Dynamic Personal Feedback in Acquiring Information to Manage Your Health

Research-in-Progress

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Abstract

This paper makes two contributions at two different levels: one is about a design principle of HCI, namely the provision of personalized and dynamic feedback in interactive applications; the second contribution is a demonstration of the need for visual and dynamic representations to explain the design of interactive interfaces.

At the first level, in the context of patients managing their health behavior, we analyze the design of feedback that builds on Visualization, Personalization, and Interactivity. Utilizing these elements DPF creates the right atmosphere for a unique InfoVis experience.

We argue that such feedback will increase comprehension, participation in planning health behavior and self-efficacy. These three factors positively affect intentions to change behavior as recommended by the medical staff. A pilot study demonstrates the feasibility and impact of personalized and dynamic feedback.

At the second level, we demonstrate how to use, contingently, three forms of visuals: static, dynamic distilled visuals and dynamic visuals in context (film)

Keywords: Human-computer interaction, Visualization, Feedback, Healthcare Information Systems

Introduction – Dynamic Personal Feedback (DPF)

This paper makes two contributions at two different levels: one is about a design principle of HCI, namely the provision of personalized and dynamic feedback in interactive applications; the second contribution is a demonstration of the need for visual and dynamic representations to explain the design of interfaces in interactive applications. In hindsight, the use of dynamic representations to explain dynamic designs seems trivial and yet it is uncommon in our dissemination of such research. We exploit three forms of visuals: static, dynamic distilled visuals and dynamic visuals in context (film).

The following text is devoted primarily to developing the design principle (first level of analysis), while the embedded use of dynamic visuals (second level of analysis) is demonstrated by doing. We begin with the design of *dynamic personal feedback* (DPF) in the context of a short scenario, proceed with a model of the impact of DPF on the patient's health behavior and demonstrate the model with a pilot study. We return to the use of dynamic visuals in the conclusion.

The scenario is about chronic patients at home managing their health. The medical world nowadays attempts to empower patients so they can take responsibility over their medical condition. For that purpose the patient needs relevant information and needs to understand the information, but *information by itself is insufficient;* patients must also be motivated to change their attitudes and behavior. We argue that the way information is delivered affects both comprehension and motivation, due to DPF's contribution to a holistic Information Visualization experience. As we describe later, during Information Visualization (InfoVis) experience users are active participants in an engaging cognitive event in which both aesthetic representation and interaction take part (Faisal et al. 2005). We believe that gaining medical knowledge in such atmosphere could be effective on patient's motivation.

Specifically, consider a chronic patient suffering from high blood pressure (Hypertension). Medical studies have shown that when people lower their salt (Sodium) intake, their blood pressure tends to decrease. The patients, who are aware of their health condition, use an information system to collect their daily nutritional menu, to decide on their future food consumption and to maintain a routine of home-tests for blood pressure. The user has the opportunity to be an active player in the interaction with the information system. The user can experiment with alternative diets (e.g. choose different food items in the personal daily menu) and learn from the outcome about the relations between food and health (e.g. lower blood pressure level in the graph when sodium decreases).

DPF is information generated in response to user activity that contains a dynamic and visual demonstration of the food consumption decision *process*. It is generated in response to the user's action (Renaud & Cooper, 2000). It is dynamic, showing the progression of the process, as opposed to static feedback that shows only decision outputs (Te'eni, 1992), and it is presented incrementally to represent the dynamics with seemingly natural motion as in direct manipulation (Shneiderman & Plaisants, 2010). We used visual feedback rather than verbal feedback because the speed of processing and the holistic nature of information processing are essential in dynamic processes. It is argued in literature that visual feedback is simpler to process than factual feedback which requires greater processing effort by the user (Ham & Midden, 2010).

Chronic patients need to be persuaded not only to act upon the system or to make a single action (as an online consumer for example) but to be convinced and motivated enough to change behavior and maintain it over a long period of time. Persuasion is a key element in behavior and attitude change (Oinas-Kukkonen, 2010). In Fogg's Behavior Model (FBM) for persuasive design (Fogg, 2009) behavior is a result of three factors: motivation, ability and triggers. The FBM model describes several types of triggers which call for action. We believe DPF is designed to promote activity and it provides several trigger types. Shedroff (2000) defines "trigger" as "Every sensorial (design) decision". The challenge is how to deliver the message in a relevant, interesting, informative and persuasive way (Noar et al., 2007)

In order to promote the two objectives of the feedback (explain the effects of user's food choices on health and motivate the user to act on the medical information) we argue that DPF should include three elements that generate a unique cognitive and emotive user experience: *Visualization*, *Personalization*, and *Interactivity*.

