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Cognitive Bias Modification for adolescents with substance use problems – Can serious games help?

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Background and Objectives: Excessive use of psychoactive substances and resulting disorders are a major societal problem, and the most prevalent mental disorder in young men. Recent reviews have concluded that Cognitive Bias Modification (CBM) shows promise as an intervention method in this field. As adolescence is a critical formative period, successful early intervention may be key in preventing later substance use disorders that are difficult to treat. One issue with adolescents, however, is that they often lack the motivation to change their behavior, and to engage in multisession cognitive training programs. The upcoming use of *serious games for health* may provide a solution to this motivational challenge.
Methods: As the use of game-elements in CBM is fairly new, there are very few published studies in this field. This review therefore focuses on currently available evidence from similar fields, such as cognitive training, as well as several ongoing CBM gamification projects, to illustrate the general principles.
Results: A number of steps in the gamification process are identified, starting with the original, evidence-based CBM task, towards full integration in a game. While more data is needed, some steps seem better suited for CBM gamification than others. Based on the current evidence, several recommendations are made.
Limitations: As the field is still in its infancy, further research is needed before firm conclusions can be drawn.
Conclusions: Gamified CBM may be a promising way to reach at risk youth, but the term "game" should be used with caution. Suggestions are made for future research.

1. Introduction

Alcohol- and drug misuse among adolescents pose a major societal problem. They predict school dropout and academic underperformance (Singleton, 2007; Wood, Sher, & McGowan, 2000) and, as they are relatively likely to escalate into more problematic use (Thatcher & Clark, 2008), may ultimately lead to later addiction problems. There are indications that young binge drinkers (i.e., adolescents who consume large amounts of alcohol, e.g., more than five drinks, within a short time period) are likely to develop atypical reactions to alcohol, which is reflected in their enhanced cue-reactivity (e.g., Tapert et al., 2003) and reduced ability to perform in executive cognitive tasks (Duka et al., 2004; Maurage et al., 2012). Similar neuroadaptations have been found for other popular substances in youth such as cannabis (e.g., Cousijn et al., 2012; 2013). As such, successful intervention during adolescence may help to prevent cognitive decline and substance use disorders later on. Several interventions exist that aim to persuade adolescents to abstain from or regulate their substance use. We can distinguish between explicit and implicit interventions. For example, explicit warning messages about the dangers of substance use are applied frequently (e.g., Drug Abuse Resistance Education, DARE), although their efficacy has been refuted on multiple occasions (e.g., Werch & Owen, 2002). Motivational interviewing (Miller & Rollnick, 2002) is another explicit, but more personalized technique, which has shown support in young adults (for review, see Larimer & Cronce, 2007), although its efficacy in adolescents has been questioned (e.g., Thush et al., 2009), showing mixed results (for review, see Barnett, Sussman, Smith, Rohrbach, & Spruijt-Metz, 2012). An alternative, more implicit intervention is cognitive training (introduced below).

Many adolescents do not consider their alcohol use as problematic or harmful (Johnston, O'malley, Bachman, & Schulenberg, 2012). For example, Wiers, van de Luitgaarden, van den

