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PADMEH: Personality-based Adaptive moDEL for Mobile E-Health

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ABSTRACT

Studies suggest that e-Health coaching applications should be tailored to each user in order to elicit motivation and long-term adherence. E-Health coaching and current models for adaptive human-computer interactions could thus benefit from Psychology theories related to motivation and inter-individual differences. This article introduces the PADMEH model (Personality-based Adaptive moDEL for Mobile E-Health) which inspires from the Self-Determination motivational Theory and the Regulatory Focus personality Theory. We describe the two dimensions of this model ("Triggering Elements" and "Adapted Elements") and we explain how they enable to adapt the interaction with different users to better motivate them for physical activity. We conclude by future directions regarding PADMEH's validation.

CCS CONCEPTS

• **Human-centered computing** → **HCI theory, concepts and models**; *Human computer interaction (HCI)*; • **Social and professional topics** → **User characteristics**; • **General and reference** → *General conference proceedings*; • **Information systems** → *Personalization*.

KEYWORDS

Health - Well-being, Personalization, Sports/Exercise, Adaptive interactions

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1 INTRODUCTION

Being physically active prevents from chronic diseases and we need to motivate people for physical activity [23]. Current persuasive technologies are often limited to the mere selection and display of tailored text messages [1]. There is a need for a more global adaptation of motivational interactions to each user's personality and motivation.

Several frameworks have been proposed for exploring adaptation in HCI. *ISATINE* [17] expresses the adaptation of user interfaces as a coordination between the user and the system. It uses Norman's interaction model [24] to build a progressive adaptation whose result is perceived, interpreted and evaluated in turn by the user and the system. The *PDA-LPA* (Perception Decision Action - Learning Prediction Adaptation) design space [3] regards the user and the system as two entities being able to perceive, to decide and to act. The user goes through a *PDA* loop to complete her objective through interactions with the system. This vision of interaction is broadened with the *LPA* loop: the user learns from the actions of the system. The system does the same, to predict what the user expects from the next interaction. Adaptation is seen in *PDA-LPA* as a continuous exchange of actions and predictions between the user and the system.

Adaptation in HCI usually includes two components: adaptability and adaptivity [28]. Adaptability is user's ability to change the behaviour of the system. Adaptivity is the system's own ability to automatically adapt to the user. Machado et al. [19] propose a framework focusing on adaptivity. It

involves user profiles to drive the adaptation process in E-health applications. A user profile is composed of four components: preferences, personal data, visual health and cognitive health. Sensors collect physiological measures to fill visual and cognitive health components. Such information is collected automatically and continuously to allow for real-time adaptation to a given user.

Unfortunately, the different design frameworks about adaptation in HCI mentioned above do not consider personality theories from Psychology to tailor interactions. The Five Factors Model (FFM) is one of the main theories of personality used in HCI. It enables to describe user's personality through five factors[22]. Yet, it is a descriptive approach and it does not aim at explaining user's behaviours (which we need if we want to motivate the users for healthy behaviours). In our work, we rely on two other theories: Self-Determination motivational Theory (SDT) and Regulatory Focus personality Theory (RFT).

Self-Determination Theory (SDT) [7] is a theory about motivation which identifies three basic needs any individual must meet to achieve motivation and well-being: autonomy, competence and relatedness. Autonomy consists in acting in line with one's own goals and values with strength and will. Competence describes the feeling of being able to accomplish something and being efficient in doing so. Finally, relatedness describes the feeling of being part of a group and connected to other people. The METUX Model (Motivation, Engagement, and Thriving in the User Experience) is a framework for designing well-being application based on SDT and can be used as a blueprint for designing motivational technologies [26]. METUX considers six spheres of experience starting when a user learns about a brand new technology and ending with the possible impact of this technology on society.

Regulatory Focus Theory (RFT) [6] describes people's decision-making strategic leanings according to their goal and how they intend to reach their goal. *Promotion focus* individuals aim at progress and achievement. Instead, *Prevention focus* individual look for security and avoid situations which pull them away from their aimed end-state. Two individuals with opposite regulatory focuses can aim for the same goal using different approaches to reach it.