1) *Visualization*: DPF demonstrates visually how the process dynamically leads to outcomes so that the users realize how their actions (part of the process) affect their health (outcome). The Dynamic representation keeps the users informed about their past actions and the system's past responses (Renaud & Cooper, 2000). Together with the immediate visual effect of the relationships between factors, DPF creates a special learning environment while explaining the effects of the users' actions on their health (Balzer et al., 1989; Kerren et al., 2007). Providing dynamic visual aid to understand the process "without words" contributes to the feedback's effectiveness while consuming minimal cognitive resources (Ham and Midden, 2010).

Figure 1 depicts the DPF screen (because of the language, the screen is read from right to left). Of the three major rectangles, the rightmost rectangle describes food preferences, the middle rectangle shows a vertical bar chart with sodium consumption broken into home cooked food versus industrial food according to the food preferences, and the leftmost rectangle shows graphically along time the estimated blood pressure. Clicking on the picture activates a video that explains the DPF structure and function.

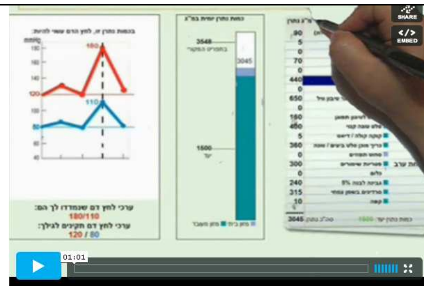

Figure 1. DPF screen – click for video

2) *Personalization*: DPF builds on the premise that the user and the user's personality are at the center of the interaction. The search for elements which can affect the behavior of medical information system users produced many studies in the field of Human-Computer Interaction, using elements of tailored information and personalization. Diverse solutions were suggested such as telemedicine (Riva & Gamberini, 2000), patients support by weekly emails, or sending automatic reminders to cell phone to encourage participating in a physical activity (Klasnja, Consolvo, McDonald, Landay & Pratt, 2009). Other interesting solutions checked the effect of giving feedback using an animated figure which expresses positive or empathetic emotions, regarding the patient's activity while using the interface (Blanson-Henkemans et al., 2009).

While the information in Figure 1 could be general information that presents average patients or certain stereotypes, the DPF system describes the user's *personal* information (see in Figure 2 the yellow callouts highlighting personal information). By manipulating directly the *personal* data, the motivational feedback is tied to the specific user's performance level and makes the feedback meaningful (as described in Hodges, 2004; Song & Keller, 2001).

In this study we refer to two aspects of personalization:

a) The patient learns a medical rule as it is applied to the patient's own medical and nutritional information. DPF explains the relationship between personal nutritional behavior and personal medical data. Personal information is more concrete and relevant, and therefore easier to understand.

b) Information is presented to users according to their own tastes and needs: the information categories, the level of detail, and the timing. Prochaska et al. (1994) found that people pass through a series of stages when change occurs. It is, therefore, important to provide the information at the appropriate stage. The type of information provided to the user is appropriate to his current phase as a medical information consumer, according to the phase model described by Bar-Ilan, et al.,(2006). The patient can use the system at any time of the day, independent of medical staff or availability of external agents that might dictate use time that is not according to the user's readiness.

Tailoring the information to fit the users' need, bridges efficiently the gap between the general information suggested by the medical staff, and the personal information.

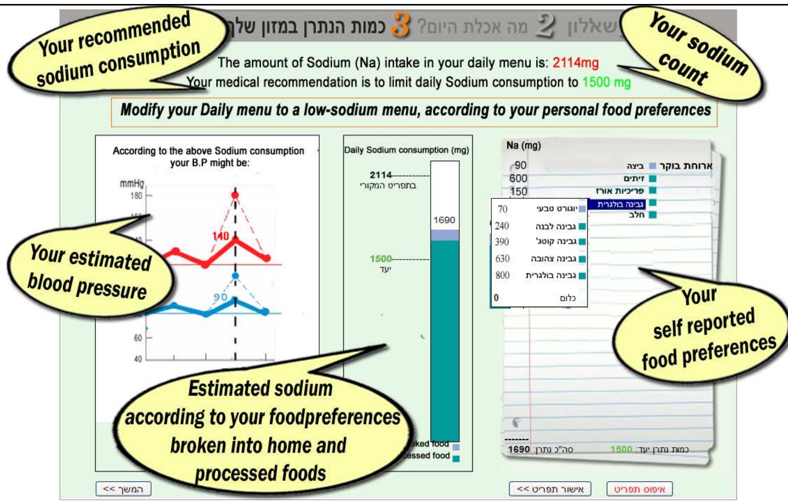

Figure 2. personalization in DPF

3) *Interactivity*: The ability to change properties and immediately see the effects is critical for learning in many contexts (Guzman et. al, 2006). Importantly, interactivity not only clarifies relationships but also enhances the users' motivation by increasing participation in the activity. DPF is designed to *motivate* the user to participate in the process in an active manner on two dimensions:

   a) *The "what if…" manipulation*, i.e., the patient's ability to act retroactively on the patient's own nutritional data and see the effect of such changes on medical symptoms measured in the past.