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Wildenberg, and Smulders (2005) found that while 74% of their pre-screened sample of 96 late adolescents met diagnostic criteria for likely alcohol problems, only one of them actually self-indicated to have an alcohol problem. This lack of awareness may exist because adolescents tend to perceive more positive than negative effects of their alcohol use (National Institute on Alcohol Abuse and Alcoholism, 2005). As such, adolescents' motivation to change is often low and explicitly confronting them with their substance use may not be the most efficient way to prevent serious problems. Inspired by dual process models of addiction (e.g., Deutsch & Strack, 2006; Wiers et al., 2007), several varieties of cognitive training have been developed. These models posit that prolonged use of addictive substances leads to two important sets of cognitive changes. First there are several distinct impulsive or motivational reactions (biases) towards substances, such as attentional bias (e.g., Field et al., 2007; Schoenmakers et al., 2010), automatic memory associations (e.g., Houben, Havermans, Nederkoorn, & Jansen, 2012; Stacy, 1997) and approach bias (Wiers, Eberl, Rinck, Becker, & Lindenmeyer, 2011; Wiers, Rinck, Dictus, & Van den Wildenberg, 2009). Second, it was posited that cognitive control processes that regulate these impulsive reactions, such as response inhibition (Houben & Wiers, 2009; Peeters et al., 2012) and working memory capacity (Grenard et al., 2008; Thush et al., 2008), may become weakened through prolonged use and eventually fail to fulfill their regulatory function. However, a recent review has shown that there is stronger support for enhanced motivational reactions to stimulus cues than for impaired control functions as a result of adolescent substance use (Wiers, Boelema, Nikolaou, & Gladwin, in press). Meanwhile, there is evidence that premorbid weak control functions are predictive of later substance use escalation (De Wit, 2009; Verdejo-Garcia, Lawrence, & Clark, 2008), and the underlying mechanism may be that these individuals have more trouble in controlling their enhanced implicit motivational processes (Peeters et al., 2013; Wiers, Gladwin, Hofmann, Salemink, & Ridderinkhof, 2013; Wiers et al., in press). The resulting imbalance between these stronger impulsive and relatively weak control processes can then lead to the development of addictive behaviors. Restoring balance may slow down this development, and eventually lead to a decline of substance use. In order to do so, Cognitive Bias Modification (CBM) techniques can be used to change these biased automatic, impulsive reactions by providing more time to make decisions regarding the use of a substance (Wiers et al., 2013). Additionally, cognitive control over the impulses may be strengthened through executive function training (for review, see Klingberg, 2010), and has shown promise in addiction (Houben, Wiers, & Jansen, 2011).

CBM is a collection of different training techniques aimed at changing relatively fast or impulsive reactions to disorder-relevant stimuli (Koster, Fox, & MacLeod, 2009). For example, heavy alcohol users often show selective attention (Field et al., 2007) or approach tendencies (Wiers et al., 2009) towards alcohol-related cues, resulting in cognitive biases. CBM is often applied through computer based reaction time tasks that aim to modify the bias through extensive practice, rather than explicit instruction (Koster et al., 2009). The efficacy of CBM remains subject of debate (Emmelkamp, 2012), but there certainly are indications that these processes can successfully be retrained, with positive clinical effects in addiction and related disorders (for review, see Wiers et al., 2013). In anxiety, Clarke, Notebaert, and Macleod (2014) noted that out of 29 reviewed studies on CBM-Attention (CBM-A), 26 showed a clear link between achieved bias modification and observed change in emotional vulnerability: either both were observed ($n = 16$), or both were absent ($n = 10$). Hence, effects on behavior can only be expected when a change of bias has occurred.

Although CBM seems to be a promising new technique, the repetitive nature of the training tasks often makes them inherently boring (Beard & Weisberg, 2012). Moreover, subjects often have a hard time believing that a simple computer task such as CBM training can really help them control their substance use (Beard & Weisberg, 2012). Therefore, an intrinsic motivation to change may be necessary for participants to follow through with the full training program. Most CBM studies trained adult patients, who often have a long history of substance use problems, and tend to be motivated to change their habits. Adolescents rarely have this insight, nor do they have a strong motivation to change their behaviors. And even when they do recognize that they have a problem, they may still need to be motivated to do the full training. Gladwin, Figner, Crone, and Wiers (2011) identified several ways to tackle this problem, one of which is to introduce game-elements. The products of such combinations are sometimes called *serious games for health*. In the next part of this review, an overview is given of several ways of including game-elements to improve adolescents' motivation to train using CBM techniques.

1.1. Serious games for health

To understand how applying serious gaming techniques may help motivate adolescents to complete CBM training, let us first look at what constitutes a *serious game*. Unfortunately, despite the recent surge in the number of studies about serious games, there is no consensus yet on what defining elements should comprise a serious game (Bedwell, Pavlas, Heyne, Lazzara, & Salas, 2012). One reason might be the very diverse application of gaming techniques for serious purposes. Granic, Lobel, and Engels (2014) provide a comprehensive review of the many types of serious games and their use in fields such as education, medicine and mental health. They conclude that, although very promising, there are still relatively few serious games specifically aimed at improving mental health. A quick online search on the term "serious games" also reveals that many diverse techniques are used, such as virtual reality and motion capture techniques, to increase physical exercise and activities through gaming (also known as *exergaming*), as well as online games and lab-based games. To narrow down this wide field of serious games towards identifying the useful elements for CBM training, we make several distinctions in the ways gaming techniques can be applied to intervention techniques, such as CBM.

