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Effective Feedback Procedures in Games for Health

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Participants: Kelly Bower,² Paul Krebs, PhD,³ Claudine J. Lamoth, PhD,⁴
and Elizabeth J. Lyons, PhD, MPH⁵

Feedback on game performance can be provided in many ways (e.g., cumulative points on game achievements, points on selected aspects of game play, biofeedback, brief statements offered during gameplay on choices made, verbal feedback at end of gameplay on overall performance, etc.). Feedback could be used motivationally to maintain player interest and involvement, informationally to guide the player in more effective choices, to build player confidence, and for a variety of other purposes. Although diverse feedback types and purposes are possible, some are more likely to be useful and effective. We have contacted several accomplished game designers and game researchers to obtain their insights into issues in feedback in Games for Health Journal.

Tom Baranowski: *Welcome to our Roundtable Discussion. Let's start with the first question: Please describe the purpose(s) and procedure(s) for providing player feedback in at least one of your games for health or a game you have studied. Was it effective in achieving your purpose? Why or why not?*

Claudine Lamoth: Currently within the project group "Exergaming for Balance Training of Elderly" of the University Medical Centre Groningen (SPRINT),¹ we are developing a game for balance and mobility training of seniors at home. We were interested if the type of feedback influenced the quality of the movement and the experienced task difficulty, enjoyment, and experienced mental and physical fatigue. Many studies have assessed the benefits of biofeedback for the purposes of balance training of elderly,^{2,3} but few studies assessed the clinical benefits of specific game feedback.⁴⁻⁶ We first used a commercially available balance game and made some adjustments. Older and young adults had to perform a balance exercise task on a wobble board without and with real-time feedback.^{7,8} Visual feedback was provided by visualization of the movement without and with a competitive game element. The game element was that the subjects had to pick up as many balloons on the screen as possible by shifting the weight from left to right, or backward and forwards, on the wobble board. Scores were visualized on the screen. As expected, the task without feedback was always performed

worst. However, we didn't find any additional benefit of the game element to the real-time feedback on balance performance, although the gaming task was perceived as the more interesting and challenging task. The older adults reported also that the game element required much attention and experienced fatigue. In my opinion these results showed two important factors to consider when making games for training of motor function of older people. First, direct explicit feedback about the quality of the movement might not be that beneficial at all. When providing direct feedback about the movement, the player is continuously directed toward making corrective responses. One factor that has been shown to enhance the performance and learning of motor skills is the performer's focus of attention.⁹ When playing games, people tend to concentrate on the outcome of their movements in the projected environment and not on the body movements themselves; the game takes the player's attention away from the motor task and focuses on achieving game goals, while simultaneous physical function is practiced. The adoption of an external attention focus results in greater automaticity of postural control.^{10,11} In contrast to providing direct feedback to correct movements, feedback should be facilitated by the game environment without much conscious attention. Thus, the attentional role of feedback needs to be considered in developing games. Second, the game we assessed was too difficult for the older adults, providing an attentional

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overload, and they experienced fatigue. Most off-the-shelf exergames are not developed for the elderly and do not meet the usability requirements for the elderly. Games for seniors should be at the level of interest of seniors, and there should be an optimal relation between the ability and level of challenge, particularly when training/rehabilitation is the aim.

Kelly Bower: Feedback can be beneficial to increase motivation and adherence to exercise regimens, and importantly in rehabilitation it can serve to enhance motor learning.¹² Intrinsic feedback (i.e., sensory information from the body) is often compromised following stroke, so extrinsic feedback (through knowledge of performance or knowledge of results) can help to optimize recovery. Research has found that both visual and auditory feedback training can improve balance and mobility outcomes after stroke,^{12,13} and active computer games show promise as an engaging and effective treatment approach.¹⁴