   b) *Using direct manipulation* both to enhance satisfaction while interacting with the system and to visually represent the progression of the process (Te'eni, 1990). This requires immediate feedback; delayed feedback breaks the flow of interaction. Furthermore, the feedback is embedded in the user's action and supports user control and participation. Direct manipulation is more playful, makes the learning experience more positive and encourages curiosity and investigation followed by personal success (Shneiderman & Plaisant, 2010). In Figure 3 we use a visual to explain immediate versus delayed DPF.

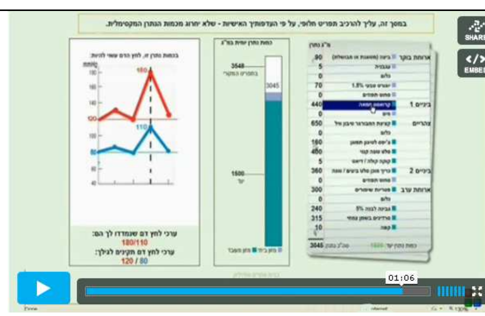

Figure 3. Immediate feedback as part of interactivity ([click for video])

The Impact of DPF

The Impact on Intermediary Constructs: Having described DPF, we now explain how it impacts health behavior by introducing three intermediary constructs: comprehension, participation and self-efficacy (see Figure 4).

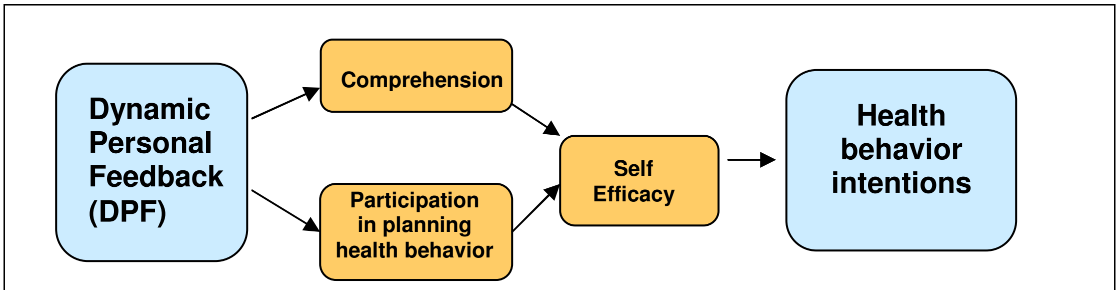

Figure 4. A cognitive-experiential model of feedback and behavioral intentions

A. *Comprehension* is about understanding medical information and how it can be applied to one's health condition, which in our setting is being aware of the connection between nutritional behavior and health condition.

The first role of DPF is to enhance learning. By encouraging active and personalized learning, DPF is expected to improve comprehension. According to Papert and Harel's (1991) theory of meaningful learning, the process of building new knowledge is more efficient when learners are engaged in applying knowledge that is realistic, personal, and meaningful to the learners or their surroundings (Löfström & Nevgi, 2006).

Many studies of patient empowerment assume that knowledge empowers the patient, and "knowledgeable" and "empowered" patients take responsibility over their health (Harris & Veinot, 2004; Harrison et al., 2006). The knowledge itself is an important part of empowering the patient - **but that is not sufficient to change his behavior.** Certain studies demonstrate that knowledge by itself almost doesn't change health behavior (Funnell & Anderson 2000; Mazzuca, 1982). Although people know the problems and risks of lack of treatment, the problem of implementing knowledge and persistence over time still remains (Blanson-Henkemans et al., 2009).
Hence, in our research two questions derive:

H1 - DPF, compared with non-dynamic feedback will increase comprehansion.
H2 - Comprehension will be positively related to self-efficacy

B. *Participation in planning health behavior*. The patient participates in the process of planning and conducting a healthier life. This participation makes you see yourself as an active and engaged participant (Faisal et. al, 2007; Papert & Harel, 1991). In our setting, participation is facilitated by the information system so that higher participation also involves more intensive human-computer interaction for planning behavior.

As discussed above, a second role of DPF is to draw users to be active in planning their health. Too often people are passive users of health information systems that provide treatment information as a set of rules to be implemented. Shedroff (2000) claims that if patients are given the opportunity to be involved in the creation of the rules, they gain a sense of involvement and ownership which will make the treatment more meaningful, and that interactive systems can make it easy for the patient to get involved.