First, there is the focus of the game-development. As a serious game ideally is a combination of a serious component (e.g., a training) and a fun component (i.e., a game), the development of a serious game will usually start from one of these two positions. Coming from the game perspective, one can start with a so called "Off The Shelf" (OTS) game, which often is commercially developed and primarily meant for entertainment, and use it for serious purposes, such as cognitive training. Several studies have looked at the effects of prolonged gaming on cognitive abilities (for review, see Granic et al., 2014), and there is growing support for the notion that, contrary to popular belief in recent years, gaming may also have positive effects. However, when examining OTS entertainment games in more detail, it is hard to disentangle which aspect of the game is responsible for the desired training effect. This may limit the scientific use of OTS entertainment games for developing specific training games (e.g. CBM). Alternatively, one may start with a training procedure or training concept and introduce game-elements to make it more fun and motivating. For example, Merry et al. (2012) developed an intervention game called *SPARX*, based on cognitive behavioral therapy (CBT) principles. This game, aimed at adolescents seeking help for depression, proved to be as effective in treating depression as a therapist-administered CBT program. As the field of CBM already possesses a relatively strong scientific evidence base, this would seem to be the option of choice. Interestingly, however, a review by Kharrazi, Lu, Gharghabi, and Coleman (2012) showed that the recent surge of health game publications still often lacks underlying theoretical frameworks.

Another distinction that can be made within the serious games domain, concerns the difference between the explicit messaging, versus a more indirect, implicit varieties of training. For example, Noble, Best, Sidwell, and Strang (2000) introduced game-elements to explicit drug education, which was evaluated as being more fun than the regular method. In contrast, Prins et al. (2013) used evidence-based executive function training principles as the basis for their *Braingame Brian*. In this cognitive training with game elements the participant trains executive functions, such as working memory and inhibition through a diverse set of puzzles, while walking around in an extensive virtual world.

Finally, and perhaps most importantly, serious games differ with regard to the intrinsic and extrinsic motivational elements used. Intrinsic motivation can be defined as “doing something because it is inherently interesting or enjoyable” (Ryan & Deci, 2000, p. 55). In terms of motivating game-elements, this would mean that the tasks in the game, such as exploring the level or immersing in the story-line, are motivating or rewarding on their own. In contrast, extrinsic motivation refers to “doing something because it leads to a separable outcome” (Ryan & Deci, 2000, p. 55). In games this is often reflected by various point-based reward systems, such as collecting coins or achieving bonus rewards. While extrinsic motivation is sometimes viewed as a less effective (even if powerful) form of motivation, Ryan and Deci's Self-Determination Theory suggests that the efficacy of extrinsic motivators may depend on a person's internal perceived locus of causality (Deci & Ryan, 1985).

2. CBM gamification: some examples

As there are as yet very few publications on CBM using game-elements, we will use examples from several ongoing projects to describe a number of steps to introduce game-elements to increase motivation to train in a typical CBM training. One of the most frequently applied CBM techniques is focused on selective attention (CMB-A[1]; MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002). To measure and train selective attention, most CBM-A interventions use varieties of the Visual Probe Task (VPT; MacLeod, Mathews, & Tata, 1986). VPT versions aimed at substance-related attentional bias (e.g., Field et al., 2007; Field & Eastwood, 2005; Schoenmakers et al., 2010) usually use a pair of two visually similar pictures, shown simultaneously on the screen. This pair consists of a target and a contrast picture, e.g., an alcohol-related stimulus, such as a bottle of beer and a neutral picture of a soda, like a bottle of Coke. After a short while, usually 500 ms, a small probe, e.g., an arrow, is shown at the center of the position of one of the pictures (depending on the version of the task, the pictures also disappear at this point, showing only the arrow, or they may stay visible, and the arrow is superimposed on one of the pictures, see Fig. 1a). The arrow may point upwards or downwards, and the participant is instructed to respond to the arrow's direction as quickly and as accurately as possible by pressing the corresponding key on the keyboard. The placement of the target and contrast stimuli (left or right) and the arrow direction (up or down) are random. To measure the attentional bias, the arrow appears in the target stimulus' spot equally as often as in the contrast stimulus' spot. The idea behind the task is that attention is drawn more quickly to and maintained longer at the spot where the object of one's selective attention is located. Thus if the arrow is shown at that same location as is the focus of one's attention, reaction times will be shorter, on average, than when the arrow is shown at the other location. The attentional bias towards the target can be calculated by subtracting the average reaction times on target trials (i.e., when the arrow appears in the same spot as where the target picture was shown) from those on neutral trials. When the VPT paradigm is used for CBM training, the location of the arrow is changed to always match the contrast stimulus' spot (instead of in half of trials in the measurement version). The participant then implicitly learns to focus attention away from the target stimuli, towards the contrast stimuli.

