D5.3a Models for effective feedback strategies – initial

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Summary

The goal of this document is to make suggestions for personalised adaptive feedback strategies. The result can be used to define specifications for an application that aims at increasing or improving a subject's pattern of physical activity. To achieve our goal we first determine which individual characteristics can be considered key factors; factors of significant importance with respect to changing level of physical activity. Based on these key factors, available data from Philips Research and Roessingh Research and Development are analyzed and discussed. From this analysis we can distill typical users, or personas, for which models for personalised adaptive feedback strategies will be described. Furthermore, a short experiment is described as a suggestion to gather further evidence.

The personalised adaptive feedback strategies we envision relate particularly to physical activity and physical well-being (at home). This is in contrast to WP3/WP6 activities that mainly focus on mental well-being (at work). Indeed, physical activity contributes to mental well-being (see Deliverable 1.3a) and can perfectly be performed in both work and home situations, which is why, ultimately, these two applications/services will be combined to form one service for increasing well-being at home and at work.

Contents

1 Introduction

The goal of WP5 is to construct, demonstrate and evaluate well-being applications that incorporate results from user studies and technological results from WP1, WP2, WP3 and WP4. Furthermore, demonstrators will be validated in a pilot study situated in everyday life. Elaborating on previous deliverables (1.3a & 5.1a), the current deliverable aims to provide suggestions of effective feedback strategies and a specification of the target group for applications that are able to increase a subject's well-being.

To achieve this, we will start with a summary of Deliverables 1.3a and 5.1a. These deliverables provide several theories and constructs that can be considered key factors for achieving effective behavioural changes for the individual user. Next, we will analyze and discuss data from earlier research from Roessingh Research and Development (RRD) and Philips Research concerning the level of physical activity, changes in physical activities and its correlation with the key factors identified from literature. Based on this analysis it is identified which of these key factors are of particular importance for changing behaviour and how they are represented in patients in a rehabilitation setting (data from RRD) and consumers (data from Philips Research). Based on these results, several personas that probably need different feedback strategies can be identified. Personas as used in this document should not be considered as "the" user, but as typical individuals who could use the system (Perfetti, 2001). For each persona, personalised adaptive feedback strategies will be described using the knowledge from behavioural change theories. For example, it is imaginable that a user who thinks that one's level of physical activity is high, but who actually moves little, should receive other feedback than an individual who is aware of his or her low level of physical activity. After specifying the different feedback strategies we will conclude with a suggestion for an experiment to gather further evidence with respect to our initial feedback strategies.
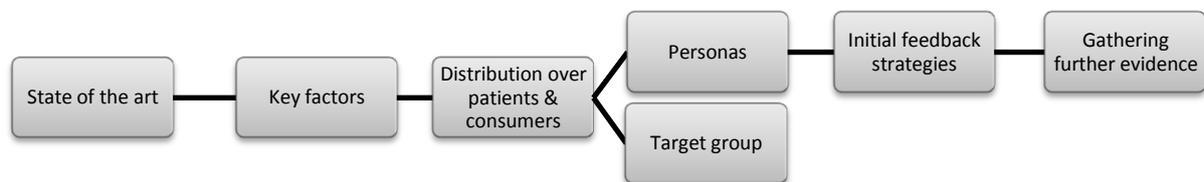

Figure 1. Content of current deliverable

1.1 State of the art

The key findings regarding technology aided services that support users to become more physically active, as described in D1.3, can be summarized as:

- Caspersen, Powell and Christenson (1985) identified four elements of physical activity: 1) physical activity consists of bodily movements via skeletal muscles, 2) physical activity results in energy expenditure, 3) energy expenditure (kilocalories) varies continuously from low to high, 4) physical activity is positively correlated with physical fitness. This means that even the slightest movement is considered physical activity.
- To measure the level of physical activity, several methods and techniques are available that all have their pros and cons. The use of doubly labelled water is considered the most accurate and golden standard. However, it is a rather obtrusive and invasive technique, which does not make this an attractive option when the goal is to measure daily level of physical activity. For this

reason, pedometers and accelerometers are much better suited. Especially accelerometers that measure acceleration in three planes can provide accurate estimates of a user's level of physical activity throughout the day/during everyday life.

- Based on these measurements, users can be provided with feedback about their level of physical activity in the following three ways: 1] on smart phone/device, 2] via a web based portal or 3] through a third person, e.g. a professional or friend. Most publicly available applications rely on data from the user's smart phone and provide feedback on the smart phone. For example, GPS is used to track the user during an exercise (e.g. running), after which information about energy expenditure is provided. Other applications do not allow for automated tracking and need manual input from the user to provide information about level of physical activity. Only few applications use the second way of feedback; a web portal where users can view their previous activities and progress, in addition to the first one. Even less, only two interventions, used the third way of feedback, namely feedback provided by a professional. It is recommended that all three feedback loops are available in the application to be able to be useful for a large group of users ranging from active subjects to patients. Thereby, a professional or peer can also access data. However, none of the publicly available applications has all these characteristics.