Besides contributing to the meaningfulness of the experience, the users' activity impacts their perception of engagement both with the system and with the content the system provides. Research on user engagement with media stress this impact e.g., Jeeyun et al. (2010), who define engagement as a "form of user experience where physical interactions and cognitive experiences of the user lead to absorption with media content and outreach".

As Faisal et al. (2005) describes the uniqueness of participation within an InfoVis experience, "it is through interaction that user manipulates the visual representations, therefore gaining additional insights" in a process of cognitive engagement.

The search for an effective approach to deliver health information and encourage patient to be active, suggests most recent education programs such as a group-based, interactive learning experience called IDEA (Interactive Dialogue to Educate and **Activate**) used to educate Diabetes patients to self management. (Fernandes et al. 2010).

As DPF role is to trigger patient to a more active usage of the information system, it can be expressed by willingness to further self-exploring (i.e number of clicking on further nutrition alternatives even after completing the formal task etc.) It is this exploring that reflects the unique InfoVis experience wherein both interaction and visual representation take part. (Faisal et al. 2005).

To find out how using DPF influences participation and actual involvement in the process, we make the following hypotheses:

H3 - DPF, compared with non-dynamic feedback will increase participation
H4 - Participation will be positively related to self-efficacy

C. *Self-efficacy* is people's belief in their capabilities to exercise control over their own functioning and over events that affect their lives (Bandura, 1997); it is the confidence to perform the required action successfully in order to achieve the required goal (Bodenheimer et. al, 2002). People's motivation to perform a task is influenced by their expectations of the results of their behavior, which depend on their sense of efficacy to perform the task: a positive previous experience will develop expectations to succeed in similar tasks in the future (Bandura, 1997). Research on self-efficacy in health has established the impact of self-efficacy of chronic patients when planning their therapy (Kneckt, 2000).

Furthermore, self-efficacy is associated with the idea of locus of control, i.e., the extent in which individuals believe they can control events that affect them. DPF creates a sense of control by letting the user control the pace of learning and processing information (Frank & Barzilai, 2004) and by letting users consider their health condition according to their own activity.

Regarding to the relationship between DPF and self efficacy we make the following hypothesis:

H5 - Increasing self-efficacy will be positively related to intentions to change health behavior.

Behavioral intention is defined in literature as an indication of an individual's readiness to perform a given behavior (Ajzen & Fishbein, 2005) and as personal goals, either self-imposed or other-imposed (Schwarzer, 2008). In our case, Health behavior intentions describe patient's self-reported readiness and willingness to perform certain nutritional consuming goals to change his health behavior.

The Impact on Health Behavior: The dependent variable we wish to affect through these three intermediary constructs is the patient's health behavior (Figure 4). We stop one step before actual behavior and examine intentions to behave in a certain manner as a basis to predict behavior (Ajzen & Fishbein, 2005).

Most social-cognitive theories assume that actual changes can be predicted by intentions to change, but often there's a gap between people's intentions and their behavior (Schwarzer, 2008).

In our model design we suggest a combination of several possible solutions for factors that prevent actualizing implementing the intentions. We believe that these solutions derive from the unique activity that occurs within an information system using a DPF and we attend to test this empirically in the future:

1. The integrative model of behavioral prediction suggests that people do not act upon their intentions because they lack the skills to perform the behavior. Therefore, an intervention should aim to improve people's skills (Fishbein, 2003). Our Information system focuses on patient's being active during information acquiring, and allows him to experience finding variants for his health menu by experiencing a playfulness direct manipulation. By watching an immediate visual change with no risk, the patient realizes and internalizes the variety of nutrition options he has. In a way he improves his level of skills to find variants and menu alternatives, without being dependant on medical staff. This process contributes to an increased self efficacy perception.

2. Schwarzer (2008) claims that intentions should be supplemented by more proximal predictors that might facilitate the translation of intentions into action. According to his Health Action Process Approach (HAPA), without action plan there's less possibility for intentions to predict actual behavior.

Schwarzer (2008) claims that the existence of both **self-efficacy** and **strategic planning** helps to bridge the intention-behavior gap. Therefore we added specific time schedule for behavior change in our questionnaire, which added a sort of exact planning action and not a vague plan.

3. According to The Health Belief Model (HBM) two conditions must exist in order to motivate behavior change: the belief that a certain activity will provide the desired benefit, and a patient's belief the he can perform that activity (Maddux & Roggers 1983). Designing a DPF based user experience provides both conditions. The visual realization of the result or health behavior (i.e. a balanced blood pressure level) strengthens the belief in the connection between behavior and desired benefit. The positive experience in a simulation of the real life behavior strengthens his sense of self efficacy to actually act this way.

Patients who have been part of the decision-making process are more likely to have a greater intention to adopt or change a behavior than patients who have simply been told to make a change (Cole & Kern, 2006). They most likely will feel more in control and perceive higher self-efficacy having received positive feedback during their participation.