Cesario et al. [4] link the sensation of "*feeling right*" with persuasion: they propose to use a regulatory fit to persuade a person to follow or change behaviour. According to these authors, a person presented with a persuasive message framed according to her own focus (e.g. there is thus a fit between the regulatory focus of the user and the regulatory fit expressed by the message and its framing context) should *feel right* and should be more influenced by the message than when there is not fit. They conclude that experiencing such a fit increases persuasion. Emotions have nevertheless a strong

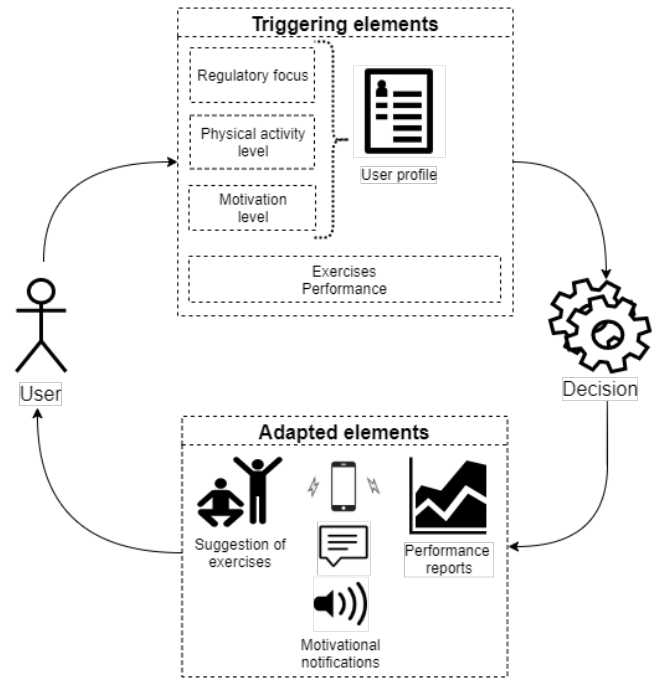


Figure 1: PADMEH considers a set of Triggering Elements to tune and combine a set of Adapted Elements for motivational interactions.

impact on the persuasion process. *Feeling right* for positive thoughts tends to increase persuasion, while the contrary tends to decrease it. Similar conclusions are drawn by Lee and Aaker [16]. They explore the relationship between regulatory focus, perceived risk and framed-message effects on persuasion, especially within a gain and loss context. They conclude that promotion-focused messages presented within a perceived low-risk context are more persuasive, and accordingly, prevention-focused messages presented within a perceived high-risk context are more persuasive too. Moreover, experiencing fit eases message understanding, thus improving persuasion.

Martin and Clavel [20] propose the WE-nner framework for tailored and multimodal interactions. Motivational messages that are in fit with user's regulatory focus (collected via a validated questionnaire) are either displayed on a smart-watch in order to motivate users to achieve their recommended 10000 steps per day, or spoken by an expressive virtual character while the user is standing on a stepper [5].

Researchers in HCI propose several models for adaptive interactions, with the ability to adapt to each step of an interaction between a user and a system. Psychology is able to describe precisely user's personality, strategic inclinations and motivations, through accepted theories. Some researchers have made cross field works, especially linking regulatory

fit with persuasive technologies, and by using self determination theory for adaptive interactions. There is still a void on describing user's personality and motivation for adaptive human-computer interactions. Through this paper, we propose such a model, applied to physical activity practice.

In the next section, we introduce PADMEH, a novel model of adaptation, based on users' personality. Section 3 provides two illustrative scenarios.

2 PADMEH: A PERSONALITY-BASED ADAPTIVE MODEL

PADMEH (Personality-based moDel for Mobile E-Health) is a model for supporting adaptive human-computer interaction (Figure1). Day-to-day interaction aims to improve motivation for physical activity through personalised coaching. Based on user's initial profile and her performance on current physical activity exercise, the model selects next relevant physical exercises, displays tailored motivational multi-modal messages including graphical reports on user's previous activities.

PADMEH has a representation of the *intervention* proposed to the user [21]. A PADMEH *intervention* is composed of several *sessions*, each being a collection of physical *exercises* spanning a few tens of minutes. An *exercise* usually lasts for a few minutes.

The *system* refers to the combination of all procedures and elements created to improve user's motivation for physical activity. To reach this goal, it uses adaptivity. At the start of the intervention, the user fills in questionnaires, the output of which is included in her initial profile. *Triggering elements* are measured continuously to activate the adaptation process appropriately. The adaptation process alters *adapted elements*, which define the new behaviour of the *system*, thus completing an adaptive interaction cycle.