- None of the applications or services included aspects of theories or models from behavioural sciences, while these can increase long-term adherence and/or make for larger effect sizes when applied correctly. The lack of influence from behavioural sciences led to the recommendation that aspects of these theories should be included in future applications: they provide several constructs that can be considered key factors regarding behavioural change that should be incorporated in applications that aim to increase well-being.

- Two key factors regarding behavioural changes are *Stage of Change* and *Self-efficacy*.
  - According to the Trans Theoretical Model (TTM) (Prochaska & DiClemente, 1983) subjects can be classified into five stages of change: precontemplation, contemplation, preparation, action and maintenance (see Table 1). It is best described as a circular model, since subjects can enter and exit at any point and relapse to an earlier stage. Different cognitions may play a part in different stages, implying that subjects in a particular stage should be approached in a different way than subjects in another stage.
  - Self-efficacy is the subject's belief that a particular behaviour is, or is not, within his or her control. Again, it is imaginable that subjects with a high level of self-efficacy should be approached differently than subjects with a low level of self-efficacy. In other words, feedback should be tailored: the content and possibly also the form of feedback should be based on specific individual user characteristics.

Table 1. The five Stages of Change of the Trans Theoretical Model

Precontemplation	No intention to change behaviour within six months.
Contemplation	Intention to change behaviour within the next six months.
Preperation	Intention to take steps to change behaviour within the next month.
Action	Has changed behaviour for less than six months.
Maintenance	Has changed behaviour for more than six months.

2   Changing level of physical activity

Starting from the fact that Stage of Change and Self-Efficacy are two key factors in behavioral change theories (see Section 1.1), data from earlier research performed by Roessingh Research and Development (RRD) and Philips Research (PR) will be analysed to get more insight in how these key factor are present in patients and consumers and how exactly they are related to physical activity and changes in physical activities.

2.1   Available data regarding key factors

Data are available of 81 patients coming for physical rehabilitation and 300 healthy controls (of which n=32 from RRD). Patients suffered from Chronic Obstructive Pulmonary Disease (COPD) (n=38), Chronic Low Back Pain (CLBP) (n=20) or cancer (n=23). All participants were using one out of two different systems: the Activity Based Feedback module (ABF) from RRD (Figure 2) or the DirectLife (DL) system from PR (Figure 3). The aim of the studies was to get insight in the physical activity patterns and or in the changes achieved in physical activities using the ambulant activity feedback module or the direct life module.

Figure 2. Activity based feedback module from RRD

Figure 3. DirectLife sensor from PR

2.1.1   Activity based feedback module

The system used in the studies from RRD comprises a tri-axial accelerometer, a personal digital assistant and a web portal. The accelerometer sends data to the PDA, which is programmed such that the display shows a line indicating cumulative level of physical activity over the day. Furthermore, a reference line is shown, which represents the average level of activity of healthy controls over the day. Last, users can see their percentage of deviation from this reference line; if users are too active they receive an advice to decrease their level of activity (e.g. take a short break), and if they are not active enough they are encouraged to become more active (e.g. take a short walk). Users can also see their previous performance and progress on a web portal that can also be accessed by a healthcare professional.

The number of days participant wore the system (Weering, 2011) differed across studies and the studies did or did not include a final measure to investigate increase in level of physical activity. Therefore, only baseline activity level is used here. Stage of change was assessed on baseline using a questionnaire. With respect to achieving a balanced level of physical activity over the day, data was registered in such a way that the user's level of activity in the morning, afternoon and evening could be computed.

2.1.2 DirectLife

DirectLife is a commercially available activity monitor combined with an online support service. It is aimed at supporting users to bring their daily amount of activity to a healthy level. Users are encouraged to make gradual changes to their lifestyle and incorporate more physical activity in their daily routines. Data from the activity monitor can be uploaded to the computer via the USB port, after which users can view their results on their personal DirectLife web page.