Moreover, intentions that are derived from internal feelings and motivation are regarded as more effective than those existing in patients who are dependent on external professional agents (Prochaska et al., 1994). The three intermediary constructs reflect an impact on behavior that includes cognitive and emotive aspects necessary for both learning and motivation, which are crucial for changing behavior. People need to be persuaded to act, not only informed how to act (Oinas-Kukkonen, 2010).

Self-efficacy is directly related to health behavior, but it also affects health behavior indirectly through its impact on goals. Self-efficacy influences the challenges that people take as well as the level they set their goals. Individuals with strong self-efficacy select more challenging goals (DeVellis & DeVellis, 2000 as described in Schwarzer & Luszczynska, 2008). In the theory of planned behavior it is argued that increasing knowledge alone does not change behavior but when increased knowledge co-exists with self-efficacy or locus of control it changes behavior (Ajzen & Fishbein, 2005).

A Pilot Study

The argument presented in this paper is part of a PhD dissertation in progress at the Information Science Department at Bar-Ilan University. We conducted a pilot study to test the feasibility and usability of DPF and to test measures of the constructs in our model. A nutrition information system was developed with dot.Net and accessible with Explorer. The system helps manage a low-sodium daily menu, in order to avoid high blood pressure, which is affected by the amount of salt in the food (as discussed above, see Figure 1).

The Task was to use known food items to assemble a daily menu resembling the user's regular daily nutrition. The system would then calculate the total sodium consumption, display it to the user, and show the blood pressure levels estimated for a patient with high blood pressure. Other information that was displayed was the maximum daily intake of sodium as recommended by the medical staff and the source of sodium in the food items (whether it came from industrial products or added at home). Subjects had to retroactively amend their daily menu, in order to reach the recommended maximal sodium value, and accordingly watch the influence of this change on a graph of blood pressure that was supposed to be measured following task completion.

Sample Population consisted of 40 graduate students enrolled in an HCI course who participated voluntarily on their free time. The task was adjusted accordingly to fit healthy people (e.g. relating to daily sodium intake which interests every nutrition conscious person). During the pilot period, 35 students accessed the system. Several students were disqualified for not fully filling out both questionnaires, or filling the questionnaires repeatedly. That left 30 students for the analysis. No technical difficulties were observed during the pilot period.

Experimental Design and Measures. Each student was randomly related to one of four test groups, each group interacting with one of four configurations of DPF but with the same above mentioned task. All groups had access to the same information; they differed only in the way it was presented and visualized to them. All groups filled pre and post-task questionnaires for comprehension, participation and self-efficacy and a questionnaire for health intentions; these were based on validated questionnaires: Self-efficacy Questionnaire for diabètes (Bandura, 2006), Managing chronic disease (Bandura, 2006), Managing chronic disease (Schwarzer & Renner, 2010), Perceived Competence for Diabetes (Deci & Ryan, 1985), TPB Questionnaire Construction (Ajzen, 2006). The questionnaires used a 5-pt scale from strongly disagree to strongly agree.

The four DPF configurations were:

1. Full dynamic feedback, in which every change of food items affected the display of sodium level and its origins (home-made or processed food), and the correlation to blood pressure graph that was formed in front of the user, completed the realization (this is the dynamic feedback as demonstrated in Figure 3).

2. Visual feedback which was not dynamic - the realization was displayed only after task completion and not during the task (delayed feedback, see Figure 3).

3. No visual realization of the correlation to blood pressure (left rectangle in Figure 1).

4. No visual realization of sodium level and its origins (middle rectangle in Figure 1).

In addition, we captured the user's use of information system by recording the user's navigation pattern and we filmed the interaction of three subjects performing the task and thinking aloud, and we analyzed their reactions. This data will be used to assess the user's participation level.

Results of Pilot. Using the questionnaire data to compare before and after interacting with the system, we found no statistically significant differences between the different configurations of DPF but all configurations were effective in increasing intentions to act according to the health recommendations. Only in the post-questionnaire data (after the task), were there positive correlations between comprehension - intentions ($r=.562$, $p<.001$) and comprehension - self-efficacy ($r=.428$, $p<.05$). In comprehension, significant increases were found for all groups (Dynamic feedback groups increased from $M=.9375$, $SD=1.29$ of correct answers before the task to $M=2.500$, $SD=1.88$ after the task. Non-Dynamic group increased from $M= 1.3889$, $SD=1.31$ to $M=2.500$, $SD=1.25$ after the task).

We also analyzed both log-file data and sample observation information. The log files are summarized in Table 1. We measured the number of changes the users needed to modify the daily menu, and also the number of repeated changes made in certain items, i.e., items that were changed at least twice before a decision was made. These measures of change reflect the number of alternative plans examined before finalizing the decision. Group 2 with delayed feedback (in comparison with the dynamic feedback groups) examined fewer alternatives and needed more time to complete the task.