2.1. Step 1 – Adding game-elements to the evidence-based training task

As a first step towards incorporating motivating game-elements, different kinds of reward systems can be included in the training. First, *motivating feedback*, such as sounds or animations, can be given after each trial or after a block of trials, telling participants how well they are doing, and optionally how to improve their performance. Similarly, progress bars can be included to show how far along the training session they are. Second, a *point system* can be included, either based on participation (e.g., after completion of the training, the participant is awarded a prize, money or course credits; Anguera et al., 2012; Jaeggi, Buschkuehl, Jonides, & Shah, 2011) or performance (e.g., bonus points for doing well on the task, such as fast correct responses; van Deursen, Salemink, Smit, Kramer, & Wiers, 2013). While it has been suggested that extrinsic rewards, such as money, may hinder performance (Jaeggi, Buschkuehl, Shah, & Jonides, 2014) by undermining intrinsic motivation (Deci, Koestner, & Ryan, 1999), Dovis, van der Oord, Wiers, and Prins (2012) compared several types of rewards in a working memory task and found that children with ADHD were highly sensitive to performance based increases of the chance to win a (relatively large) monetary reward. This discrepancy may be explained by cognitive dissonance theory (Festinger, 1957), in that participants performing a training task without monetary rewards may justify their behavior (i.e., doing the boring task) by changing their conflicting cognition. For example, a participant may not be intrinsically motivated to train, but does so anyway. Then their cognitive dissonance may lead to reasoning along the lines of “why would I do this if it is not rewarding? – I'm doing it; therefore, it must be rewarding after all.” In contrast, participants who do get rewarded may not be inclined to change their cognitions, or even worse, reason along the lines that “I am doing this for the rewards; therefore, the training itself is really not that much fun.”

2.2. Step 2 – Intrinsic integration with the evidence-based training task as a basis

While such game-elements may work to motivate participants to continue training, their motivation will in principle be extrinsic. That is, they may still not like doing the training trials, but the external reward keeps them going. Both psychological theory and the game design literature agree that, although this technique may be effective and is indeed used in many games, the most direct and effective way to motivate is through intrinsic motivation, or in this context, making the participant enjoy doing the gamified training trials. So in order to minimize the distance between the task and the motivating elements, an evidence-based training can also be transformed into a game itself. This makes the training itself more fun, which should increase the intrinsic motivation to train.

[1] For clarity, the following sections will focus on CBM-A examples, to make comparisons more easy. The described techniques do apply to different types of CBM.

