a room for the whole week, *no hotel is available*.

Scenario 3 considers reservations in the same period of time, but here the user's requirement is less demanding – she is searching a room only for the first day of Milan Fashion week. There might be rooms available on that single date. Still, it may happen that other people are simultaneously trying to make a similar reservation, so that when the user takes her decision, the chosen hotel *is not available any more*.

In scenario 4, the user hasn't decided yet when she exactly will go to Rome, and her dates are flexible. It is likely that she has not specified the reservation period at the beginning of the process, and finds many alternatives matching her preferences on hotel characteristics. Still, the preferred time frame for reservation – mid September – is high season in Rome, and finding a hotel in that period time may be difficult. When she make a specific choice, decides the dates and attempts to make a reservation, the selected hotel may result to be fully booked.

## 2.2 The decision making process

In all contexts depicted in the above scenarios, the user is facing a problem falling in the class of so called “preferential choice problems” [17], i.e., she needs to take decisions across *an initially vast set of potential alternatives*. In this context, decision making processes are typically modeled as “bounded rationality” phenomena [10]. Bounded rationality – which provides a key theoretical underpinning for RSs – is the notion that, in complex decision-making environments, individuals are often unable to evaluate *all* available alternatives in great depth prior to making their choices, due to the cognitive limitations of their minds, and the finite amount of time they have to make a decision; hence they seek to attain a satisfactory, although not necessarily an optimal, level of achievement, by applying their rationality only after having greatly simplified the set of choices available.

Several authors suggest that the cognitive effort can be reduced with a multiple-stage decision-making process, in which the depth of information processing varies by stage [6][18]. Initially, individuals screen the *complete solution space* (e.g., the set of all hotels featured by the on-line reservation service provider) to identify the (large) set of potential alternatives, or *search set* (e.g., the set of hotels that could be of some interest); then they search through this set, and identify a subset of promising candidates (the *consideration set*). Subsequently, they acquire detailed information on *selected* alternatives to be seriously considered (*in-depth comparison set*), evaluate and compare them in more detail, and finally commit to a specific choice. Although some of the above actions can be iterated, this process is intrinsically linear and it is likely to end with the user making a specific choice and hopefully buying a service.

The same process may not apply exactly in the same terms in the situations described in scenarios 2, 3 and 4 (Figure 2). In scenario 2, the search set is likely to be empty (no hotel is available for the specified period). In scenarios 3 and 4, the search set, the consideration set and the in-depth comparison set are not empty, initially. Still, *their size decreases as the decision process proceed* (e.g., because other users buy some items, or because the user refines her decision criteria, e.g., fixing the dates). Hence, when the user reaches the final step and makes a decision, her choice will likely result unfeasible. In all these cases, after experiencing the unavailability of resources, i.e., of rooms in the desired hotel(s), the user may either *give up* (e.g., she leaves the current on-line reservation service and tries a different one) or *iterate* the