Table 1. Changes to modify menu

Group	Changes in menu	Repeated changes	No. of users	Change Time (mm:ss)
G1	8.0	1.9	9	03:02
G2	6.9	0.6	7	07:03
G3	6.3	0.3	6	02:11
G4	11.1	2.5	8	03:44

The video of a user (Liat) interacting with the system to complete the task (Figure 5) demonstrates our analysis of observations (the analysis was performed on the filmed interaction). This edited video shows Liat reacting to the DPF, in words and in body language, and also explaining the repeated changes she makes while modifying the menu. Our analysis looked for measures of participation and engagement and for the user's reasons for acting as she did.

Figure 5. Filmed interactions –click for video

Notice in the video how Liat's body position changes from one rather stationary and detached position while filling the pre-questionnaire and daily menu to a second more intense and engaged body position while modifying menu to a low-sodium menu. Then she changes back to the first position while filling the post-questionnaire. The relationship between body posture and engagement to a given task is being addressed in psychological researches (Mota and Picard, 2003; D'Mello et al., 2007). This relationship has been observed during the pilot, and we intend to investigate it later at the research itself.

In the second part of the video, Liat explains how her behavior is affected by DPF. Once she reached the recommended level of sodium, she goes back to some of the food categories she had visited and changes them (these are the repeated changes in Table 1) without calculating their impact but simply choosing preferred food items and glancing to see whether it increases her sodium read (her example of choosing chocolate brownies). Her actions become more automatic and less controlled, as she relies more confidently on the system.

Summary of Pilot. Using DPF to enable an effective mode of "What if manipulation", we studied the human-computer interaction as a personal experience in which a realistic health situation is subject to modifications tailored to the user's personal needs and preferences. The pilot demonstrated the feasibility of constructing DPF and the usability and impact of the feedback.

From the correlation analysis of the questionnaire data, we also found that DPF affected the relationships between the intermediary and dependent variable in our model of DPF impact. Additionally, we analyzed the log data of user activity and the observations recorded by video. These analyses reinforce our conclusions that DPF is effective in driving the user to participate more actively in the process of planning, exhibiting a higher level of engagement and more concentrated effort in the planning process.

Conclusion

First Level of Analysis – DPF and Its Impact on Health Planning Behavior

Dynamic and Personal Feedback (DPF) was designed to include visualization, personalization and interactivity to support comprehension, participation and self-efficacy. We have demonstrated the feasibility of such feedback and its importance in promoting changes to health behavior according to medical recommendations. Both motivation and knowledge are important in enabling change and both can be influenced with appropriate designs of information systems, DPF in our case. The user experience triggered by DPF must be analyzed by considering both cognitive and emotive aspects of the human computer interaction as well as aspects of knowledge and involvement of planning one's health behavior. By providing the patient with the appropriate interactive visual interface, an effective InfoVis experience can be reached.

DPF contributes to the InfoVis experience in numerous channels – interactivity, Dynamic Feedback, visualization, etc. The video in figure 6 demonstrates how one of the aforementioned channels, the Dynamic Feedback, contributes to user experience.

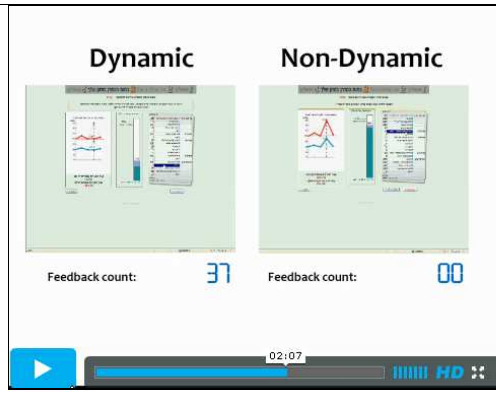

Figure 6. Dynamic feedback and InfoVis experience –click for video

We think this model can be generalized beyond this particular case of salt and blood pressure to other cases of self-managed chronic patients and beyond that to other non-medical contexts where dynamic and personal aspects of the user's activity are central. However, this study is only a pilot to lab and field studies, which are on their way. We are now studying similar systems for managing sugar consumption for patients with diabetes. The research will be conducted using chronic patients, and will be based on the relevant conclusions from the healthy students' pilot.

Second Level of Analysis – Use of Visuals to Perform and Disseminate Research

Having been given the opportunity to explain a new design of human-computer interaction by incorporating dynamic visuals, it will be difficult to make do with verbal descriptions and static visuals. The representation of dynamic physical behavior with dynamic visuals seems compelling. We used three forms of visuals: the static, the distilled dynamic and the dynamic embedded in context.