I have investigated two game systems for physical rehabilitation after stroke: (1) the Nintendo [Kyoto, Japan] Wii™¹⁵ and (2) customized games utilizing a depth-sensing camera. The Wii can provide rich visual, auditory, and even sensory (vibration of the remote) feedback as well as scoring; however, these games have levels of challenge that cannot be easily graded. Individuals with physical and cognitive deficits may have difficulty using these systems, which are designed for the general population.¹⁶ This can lead to failure, resulting in negative feedback to the user (e.g., the slumped Mii character and a message saying “unbalanced!”) and consequent poor engagement. Furthermore, many Wii games do not accurately record and provide feedback on movement quality and may even encourage inappropriate movement patterns¹⁷; therefore additional verbal or physical feedback from the therapist may be required. We recently developed four customized games to address several of these issues. These games, which utilize a depth-sensing camera (PrimeSense [Tel Aviv, Israel], the same technology used in the Microsoft® [Redmond, WA] Kinect®), provide simple visual feedback in response to three-dimensional upper body movements (e.g., leaning the torso to tilt a maze board in order to guide a ball into the hole; or moving the upper limb to shoot bubbles at fish) and auditory feedback when goals are achieved (e.g., hitting a target). Scores are provided in addition to other information that may be of particular interest in stroke rehabilitation, such as time spent playing, left-right bias, and number of movement repetitions performed. The relatively simple interface and ability to be played in sitting or standing with varying levels of difficulty (e.g., changing the speed) means that these games are able to be used by people with a broad range of abilities. In general, both the Wii and our customized games have been found to be enjoyable and challenging and perceived as helpful by people who are undertaking stroke rehabilitation. The provision of feedback scores serves to increase user motivation (e.g., to advance individually or compete against others) and can provide clinicians with a way of monitoring change in performance over time.

Elizabeth Lyons: We’ve studied feedback from videogames and game-like applications in several different projects. Last year, my lab conducted a study that assessed feedback and

other behavior change strategies across active videogames available for home consoles.¹⁸ We were looking at feedback as it is typically conceptualized in health promotion interventions, as feedback on behavior and behavioral outcomes. We found that all 18 of the games we play-tested included some form of behavioral/outcome feedback, typically delivered as graphs of play time and/or calorie burn over time. The games did differ substantially in how specific and rich that feedback was (although we weren’t able to include much of that deeper analysis in the already long article). Many of the games allowed players to compare their current progress with past performance (graphs over time) and with other players (leaderboards), either in terms of percent completion towards a goal or in terms of accuracy. Some of the feedback types were unique to interactive media, such as the use of a colored outline or lines superimposed on a video of the player’s body to show correct posture and form. That kind of evaluative feedback could be really beneficial to preventing injury in at-home exercise interventions, and we typically don’t concentrate on that type of feedback in our health promotion interventions.

Beyond measuring feedback in available games, we also use it in game-based interventions. We shaped the content of our telephone counseling guides in one study around the feedback available in “Zombies, Run!” That game provides very extensive feedback on activity frequency, duration, and intensity (through a “Runkeeper”-esque log and mapping system) and progress through the game (via achievements, collection of virtual town-building materials, and progress through a set storyline). In addition to benefits to the player that we hypothesize exist (and that hopefully we will be able to report and measure soon once the trial is over!), this feedback also helps us as interventionists. In order to individualize counseling content, we often have to go to quite a bit of trouble to collect and analyze participant data. Automatic feedback such as this game collects and reports allows us to very quickly determine whether participants met their weekly goals and how we might help them improve on their performance in the future.

Paul Krebs: In contrast to many of the games that have focused on physical activity, we have been designing a game to help people through the process of quitting smoking. Our game is based on behavioral rehearsal therapy to help smokers identify, model, and practice coping strategies to identify and manage smoking cues. We thought that a game modality would be ideal to translate and even improve upon the role-playing we do clinically (e.g., “So what will you do when you are out with friends...etc.”). A computer game enables individuals to interact with realistic environments and thus is uniquely suited for engaging smokers in skill-building activities for managing urges to smoke. After getting feedback on various concepts from a focus group, we designed the game as a series of intertwining episodic stories, which link a group of four travelers stranded at an airport during a blizzard as they sit at a restaurant and relate stories of how they quit smoking. The players are taken to flashback scenarios in which they attempt to reenact the characters’ trigger situations without smoking.