Upon receiving the system, the user's baseline activity level is measured during a one week assessment period. During the assessment week users are instructed to follow their regular routines and to wear the activity monitor continuously in order to obtain a measurement that is as accurate as possible. After completing the assessment, users are invited to participate in a twelve-week *Activity Plan*, during which they are encouraged to gradually increase their level of activity. Based on the outcome of the assessment week and the user's ambitions and preferences, a personalised activity goal is suggested. An average goal entails a 15% increase in activity over the course of twelve weeks (Figure 4). The user can accept this goal or set another, more or less ambitious, goal. Once the end goal is set, daily activity targets are defined, which gradually increase week by week.
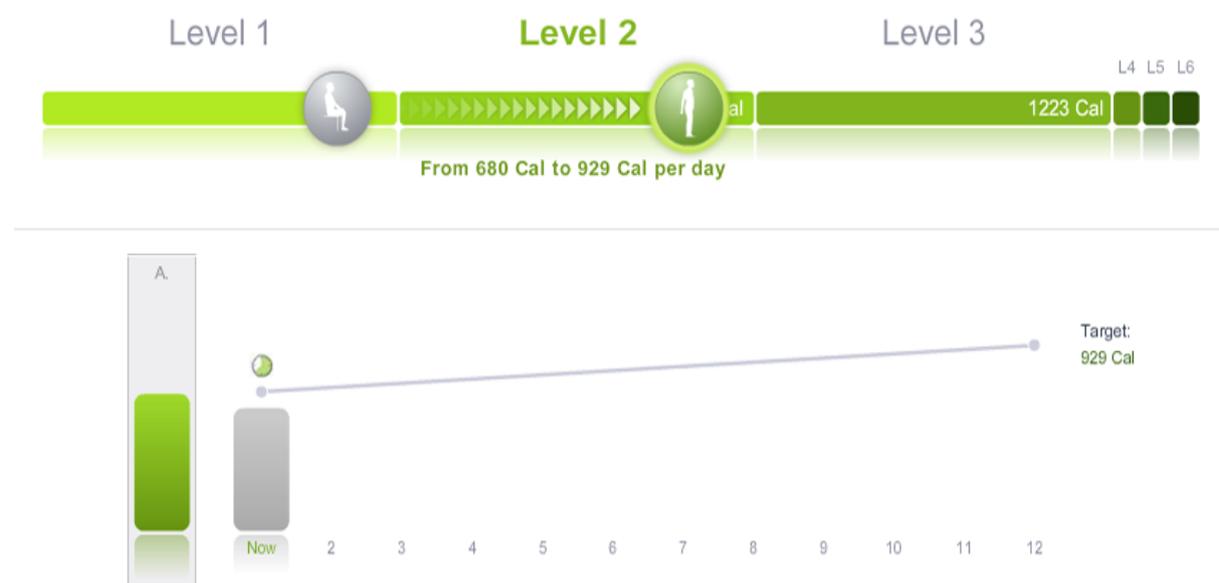
Figure 4. Personalised activity plan with gradually increasing targets

During the plan, users are encouraged to meet their daily activity targets. Feedback about target achievement is given on the DirectLife activity monitor by means of a row of blinking LEDs and on the web portal (see Figure 5). In addition, the service offers coaching by a human coach, an online community and general advice about physical activity and healthy behavior.

Figure 5. Feedback about daily target achievement presented on web portal

Participants in the study followed the regular DirectLife plan. During an assessment week, the user's self-efficacy and stage-of-change was assessed by means of two questionnaires. The Self-Efficacy questionnaire is based on Marcus et al. (1992) and asks the user to rate their confidence that they are able to stay active in various adverse situations (see Section 7.2). The Stage of Change questionnaire asks the user to indicate whether they intend to increase their activity or have already taken steps to do so. The complete questionnaires can be found in the Appendix. To assess the results of the DirectLife intervention and the influence of the psychological constructs, baseline physical activity level (PAL) was compared to the activity level during the final three weeks of measurement.

2.2 Results and conclusions

Data from the studies from RRD are summarized in Figure 6. When all patients are compared to a control group, patients can be identified as less active during the entire day. It is interesting to see that:

1. Patients in the maintenance stage of change can be considered equally active as control subjects, which is not true for patients in other stages of change.
2. The drop in level of activity over the day is considerably larger in patients than in control subjects. Figure 6 indicates that almost all patients start the day being relatively active, but end the day being very inactive; their level of physical activity is not balanced. The danger of this is that patients do most of their "must" tasks, e.g. household chores, in the morning and do not have any energy left to engage in fun or social activities in the evening.
3. Patients in the maintenance stage are more active than patients in other stages of change, but they show a comparable drop in activity over the day. This drop in activity is significantly greater than in control subjects.
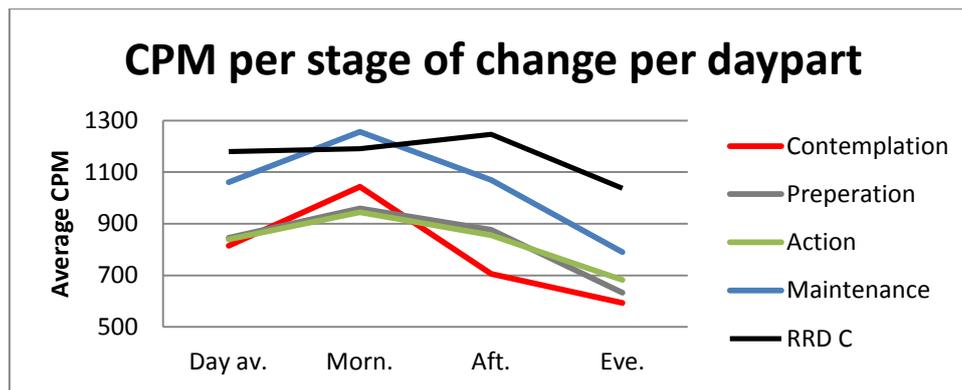
Figure 6. Activity (Counts Per Minute) per stage of change per day part. Patients are classified per stage of change and compared to activity of healthy controls (RRD C)

2.2.1 Role of stage of change
(Confidential to SWELL project. Not publicly accessible)

2.2.2 Role of self efficacy
(Confidential to SWELL project. Not publicly accessible)

2.3 Implications for models for effective feedback strategies

Results of the combined data of RRD and Philips show that self-efficacy is related to the level of activity at baseline as well as to the percentage of change as a result of the intervention. The higher a subject's level of self-efficacy, the higher his or her level of physical activity is. Also, for subjects who are inactive at the start of the intervention, a higher level of self-efficacy is associated with a higher level of increase. With respect to patients it was found that they have difficulty distributing their activity evenly throughout the day, regardless of their stage of change.

This has implications for models for effective feedback strategies. For example, a user with a high level of activity and high self-efficacy does not need the same guidance that a user with low activity and self-efficacy needs. With respect to stage of change, although no differences were found on a behavioural level, i.e. no differences were found in level of activity between various stages of change, differences in cognitions per stage of change do make for a need for different feedback strategies. By this, we mean that users in the maintenance stage usually are satisfied with their performance and do not have intentions to change, unlike users in earlier stages. If users have no intention to change, they should be approached in a different way than users who do have intentions to become more physically active. This indicates that, with respect to the service we intend to develop, we posit that it is essential to provide personalised adaptive feedback at least based on the user's level of self efficacy, baseline activity and stage of change.

2.3.1 Target group
Now that we have identified some key factors and their implications, the following will be a description of the target group. In deliverable 5.1a the target group is presented as comprising two

populations: the "worried well" and (ex)patients. The "worried well" are individuals who are still healthy, but for some reason worry about their health. This could be an incident in their near environment (e.g., a friend or family member getting sick), or the awareness of an elevated genetic risk. These people are worried that if they continue their current lifestyle, this will eventually cause serious diseases. However, they cannot manage on their own and need guidance to adopt and maintain a healthier lifestyle. The second group, patients or ex-patients, consists of individuals who are or were under treatment by a healthcare professional. Patients could be suffering from several conditions (e.g., diabetes, cardiovascular problems, chronic pain, COPD). Regardless of the exact condition, these patients could benefit from support to change their behaviour, since unhealthy lifestyles play an important contributing role in many diseases.

3 Personas

In the previous chapter, Self-Efficacy, Stage of Change, balancing level of activity and activity on baseline were identified as key factors. Therefore, we will base our personas on users with varying scores on these factors. The personas described here should not be confused with the personas described in D1.1a; the current personas are based on other variables.

Self-Efficacy

Using the Self-Efficacy Questionnaire (see Section 7.2) users can be classified as having a low, average or high level of self-efficacy with respect to physical activity. Since the relationship between level of physical activity and self-efficacy, as discussed in Section 2.2, is quite similar for users with an average or high level of self-efficacy (see Section 2.2), users will be divided into two groups: users with low self-efficacy and users with average/high self-efficacy. Low self-efficacy is defined as a score of 5 through 12. Scores of 13 through 17 and 18 through 25 are considered average and high respectively.

Activity pattern

Concerning the activity pattern results of the RRD studies showed that this can be improper in two different ways. One is an imbalanced distribution over the day. The other one is a too low level of physical activity. Combining these two aspects, the user's activity is only proper if both the level as well as the balance is ok. In all other combinations, inactive and unbalanced, inactive although balanced, active although unbalanced (see table 2), the activity pattern is classified as improper.