User profile. In PADMEH, the user profile has three dimensions: motivation, regulatory focus (personality) and physical activity level. There are different ways to measure these dimensions and PADMEH is independent from them. For instance, motivation can be assessed using the global motivation scale [11] which provides three possible values for motivation: autonomous motivation, controlled motivation or a lack of motivation (amotivation) as defined by the SDT theory [7]. Regulatory focus can be evaluated using the Regulatory Focus Questionnaire (RFQ) [14]. Finally, there are multiple scales for measuring physical activity level [10]. The user profile is initialised when the user launches the application for the first time using answers to such scales. It is then updated according to ongoing interactions, user's behaviour and performed exercises.

PADMEH Dimensions. *Triggering elements* are mechanisms used to trigger the adaptation process. Three of them are used to initialise the user profile: regulatory focus, motivation and physical activity levels. User's performance during previous physical exercises is also used as a *triggering element*. The *system* adapts its behaviour depending on *exercise* outcome, on duration of previous *session* and previous *exercise*, on the number of *exercises* achieved during a *session* or during the global *intervention*. Triggering elements may be considered by PADMEH at different time, for example the time of events occurring before, during or after an *exercise*. The first event is the initialisation of the application, during which the user profile is created. Table 1 illustrates *adapted elements* according to time (columns) and *triggering elements* (rows).

Adapted elements are components, functions and processes of the interactive motivational application that are selected and tailored to fit the profile of the user. They are modified at different points in time, and activated by different *triggering elements*. For example, a summary report is displayed at the end of a session to sum up what happened during the exercises and how the user performed. These overviews are personalised to fit the profile of the user. For instance, if the user has a promotion regulatory focus, then displayed messages during an *exercise* are promotion-oriented to get him to challenge himself [18].

Adaptation process. This process links together PADMEH dimensions to create the adapted behaviour of the model. Its inputs are triggering elements, which is information about who is the user or what she did during her use of the application. The outputs of this process are the changes made to the application. For instance, a motivational message is composed of a frame (how it is presented), a content (the message itself) and a timing (when it is presented). The frame and the content of the message can differ depending on the regulatory focus. The frame of promotion-focused messages aim to reach a desired end-state (e.g. "be healthy") where as the frame of prevention-focused messages aim to avoid a non-desired end-state (e.g. "do not gain weight") [13]. Promotion content is framed according to risky or enthusiastic strategies, where as prevention content is more focused on safe and calm strategies [12]. Another example: reports about the activity of the user, such as exercises or sessions reports, are adapted to their regulatory focus too. For example, promotion-oriented people are more directed to abstract and global data where as prevention-oriented people are more interested by precise and local data [9].

Time and events	Profile creation	Intervention or session beginning	During session	End of session	End of intervention
Triggering elements					
Physical activity level	User profile	Proposed exercises			
Motivation	User profile	Intensity and objectives of exercises			
Personality	User profile	Objectives reminder	Motivational messages	Report display	
Exercise performance		Intensity and objectives of exercises	Badges, audio and text messages, vibrations	Report display, badges	Physical activity level update, motivation update

Table 1: Adapted elements according to time (columns) and triggering elements (rows)

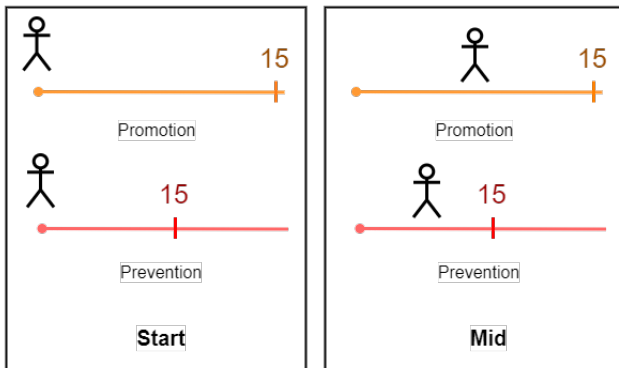


Figure 2: Graphical display of distance to the current goal (exercise during 15 mn) adapted to the current performance (location of the simple cartoon character) and the regulatory fit of the user (Above: promotion display in orange ; below: prevention display in red).

