

A Preference Evolution Perspective on Lifelong User Modeling

Anthony Jameson and Silvia Gabrielli*

Fondazione Bruno Kessler
Trento, Italy

Abstract. This workshop paper briefly presents a theoretical framework for explaining and predicting differences and changes in users' preferences concerning the systems they use—in particular, user-adaptive systems. The ultimate purpose of this framework is to increase our ability to understand and predict users' preferences and to design (user-adaptive) systems accordingly. In our workshop presentation, we will apply this framework to the other contributions to the lifelong user modeling workshop.

1 The Nature of This Submission

Since this workshop submission does not fall into either of the two normal submission categories, we will begin by explaining its intent.

In the context of the targeted research unit PREVOLUTION, the authors have been developing a theoretical framework for understanding and predicting users' preferences with regard to interactive systems, in particular those that involve some sort of intelligent processing. This framework has been applied to a number of specific systems and problems, and it formed the basis for the full-day IUI 2009 workshop on *Users' Preferences Regarding Intelligent User Interfaces: Differences Among Users and Changes Over Time* ([1]; <http://prevolution.fbk.eu>). Some of the participants in that workshop are currently preparing articles for a special journal issue on this topic.

Because of its attention to the evolution of preferences over time, this framework has a good deal of relevance to the topic of lifelong user modeling, as will be explained below. In the Lifelong User Modeling workshop, we will (a) explain the framework on a general level and (b) apply it to the particular systems and studies that are described in the papers of the other workshop participants. In this way, we hope to be able to encourage cross-fertilization among the workshop participants, while at the same time expanding and enriching our own theoretical framework.

In the following sections, we will first give a brief discussion of our evolving framework and then (in Section 5) discuss its relevance to the topic of lifelong user modeling.

* The research described in this paper is being conducted in the targeted research unit Prevolution (code PsychMM), which is funded by the Autonomous Province of Trento.

2 Introduction: Choices People Make Regarding User-Adaptive Systems

Because building user-adaptive systems that accurately model their users is in itself such a challenging problem, it is easy to forget that the users of such systems are not just passive entities waiting to be modeled; they regularly make *choices* about how they are going to deal with the modeling and adaptation that is offered by the system. But ignoring these choices can be a big mistake. As anyone who looks at the way in which users respond to user-adaptive systems will have noticed, people often exhibit striking differences in the individual choices that they make as well as in the *patterns of choice* that they exhibit when they are faced with multiple choices of the same type (cf. [2]).

These differences can arise at different levels:

- When faced with a choice between an adaptive and a nonadaptive version of the system, typically some people prefer the former and some prefer the latter (see, e.g., [3]).
- When a decision about adaptivity can be made on a case-by-case basis, some users may choose adaptivity more often than others, and their criteria for doing so may be different.
- Where an adaptive system offers some flexibility in the way in which the adaptivity can be used (for example, allowing the user to choose between automatic adaptation and adaptation on demand, as in [4]), users may again make different choices, for different reasons.

When we observe people using a user-adaptive system over an extended period of time, in addition to the differences just mentioned we typically also see *changes* in users' patterns of choice over time. People may come to appreciate the adaptivity more or less, or (on a more detailed level) they may use the adaptive functionality in different ways.

There are several reasons why it is important to be able to understand and anticipate differences and changes in users' patterns of choice at least to some extent:

- We can then better make sense of the sometimes puzzling results that emerge from studies of the use of user-adaptive systems.
- By being aware of typical changes over time, we are in a better position to extrapolate from the results of such studies, which usually are restricted to a limited period of time.
- When designing a user-adaptive system, we can anticipate likely differences and changes in patterns of choice and try to design the system accordingly.
- The specific ways in which patterns of choice differ and change often turn out to be surprising and not necessarily in the best interests of the users in question; we may say that a user's patterns of choice are not necessarily *well-aligned* with their actual needs (though defining and determining "actual needs" is admittedly a tricky matter). It is therefore not enough simply to provide a good user-adaptive system, enable users to learn how to operate it correctly, and assume that users will arrive at patterns of choice that are in their own best interests.