Feedback is integrated in a number of ways and is designed to emphasize experiential learning. Learning to monitor and manage urges to smoke is a core aspect of tobacco cessation

treatment; therefore, an “urge meter” serves as the hook and primary feedback mechanism to engage decision-making and game play. The “urge meter” appears as a slider bar in gradations from green to red and forms the basis for the game dynamic. As the characters encounter trigger situations (e.g., arguments, work stress, traffic, etc.), the meter increases. If players choose useful coping strategies, the meter decreases; if not, it continues to rise, and the character smokes. The opportunity to use coping strategies appears four or five times in an episode as a set of cards (e.g., deep breathe, chew nicotine gum, walk away, etc.) that players click on. When they click on a card, they also get subtle feedback in the form of a positive sound for a useful strategy or a negative tone when the strategy would not aid in that situation. Feedback also takes the form of an “After Action Report” in which the character played in that scene reviews choices the player made (e.g., “In this scene you helped me avoid smoking by using the gum, but could have also chosen to throw away my cigarettes”). While we are just commencing our pilot randomized trial phase, results from alpha testing with users indicated the “urge meter” needs to be clearly recognizable and intuitive and that how their choices influence how a scene plays out is effective in helping players rethink their smoking.

Tom Baranowski: *What formula, rules, or algorithms did you use for assigning points or for giving verbal feedback? How might it be improved?*

Claudine Lamothe: The game consisted of a conventional wobble board, which was combined with interactive training software via a screen and a computer. The player shifted his or her weight to control the center of pressure (COP). Using sensors in the board, there was immediate feedback of the movements made on the board, in the form of a moving dot on the screen (COP feedback). The goal of the gaming task was to transport as many balloons as possible from one side of a play field to the other side. When the balloon was carried to a specified point, a new one appeared. The total number of balloons and time to transport one was displayed on the screen, providing the player with a game score. Direct visual feedback of the COP was given during gameplay, and game score was provided at the end of the game. Currently we are developing a game specifically to train balance of older people. In this exergame different game levels are related to different aspects of balance control, like coordination, muscle strength, etc. Instead of providing direct feedback about movement outcome, we use an exploratory, and implicit, learning approach in which feedback is given by the game environment and is formulated in terms of game performance and goals, thereby creating an external focus of attention. In addition, feedback should also reflect the benefits gameplay offers such as improvement in balance or changes therein. We know that adherence to conventional exercises is low, particularly when prevention is the aim. Because there is no direct visible benefit, high levels of motivation are required. Moreover, elderly are open for new technologies if it is clear what the benefit is.¹⁹ Dr. Lyons refers, in that respect, to an important potential of game feedback, namely, beyond measuring directly game feedback, games can give “automatically” feedback about frequency, duration, and intensity of interventions that helps to show the benefits,

monitoring progress or decline and tailoring interventions to individual needs.

Kelly Bower: The feedback provided by our customized games included immediate visual feedback on movement (as movement of the body translates directly to movement of an object on the computer or television screen), provision of scores (e.g., hits and misses), and basic monitoring of movement repetitions and play time. We attempted to develop games that were applicable to a broad range of abilities and limited negative feedback to the user. Handling failure in positive ways may be particularly pertinent to rehabilitation populations²⁰; however, the activity still needs to be challenging enough to be engaging. Our customized games are currently basic prototypes, which we are looking to develop further. The integration of baseline configuration and calibration (e.g., movement assessment) and dynamic adaptation of the game based on performance would assist in providing the user with an appropriate level of challenge. More sophisticated systems could provide detailed and accurate feedback on movement quality. This may serve to enhance performance, inform future treatment approaches, and monitor change over time. Importantly, the feedback provided needs to be appropriate to the aim of improving real-world function.^{17,21}

Elizabeth Lyons: I typically view feedback through the lens of social cognitive theory (SCT), which offers a number of suggestions for methods of increasing self-efficacy, or the confidence to engage in a behavior under a specific set of circumstances. A recent study compared two walking interventions: one that stuck close to SCT-based recommendations for increasing self-efficacy (including feedback provision) and one that did not.²² The theory-based intervention provided feedback that (1) was specific and that gave a clear picture of how well the individual was doing, (2) compared present individual performance to past performance, (3) compared the individual's performance with that of similar others, and (4) compared individual performance to specific goals. The intervention that used SCT-based feedback was more successful in producing behavior change than the standard intervention. These results have definitely shaped my thinking about how much behavioral feedback is enough, and now I try to include/emphasize as many of these four types as possible.