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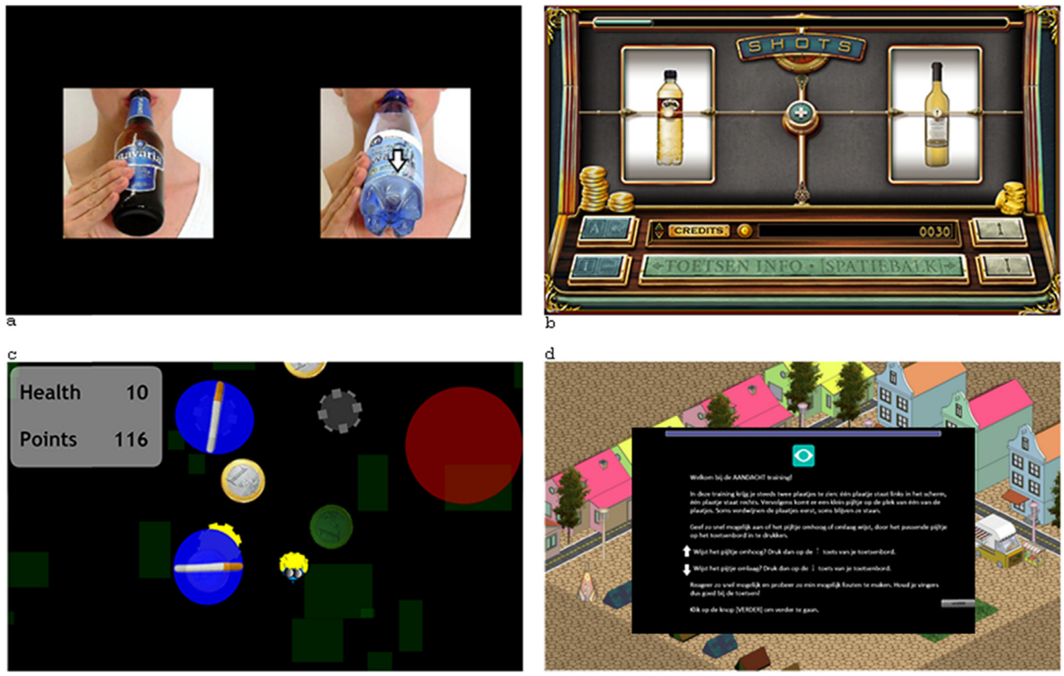

Fig. 1. Four versions of CBM-Attention using different types of game-elements. **a**. The original *Visual Probe Task* (VPT), without game-elements. **b**. *Shots Game*, a game version of the VPT, using the same set-up, but with various game-elements added. **c**. *BombDodger Game*, which is based on scientific attention and approach bias principles, but with a different form of presentation. **d**. *City Builder Game*, where the original VPT, with added progress bar and point reward system, is integrated within a game-shell.

Interestingly, Dovis et al. (2012) also looked at a gamified version of their task, in which their original working memory task was fully integrated within a digital game. They found that both a regular version with a strong monetary incentive and their gamified version improved performance in children with ADHD, compared to the regular version with feedback only. A CBM-related example can be seen in Fig. 1b, where the traditional VPT has been transformed into a game. In this game version of the VPT called *Shots* (van Schie & Boendermaker, 2014), participants watch two spinning wheels (visually like a slot machine, but without a gambling element), and when they stop an arrow appears, to which they have to respond, as in the original VPT. Doing well provides the participant with extra coins and the possibility to level up the machine. Another recent example comes from Dennis and O'Toole (2014), who developed a mobile app where participants watch two cartoon characters with different facial expressions (angry versus neutral), which after 500 ms simultaneously disappear into a field of grass. Only one of the faces leaves a trail, to which the participant should respond. Correct responses are rewarded with different jewels, based on speed. Both examples consist of a richer context for the points earned, very close to the actual task. Although there is no elaborate story line or character development (like in Dovis et al., 2012), performing a trial is more fun. An important aspect of this 'intrinsic integration technique' is that, in order to make the training more fun, changes are often made to some of the original features and task parameters. As these features may actually be essential to the workings of the training, removing them may very well render the training less effective. Hence, the adapted cognitive training should always be re-validated.

2.3. Step 3 — Intrinsic integration leaving the evidence-based training paradigm intact

To take the intrinsic integration technique a step further, instead of starting with an evidence-based task, such as the VPT, one may also start with the more fundamental principles of the theory behind the paradigm. For example, Notebaert, Clarke, Grafton, and MacLeod (2015) used the popular card game 'snap' as a basis for their person-identity-matching (PIM) task. The task features virtual cards with happy and angry faces and requires participants to make matching judgements, based on the identities of the faces. While only loosely based on the attention paradigm, the task was demonstrated to effectively modify attention bias away from threat. In a similar project, T. Pronk (personal communication, July 11, 2014) developed a game called *BombDodger* (Fig. 1c), which has the participant selectively attend to and approach certain neutral stimuli, while disengaging from and avoiding others (in this case, cigarettes). While this theory driven game was praised for being fun to play, there is some discussion about which bias is affected, as both approach tendencies and attention processes are targeted. As a training game, it could thus very well be effective, but as a research tool, it would be hard to disentangle which bias modification led to the effect. Adjusting the game to target one bias at a time could help make the CBM game more specific.

