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The influence of success experience on self-efficacy when providing feedback through technology

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ABSTRACT

Background: as a high level of self-efficacy is associated with bigger behavioral changes as well as to higher levels of physical activity, the development and implementation of strategies that successfully improve self-efficacy are important to technological interventions. We performed an experiment to investigate whether self-efficacy regarding a specific task can be influenced by using feedback strategies that focus on success experience and are provided through technology. *Method:* subjects were asked to walk from A to B in exactly 14, 16 or 18 s, wearing scuba fins and a blindfold. The task guaranteed an equal level of task experience among all subjects at the start of the experiment and makes it difficult for subjects to estimate their performance accurately. This allowed us to manipulate feedback and success experience through technology-supported feedback. *Results:* subjects' self-efficacy regarding the task decreases when experiencing little success and that self-efficacy regarding the task increases when experiencing success. This effect did not transfer to level of self-efficacy regarding physical activity in general. Graphical inspection of the data shows a trend towards a positive effect of success experience on task performance. *Conclusion:* experiencing success is a promising strategy to use in technology-supported interventions that aim at changing behavior, like mobile physical activity applications.

1. Introduction

More and more people live a sedentary lifestyle, resulting in a decrease in health and posing a risk for various diseases (e.g. Bankoski et al., 2011; Warren et al., 2010). On the other hand, a physically active lifestyle has significant positive effects on prevention of chronic diseases, such as cardiovascular disease, diabetes and cancer (Warburton, Nicol, & Bredin, 2006). Also, a sufficient level of physical activity has positive effects on mental health condition through reduced perceived stress and lower levels of burnout, depression and anxiety (Jonsdottir, Rödjer, Hadzibajramovic, Börjesson, & Ahlborg, 2010). Numerous interventions have already been developed to improve the level of physical activity in the general population (e.g. Dishman & Buckworth, 1996; Marcus et al., 1998). They are usually delivered through public media, flyers, e-mails, or consist of face to face (group) consultations, and show moderate effect sizes (Dishman & Buckworth, 1996).

A recent development regarding physical activity interventions is using mobile, technology-supported applications to achieve the desired effect. Examples include UbiFit Garden (Consolvo et al., 2008), BeWell+ (Lin et al., 2012) and Move2Play (Bielik et al., 2012). A study by Op den Akker, Jones, and Hermens (2014) concluded that many interventions apply tailoring, i.e. personalization of information or feedback, which increases the effect of the intervention (Hawkins, Kreuter, Resnicow, Fishbein, & Dijkstra, 2008). The most common technique is to provide previously obtained information about the individual and some also include a tailored goal and tailored inter-human interaction. Although the effectiveness of tailoring based on constructs from behavioral science – or adaptation (Hawkins et al., 2008) – has been proven, Op den Akker et al. (2014) show that none of the interventions used adaptation as a tailoring strategy. Such lack of adaptation in technology-supported physical activity interventions was also noticed by Achterkamp et al. (submitted for publication), who developed specific feedback strategies for these types of intervention. Four of the six feedback strategies include a focus on increasing self-efficacy, making it an important aspect when designing mobile activity coaches (Achterkamp et al., submitted for publication).

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The concept op tailoring information or feedback enhances relevance for the individual and increases the impact of the message; guidelines for designing effective physical activity interventions strongly recommend tailoring feedback (Greaves et al., 2011). Traditional, non-technology-supported interventions that apply adaptation, e.g. by providing tailored information based on subjects' attitudes, stage of change, social support or processes of change, show significantly larger effect sizes than interventions that do not tailor on these constructs (Noar, Benac, & Harris, 2007). Additionally, self-efficacy seems of major importance (Hawkins et al., 2008); a construct that is common in models and theories that explain behavior and behavioral change. High self-efficacy not only increases intention to perform the target behavior, it also leads to actual performance of the target behavior (Gist & Mitchell, 1992). Additionally, Achterkamp et al. (submitted for publication) showed that the level of self-efficacy is related to (1) level of activity at baseline: the higher the subjects' level of self-efficacy, the higher their level of physical activity; and (2) the percentage of change as a result of a twelve week intervention: 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 in physical activity. Bandura (1994) describes four sources of self-efficacy:

- Mastery experience: the subject successfully performs the target behavior.
- Vicarious experience: the subject observes a similar other perform the target behavior.
- Verbal (or social) persuasion: expressing faith in the subject's capabilities.
- Physiological/affective states: correcting misinterpretations of bodily states.