I also view feedback from the perspective of self-determination theory (SDT), which is a very useful theory for games for health development, implementation, and criticism. According to SDT, ideally games foster individual feelings of autonomy, competence, and relatedness to promote intrinsic (volitional) motivation.²³ Unfortunately, it is all too easy to inadvertently use feedback in a way that actually decreases some of these perceptions. Within the general literature related to SDT²⁴ and studies that specifically apply SDT to videogaming,²⁵ authors emphasize the importance of informational rather than controlling feedback. We try to avoid using games with feedback mechanics (for either health behavior feedback or game-related feedback) that impose values on behavior. I have mixed feelings about achievements/trophies/badges, as I know a lot of people do, because they can serve the purpose of informational feedback, social networking, or displaying status,^{26,27} while at the same time they

can also come across as really controlling, requiring a certain type of play.

We use a lot of our own formative data as a basis for which games we choose and how we ask participants to use them. Both younger and older adults in our studies have often expressed irritation at voice-overs during dance or workout games that make snarky or sarcastic comments about their performance. Attempts to couch failure in positive terms can end up feeling worse to players than plain informational feedback on performance, depending on how it is provided. (A chipper “There’s always tomorrow” or “You did your best” can feel downright condescending, even insulting.) Another common irritation among participants has been shaming tactics, such as the moment in “Wii Fit” in which one’s avatar visibly fattens and then slumps forward in defeat/shame as it’s announced “That’s overweight!” In addition to our qualitative findings that this tactic is perceived as controlling and unpleasant, there are also several preliminary studies that suggest using avatars for more aspirational purposes (to virtually self-model health behaviors and/or to represent an ideal or possible self) may be a more successful tactic than using avatars to punish or shame.^{28–31}

Paul Krebs: Our main feedback mechanism, the “urge meter,” is indexed based on evidence of the effectiveness of particular coping strategies for categories of emotional and behavioral situations that are often smoking triggers. To provide data for the meter, we created a spreadsheet listing categories of trigger situations by categories of coping strategies. Then, each coping strategy was assigned a 5-point ranking of effectiveness for each trigger from weak to strongest with each indexed by 0.25. For instance, for the trigger Anger, using nicotine replacement would be a weak coping strategy and barely decrease the urge, whereas Relaxation Strategies would be a strong coping tool and bring down the meter more. This formulation is largely based on evidence-based interventions from the behavioral health and tobacco cessation fields. The goal is to subtly help players develop situational awareness of triggers and be able to accurately apply the most efficient coping strategy from a range of possibilities (i.e., a “coping toolbox”). Players also earn points in each scene represented by up to four stars, with scores increasing depending on the relevance of each strategy to the trigger.

Verbal feedback is given by the character in the After Action Report. The After Action Report is designed to reinforce the positive choices players made and serve as a reflective device by promoting self-efficacy for better choices that players could make in future sessions. The After Action Report was initially text-based in which the player would read a summary of his or her coping choices after each scenario. To promote engagement in the game and consistency of the narrative arc, at the end of a scene it now cuts away to the character narrating and reviewing the player’s choice of coping strategy providing constructive feedback. Thus, similar to Elizabeth’s work, we have also incorporated multiple levels of feedback: Moment-to-moment, sustained, and cumulative.

Tom Baranowski: *What published references did you use, if any, for guiding your provision of game play feedback?*

Claudine Lamothe: There are not many studies yet which published on the clinical benefits of specific game feedback for the purpose of training balance and mobility in the elderly,

since it is a relatively young area. We adopted an approach in which different experts from the area of game developers/designers, human movement sciences, rehabilitation sciences, and biomedical engineering work together in developing a serious gaming tool for the elderly to train balance and mobility. Consequently, published references are used from many different sources, ranging from scientific publications in the area of psychology, rehabilitation, movement sciences, and gaming sciences to more practical reports, conference proceedings, and books about virtual reality and serious gaming. Apart from the literature our project builds on a user-driven approach. By using focus groups in all phases of the development process, user requirements are identified (e.g., type of feedback).^{32,33}

Kelly Bower: As mentioned by Dr. Lamothe, some research on feedback exists for rehabilitation populations; however, there is very little specific research in the area of game-based feedback, especially in stroke. The development of our customized games involved collaboration among clinicians, researchers, and a local game development company, and they were tested by a range of people with stroke. We were informed by the benefits and limitations found in the existing commercially available systems and guided by published literature from a variety of sources on feedback, motor learning principles, and game-based rehabilitation. I have found several references helpful in relation to feedback and game-based interventions after stroke^{12,17,20,34}; however, this is a rapidly growing area of research, and there are many recent conference papers and articles.