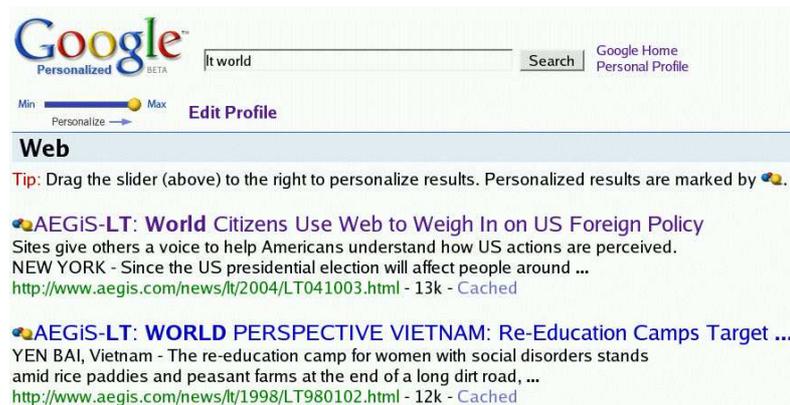


Fig. 1. Screenshot of the experimental, profile-based version of Google’s personalized search that was used in Google’s “Lab” in 2005. (By moving the slider in the upper left, the user could change the degree to which the search results were reranked on the basis of a previously specified interest profile. The reordering was visualized with an animation.)

Since speaking of “choices or patterns of choice” can be awkward, in the rest of this paper we will often use the broader term *preferences* instead; but the discussion above about what is more specifically meant should be borne in mind.

3 A Framework for Understanding and Prediction

When looking at any particular system or study, we may seem to be able to explain the observed preference differences and changes in terms of one or two fairly obvious factors, such as the user’s level of experience or their personality traits. But when we look at a broader range of experience with user-adaptive systems, we see that there is a great variety of factors that can influence user’s preferences; a focus on any subset is likely to lead to inaccurate conclusions.

Therefore, in this brief paper we offer a high-level view of users’ preferences that aims to capture in a structured way all of the factors that can lead to differences among users and changes over time. This theoretical framework has been continually evolving and expanding as we have applied it to one case after the other, and we expect it to evolve further on the basis of feedback at the Lifelong User Modeling Workshop, as we engage in dialog with participants about how the theory can be applied to their specific systems.

The framework is presented in Tables 1, 2, and 3 (which are separated only because of the limited page size). On the highest level, three categories of factors are distinguished that can help to explain differences in users’ preferences: *Users’ needs*, *The system’s properties*, and *Aspects of process of preference formation and evolution*. For each individual factor, it is usually possible to offer some hypothesis about how the factor changes over time (see the second column); these hypotheses are relevant

Table 1. Overview of the factors that can lead to differences and changes in users' preferences concerning user-adaptive systems (continued in the next two tables). (Symbols like “+++” indicate roughly, on a scale from “-” to “+++”, the amount of attention that the factor has attracted so far in the literature.)

Factor	Systematic evolution	Reason(s) for evolution
<i>Users' needs</i>		
<i>Needs relevant to success at task performance:</i>		
+++ Tasks to be performed	++ May expand in scope and increase in complexity	Experience with system makes additional tasks manageable
+++ Skills	+++ Will usually increase	Use of system provides relevant practice
+++ Typical usage contexts	++ May expand	Experience with system makes additional contexts manageable
++ Usability priorities	++ May shift away from learnability and become more realistic	Experience diminishes importance of learnability and reveals which priorities are most important
<i>Other needs:</i>		
++ Aesthetic preferences, values, and attitudes (e.g., culturally determined)	+ May shift in favor of system	Habituation to system
++ Relevant personality traits	+ No systematic tendency	Traits are generally stable; any change can be favorable or unfavorable
+ Habits formed with other systems	+ May decline in influence	Experience leads to formation of new habits more favorable to system
+ Desire for novelty	+ Should favor system less, if system was initially novel	What was initially novel does not remain novel

to the prediction and understanding of preference change. The third column states the rationale underlying the hypothesis.

Most of the content of these tables are actually applicable to interactive systems in general, but the discussion here will focus on the case of systems that adapt to their users.

Table 2. Continuation of Table 1.