The static visual is the traditional static figure, e.g., a photograph (still) or diagram. In Figure 2 we used a visual to demonstrate concretely what we mean by personal feedback. A dynamic visual would not add but could very well distract. In Figure (video) 3 we relied on the dynamics of the video to show the difference between immediate and delayed feedback. The video was generated with BSR Screen Recorder (a product of BSRSoft) as a series of screens. We annotated the video with a few slides to explain and highlight some issues. We refer to this type of dynamic visual as distilled in the sense it was created in an artificial and constrained context (or could be distilled from a natural or rich context). In our case it was generated to exhibit the progression of screens as the user might see it in response to a predefined set of inputs, once in the immediate mode, and once in the delayed mode. Adding other aspects, such as a user clicking on the right button, would not add to the explanation; again, it might distract and detract.

The other type of dynamic visual is a video of a user in a natural or controlled environment. The video was recorded with home equipment and then edited using Windows Movie Maker. Video in Figure 5 shows how a user interacts with the system to capture her reactions to specific information and designs. We capture here the verbal explanations to information she sees (the screen shots in the upper left part of the screen) and we also observe her body language. Had there been other environmental effects such as people we could have examined their impact too. These are aspects of the user experience that cannot be captured by verbal or log data and moreover, require a dynamic representation.

As noted above, we managed to see indicators of participation not evident in questionnaires or logs. In fact, we believe it would have been difficult if not improbable to detect some of these indications in real time observations. It was in a retrospect analysis of the video, given time to view and review the video, that we could come to some of our conclusions. In that sense, the video is not only a tool for dissemination but also a research technique. Of course, the raw recording that served for the analysis was edited substantially before dissemination to highlight the messages with specific incidents. The final video lasts 2:43 minutes, which is less than 10% of the unabridged video.

The contingent use of different types of visuals has proved effective for us. We created the visuals with home equipment and free software, avoiding the temptation (and expense) to turn to professional production. We relied on an expert producer only to combine two videos on the same screen. If visuals are to become commonplace in disseminating research, they must be accessible and affordable to all.

On a final note combining both levels of analysis – we hope the lessons learned from designing DPF will be applied to future visual techniques of disseminating research that are more active, more interactive and more personalized.

References

Ajzen, I., and Fishbein, M. 2005. "The influence of attitudes on behavior," in *The handbook of attitudes* D. Albarracín, B. T. Johnson, and M. P. Zanna (eds.), . Mahwah, NJ: Erlbaum. pp. 173-221

Ajzen, I. 2006 *Construction a TPB Questionnaire: Conceptual and Methodological Considerations* available at http://www.people.umass.edu/aizen/pdf/tpb.measurement.pdf

Balzer, W.K., Doherty M.E., and O'Conner R. 1989. "Effects of cognitive feedback on performance," *Psychological Bulletin*, *106*, pp. 410-433.

Bandura, A. 1997. *Self-efficacy: The exercise of control*. New York: Freeman.

Bandura, A. 2006. "Guide for constructing self-efficacy scales," in *Self-Efficacy Beliefs of Adolescents*, Charlotte: Information Age Publishing. pp. 307–337

Bettinghaus, E. P. 2004. "Health promotion and the knowledge-attitude-behavior continuum," *Preventive Medicine; 15* (5), pp. 475-491

Blanson-Henkemans, O.A., Van der Boog P.J.M., Lindenberg J., Van der Mast C.A.P.G., Neerinck, M.A., and Zwetsloot-Schonk B.J.H.M 2009. "An online lifestyle diary with a persuasive computer assistant providing feedback on self-management," *Technology and Health Care*. *17* (3) pp. 253-267.

Bodenheimer, T., Lorig, K., Holman, H., and Grumbach K. 2002. "Patient self-management of chronic disease in primary care," *JAMA: the journal of the American Medical Association*. *20*;288(19) pp. 2469-75.

Cole, K. A., and Kern D. E. 2006. "Patient education and the promotion of healthy behaviors," in *Principles of Ambulatory Medicine: Barker, Burton and Zieve's*, N. Fiebach, R.C. Ziegelstein, and L. Barker, (eds.), Lippincott Williams & Wilkins, seventh edition.

Deci, E. L., and Ryan, R. M. 1985. *Intrinsic motivation and self-determination in human behavior*, New York: Plenum.

Faisal, S., Cairns, P., and Craft, B. 2005. "InfoVis experience enhancement through mediated interaction." Presented at: *ICMI'05: Workshop on Multimodal Interaction for the Visualization and Exploration of Scientific Data*, Trento, Italy.