Elizabeth Lyons: I’ve found that some of the most useful references for me are from conference presentations, from either game-related or communications conferences.

Scott Rigby, a developer and one of the co-authors of many excellent articles applying SDT to videogaming, has a number of very helpful slide presentations available on his company’s Web site (www.immersyve.com/downloads/conference-presentations/). In particular, his advice on levels of informational feedback is very specific and useful. He’s proposed that feedback should occur on multiple levels, including granular (moment-to-moment), sustained (success/failure rates and streaks), and cumulative (overall performance over various periods of time—by session, by game, by player, etc.).³⁵ The purpose of feedback from this perspective is to allow players to experience challenge as well as experience and demonstrate mastery. Though often those of us in game development, criticism, and research focus on that optimal ratio of challenge to skills that produces feelings of flow, I agree with him that there is a lot to be said for portions of games that are slightly too easy (after allowing mastery to develop, providing a chance to demonstrate it) and slightly too hard (for the pleasure of re-trying and learning from mistakes—called “repositio”³⁶).

I am also a big fan of Sebastian Deterding’s work, particularly when it comes to pitfalls related to “gamification” (see slide presentations and papers available on his Web site [<http://codingconduct.cc/>]). He proposes that serious game design should translate the serious goal or task into a mechanic, rather than add game mechanics or a serious topic to one another. Thus, rather than using games as a tool to promote health, from this perspective we would attempt to re-

frame health promotion as a game.³⁷ Feedback is central both to health promotion intervention as well as to gaming, but it may be implemented very differently depending upon the frame.

Paul Krebs: I would agree with Claudine that there is far too little published on the efficacy of specific feedback techniques in games. As our game is less focused on achieving a specific target as would be a physical activity game, we drew from a somewhat different literature. The tobacco behavioral rehearsal focus required an instructional/experiential perspective and thus drew from work at the intersection of game and educational design. Our collaborators, Muzzy Lane Software, have significant experience creating educational games focused on history and language learning so their input and prior work with educators have been extremely helpful. In addition, we drew from a thoughtful review article³⁸ that was influential in translating engagement strategies into the serious game domain. The work of Geoff Howland on gameplay “hooks”³⁹ was also helpful in designing the primary game play device, the “Urge Meter,” that provided continual feedback on how player actions affected the game. Thus feedback served an encouraging and corrective role in the context of the behavioral rehearsal technique.

Tom Baranowski: *What research would be useful to you, if any, to refine your approach(es) to providing feedback?*

Claudine Lamothe: Defining the proper game feedback for training of the elderly is a very important topic for which research is still in its infancy. We clearly have to distinguish different types of feedback. At present, for the exergaming project I have two main interests with respect to feedback. First, we are exploring and studying the effect of providing feedback to the gamer during gameplay and after gameplay at different time scales.⁴⁰ We are particularly interested in adaptive game technologies, to tailor the game to the individual user’s capabilities to enhance learning and motivational aspects. Thus, we are interested in an ongoing “action–consequence–action” feedback loop for adaptive gameplay, providing continuously the optimal challenge level. Second, our aim is to develop games for balance exercising at home. Adherence to conventional exercises is low, and one of the most suggested benefits of exergaming is its motivational character. However, over a long time people might also lose their interest in exergames. Hence, it is important to assess which type, frequency, and intensity of feedback are needed to enhance the motivational component to exercise in the long term.

Kelly Bower: Literature on scheduling (i.e., frequency and timing) of feedback for stroke rehabilitation is still somewhat equivocal. It has been suggested that too much feedback may have negative effects, although this may not be the case when there is an external focus (such as in game-based interventions), and different requirements may be needed for simple versus more complex tasks.¹² It would be useful to know how best to optimize feedback scheduling in relation to rehabilitation games. Games have the potential to provide real-time feedback on movement quality, and it would be valuable to know how this information could be best presented, particularly as research has shown that an external (or outcome-related) focus is more likely to result in better performance.⁴¹

Finally, more research needs to explore how the feedback provided by games relates to longer-term adherence and improvements in real-world outcomes.