A systematic review with meta-analysis (Ashford, Edmunds, & French, 2010) shows that the most successful strategy to increase self-efficacy for physical activity is using enactive mastery experience, including feedback about previous performance/successes, followed by vicarious experience and feedback about similar others' performance.

So, traditional non-technology-supported interventions emphasize the importance of increasing self-efficacy to maximize the chance of positive results, but this knowledge is rarely applied in technology-supported interventions and it is not yet clear how this should be done. Therefore, the aim of the current study is to investigate whether experiencing success also leads to an increase in self-efficacy when using technology-supported feedback strategies. To our knowledge, no such experiment has been performed until now. Specifically, we aim to answer the following questions: what is the effect of a feedback strategy that focuses on success experience on (1) level of self-efficacy regarding a specific task, (2) level of self-efficacy regarding physical activity, and (3) task performance?

2. Method

2.1. Participants

The call for participation was distributed through e-mail, social media and the involved researchers personally. Subjects were included if they were Dutch-speaking and did not have walking disabilities. These criteria were necessary considering instructions were in Dutch and, as much as, possible rule out the influence of walking ability.

Fifteen subjects were included and participated in the study; nine women and six men. Age ranged from 22 to 36 years and averaged 27 years (SD = 4). All participants signed an informed consent. A local ethics committee reviewed and approved the study.

2.2. Procedure

The study used a repeated measures design. Subjects came to the lab of Roessingh Research and Development three times, with an interval of approximately seven days. During their first visit, subjects signed an informed consent, after which they completed a questionnaire assessing demographical variables and stage of change. Stage of change was assessed using the questionnaire by Prochaska and DiClemente (1983). A modified version of the Multidimensional self-efficacy for Exercise Scale was used to assess self-efficacy (Rodgers, Wilson, Hall, Fraser, & Murray, 2008). Next, subjects received information about the task they would have to perform. They were then asked to put on scuba fins and were allowed to practice walking in a straight line. Next, the subjects were asked to put on a blindfold and could again practice walking. Following this introduction, subjects completed a total of 15 trials of the task (see below). They were then asked to complete a self-efficacy questionnaire, after which the subject had to complete another six trials. The procedure during the second and third visit of the subject was equal to the first visit, except for signing the informed consent.

2.3. Task

Subjects were asked to walk from one side of the lab to the other (8 m), in exactly 14, 16, or 18 s (target time), wearing scuba fins and a blindfold. Subjects were told that the goal was to get as close to the target time as possible; the closer they were, the higher their reward would be. The reward was given after every trial, in the form of applause, ranging from 0 to 10 claps. Subjects started between a red light laser and reflector, which functioned as a starting gate on one side of the lab. A second laser and reflector combination functioned as a finishing gate and was placed at the other side of the lab. The distance from start to finish was approximately eight meters. The sensors were linked to the PC to measure the exact time subjects needed to reach the finishing gate. Subjects were reassured that the experimenter would correct their course if they deviated too much. Otherwise, the experimenter did not intervene during the task; the instructions for every trial and the feedback were provided automatically through speakers.

At the start of every trial, the subjects were asked the following automated question via the speakers: "To what extend do you think you can successfully accomplish this task on a scale of 0 to 100?" The experimenter entered the subject's answer in the PC. Next, the following automated message sounded: "After the countdown, walk to the other side of the lab in exactly X seconds". X corresponded to 14, 16 or 18 s. The PC randomly picked on of the three options, such that every target time was prompted five times. These times were chosen based on results of a pilot study that showed that they corresponded to fast, normal, and slow walking speeds respectively. Following the countdown, the subject walked from the starting gate to the finishing gate. Upon reaching the finishing gate, another automated message would sound: "stop, you have reached the destination." After this, the subject was given feedback about their performance; how close were they to the target time. The number of claps depended on the condition they were in.

In the positive feedback condition, subjects only received feedback as if they performed well, leading to the experience of success. Subjects always heard 6 to 9 claps, independent of their actual performance.

In the negative feedback condition, subjects only received feedback as if they performed badly, leading to the experience of failure. Subjects always heard 1 to 3 claps, independent of their actual performance.

In the correct feedback condition, subjects received correct feedback: higher deviation from the target time lead to lower rewards and vice versa. See Table 1 for the deviations and their corresponding rewards. This condition functioned as a control group.