3 SCENARIOS

Scenario #1

Let’s consider a fictive User X. He has a promotion focus: he is mostly motivated by success, achievement and progress [6]. His motivation is extrinsic: he needs an external regulation [7]. His physical activity level is *inactive*.

Profile creation. User X launches the application and provides personal data: name, age, gender, height and weight. Then he fills in questionnaires, the output of which is used to initialise the profile of this user with a physical activity level, a regulatory focus and a motivation level. This individual profile is lately used for supporting tailored interactions used to initialise the system and to set it up for its use. A message appears to confirm the user profile has been created. This message is promotion-oriented (like this very user), as it emphasises the successful experience the user is about to have: ‘Thank you! Your profile is now created. Your daily experience will be greatly improved thanks to this information.’

Session #1. The system suggests a first session for today: the user has to walk at least 45 minutes during the day [25]. This objective is divided into three *exercises*, each consisting in walking 15 minutes in a row. When the first *exercise* is launched by the user, a diagram is displayed (Figure 2 - Start), showing a small character, a scale and the number ‘15’ (mn). It represents the remaining distance to the goal in terms of number of minutes to walk. The scale and the number are coloured in orange, since promotion-oriented people are known to better perceive this colour[8].

During the *exercise*, the diagram is updated: the cartoon character gets closer to the ‘15’ mark on the scale (Figure 2 - Mid). If relevant interaction devices are available and compatible with the *exercise*, tailored motivational actions are used such as the display of a promotion-focused motivational textual message: ‘Come on, you are getting closer to your goal!’ [5], or an equivalent audio message encouraging the user to complete the *exercise*.

Let’s suppose user X did not complete Session #1. A report nonetheless displays a motivational graph, tailored to his profile. Curves are approximate and global or average values are highlighted in orange with varying hues, as promotion-focused people better perceive these details [8, 9]. Finally, a question is asked to the user in order to assess his motivation after performing the *session*.

Session #2. The day after, PADMEH suggests a new session: the user has to walk at least 30 minutes during the day. The new value for walking duration is decided thanks to knowledge about physical activity and user activity history [27]. The walking session is still divided into three *exercises*, but now each *exercise* consists in walking only 10 minutes in a row. When the first *exercise* is started, a diagram displays ‘10’ (mn) as the walking duration goal. An additional (promotion-oriented as this user) motivational message is displayed under the diagram: ‘You will get there: if you have the desire you will succeed!’ [5]. To enhance his feeling of autonomy (one of the three dimensions of SDT) [15], the choice is left to the user to follow this new *session* or to keep the previous objectives of walking 45 minutes during the day. An orange frame surrounds the new *session* to help him

make this decision [8]. In this scenario, User X is motivated by progress and thus chooses the new *session* objectives [4].

At each completed *exercise* during the *session*, the application sends to the user feedback on distance to the goal, such as 'Go for it! You are the best!'. User X gets more motivating feedback, for instance audio messages and diagram updates to encourage him to reach his goal this time. User X completes Session #2. At completion time, a message notifies him of success: 'You did it, well done!'. A summary diagram is then displayed. The same colours and shapes are used [8][9] as at the end of Session #1 to enhance the readability of the graphs. At last, a question is asked to assess user's motivation.

Scenario #2

Let's consider another user. User Y has a prevention focus, which means she is mostly motivated by security, safety and chooses conservative options [6]. Her motivation is intrinsic, as she is able to motivate herself to achieve her goals, whether they are set by herself or an external entity [7]. Her physical activity level is *active*: she is used to physical activity practice.

Profile creation. This step is the same as in Scenario #1, except the fact that the validating message is prevention-oriented: it emphasises the necessary *exercise* the user needs to do to keep her healthy: 'Your profile is now created. It will help you prevent you from an unhealthy life.'

Session #1. The system presents the same *exercise* as for User X in Session #1. A diagram is displayed (Figure 2 - Start), showing a small character, a scale and the number '15' (mn). Prevention-oriented people tend to be more sensitive to red colour, hence the hues of the scale and the number [8]. During the *exercise*, updates to the diagram are displayed: the small character gets closer to the red '15' end mark on the scale (Figure 2 - Mid). After each completed *exercise*, personalised actions are used such as a prevention-focused text message enhancing competence (a dimension of SDT): 'Come on! You need to complete one more exercise only!'. User Y is successful at the end of Session #1. Displayed graphs are personalised in a prevention-focus way: curves are sharp, minimal values are highlighted in red, and the local minima are accentuated by a grey colour [8, 9]. Finally, a question is asked to User Y to evaluate her motivation after completing the *session*.