Faisal, S., Cairns, P. and Blandford, A. 2007. "Challenges of evaluating the information visualization experience," in *People and Computers XXI: HCI...but not as we know it* 2, D. Ramduny-Ellis, and D. Rachovides, (eds.), Swindon, UK: British Computer Society. pp. 167-170

Fogg, B.J. 2009. "A behavior model for persuasive design," *Persuasive'09,* April 26-29, Claremont, California, USA.

Frank, M., and Barzilai, A. 2004. "Designing course web sites for supporting lecture-based courses in higher education – Some pedagogical aspects," *International Journal of Instructional Technology and Distance Learning; 1:12* available at http://www.itdl.org/Journal/Dec_04/article04.htm

Funnell, M.M., and Anderson, R.M. 2000. "The problem with compliance in diabetes," *JAMA; 284*:1709.

Guzman, J. L., Astrom, K. J., Dormido, S., Hagglund, T., Berenguel, M., and Piguet, Y. 2006. *Interactive Learning Modules for Feedback Fundamentals using PID Control*, 2006, available at http://aer.ual.es/ilm/.

Harris, R., and Veinot, T. 2004. "The empowerment model and using e-health to distribute information," *Vancouver, BC: Action for Health, Simon Fraser University and the Vancouver Coastal Health Research Institute*.

Harrison, T., Waite, K., and Hunter, G. L. 2006. "The internet, information and empowerment," *European Journal of Marketing, Special Issue on Consumer Empowerment*, *40,* (9/10), pp. 972-993.

Hodges, C. B. 2004. "Designing to motivate: Motivational techniques to incorporate in e-learning experience," *The Journal of Interactive Online Learning; 2(3).*

Jeeyun O., Saraswathi B., and Shyam S.S. 2010. "A conceptual model of user engagement with media," *60th Annual conference of the International Communication Association,* June 22-26 Singapore.

Kerren, A., Stasko, J. T., Fekete, J. D., and North, C. 2007. "Information visualization – Human-centered issues in visual representation, interaction, and evaluation," *Dagstuhl Seminar Proceedings 07221*

Kneckt, M. 2000. *Psychological features characterizing oral health behavior, diabetes self-care health status among IDDM patients*. Dissertation. Oulu, Finland, Institute of Dentistry, University Of Oulu. Retrieved from http://herkules.oulu.fi/isbn9514256301/isbn9514256301.pdf.

Löfström, E., and Nevgi, A. 2006. "From strategic planning to meaningful learning: Diverse perspectives on the development of web-based teaching and learning in higher education," *British Journal of Educational Technology*, *38* (2), pp. 312 – 324

Mazzuca, S.A. 1982. "Does patient education in chronic disease have therapeutic value?" *J. Chronic Dis.; 35*: pp. 521-529

Papert, S., and Harel, I. 1991. "Constructionism," *Ablex Publishing Corporation*. Retrieved from http://www.papert.org/articles/SituatingConstructionism.html

Oinas-Kukkonen, H. 2010. "Behavior change support systems: A research model and agenda," in *PERSUASIVE 2010,* T. Ploug, P. Hasle, H. Oinas-Kukkonen (eds.):, LNCS 6137, pp. 4–14.

Prochaska, J.O., Norcross, J.C., and DiClemente, C.C. 1994. *Changing for good: The revolutionary program that explains the six stages of change and teaches you how to free yourself from bad habits*. New York: W. Morrow

Renaud, K., and Cooper, R. 2000. "Feedback in human-computer interaction - Characteristics and recommendations," *South African Institute of Computer Scientists and Information Technologists. Annual Research Conference.*

Schwarzer, R., and Luszczynska, A. 2008. "Self-Efficacy and health behavior theories," *Health behavior constructs: Theory, measurements and Research* available at http://cancercontrol.cancer.gov/brp/constructs/index.html

Schwarzer, R., and Renner, B. 2010. *Health-specific self-efficacy scales,* Retrieved from http://userpage.fu-berlin.de/~health/healself.pdf. Accessed May 10, 2010

Shedroff, N. 2000. "Information interaction design: A unified field theory of design," in *Information Design*, R. Jacobson (ed.), MIT Press

Shneiderman, B., and Plaisant, C. 2010. *Designing the user interface: Strategies for effective human-computer interaction*. Fifth Edition, Boston: Pearson.

Song, S. H., and Keller, J. M. 2001. "Effectiveness of motivationally adaptive computer assisted instruction on the dynamic aspects of motivation," *Educational Technology, Research and Development, 49*(2), pp. 5-22.

Te'eni, D. 1990. "Direct manipulation as a source of cognitive feedback: A human-computer experiment with a judgment task," *Int. J. Man-Machine Studies 33*, pp. 453-466

Te'eni, D. 1992. "Analysis and design of process feedback in information systems: Old and new wine in new bottles," *Accting., Mgmt. & Info. Tech., 2 (1)* pp.1-18