Table 2. Overview of proper and improper levels of physical activity

Level of activity		Unbalanced	Balanced
	LOW	Improper	Improper
	HIGH	Improper	Proper

Stage of Change

The stages contemplation, preparation and action are combined to form one group, while the precontemplation and maintenance stage form the other group; the first group encompasses users that are thinking about, or have just started with taking action to improve their level of physical activity. In other words, they are not satisfied with their level of physical activity and have intentions to change their behaviour. On the other hand, users in the precontemplation or maintenance stage usually are satisfied with their level of physical activity and have no intentions to change their behaviour, even though their level of physical activity may be too low. These users should therefore be approached differently than users who are not satisfied with their level of physical activity.

In sum, the above makes for eight personas that need different personalised adaptive feedback strategies. In Table 1, the factor 'properness' of level of physical activity is defined using the two categories proper and improper level of physical activity. Combined with the two categories of level of self-efficacy, this results in four categories that can be applied to subjects in the precontemplation, contemplation, preparation or action stage on the one hand and subjects in the precontemplation and maintenance stage on the other (Table 3).

Table 3. Overview of personas

Intention to change (contemplation, preparation and action)				No intention to change (precontemplation and maintenance)			
		Level of activity				**Level of activity**	
		Proper	**Improper**			**Proper**	**Improper**
Self-efficacy	**Low**	Persona1	Persona2	**Self-efficacy**	**Low**	Persona5	Persona6
	Average-high	Persona3	Persona4		**Average-high**	Persona7	Persona8

4 Feedback strategies

In the previous chapters we identified the three constructs self-efficacy, stage of change and properness of level of physical activity as factors that should be taken into account when developing personalised adaptive feedback strategies. In the current chapter we will discuss available literature on how to influence or take into account these constructs; how to deal with the differences between users when providing feedback. From Chapter 2 it can be concluded that a higher level of self-efficacy is related to a higher level of physical activity. Also, a higher level of self-efficacy can make for a larger increase in physical activity. Therefore, a high level of self-efficacy is desirable and feedback strategies should be aimed at increasing a user's low level of self-efficacy. Well-known strategies to influence self-efficacy are discussed in Section 4.1. Regarding stage of change, the main difference between the two groups, described in Chapter 3, is in the presence or absence of intention to change; how this difference between the two groups should be accounted for in individual users is discussed in Section 4.2. In Section 4.3 we discuss how baseline level of activity should be interpreted and incorporated in personalised adaptive feedback strategies.

4.1 Self–efficacy

Much research has focused on how self-efficacy can be influenced and whether high self-efficacy leads to actual performance of the specific behaviour or only increases intention (Gist & Mitchell, 1992). In their review, Gist and Mitchell (1992) conclude that high self-efficacy indeed leads to actual performance of the behaviour. The data from Philips indicates that the largest effect sizes can be achieved in users whose level of self-efficacy is average to high. Thus, when self-efficacy is low, this should be increased. As described by Bandura (1994), four well-known strategies can be applied:

- Enactive mastery experience
  This strategy of influencing self-efficacy pertains to successful performance of the target behaviour. When subjects experience that they are able to execute a certain task, their level of self-efficacy will be higher than when they experience that they are not. In other words, experiencing success can lead to higher levels of self-efficacy and experiencing failure leads to lower self-efficacy. This means that when users can set sub-goals, which are easier to attain, they will experience success more often, which may lead to a higher level of self-efficacy.
- Vicarious experience
  This source of influence refers to seeing others successfully perform the target behaviour. One aspect that is of particular importance when using other individuals to model or show successful performance of a certain task is that the 'other' needs to be similar to the observer. More concretely, a patient will identify less with a healthy user than with another patient performing the target behaviour.
- Social persuasion
  This strategy is concerned with expressing faith in the user's capacities. Expressing unrealistic amounts of faith, however, is usually disconfirmed quickly by failure to execute the task. The strength of social persuasion comes from research that indicates that users exert greater effort that is sustained longer when verbal social persuasion is applied, than when it is not (Bandura, 1994).

- Physiological / affective states

  This last source of influence on self-efficacy pertains to correcting misinterpretations of bodily states. For example, users who have once suffered a heart attack may become scared or anxious with the slightest increase in heartbeat. When they engage in vigorous physical activity and notice that their heartbeat increases, they may be scared that another heart attack is imminent. As a result, they may choose to perform mostly low intense activities. However, when they are provided with the correct information, i.e. that heartbeat is supposed to go up and all feelings are normal, this can lead to higher levels of self-efficacy and physical activity.