Subjects did not receive information about whether they were too slow or too fast in any condition. After hearing the reward, the trial ended and the subject was allowed to remove the blindfold and prepare for the following trial. After 15 of these trials, the subject completed the self-efficacy questionnaire, which was followed by another 6 trials without feedback, functioning as retention trials.

Each subject completed all three conditions during the three separate different visits. The order of the conditions was randomized.

2.4. Data analysis

The three main outcome parameters are: (1) self-efficacy regarding the task, (2) self-efficacy regarding physical activity, and (3) performance.

(1). Task-specific self-efficacy was calculated by averaging the answers to the question that was prompted at the start of every trial per condition.
(2). Self-efficacy regarding physical activity was calculated by averaging the scores on the self-efficacy questionnaire per condition.
(3). Performance was measured by calculating the difference between the target time and the time the subject took to walk from the starting gate to the finishing gate in milliseconds.

2.5. Statistical analysis

A Repeated Measures Analysis of Variance was performed to test the effect of success experience (Condition) on level of task-specific self-efficacy, self-efficacy regarding physical activity and task performance. We did not correct for age or gender.

Table 1
Percentage of deviation from target time and the corresponding rewards per target time.

Deviation from target	Reward	Target 14 s	Target 16 s	Target 18 s
−>100%	0	–	–	–
−100–90%	1	0.0–1.4	0.0–1.6	0.0–1.8
−90–80%	2	1.4–2.8	1.6–3.2	1.8–3.6
−80–70%	3	2.8–4.2	3.2–4.8	3.6–5.4
−70–60%	4	4.2–5.6	4.8–6.4	5.4–7.2
−60–50%	5	5.6–7.0	6.4–8.0	7.2–9.0
−50–40%	6	7.0–8.4	8.0–9.6	9.0–10.8
−40–30%	7	8.4–9.8	9.6–8.0	10.8–12.6
−30–20%	8	9.8–11.2	11.2–12.8	12.6–14.4
−20–10%	9	11.2–12.6	12.8–14.4	14.4–16.2
−10–0–10%	10	12.6–14–15.4	14.4–16–17.6	16.2–18.0–19.8
10–20%	9	15.4–16.8	17.6–19.2	19.8–21.6
20–30%	8	16.8–18.2	19.2–20.8	21.6–23.4
30–40%	7	18.2–19.6	20.8–22.4	23.4–25.2
40–50%	6	19.6–21.0	22.4–24.0	25.2–27.0
50–60%	5	21.0–22.4	24.0–25.6	27.0–28.8
60–70%	4	22.4–23.8	25.6–27.2	28.8–30.6
70–80%	3	23.8–25.2	27.2–28.8	30.6–32.4
80–90%	2	25.2–26.6	28.8–30.4	32.4–34.2
90–100%	1	26.6–28.0	30.4–32.0	34.2–36.0
>100%	0	>28.0	>32.0	>36.0

3. Results

The average level of task-specific self-efficacy on the trials with feedback was 58.69 (SD = 23.00), 31.49 (SD = 18.75), and 59.11 (SD = 21.59) for the correct, negative and positive feedback conditions respectively. The Repeated Measures ANOVA shows a main effect for task-specific self-efficacy ($F(2,28) = 37.37$, $p < .001$). Fig. 1 clearly shows that in the negative feedback condition the task-specific self-efficacy decreases, initially steeply, whereas it increases in the positive and correct feedback condition. After three to four trials, the effect of the feedback on level of self-efficacy regarding the task stabilizes. Level of task-specific self-efficacy during the retention trials did not change significantly and was not different from level of task-specific self-efficacy during the first 15 trials, indicating retention of behavior.

The Repeated Measures ANOVA to test the effect of the various conditions on self-efficacy regarding physical activity in general was not significant; the scores for the correct, negative and positive feedback conditions averaged 70.33 (SD = 18.44), 70.29 (SD = 16.63), and 72.46 (SD = 13.85) respectively ($F(2,28) = 1.673$, $p = .206$).

Task performance did not vary significantly per condition ($F(2,28) = .557$, $p = .579$). However, Fig. 2 shows an interesting trend: performance (actual time in milliseconds minus target time) was best in the correct feedback condition (mean = −141, SD = 5460) and worst in the negative feedback condition (mean = 595, SD = 4319). In the positive feedback condition, subjects gradually shifted from walking too fast in the beginning to walking too slow in the end (mean = −184, SD = 5216). Regarding the retention trials, deviation from the target time was lowest in the correct feedback condition (mean = −12, SD = 2132), followed by the negative (mean = 268, SD = 1581) and positive (mean = 447, SD = 2340) feedback condition. This effect was not significant ($F(2,28) = .481$, $p = .623$).