Factor	Systematic evolution	Reason(s) for evolution
<i>The system's properties</i>		
<i>Variable aspects of the system:</i>		
+++ Aspects dependent on adaptation to and customization by user	+++ May (but may not) make system more suitable for each user	Customization and adaptation have this purpose, but success depends on various factors
+++ Aspects dependent on particular versions of the system	+++ Can become more or less favorable	The system itself tends to improve, but the match with user's knowledge and habits may decline, at least temporarily
<i>Incidental aspects of the system:</i>		
+ Features that are only incidentally associated with the key system features but that evoke different responses in users	+ No systematic tendency	These features can take many different forms, making systematic prediction difficult

4 Explanation of the Framework

For concreteness, we will explain the table with reference to two related examples of user-adaptivity: (a) the early profile-based personalized search introduced for a few months in 2005 in Google's "Lab" (see Figure 1); and (b) the now familiar history-based personalized search that is turned on by default in Google's search engine (with which the reader is assumed to be familiar).

4.1 Users' needs

Generally speaking, the most obvious explanation for differences in users' preferences consists in differences in the users' relevant needs. Some of these are directly related to the users' success at performing tasks with the system.

For example, the profile-based search might be expected to work relatively well for, and therefore to be relatively preferred by:

- people with no specific information need who are just looking for information that corresponds to the general interests expressed in their profile (*Tasks to be performed*);

Table 3. Continuation of Tables 1 and 2.

Factor	Systematic evolution	Reason(s) for evolution
<i>Aspects of process of preference formation and evolution</i>		
<i>Available information:</i>		
++ Amount of experience on which decisions are based	++ Should increase	Any use of system constitutes experience
+ Breadth and representativeness of experience on which decisions are based	() May or may not increase	It depends on whether the user explores different ways of using the system
() Explicitly provided information supporting preference formation	- Unlikely to increase	Such information is seldom available at all; if so, mainly at the beginning of use
+ Examples given by other persons	+ May increase	Over time, there may be more opportunities to see how others use the system
<i>Other factors outside user:</i>		
+ Time available for processing available information about the system	- May increase	User may be able to revisit particular types of information
() Inherent difficulty of making realistic judgments about the system	- May increase or decrease	Judgments about different aspects of the system may be required; no general reason for them to become inherently easier or more difficult
<i>Characteristics of user's approach to preference formation:</i>		
+ Heuristics and strategies applied in preference formation	- May become better adapted to the requirements of the system	The user may notice that their initial approach was not adequate for this system
++ (Possibly incorrect) relevant general beliefs	+ May become more accurate	Experience with the system may correct some incorrect prior beliefs

- people who are not very good at expressing their interests with query keywords (*Skills*);
- people who attach high value to being able to understand and control the system's adaptation (*Usability priorities*).

By contrast, the history-based search would be expected to be relatively preferred by users who often search for the same specific pages, who do not want to devote any attention to the matter of personalization, and who do not mind having their search histories stored on Google's computers.

When considering such factors, we can see some predictable changes: A novice web searcher who initially likes the profile-based search may acquire skill in formulating more precise queries and begin performing more ambitious search tasks— changes which, according to our table, may diminish their preference for the profile-based search

Other types of users' needs are less closely related to performance of specific tasks.

For example, the profile-based search, with its colorful icons and appealing animation, should appeal to people who like this type of interface or who more generally enjoy interacting with novel interfaces. But people who are accustomed to leaving search results in the order in which they are received from the search engine may never get used to the sort of active manipulation that is presupposed by the profile-based search (even though this manipulation does not require any particular skill).

Here again, some changes may be expected: The unfamiliarity and novelty of the profile-based interface can wear off, for better or for worse; and over time the user may become so accustomed to moving the slider on the profile-based search that they would be frustrated if deprived of the opportunity to do so.

4.2 The system's properties

At first, it might be thought that the properties of the system itself (cf. Table 2) cannot lead to differences or changes in preferences, since the system stays the same for all users. But especially user-adaptive systems are designed to adapt to—and/or be customized by—the user. So at any given moment, different users are likely to be working with variants of the system (*Aspects dependent on adaptation to and customization by user*) that are differently well-adapted to them, which in turn can lead to different preferences. For example, User *A* may be happier with the history-based search than User *B* simply because User *A*'s web history currently captures *A*'s interests better than User *B*'s history captures *B*'s interests.