2.4. Step 4 — Adding a game-shell around the original evidence-based training task

Instead of adding game-elements to the task, a full game may be added to the task. This involves taking the original training paradigm and leaving it structurally intact, while incorporating it into the look and feel of a surrounding *game-shell*. In these game-shell types of serious games, participants usually receive points for doing well on the original, unadjusted training tasks, which they may then spend during their actual play time within the shell-game surrounding the training, switching back and forth between training and playing. A key aspect of shell-games is that there are game aspects, such as a virtual world, that go beyond, and are unrelated to the training task. For example, by collecting points for doing well on the task, the player is allowed to progress in a story-based game world. Advantages of this design are that it allows the original, evidence-based training paradigm to remain intact and that it enables multiple training paradigms (e.g., both CBM and EF training paradigms) to be used within one game environment.

The *CityBuilder Game* (Fig. 1d; Boendermaker, Prins, & Wiers, 2013) is an example of this shell-game technique, embedding CBM techniques into an engaging game world. This online shell-game features a virtual world where participants can use points earned through training to build a virtual city of houses, trees, roads, etc. The game also includes a social element by allowing the participant to view the cities of other participants, which they can rate with a "thumbs up". The incorporated training tasks can be switched on and off, or set to run as a placebo version. A typical training session takes approximately 30 min and consists of a training block, using one of the original tasks like the VPT, with only a point system and a progress bar added, and a subsequent period of game time. During the game breaks, participants are also allowed to do bonus training trials to collect more points. Each correct trial earns the participant points, with bonus points for speed. Initial results indicate that participants enjoy the training environment and are motivated to train more than using a regular training.

2.5. Step 5 — Combining intrinsic integration with a game-shell

While the shell-game technique works mostly as an extrinsic motivator, it would seem that a combination of intrinsic and extrinsic game elements could lead to optimal motivation. Although many serious games, including intrinsic integration versions, often do use some form of extrinsic motivators (e.g., a point system; cash or credits for participation), combining an intrinsic integration CBM game with a full shell-game has, to our knowledge, not been attempted before. Perhaps this is because integration of the core CBM elements with intrinsic motivators, as well as a motivating extrinsic reward system, which all match the feel of the game also make this option the hardest to realize. The cognitive control-training Braingame Brian (Prins et al., 2013) could arguably fit within this category, as the original training tasks on which the game-training is based remain intact, while they are also extensively integrated into the game-shell. Verbeken, Braet, Goossens, and van der Oord (2013) and van der Oord, Ponsioen, Geurts, Ten Brink, and Prins (2012) have used Braingame Brian and reported positive training effects in obese children and children with ADHD, respectively. These results in executive function trainings provide a good starting point for applying these techniques to CBM training principles.

2.6. Step 6 — CBM using OTS entertainment games

As a final step towards gamification, one may use an actual OTS entertainment game and just measure improvements on the selective attention of the players (e.g., Boot, Kramer, Simons, Fabiani, & Gratton, 2008; Green & Bavelier, 2003). While arguably the most fun for the participant, CBM often includes many disorder-specific stimuli, which may be difficult to incorporate into an existing commercial game. For example, the games used by Green and Bavelier (2003) were mainly action oriented shooters and race games. Adding a substantial number of alcohol pictures to these games, requiring quick and accurate responses, would seem practically impossible. Moreover, the fact that these games were not designed to incorporate the many stimuli used in CBM could render the game unplayable or much less motivating. As such, while it may not be impossible, most OTS entertainment games will be unsuited for CBM training.

Of course, combinations of the formats discussed above are possible, and it is hard to classify existing projects exactly into one of them. Nevertheless, taking the evidence-based VPT paradigm through several steps of gamification may give a good example of the practical possibilities. Given the notion that both ends of the spectrum may be seen as suboptimal for CBM in adolescents, being either too boring or insufficiently evidence based, the optimum may be found somewhere in the middle (e.g., steps 2 and 4, or their combination, step 5; see Fig. 2).