A recent systematic review with meta-analysis summarizes 27 intervention studies that all aimed at increasing a subject's level of self-efficacy with respect to physical activity (Ashford, Edmunds & French, 2010). The authors performed a meta-analysis to identify the most successful strategies to increase self-efficacy for physical activity. With respect to the four strategies described above, it is concluded that feedback on previous performance or similar others' performance can cause the highest effect sizes, followed by vicarious experience. Interesting is the finding about graded mastery, i.e. increasing the level of difficulty in tasks: in studies were graded mastery was applied as a strategy to increase physical activity, self-efficacy tended to decrease. This is in contrast to other research that shows breaking down distant goals in proximal sub goals increases self-efficacy (Stock & Cervone, 1999). One possible explanation is that this strategy initially decreases self-efficacy and is more helpful for maintaining self-efficacy. The risk for users with low self-efficacy is that if goals are too high, users fail to experience success and self-efficacy will decrease.

The research described in the review mentioned above has many similarities with the SWELL project and our attempt to increase level of physical activity. The difference, however, is large and mainly in the fact that we will use technology supported services to achieve our goal, instead of face-to-face contact.

4.2 Stage of change

As mentioned above, the main difference between the two groups we identified in Chapter 3 is in the presence or absence of an intention to change. When the user does have an intention to change, i.e. is in the contemplation, preparation or action stage of change, he or she should be provided with appropriate tools and be motivated to take action. This can for example be done using implementation intentions and providing the user with information about pros and cons of inactive behaviour. Implementation intentions are specifications of when, where, and how the target behaviour is to be performed by the user. When users indicate no intention to change and have a proper level of physical activity, they should be motivated and challenged to maintain their current lifestyle. When, however, they actually have an improper level of physical activity, these users should first be confronted with their actual level of activity, to make them aware of the discrepancy between their perceived activity and their actual activity.

4.3 Initial level of activity

When providing subjects with a system that tracks their level of physical activity, a baseline measurement should first be obtained. Based on this first measurement, it can be decided whether

the subject has a proper or improper level of physical activity. When the former is the case, the goal should be to keep the situation as it is, although different feedback strategies need to be applied when self-efficacy is low or average-high. There are patients who show a high level of activity, but a low level of self-efficacy. It has high face validity that those users need to be reassured that their level of physical activity is sufficient. On the other hand, when users have a proper level of physical activity and a high level of self-efficacy, they probably do not need reassuring feedback, but instead be kept motivated and challenged to maintain their level of physical activity, for example by setting challenging goals. Another situation that can occur is that users have an improper level of physical activity. When this is the case, but users do have a high level of self-efficacy and an intention to change, they should again be provided with tools to increase their level of physical activity. When this intention is absent, users should first realize that change is needed. If, in addition, a user's self-efficacy is low, this should be increased using one of the strategies described in Chapter 5. For an overview of the strategies described here, see Tables 3 and 4.

5 Models for personalised adaptive feedback strategies

Based on the strategies to influence self-efficacy and take into account stage of change and initial level of physical activity, six different personalised adaptive feedback strategies can be developed. The strategies are summarized in Tables 3 and 4, parallel to the eight personas described in Chapter 3. Of the strategies to increase self-efficacy, only vicarious experience is applied because of research showing this strategy to have the largest effect size.

Table 4. Feedback strategies (FBS) for users with intention to change

		Improper activity pattern	Proper activity pattern
Self-efficacy	**LOW**	FBS1: Increase self-efficacy By vicarious experience/feedback and letting users experience success.	FBS2: Increase self-efficacy Reassure users that level of activity is high enough.
	AVERAGE / HIGH	FBS3: Take action Support user to achieve better balanced life-style. Provide tools that can help the user to distribute activity better.	FBS4: Maintain situation Let user set goals. Keep challenging and fun.

Table 5. Feedback strategies for users without intention to change

		Improper activity pattern	Proper activity pattern
Self-efficacy	**LOW**	FBS5: Make aware and increase self-efficacy Confront with actual level of physical activity. Increase self-efficacy by vicarious experience/feedback and letting users experience success.	FBS2: Increase self-efficacy Reassure user that level of activity is high enough.
	AVERAGE / HIGH	FBS6: Make subject aware and take action Confront with actual level of physical activity. Provide tools that can help the user to distribute activity better.	FBS4: Maintain situation Let user set goals. Keep challenging and fun.

To summarize, six different feedback strategies are proposed for eight personas. One of the strategies focuses on taking action (FBS3), another on helping the user to maintain the situation as it is (FBS4) and a third focuses on making the subject aware of the situation (FBS5/6). It, however, is more interesting to see that four personas need a feedback strategy that includes a focus on increasing self-efficacy (FBS 1, 2 and 5).

The following are descriptions of the feedback strategies that are summarized in the tables above.