4. Discussion

The main aim of the current study was to investigate whether experiencing success leads to an increase in self-efficacy when using technology-supported feedback strategies. Specifically, we focused on the effect of a feedback strategy that focuses on success experience on (1) level of self-efficacy regarding a specific task, (2) level of self-efficacy regarding physical activity, and (3) task performance. The task was to walk from A to B (eight meters), in exactly 14, 16, or 18 s (target time), wearing scuba fins and a blindfold. Subjects were told that the closer they were to the target time, the higher their reward would be. Feedback was manipulated to simulate success experience and failure. Additionally, a ‘correct feedback’ condition was included.

Results show that it is possible to manipulate task-specific self-efficacy using specific feedback (1). When subjects were asked to perform a new task, self-efficacy regarding the task rapidly decreased and stayed low when subjects did not experience success. On the other hand, self-efficacy regarding the task rapidly increases and stays high when subjects do experience success. This is in accordance with theory by Bandura (1994); failure and success lead to decreased and increased sense of self-efficacy respectively.

The effect of the feedback on level of self-efficacy regarding the task did not transfer to self-efficacy regarding physical activity in general (2). Self-efficacy is known to be task specific (Bandura, 1986, 1989), but also to transfer to tasks on related domains under the following conditions: (1) when the task relies on similar sub-skills, (2) when skills in various domains are developed together (co-development), and (3) through extremely

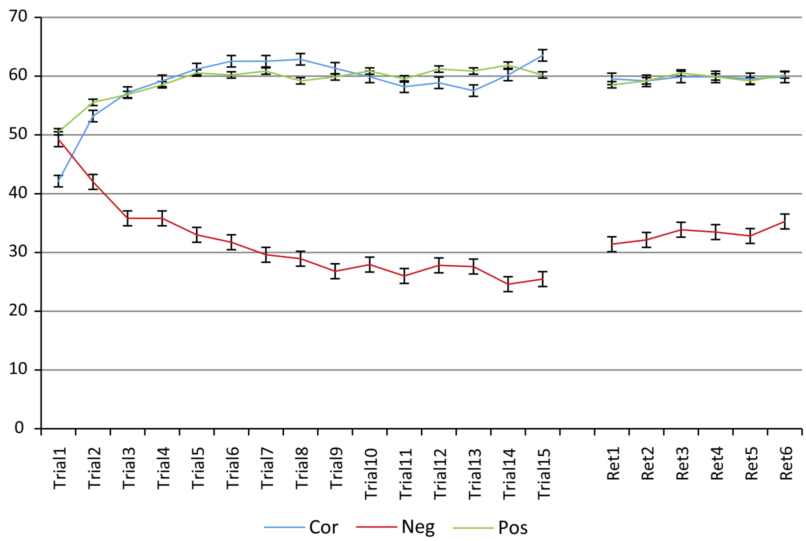

Fig. 1. Self-efficacy regarding the task over time per condition.

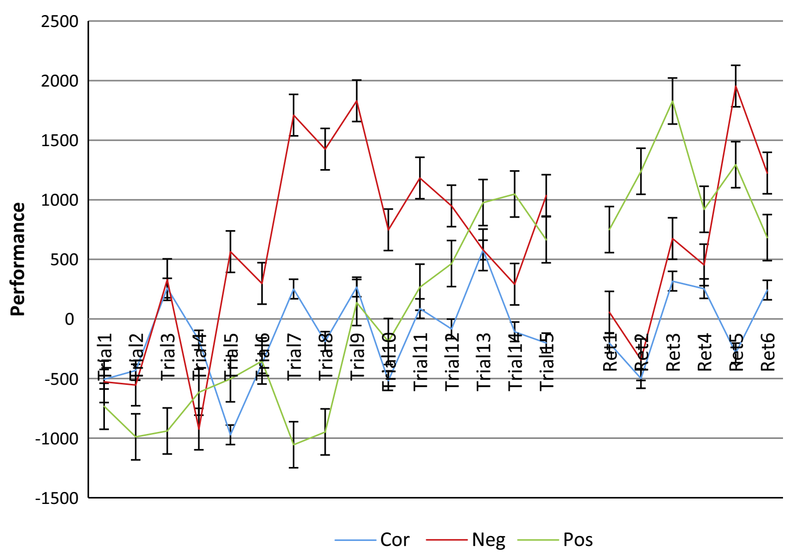

Fig. 2. Deviation from target time (performance) over time per condition.

powerful mastery experiences (Bandura, 1997; Woodruff & Cashman, 1993). Apparently, these principles did not apply enough to the task in the current study to transfer to a high level of self-efficacy regarding physical activity; subjects developed skills during the experiment that were not similar enough to skills that are relevant to physical activity in general. However, the goal of the current study required that subjects had equal task experience at the start of the experiment and difficulty to estimate performance, leading to the somewhat unusual task. A different, less artificial task that is more closely related to physical activity should be investigated if establishing this transfer is the main goal.