3. Recommendations

3.1. The G-word

Although game-elements may indeed enrich regular CBM training, the level of fun will probably never be comparable to an OTS entertainment game. This of course has to do with the serious nature of the games, for example the many repetitions needed for CBM, but also the often limited budgets for developing them. But the question is how much fun should serious games be expected to be? Indeed, Buday, Baranowski, and Thompson (2012) suggest that a direct comparison with entertainment games should perhaps be avoided. Given the fact that even expensive OTS entertainment games sometimes fail to interest players and are viewed as boring by the gaming community, what can realistically be expected of (relatively) low-budget games that also have to sacrifice fun for training purposes? As the word "game" undoubtedly creates certain expectations in youth, based on their previous gaming experience, perhaps the word should be used with caution when used to describe a serious game for health. Carefully using the word "game" may prevent users from having unrealistic expectations that can lead to disappointment and perhaps even *de*motivation, thus eventually to the opposite of what they should add to the training. It would be interesting to study specific participant expectations with regard to CBM, especially when it is accompanied by game-elements, and their possible effects on motivation and treatment outcome. A related problem that may occur when scientifically studying these training games is that after a game training, there usually are no game-elements during the post-measurement. This sudden lack of motivating elements might actually demotivate participants to do well, potentially even canceling out the possible training effect on the measure. Future research should study whether this is indeed the case, and whether including game-elements in measurement versions of cognitive tasks can solve this problem, without causing too much distraction to render the measurement unreliable.

3.2. Quantity and quality

Many cognitive training games aim to motivate participants to keep training as long as possible, as this may increase training efficacy. However, even the best OTS entertainment games eventually lose their appeal to most players. Therefore, an important aspect that should not be overlooked when evaluating a serious game training is whether the added game-elements are motivating enough to not only heighten initial motivation to train, but also to maintain that level of motivation throughout the multiple sessions of training. If the initial motivation is high, but it diminishes over sessions, it may actually start to work against the participant. Moreover, as participants may still have the expectation that doing the game training should be fun, when this is no longer the case, their motivation may even drop below the level of motivation that they would have had without game elements to begin with. As such, adding game elements may work better when training time is relatively short. Therefore, game elements should be carefully matched to the intended number of training sessions, as well as the average session duration. A related question is whether adding

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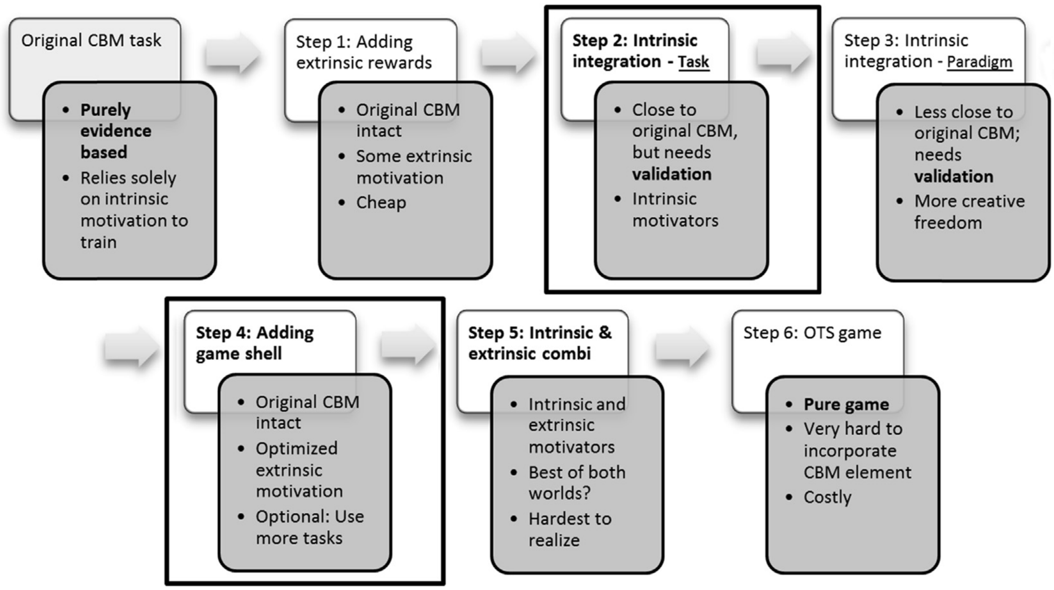

Fig. 2. Six gamification steps from evidence-based paradigm (CBM) to OTS game. For CBM, Steps 2 and 4, and perhaps their combination in Step 5, may be optimal for CBM gamification.

game-elements to CBM not only increases the quantity of trials that participants will be motivated to do, but also increases the quality of the performance, in terms of training effects on the underlying ability or bias. If this is the case, then perhaps fewer or shorter sessions are possible. To our knowledge, these issues have never been studied directly.