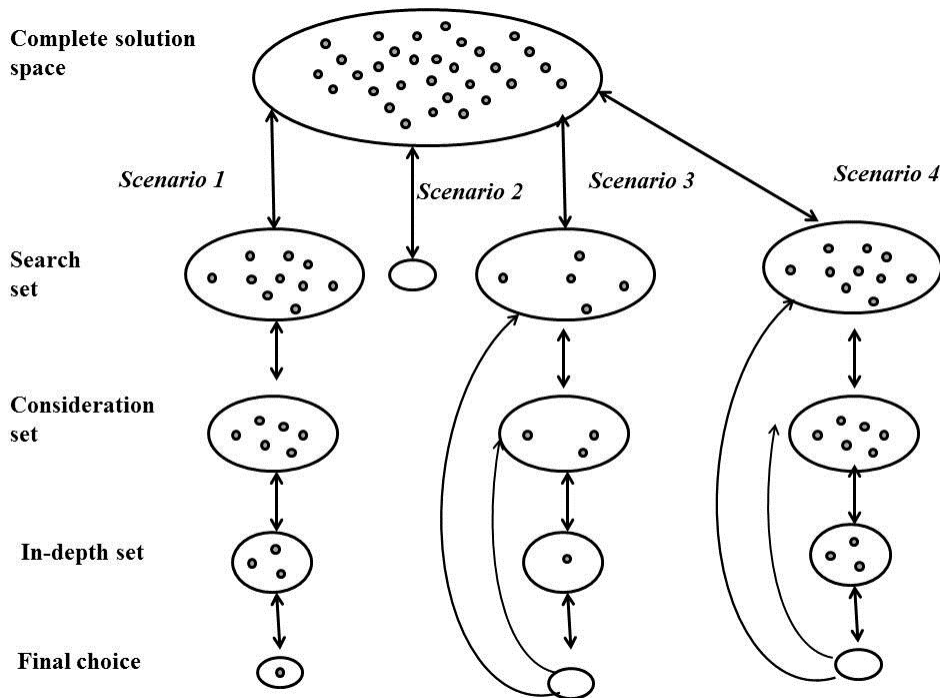


Figure 2: Decision making processes in the four scenarios

process, providing extra input to modify their preferences, exploring the search set, consideration set and in-depth set again, and attempting to make a different decision.

### 3. CHALLENGES FOR RS DESIGN AND EVALUATION

The examples discussed in the previous section highlight that the decision process in RSs is influenced by the characteristics of both users' goals and the resources meeting users' needs and preferences. How the nature of the goal (sharp or soft) and the dynamic of resources play in the decision making process has been marginally explored in current RS research, and opens a number of research challenges.

A first challenge is to understand the degree at which some key theoretical assumptions underlying most of the existing RSs, such as "bounded rationality", are valid in the context of users' *soft goals*, and how the structure of RS supported decision making processes can be defined in these situations. On the one side, it remains true also that a decision-maker lacks the ability and cognitive resources to arrive at the optimal solution in a vast set of alternatives, and at some point of time she needs to apply her rationality after having greatly simplified the choices available. On the other side, the decision-maker might not be modeled as a "satisfier" - one seeking a satisfactory solution rather than the optimal one, minimizing the cognitive effort - *along the entire decision making process*. At the beginning of the process, the user may indeed be looking for an optimal solution, because her needs and preferences are initially poorly defined, and she does not know yet what the characteristics of such optimal solution are. Hence the initial step of the decision process is more a kind of "sense making" activity than a focused "search": the user is attempting to understand the complexity of the domain and the characteristics of the items in relationship to the specific field of interest, in order to decide what she needs and wants. In this context, the decision making process seems to include a *preliminary phase*, taking place before the progressive

elaboration of alternatives, in which the user forges her own preferences, and transforms a soft goal into a sharp goal that characterizes an actual "preferential choice problem". In this preliminary "sense making phase", optimizing cognitive resources and reducing effort might not be an issue, as suggested by some studies [1].

This analysis has challenging implications for RS design in domains where both sharp and soft goals coexist. In these contexts, a designer's goal should go beyond the support to findability - to enable users easily locate what they are precisely looking for - and to the tasks involved in the decision making process as it is conventionally intended. RS design should also support tasks that are essentially *explorative* in nature [1][11], and are oriented towards constructing preferences in the specific domain and decision environment. The challenge is to provide a seamlessly integrated set of interactive design strategies that leverages existing patterns of exploratory interaction, such as faceted navigation and search [13], with existing RS design strategies. It is worth noticing that serendipity can be an important goal also in this exploratory phase and not only when providing recommendations. Promoting crucial contents the existence of which users did not even suspect, so that users can stumble and get interested in them (even if they were not looking for that kind of information), can be as effective (or perhaps more effective) in this phase than in following phases of the decision process.

From a different perspective, also the bounded resources condition challenges existing results concerning the decision making process in typical RSs. The process depicted by [13] and discussed in the previous section applies well in the context of "*unbounded resources*", exemplified by scenario 1 and characterized by a *very vast set of alternatives that remains large when screened and filtered according to user's preference criteria*. In this situation there are theoretical arguments as well as a large number of empirical studies - mostly in the e-commerce

domain [7][8] - that claim that *typical* RSs can provide effective support to users in *all* stages of the decision-making process. They facilitate both the initial screening of available alternatives and the in-depth comparison of item alternatives within the consideration set, reducing the total size of information processed by the users in the search set, consideration set and in-depth search set [13]. Hence we can posit that, *under the unbounded resources condition, typical RSs reduce users' decision effort and users' decision time, hence improving the quality of the decision process.* In all cases depicted in scenarios 2, 3 and 4, the decision process is influenced by the “bounded” characteristics of the resources meeting users’ needs and preferences, which may affect the validity of the above proposition and the effectiveness of traditional RSs for decision making purposes.