Feedback strategy 1

This strategy is appropriate for users who show a low or imbalanced level of activity, in combination with a low level of self-efficacy. The main goal is to increase self-efficacy by letting users experience that similar users are also able to maintain a balanced level of physical activity. For example, users in the same therapy group could be provided with each others' goal achievement or daily performance on their PDA. In addition, these users should be supported in setting easily achievable short term goals, in order to let them experience successes. Feedback messages should be positive and complimenting.

Feedback strategy 2

Users who show a proper level of physical activity, but have a low sense of self-efficacy, should be reassured. The danger to these specific users is that they set unachievable goals. For example, users can feel the need to change, but do not know how, although they already have a proper level of physical activity. Therefore, this feedback strategy focuses on letting the subject experience that he or she is already doing fine. This strategy too contains complimenting messages.

Feedback strategy 3

The users who need this feedback strategy show an improper level of physical activity, but do have the intention to change and an average to high level of self-efficacy. Therefore, they need guidance to achieve a more proper level of physical activity. They need a tool that supports them in improving their physical activity. With help from this tool, users can self-set goals and track their activity levels throughout the day. The messages provided by the tool can be either complimenting or confronting.

Feedback strategy 4

This strategy is for users with an average to high level of self-efficacy and a proper level of physical activity; exactly the scenario we aim to achieve in the other personas. The goal here is not on learning how to set goals, but on staying at the current level, for example by setting challenging but achievable goals. Another possibility is to provide new tasks with which users can even further increase their level of activity, e.g. taking the stairs instead of the elevator. Feedback messages can be either complimenting or confronting, but should not be provided as often as in the other feedback strategies to not bother the user with an overload of compliments.

Feedback strategy 5

This strategy is meant for users who have an improper level of physical activity, low self-efficacy and no intention to change. The main difference between these users and the users who receive feedback strategy 1 is the absence of an intention to change. When the user does not have an intention to change, change will be difficult to achieve. Therefore, this feedback strategy aims at creating the intention to change physical activity. One way of doing so is confronting users with their improper level of physical activity and focus on what users can gain from being more physically active. Next, self-efficacy should be increased by the same strategies proposed in feedback strategy 1; let users experience that similar users are also able to maintain a balanced level of physical activity and provide help with setting easy to achieve, short term goals, in order to let them experience successes. Messages should be framed positively, i.e. telling what can be gained from a more active lifestyle, and be complimenting.

The users who need this feedback strategy are, just like users who need feedback strategy 5, not aware of their improper level of physical activity. Again, an intention to become more active is missing and should be created within the individual. Therefore, the user should be confronted with his or her actual performance and informed about possible gains to a more active lifestyle. Since these users do have an average to high level of self-efficacy, users should hereafter be able to set goals. Feedback messages can either be complimenting or confronting.

With respect to these feedback strategies, figure 9 gives an indication of the percentage of users that can be expected per feedback strategy. It should be noted that these results come from the dataset from Philips which included healthy control subjects only. The participants in Philips' studies were asked to use the DirectLife system, instead of having bought the system themselves. Therefore, the percentages do not map perfectly to our target groups of "worried well" and (ex)patient, but can be used as an indication of how often the feedback strategies are expected to be addressed.
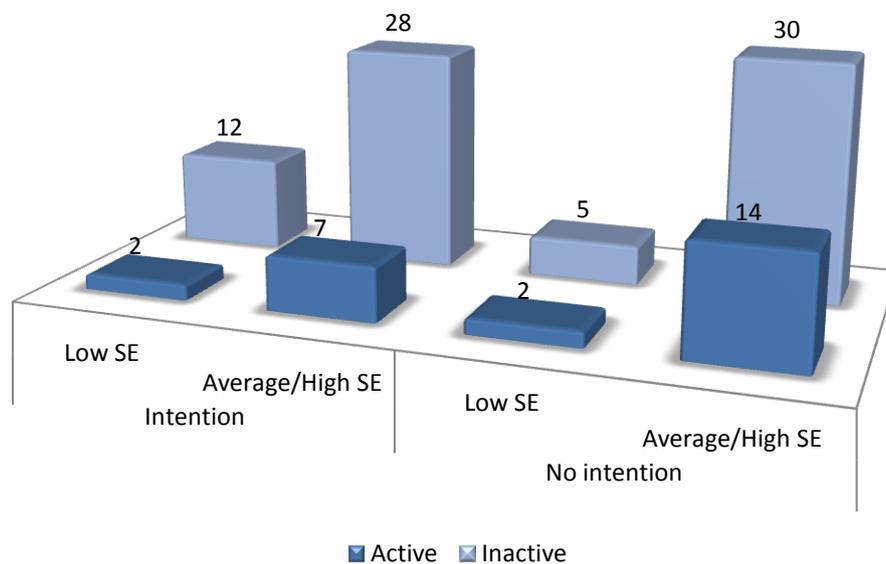