3.3. Critical notes

While the field of CBM games is still largely uncovered, evidence from similar fields shows promise. However, some critical notes also apply. First, preliminary data from Katz, Jaeggi, Buschkuehl, Stegman, and Shah (2014) seem to suggest that some motivating elements, such as real-time scoring during play, may in fact distract from the training, and can actually lead to reduced task performance. It would therefore be wise to measure the degree to which motivating game-elements add to the cognitive load during task performance, which elements actually add to the training effect, and which are better left unused in the context of CBM games. To our knowledge, this has not been done systematically. Second, intrinsic motivators in games are often reported to be better than extrinsic motivators, and some data indeed seem to suggest this is the case (Habgood & Ainsworth, 2011). However, they are often harder to achieve than extrinsic motivators, in terms of both costs and design. The question therefore remains whether a set of extrinsic motivators might be good enough for CBM training purposes. Or perhaps a combination of both works best. As Deci and Ryan (1985) stated, the level of the perceived extrinsic versus intrinsic nature of a motivator may depend on a person's internal perceived locus of causality. An interesting hypothesis that could be tested is whether the efficacy of the extrinsic motivators in a game training in fact depends on the efficacy of its intrinsic motivators. So perhaps only if a game is intrinsically motivating to someone and immersion is relatively high, extrinsic motivators such as points are relatively more effective. More systematic research is needed to disentangle these two types of motivators before any definitive conclusions can be drawn as to which is more effective for CBM training. Third, we should perhaps more clearly differentiate between the two aforementioned types of motivation involved in CBM. Besides having a motivation to change one's behavior (e.g., maladaptive substance use), there is a related, but separate, motivation to complete a potentially tedious multi-session training in order to do so (Boffo, Pronk, Wiers, & Mannarini, 2015). While it remains unclear whether one needs both in order for CBM to be effective, participants may still need at least some degree of an intrinsic motivation to change their behavior in order for CBM to have any effect (Wiers et al., 2013; Wiers, Houben, et al., 2015). As it seems reasonable to assume that the use of game elements mainly affects *motivation to train*, the awareness of the problem itself may be targeted separately, in order to improve *motivation to change*. This means that, while using the term “game” with caution to prevent disappointment, trainings should also not hide the fact that they actually do have a serious purpose: helping to gain more control over one's substance use. Future research should take these considerations into account, especially when developing CBM games for prevention in younger adolescents. Specifically, the relationship between motivation to train and motivation to change could be further studied to see if and how one affects the other. For example, a very motivating CBM gamification could still fail to increase motivation to change, or it could even have a negative influence (cf. Deci et al., 1999). Finally, when introducing game-elements into CBM interventions, the core CBM mechanisms may become altered to some degree. Given the strong link between CBM-A efficacy and desired clinical outcome reported by Clarke et al. (2014), it is essential to validate these new gamified tasks and see how well they affect the targeted cognitive bias compared to the original CBM task.

4. Conclusions

To our knowledge this is the first review that considers the use of serious gaming techniques as a possible tool to motivate at-risk adolescents to use CBM. With this review we have attempted to give an overview of techniques that can be used to apply game-elements to motivate adolescents to follow through with their CBM training. Although many projects are currently in progress, our main conclusion has to be that at this point there is not yet enough evidence to draw any firm conclusions as to its efficacy. However,

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results from similar fields such as executive function training do show promise. Serious games may therefore be a promising new way to reach at risk youth (through prevention as well as intervention). While several interesting questions remain unanswered at this point, we feel confident that future studies will be able to address them in the coming years.

Declaration of interest

Dr. Prins is a member of the Foundation Gaming & Training, a non-profit organization that develops and implements on-line interventions for children and adolescents.

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