Elizabeth Lyons: I would love to see a compendium of best practices for feedback provision, based on evidence across multiple health behaviors. It would be very helpful to have guidance on various aspects of feedback provision all in one place (i.e., something like Michie and colleagues’ coding system for interventions that looks at different behavior change strategies,^{42,43} except more specific to how to implement those strategies). There are some meta-analyses and meta-regressions that demonstrate best practices for, for example, increasing self-efficacy or intervening on a particular behavior. However, I’m not aware of very many studies that have sought to examine best practices for actually implementing those strategies.

Paul Krebs: I agree that a compendium of best practices would be extremely valuable. Right now it appears we only have best judgments and experience to guide our provision of feedback. We have relied on qualitative research including focus group and cognitive interviews to provide end-user data regarding preferences for feedback, but preference does not necessarily translate into knowledge of feedback efficacy. I would like to see efficient factorial experiments that vary various options for feedback in a cohort of players, which would provide data as to their relative efficacy.

Tom Baranowski: *The purposes and methods of feedback vary by type of game. Feedback enhances performance (as long as it is not condescending) in all the games, but the optimal method and dose await further research. Existing exergames may be too difficult for some stroke patients and older adults, suggesting there is a substantial market to develop new games to meet the needs of these potential gamers. Behavioral theories were identified to guide the design and delivery of feedback messages, but formative research with targeted game players is critical to effective feedback delivery. Diverse references were identified to be helpful to readers about feedback in games. Finally, a diverse research agenda was outlined. We are obviously in the earliest stages of learning how to optimally deliver feedback in videogames. I hope many of these future research reports will appear in the G4HJ.*

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Brief Biosketches

Kelly Bower is a physiotherapist at the Royal Melbourne Hospital and PhD Candidate at the University of Melbourne, Melbourne, Australia. She has developed clinical expertise in neurological rehabilitation and has a special interest in the use of active videogaming technologies for assessment and treatment after stroke. In addition to her postgraduate research, which has focused on the Nintendo Wii, she

has investigated the use of the Microsoft Kinect camera for movement assessment and has worked with a commercial partner (Current Circus) to develop customized stroke rehabilitation games. Kelly has been awarded several competitive grants to support her research in this field.

Claudine Lamoth, PhD, is Assistant Professor and Principal Investigator at the Centre for Human Movement Sciences of the University Medical Centre Groningen, University of Groningen, Groningen, The Netherlands. She is project leader of the research program "Exergaming for Balance Training of Elderly at Home," which is part of the research center SPRINT of the

University Medical Centre Groningen. Lamoth's research focus is in the area of motor control of learning, aging, and movement disorders, using concepts and tools from dynamical systems theory. She combines fundamental knowledge of motor control with game and sensor technologies and innovative data analysis in order to develop solutions for sup-

porting independent mobility, preventing falls, and improving health in the elderly.

Elizabeth J. Lyons, PhD, MPH, is an Assistant Professor in the Institute for Translational Sciences at the University of Texas Medical Branch, Galveston, TX. Her research concerns the use of technology to increase motivation for behaviors related to energy balance (that is, physical activity, sedentary behavior, and food intake). She is particularly interested in the power of narrative and character identification to increase

motivation and self-efficacy. Although most of her research is on commercially available videogames, she is also studying other media that include characteristics of videogames such as activity monitors and their competitive mobile applications.

Paul Krebs, PhD, is an Assistant Professor in the Department of Population Health at New York University (NYU) School of Medicine and a member of the NYU Cancer Institute's Epidemiology & Cancer Control Research Program. A clinical psychologist, he practices in the primary care mental health team at the Veterans Administration New York Harbor Healthcare System. His work fo-

cuses on extending the reach of tobacco cessation and health behavior change strategies, especially among cancer patients. He is particularly interested in the use of technologies to facilitate behavior change. His projects have explored use interactive video, computer gaming, and mobile devices to promote physical activity, improved dietary practices, and tobacco cessation.