Since adaptation and customization are supposed to make the system better for each user over time, the default expectation would be increased acceptance by users over time, providing that they use the system long enough to benefit from the adaptation or customization. But the time course of such changes can be very different for different adaptation techniques: With the history-based personalized search, there tends to be a gradual improvement over time, in addition to possible short-term benefits; with the profile-based search, the benefits may actually be greatest early on and decline over time as the user's initially specified interest profile falls out of date.

4.3 Aspects of process of preference formation and evolution

As is indicated in Table 3, there are also a number of interesting aspects of the *process* of preference formation and evolution that can determine differences and changes in preferences. These factors are relevant to both the initial, rapid formation of impressions about a system and the longer-term evolution of preferences; in the context of this workshop, we will focus on longer-term evolution.

All of the first four factors listed in Table 3 concern types or aspects of information that are generally relevant for sound decision-making. On the whole, consideration of these factors would suggest that, over time, users' preferences regarding adaptive systems ought to become better aligned with the users' actual needs. For example, during initial use, a user's evaluation of some aspect of a system can easily become unrealistically positive or negative because of some untypical experience with the system (e.g., an especially fortunate or unfortunate adaptation by the system). With increasing experience with the system, and increasing opportunities to learn about it from sources such as other persons or system documentation, we would intuitively expect cases of poor preference alignment to become less frequent.

But a tendency toward improved preference alignment is not inevitable: For one thing, the user's experiences with a given aspect of the system will not increase at all if the user stops using it early on because of some negative experience. For example, the query shown in Figure 1 actually suffered from personalization: The user's intent was to locate a language technology-related website called "LT World", which was not related to the user's general interests and consequently did not appear among the first few personalized search results (though it would have appeared among the first few nonpersonalized search results). If, on the basis of an early experience like this, a user decides to discontinue use of the personalized search, they will never discover that the personalization is quite useful with some types of query. And even if use does continue for an extended period, the user's experience may be limited and biased (*Breadth and representativeness of experience on which decisions are based*). For example if the user for some reason believes (*Possibly incorrect*) *relevant general beliefs* that personalization will be useful only with queries concerning free-time activities such as sports and movies, they will never acquire experience with other types of query that could lead to the formation of different preferences.

The nature of the information that a user acquires can in turn depend on the user's approach to preference formation (*Heuristics and strategies applied in preference formation*), which can range from a tendency to form quick snap judgments to a desire for systematic exploration of the system and acquisition of information. This approach to preference formation may in itself change over time, if the user notices (on a metacognitive level) that the approach that they have been taking so far hasn't been appropriate. For example, a user might notice that it is worthwhile to take some time to experiment with the profile-based personalized search in order to find the best ways of using it for different types of query.

5 Relevance to the Lifelong User Modeling Workshop

The framework introduced in the previous sections can be applied to the topic of lifelong user modeling on two quite different levels:

5.1 Application to Preferences Concerning Systems That Include Lifelong User Modeling

This level of application is the one that has been assumed in the exposition so far.

A system that performs lifelong user modeling will in general be used over an extended period of time. Consequently, users' preferences regarding this system are likely to undergo considerable evolution over time. Hence systems for lifelong user modeling constitute especially interesting examples for the analysis of the evolution of preferences concerning user-adaptive systems.

Although we do not expect the other contributions to the workshop to offer much in the way of hard data or explicit hypotheses about such preference change, when discussing these contributions we will do our best to derive plausible hypotheses and to raise interesting questions that can be discussed during the workshop.

5.2 Application to the Long-Term Modeling of Users' Preferences Concerning Interactive Systems

On this level, we are applying the framework introduced above to interactive systems in general, not just to user adaptive-systems.

Although many different aspects of users can be modeled in lifelong user modeling, one important thing that can be modeled is users' preferences regarding any interactive systems that they use (e.g., the commands that they use most often, or how they would like the interface to be configured). This type of modeling has long been a popular topic in the user modeling field. We believe that this sort of work has so far not had a very solid theoretical foundation in terms of an understanding of how preferences naturally evolve over time without modeling or intervention by the system, and we hope to help remedy this deficit.

If there are contributions to the workshop that concern modeling of preferences concerning systems used by users, we will analyze these contributions in terms of our framework, again formulating hypotheses and raising questions with the goal of stimulating productive discussion.

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