Results indicate that the feedback did not significantly influence subjects' task performance measured by the deviation (in milliseconds) from the target time (3). So, as opposed to research that shows that changes in self-efficacy lead to changes in behavior (Gist & Mitchell, 1992), the amount of success subjects experienced did not change performance. However, results do show a trend when looking at the correct and negative feedback conditions: the less success subjects experience, the more they deviate from the target time. Subjects seem to base their strategy for the oncoming trial on the feedback they received after the previous trial; when this indicates bad performance, as in the negative feedback condition, subjects change their behavior into a new approach. Contrarily, subjects only slightly change their behavior in the correct feedback condition. The same conclusion can be drawn when looking at the positive feedback condition. However, performance in the positive feedback condition does deteriorate due to an inability to accurately estimate actual performance and change behavior in the correct direction. In other words, it seems that experiencing success leads to increased self-efficacy even when performance is not optimal. This would mean that, to achieve increased self-efficacy and optimal performance, feedback should be as positive as possible, but at the same time also be correct. The lack of a significant effect could be explained by the low number of subjects in the current study, insufficient difficulty of the task, or too small differences between conditions.

Summarizing, incorporating mastery experience in technology-supported interventions can potentially increase self-efficacy and possibly even effectiveness in the same way as in of non-technology-supported interventions, indicating that adaptation might indeed be of added value. Applying these feedback strategies leads to increased self-efficacy and could possibly lead to changes in behavior. However, it does not mean only positive feedback should be provided; results tend to show it is most effective to only let users experience their success at the moment they performed well, otherwise self-efficacy might increase while performance is not optimal (see Figs. 1 and 2).

Whether these results can be replicated in an ecologically valid environment or daily life is still a topic for future research. One example to apply adaptation in mobile activity coaches is to prompt a questionnaire to assess level of self-efficacy at baseline, after which subjects receive feedback based on their score on the questionnaire. Achterkamp et al. (submitted for publication) does describe a set up and plans for testing such adaptation versus no adaptation in a certain mobile activity coach, but no results are published yet. Furthermore, Arteaga, Kudeki, Woordworth, and Kurniawan (2010) tested a form of adaptation in a system in which subjects' personality traits, like extraversion and openness, determined which games they received. However, the authors did not include a control group that received the games at random, meaning no statements can be made about the effectiveness of adding this type of adaptation.

Future research should also investigate feedback strategies that aim at other sources of self-efficacy regarding physical activity to maximize effectiveness of technology-supported interventions, i.e. vicarious feedback, verbal persuasion and interpretation of physiological states (Bandura, 1994). Indeed, verbal persuasion is already applied in many interventions through providing motivational messages (Op den Akker et al., 2014), but often without the explicit goal to increase self-efficacy. Although vicarious feedback is not frequently implemented, it is relatively easy to apply, for example by showing successful performance of similar others on a (mobile) device before performing the task. This is also easily combined with verbal persuasion and mastery experience; apart from the effect of these concepts separately, it is interesting to investigate the combined effect of these sources in technology-supported interventions. Regarding 'interpretation of physiological states', subjects with low self-efficacy regarding physical activity might benefit from information about the effects of (sufficient) physical activity on fatigue or muscle soreness. However, research identifies this source as the least important source of self-efficacy (Chowdhury, Endres, & Lanis, 2002).

5. Conclusion

Self-efficacy can be influenced when using technology-supported feedback strategies. This study is a first step towards adaptation of technology-supported interventions, it shows self-efficacy can indeed be increased by experiencing success; the next step is to incorporate this knowledge into tailored feedback strategies of mobile activity coaches and test its effect on both level of self-efficacy and performance. Overall, the role of self-efficacy in these types of intervention deserves more attention and it is clear that there is still much to be investigated regarding this relation.

Conflict of interest

The authors declare that there are no conflicts of interest.

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