Session #2. The day after, the system proposes more difficult objectives for Session #2. User Y has to walk at least 60 minutes during the day, divided into three 20-minutes spans. These new values for walking durations are decided following a similar process as in Scenario #1 [27]. An updated diagram appears, featuring the number '20' at the end of the scale. The goal of the previous *session* and the new goal

for *session #2* are displayed, to leave her the choice for her *session* objectives [7]. A red frame highlights the previous *session* objectives, advised by the system. User Y chooses again the previous *session* objectives, as she prefers to have control over a known environment before moving forward [4].

Only after the first completed *exercise* User Y receives an update of the diagram and a prevention-oriented message: 'You will do what is necessary to avoid failing!'. User Y completes Session #2. A prevention-oriented message is displayed: 'Congratulations! By continuing like this, you will preserve your health!'. A final report is displayed, featuring the same graphs as previously, and colours selected according to the regulatory focus of User Y. Another measure of motivation is being collected to drive the selection of the next session.

4 CONCLUSION AND FUTURE DIRECTIONS

In this article we introduced the PADMEH model of adaptive human-computer interactions, based on user's personality. Our approach inspires from two theories of psychology to design an interactive motivational application. In the future, we plan to implement this model through a user-centred approach. Semi-directed interviews with target users will allow us to gather knowledge useful for the design of the decision engine, which will be based on decision tree techniques. Ethical principles of persuasive technology design [2] will be considered during the proper implementation of the motivational application.

REFERENCES

- [1] Christina S Beck. 2009. The role of message tailoring in the development of persuasive health communication messages. In *Communication yearbook 33*. Routledge, 93–154.
- [2] Daniel Berdichevsky and Erik Neuenschwander. 1999. Toward an Ethics of Persuasive Technology. *Commun. ACM* 42, 5 (1999), 51–58.
- [3] Sarah Bouzit, Gaëlle Calvary, Denis Chêne, Eric Petit, and Jean Vanderdonck. 2017. The PDA-LPA Design Space for User Interface Adaptation. In *2017 11th International Conference on Research Challenges in Information Science (RCIS)*. IEEE, 353–364.
- [4] Joseph Cesario, Heidi Grant, and E. Tory Higgins. 2004. Regulatory Fit and Persuasion: Transfer From "Feeling Right". *Journal of Personality and Social Psychology* 86, 3 (2004), 388–404.
- [5] Céline Clavel, Steve Whittaker, Anaïs Blacodon, and Jean-Claude Martin. 2018. WEnner: A Theoretically Motivated Approach for Tailored Coaching about Physical Activity. In *Proceedings of the 2018 ACM International Joint Conference and 2018 International Symposium on Pervasive and Ubiquitous Computing and Wearable Computers*. ACM, 1669–1675.
- [6] Ellen Crowe and E Tory Higgins. 1997. Regulatory Focus and Strategic Inclinations: Promotion and Prevention in Decision-Making. *Organizational Behavior and Human Decision Processes* 69, 2 (1997), 117–132.
- [7] Edward L. Deci and Richard M. Ryan. 2008. Self-Determination Theory: A Macrotheory of Human Motivation, Development, and Health. *Canadian Psychology* 49, 3 (2008), 182–185.