Figure 9. Percentage of subjects with and without an intention to change per category of self-efficacy, depending initial activity level

5.1 Gathering further evidence

The six feedback strategies suggested above need to be developed and tested in practice to investigate the hypothesized effect. A larger scale study will be described in Deliverable 5.1b and performed later in time; we will now focus on a small scale experiment to make preliminary statements about the suggested models of feedback strategies. More specifically, because four of the six feedback strategies focus on increasing self-efficacy, we will investigate whether we are able to influence a subject's level of self-efficacy.

Ultimately, we envision developed feedback strategies to be implemented and tested for longer periods of time. For now, we aim at a 20 to 30 minute experiment to investigate the effect of different feedback strategies. To be more specific, the effect of these strategies on a subject's level of self-efficacy will be examined. It is stated above that a higher level of self-efficacy is associated with better performance of a certain task: when we apply strategies to increase self-efficacy, we

hypothesize a better performance. For now, the focus is on what is the effect of success experiences on self-efficacy. Considering the task to be performed, there are several demands:

- The task should be learnable. This way, when more trials are performed, a learning curve can be identified.
- The task should be new to every subject. This makes for an equal level of self-efficacy and experience for every subject.
- The task should be physical of nature. Cognitive tasks rely on other learning mechanisms than physical tasks. When we use a physical task, it is more ecologically valid.

Task description:

Subjects are told to walk a straight line from A to B. They will be blindfolded and wear scuba fins to guarantee that every subject has the same level of experience. At the start of the first trial, level of self-efficacy is obtained using a short to be developed questionnaire. After each trial subjects are provided with feedback about their performance. For the first group, this feedback will be accurate and in accordance with their actual performance. For the second group, feedback will be only positive. For the third group, feedback will mostly be negative, even if their performance was good. When subjects have finished the experiment, i.e. after doing 20 trials, subjects are again asked to rate their level of self-efficacy.

Providing subjects with positive or negative feedback only, makes them experience success and failure respectively. Asking subjects both before and after what they think their performance is allows for investigating the effect of these messages on the subjects level of self-efficacy. This will clarify the relationship between success experiences, self-efficacy and performance on a task, which can be used as input for a larger scale study.

5.2 Conclusion

This document provides a first step towards personalised adaptive feedback strategies. Based on the three variables Self-Efficacy, Stage of Change and properness of activity level, eight personas were identified for which six strategies are suggested. The result can be used as input for the development of smart well-being applications (Deliverable 5.2a). Furthermore, the effect of the personalized adaptive feedback strategies needs investigation; Deliverable 5.1b will contain an extended specification of an experiment to test these strategies, after which the developed feedback strategies will be evaluated, refined and adjusted. Since a balanced level of physical activity is also related to a higher level of mental well-being, ultimately, the still to be developed smart well-being application for at home situations needs to be combined with WP3/WP6 activities that aim at increasing well-being at work.

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7 Appendix

7.1 Stages of Change – Short Form

Cancer Prevention Research Center, http://www.uri.edu/research/cprc/Measures/Exercise02.htm
Question: regular exercise is any planned physical activity (e.g., brisk walking, aerobics, jogging, bicycling, swimming, rowing, etc.) performed to increase physical fitness. Such activity should be performed 3 to 5 times per week for 20-60 minutes per session. Exercise does not have to be painful to be effective but should be done at a level that increases your breathing rate and causes you to break a sweat.
Do you exercise regularly according to that definition?
1.   Yes, I have been for MORE than 6 months.
2.   Yes, I have been for LESS than 6 months.
3.   No, but I intend to in the next 30 days.
4.   No, but I intend to in the next 6 months.
5.   No, and I do NOT intend to in the next 6 months.

Scoring
answered with choice 1: stage = Maintenance
answered with choice 2: stage = Action
answered with choice 3: stage = Preparation
answered with choice 4: stage = Contemplation
answered with choice 5: stage = Precontemplation

7.2 Self–Efficacy Questionnaire

Marcus et al., 1992.
Question: how confident are you that you could be active or exercise in each of the following situations?
1. When I am tired.
2. When I am in a bad mood.
3. When I feel I do not have time.
4. When I am on vacation.
5. When it is raining or snowing.

Scoring
The questions are answered on a five-item Likert scale:
1 = Not at all confident
2 = Slightly confident
3 = Moderately confident
4 = Very confident
5 = Extremely confident