It is well known that, in *any* context, the RS attempt of reducing the user decision effort risks to create the so called *filter bubble* effect. This term, first coined by Eli Pariser in [5] describes a phenomenon in which RSs tend to show only information which agrees with users’ past viewpoints, effectively isolating the user in a bubble that tends to exclude items that may be helpful for the users’ goals, i.e., novel and serendipitous items. We cannot exclude that potentially negative effects of the bubble phenomenon get amplified in the context of bounded resources: the bubble can result so narrow that, as pinpointed by the discussion in the previous section, the intersection between the bubble and the set of available items is empty. If this is the case, the decision process must be iterated, possibly several times. This situation is likely to *increase users' decision effort and users' decision time, and therefore decrease the quality of the decision process.* This in turn have potentially negative effects on the users’ perception of on her trust in, usefulness of, and satisfaction with the RS. Even worse, the user may *give up* before completing the decision process, leaving the current on-line reservation service and trying a different one, with obvious implications for the service provider, in terms of customers’ trust and actual business outcomes.

In order to overcome these problems, users must be exposed to novel and serendipitous recommendations [2]. This is a paradigmatic shift for the role of RSs in the decision process: from a tool that helps users in narrowing the search set and consideration set in the case of unbounded resources, to a tool that expands the in-depth set in the case of bounded resources.

Defining the *design strategies* of RSs that take into account the possibility of bounded resources is a challenging issue. Some requirements that need to be taking into account are the following:

- Support to decision making processes that are strongly iterative, maximizing the usability of doing and re-doing previous steps, particularly in the re-definition of preferences as the user becomes aware of the lack of available items matching her requirements.
- Need to maintain users’ trust [9] and keep the user engaged with the decision process, in spite of the initial failures that potentially can occur because of the lack of resources. In this respect, specific explanation strategies [19] and appropriate conversational interfaces [16] should be defined, which not only improve transparency and explain how recommendations are generated, but also make the user aware of the shortage of resources
- Ability to act both as *filter* that limits the set of valuable alternatives and as *multiplier* that helps the user expand her horizons by recommending serendipitous alternatives.



Figure 3: The PoliVenus web application. Recommendations of hotels are on the lower left.

Finally, the concepts of user’s goals (sharp or soft) and bounded resources both have implications on *evaluation models, methodologies* and *empirical studies* regarding RSs as decision support tools.

Existing conceptual models for evaluation (e.g., [8][18]) do not provide explicit constructs for users’ goals. Previous studies on decision making [5] pinpoint how the nature of users’ *tasks* is an important factor affecting individual’s behavior and performance. Still, a task as defined in previous studies - “the set of functions that a working person, unit, organization is expected to fulfill or accomplish” [5] - has mainly a functional flavor. Our study emphasizes the need for extending this functional perspective and raising the level of abstraction of the task concept, to address “goals”, i.e., broader users’ needs. In addition, the discussion presented in the previous sections suggests extensions of existing frameworks for RS evaluation with explicit constructs that address the temporal and dynamic characteristics of RS resources. All these extensions can lead to more powerful *conceptual models* that can help contextualize a wider spectrum of empirical studies in a wide range of RS application domains and situations of use.

## 4. OUR WORK

Most prior work on RSs for decision support has focused on e-commerce domains where users buy on-line products, pinpointing the influence that different aspects of the user experience with the RS induce on the decision process and outcomes. Our work is currently exploring this issue in a different field, the wide application domain of on-line *services*, such as *hotel booking*. We are working in close cooperation with Venere.com, a company of Expedia Inc. and a key stakeholder in this domain. Our work contains methodological, technical, and empirical innovations.