- [8] Thérèse Dries-Tönnies. 2015. *Human-Computer-Interaction and Regulatory Focus : using Graphic User-Interfaces' Characteristics to Adapt Users' Strategic Orientation to Tasks' Framing*. Ph.D. Dissertation. Université Paul Valéry - Montpellier III. <https://tel.archives-ouvertes.fr/tel-01271731>
- [9] Jens Förster and E Tory Higgins. 2005. How global versus local perception fits regulatory focus. *Psychological science* 16, 8 (2005), 631–636.
- [10] Suparna Ghanvatkar, Atreyi Kankanhalli, and Vaibhav Rajan. 2019. User Models for Personalized Physical Activity Interventions: Scoping Review. *JMIR Mhealth Uhealth* 7, 1 (2019), e11098.
- [11] Frédéric Guay, Geneviève Mageau, and Robert Vallerand. 2003. On the Hierarchical Structure of Self-Determined Motivation: A Test of Top-Down, Bottom-Up, Reciprocal, and Horizontal Effects. *Personality and social psychology bulletin* 29, 8 (2003), 992–1004.
- [12] E Tory Higgins. 1997. Beyond pleasure and pain. *American psychologist* 52, 12 (1997), 1280.
- [13] E Tory Higgins. 2002. How self-regulation creates distinct values: The case of promotion and prevention decision making. *Journal of Consumer Psychology* 12, 3 (2002), 177–191.
- [14] E. Tory Higgins, Ronald S. Friedman, Robert E. Harlow, Lorraine Chen Idson, Ozlem N. Ayduk, and Amy Taylor. 2001. Achievement orientations from subjective histories of success: promotion pride versus prevention pride. *European Journal of Social Psychology* 31, 1 (2001), 3–23.
- [15] Jennifer G. LaGuardia and Richard M. Ryan. 2000. Buts personnels, besoins psychologiques fondamentaux et bien-être : théorie de l'autodétermination et applications. *Revue Québécoise de Psychologie* 21, 2 (2000), 281–304.
- [16] Amanda Y. Lee and Jennifer L. Aaker. 2004. Bringing the Frame Into Focus: The Influence of Regulatory Fit on Processing Fluency and Persuasion. *Journal of Personality and Social Psychology* 86, 2 (2004), 205–218.
- [17] Victor López-Jaquero, Jean Vanderdonckt, Francisco Montero, and Pascual González. 2008. Towards an Extended Model of User Interface Adaptation: The Isatine Framework. In *Engineering Interactive Systems*. Springer Berlin Heidelberg, 374–392.
- [18] Ramona Ludolph and Peter J. Schulz. 2015. Does regulatory fit lead to more effective health communication? A systematic review. *Social Science & Medicine* 128 (2015), 142–150.
- [19] Eduardo Machado, Deepika Singh, Federico Cruciani, Liming Chen, Sten Hanke, Fernando Salvago, Johannes Kropf, and Andreas Holzinger. 2018. A Conceptual framework for Adaptive User Interfaces for older adults. In *2018 IEEE International Conference on Pervasive Computing and Communications Workshops (PerCom Workshops)*. IEEE, 782–787.
- [20] Jean-Claude Martin and Céline Clavel. 2018. Tailored, multimodal and opportune interactions on a wearable sport coach: The we-nner framework. In *Global Thoughts, Local Designs*. Springer International Publishing, 24–32.
- [21] William Martin, Clémence Palazzo, and Serge Poiraudau. 2017. Development and Preliminary Psychometrics of the Exercise Therapy Burden Questionnaire for Patients With Chronic Conditions. *Archives of Physical Medicine and Rehabilitation* 98, 11 (2017), 2188–2195.
- [22] Robert R McCrae and Paul T Costa Jr. 1999. A five-factor theory of personality. *Handbook of personality: Theory and research* 2 (1999), 139–153.
- [23] Jonathan Myers. 2003. Exercise and Cardiovascular Health. *Circulation* 107, 1 (2003), e2–e5.
- [24] Donald A Norman. 1986. Cognitive engineering. *User centered system design* 31 (1986), 61.
- [25] World Health Organization. 2010. Global recommendations on physical activity for health.
- [26] Dorian Peters, Rafael A. Calvo, and Richard M. Ryan. 2018. Designing for Motivation, Engagement and Wellbeing in Digital Experience. *Frontiers in Psychology* 9 (2018), 797.
- [27] Michele Pirovano, Renato Mainetti, Gabriel Baud-Bovy, Pier Luca Lanzi, and Nunzio Alberto Borghese. 2012. Self-adaptive games for rehabilitation at home. In *2012 IEEE Conference on Computational Intelligence and Games (CIG)*. IEEE, 179–186.
- [28] David Thevenin and Joëlle Coutaz. 1999. Plasticity of User Interfaces: Framework and Research Agenda. In *Human-Computer Interaction — INTERACT'99*, Vol. 99. IOS Press, 110–117.