### 4.1 Methodology

We have defined a *conceptual model* that provides a more comprehensive framework than the existing ones, and takes into account a number of *new* aspects of the user experience with RSs which have been neglected by previous studies and may significantly influence users’ decision-making processes and

#	Question	Possible answers	Area
1	Did you already stayed in the city where the hotel is located?	yes / no	product expertise
2	Did you already stayed in the selected hotel?	yes / no	product expertise
3	Would you have preferred to book a different hotel?	yes / no	decision quality
4	If yes to the previous question, would you have preferred a hotel (more answers are feasible):	cheaper / with more stars / in another city zone / in other dates	decision quality
5	Are you satisfied with your final choice?	not much / fairly / very much	decision quality
6	How much the proposed hotels match your personality?	not at all / fairly / very much	decision quality
7	How long have spent for booking the hotel (minutes)?	5 / 10 / 15 / 20 / 30 / 60	decision effort
8	The time required to choose the hotel is:	reasonable / overmuch / short	decision effort
9	The hotel selection process has been:	easy / hard / very hard	decision effort
10	The range of hotel presented is:	poor / broad / very broad	recommendation quality
11	The set of proposed hotels is:	predictable / with original and unexpected items / very surprising	recommendation quality
12	How much do you think that the characteristics of the reserved hotel will correspond to the real one?	not much / fairly / very much	perceived product risk and trust
13	Do you use online booking systems?	never / sometimes / regularly	profiling
14	If you have used online booking, have you ever used Venere.com to make reservations in the past?	never / sometimes / regularly	profiling
15	Average number of journeys with accommodation per year for holiday purpose		profiling
16	Age, Gender, Nationality, Educational qualification, Occupation		profiling
17	When you travel for holiday, which are the priority criteria with which you choose a hotel?	price / offered services / location / suited for people traveling with me	profiling
18	Where are you in this moment?	home / work / vacation / traveling	context

Figure 4. Questionnaire

outcomes. These include the characteristics of the *goals* – sharp vs. soft – performed with the system (e.g., booking a hotel for vacation or for a business trip) and the *dynamic* characteristics of items (e.g., *availability* during the search process).

## 4.2 Technical work

We have developed a web-based software framework, *PoliVenus*, for evaluation that facilitates the execution of controlled user studies in this field driven by the constructs of our conceptual model (Figure 3). The framework is based on a *modular* architecture that can be easily customized to different datasets and types of recommender algorithms, and enables researchers to manipulate and control different variables in order to systematically assess the effects of RS use on users’ decision making processes.

PoliVenus duplicates all the functionality of the Venere.com online booking system, with the exception of payment functions, and contains a catalogue of 6000 accommodations and 500000 users’ reviews on the same accommodations. PoliVenus can simulate high-season periods by “reducing” the number of rooms available in a range of selected dates.

Selected users on PoliVenus can be provided with recommendations. Recommendations, in turn, can be provided with any type of algorithm (collaborative and content) from a library of 20 algorithms. Hybrid recommendations can be provided as well, combining any two algorithms. The algorithms have been developed in cooperation with ContentWise<sup>2</sup> (algorithms and datasets can be obtained by mailing the authors). The user profile is implicitly created by monitoring user’s interaction with the “objects” (e.g., pages) describing accommodations.

<sup>2</sup> [www.contentwise.tv](http://www.contentwise.tv)

Recommendations can be provided in different phases of the interaction process (e.g., as alternatives when watching the description page of an accommodation, as a sorting option in a list of hotels).

## 4.3 Empirical Work

We have designed an experimental setup that allows three different experimental conditions: (a) RS use conditions, (b) bounded resources conditions, (c) RS characteristics, and (d) consumer decision processes.

The first condition is obtained by asking the user to execute one between different tasks, each one representing a different system scenario.

The second condition refers to the configuration of the system, i.e., the possibility to use the application without or with RS support. It should be noticed that this second condition is different from most cases of study discussed by Xiao and Benbasat in [18]. In our implementation, the RS integration doesn’t exclude the normal functionalities of the application without RS. This coexistence leads us to reconsider the concept of RS use in our research.

The third condition refers to the possibility to choose a different recommender algorithm among a wide range of recommender algorithms either collaborative, content or hybrid.

The fourth condition allows analyzing the user behavior under limited or unlimited items availability. In our experimental setup, item availability can evolve with time (e.g., the longer is the user decision process, the higher is the probability for the selected item to be unavailable, or the higher is the final price for the selected item).

Therefore we have used the testing environment PoliVenus in a number of preliminary empirical studies, for three key aspects of the bounded resources concept:

- Unavailability: resources may be unavailable for the user (e.g., after selecting hotel and accommodation period, the system informs the user that there are no rooms available).
- Time scarcity: resources may become unavailable as the time passes (e.g., as the user session goes on, the availability of rooms in a hotel decreases).
- Price alteration: prices may change depending on availability of resources (e.g., the system simulates price increase in relation to rooms' availability).

#### 4.4 Participants and Context of Execution

In this section we present the results of a preliminary study executing by using the PoliVenus system. The study was designed as a between subjects controlled experiment, in which we measured the first following experimental conditions, each condition tested with two *independent variables*:

**RS use.** We have tested two independent variables: (i) with and (ii) without recommendations.

**Resources availability.** We have tested two independent variables: (i) rooms are always available in any date for any hotel, and (ii) no rooms are available in the first hotel in which the user tries to book, regardless of the dates. We will refer to the two scenarios as *rooms available* and *shortage of rooms*, respectively

We have a total combination of four research variables. We have recruited 15 subjects for each group. Overall, the study involved 60 male users aged between 24 and 50. None of them had been previously used Venere.com.

Each participant was invited to browse the hotel catalog of PoliVenus to search for a double hotel room in Rome and to complete the simulated payment procedure booking the room for two nights. The user was then invited to reply to a set of 18 questions related to the quality of the interaction procedure and satisfaction of the chosen hotel (Figure 4).

#### 4.5 Results

Table 1 presents some results of our preliminary study. Only statistically significant results are presented.

**Personalization.** The first row of the table summarizes the answers to Q6 in the questionnaire and measure the degree of perceived personalization in the hotels presented to the users during their interaction with the system. As expected, all the users that did not receive recommendations perceived the presented hotels are “not personalized”. However, only 10% of the users that did receive recommendations perceived these recommendations as matching their personality.

**Table 1: Results**

	Without RS	With RS
The proposed hotels match your personality (very much)	0%	10%
Task execution time	5'45''	6'30''
rooms always available	6'00''	6'30''
shortage of rooms	5'30''	6'30''
Consideration set (# of explored hotels)	3.5	11
rooms always available	3	9
shortage of rooms	4	13
Task perceived time	8'40''	8'20''
rooms always available	8'15''	7'40''
shortage of rooms	9'00''	9'00''

**Task execution time.** The second row of the table estimates users' effort by measuring the time required for the completion of the task. Surprisingly, users receiving recommendations required significantly more time (almost one minute more) than users without recommendations. This results may lead to think that recommendations increase the effort of the decision making process. The last two rows in the table provide a different explanation.

**Consideration set.** In order to analyze why users receiving recommendations takes longer to complete their task, we have measured how many hotels they explore during their interaction with the system (the consideration set). The third row of the table shows that users receiving recommendations explore a much larger consideration set (almost three times the number of hotels with respect to users not receiving recommendations). This result suggests that recommendations help user to explore a larger number of alternatives. This effect is more evident if we compare the two scenarios “rooms available” and “shortage of rooms”. Users not receiving recommendations explore the same small number of hotels, regardless of the difficulties in finding rooms. On the contrary, users receiving recommendations explore twice the number of hotels if there are few rooms available. This suggests that recommendations help users in exploring a larger number of alternatives especially in the scenario of bounded resources.

**Perceived time.** The last row of the table presents the perceived effort of the decision making process measured with the perceived time for completion of the task (Q7 in the questionnaire). Even if users with recommendations required a significantly longer time to complete their task and explored a much larger number of hotels during their session, their perceived time is the same as the time perceived by user without recommendations. In both cases (with and without recommendations) users dealing with shortage of rooms perceived a longer time for their task, even if the task completion time does not change significantly between the “rooms available” and “shortage of rooms” groups.

### 5. DISCUSSION AND CONCLUSIONS

The analysis of the results presented in the previous section suggests a number of interesting considerations.

- RSs do not reduce the time required to complete a decision making process. On the contrary, RSs stimulate users to explore more alternatives before making their final choice.
- The effort of the decision making process does not change with the adoption of RSs. Users' perception of the elapsed time is not related to the larger number of explored choices.
- The effort of the decision making process increases in the case of bounded resources. RSs seem not able to alleviate this perceived effort.

Our research has its weaknesses, most notably the limited sample size (60 participants) used for this preliminary test. In spite of the above limitation, our work provides contributions both from a research and practical perspective. To our knowledge, this is the first work that systematically analyzes RSs as decision support systems in the scenario of on-line booking services, focusing of the correlation between resources availability and effectiveness of the recommendations. For the practice of decision support systems design and evaluation, our work may promote further approaches that move beyond the attention to conventional perceived relevance metrics and shift the emphasis to more effort-centric factors.

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