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Emotional self-regulation, virtual reality and neurofeedback

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ABSTRACT

The most common mental problems are anxiety disorders, affecting today about 264 million people in the world. The reference treatments present limitations, such as their side effects and long intervention periods. Recently, various approaches have emerged, such as neurofeedback, virtual reality and serious games.

Objective: This study serves to determine preconditions and requirements for a game development, reusing virtual reality and neurofeedback to enhance the emotional self-regulation competences in individuals with anxiety disorders.

Methods: a scoping review was performed to identify the serious games' characteristics, resourcing to neurofeedback existent in this scope; and a focus group to ascertain the specialists' more relevant perspectives about preconditions and requirements integrating a game with these characteristics and objectives.

Results/conclusion: the scoping review results illustrate that the combined use of serious games, neurofeedback and virtual reality is still a very residual approach and without consolidated evidence, justifying the importance of further research. The specialists who formed the focus group emphasized, among others, the importance of gradual stimulation, co-creation and personalization of the developing resources.

1. Introduction

Psychiatric disorders and problems related to mental health are increasing in the world and, given their prevalence, they represent a big strain on individuals, society and the economy (Kessler et al., 2009; The Joint Action for Ment, 2016). Currently, anxiety disorders are the most common type of mental disorders, along with depression (Bystritsky et al., 2013; Lahousen & Kapfhammer, 2018; World Health Organization, 2017) affecting nearly 264 million people globally (World Health Organization, 2017). It is estimated that up to 33,7% of the world's population is affected by an anxiety disorder at some point in life (Bandelow & Michaelis, 2015).

According to the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) (American Psychiatric Asso, 2013), anxiety disorders are characterized by persistent and excessive anxiety and concerns that are disproportionate to real danger. These can have numerous designations, encompassing various diagnostic categories and, although they can be comorbid between them, they are distinguished mostly by the feared and avoided situations and/or by the content of thoughts and beliefs.

Several studies point to an association between emotion regulation and anxiety, emphasizing the anxiety disorders mostly as "emotional disorders" (Amstadter, 2008; Barlow, 1991; Yen et al., 2017). However, the mechanism responsible for this association remains uncertain (Cisler & Olatunji, 2012). Emotion regulation consists of the use of conscious and unconscious strategies, used to increase, maintain or diminish the several components of emotional response (feelings, behaviours, cognitions and physiological responses) (Gross, 2001). According to the process model developed by Gross (Gross, 1998), there are different emotion regulation strategies temporally distinct at an emotional process level: emotion regulation strategies that precede emotion and strategies that occur after emotional activation. Within these strategies, two are commonly highlighted: cognitive reappraisal and emotional suppression. Cognitive reappraisal is an emotion regulation strategy that precedes the activating stimulus, which involves the modification of the meaning associated with the situation, impacting the experienced emotion by the individual. According to some studies, this leads to a decrease in the experience and a negative emotional expression (Gross, 1998; Gross & John, 2003). Emotional suppression is centred in the response, with the objective of modification of the behavioural component, but it is not capable of reducing the negative emotional experience from being experienced (Gross, 1998; Gross & John, 2003; Machado Vaz & Martins, 2009). This way, this strategy is considered maladaptive, with negative

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social, affective and cognitive consequences (Gross & John, 2003; Machado Vaz & Martins, 2009).

The use of adaptative emotion regulation strategies, such as cognitive reappraisal, is associated with a reduction of stress-induced emotions (Yen et al., 2017). On the other hand, emotional regulation dysfunctional strategies, like emotional suppression, seem to influence the pathogenesis of anxiety and depression (Cisler & Olatunji, 2012; Yen et al., 2017). Individuals differ in the way they accept their emotions (Gross and John, 1995, 1998), which relates with the psychopathology in two ways: first, the perception of certain emotions as aversive, associated with behaviours related to certain disorders; second, the appraisal of emotions, related to subsequent attempts of regulation (Amstadter, 2008; Gross & John, 2003). When an emotion is considered aversive, it is normal to have an attempt at regulation. However, when maladaptative emotion regulation strategies are used, the results are not always effective, which may produce undesirable effects. In individuals who suffer from anxiety disorders, certain emotional states may be considered more aversive than what is expected from most of the population. This leads to the unacceptance of emotion and production of negative appraisals, which leads to the use of emotion regulation strategies to avoid its emergence, or to repress when it has already been generated (Amstadter, 2008). So, these individuals make inadequate judgments of their internal states (emotions, thoughts), which promotes disproportional attempts of regulation, since emotion regulation can enhance the contribution of emotional reactivity for the anxiety disorders' symptoms (Amstadter, 2008; Cisler & Olatunji, 2012).

There is still an increasing array of evidence that supports the conceptualization of emotion regulation as a transdiagnostic construct or an underlying mechanism of the psychopathology of these disorders (Norton & Paulus, 2016; Sloan et al., 2017). The results of a systematic revision demonstrate that the interventions, aiming specifically for emotion regulation, may not only promote a positive emotion regulation but also mitigate the psychopathological symptoms associated (Sloan et al., 2017). Moreover, in other studies, emotion regulation therapy has been reported as an effective treatment for emotional dysfunctions, such as anxiety (Mennin et al., 2015; Yen et al., 2017).

The major prevalence of anxiety disorders and their limited functional nature justifies the need for early intervention, so the training of emotion regulation competencies should be included. According to the literature, the treatment for these disorders is not only based on pharmacological interventions but also non-pharmacological (Antai-Otong, 2016; Bandelow et al., 2015; Love & Love, 2019). According to the National Institute for Health and Care Excellence (NICE) guidelines (National Institute for He, 2013; National Institute for He, 2014; National Institute for He, 2019), the non-pharmacological intervention includes Cognitive Behavioural Therapy (CBT), which has stronger evidence (Strohle et al., 2018), applied relaxation, psychodynamic psychotherapy, psychoeducational and self-help groups. These interventions are recommended as first-line treatments, preferably to the pharmacological treatments (National Institute for He, 2014), because these last ones present limited efficacy (Amorim et al., 2018; Shafiee et al., 2018), due to side effects associated (pharmacotherapy) and long periods of duration (Baldwin et al., 2014; Bandelow et al., 2012; National Institute for He, 2013; National Institute for He, 2019), translating to high costs for the health systems and the patients (Marciniak et al., 2005; Stuhldreher et al., 2014). So, it is necessary to explore new techniques of the therapeutical approach, which provide more effective treatments.

Currently, some approaches to treat anxiety have emerged, such as neurofeedback (Blaskovits et al., 2017; Kaur et al., 2019; Micoulaud-Franchi et al., 2015). This constitutes a non-invasive approach (Reiter et al., 2016), based on the brain-computer interaction, allowing individuals to voluntarily train and learn to optimize their brain activity and to modify functional biomarkers related to a mental disorder (Batail et al., 2019). The repetition of neurofeedback sessions enables the creation or reinforcement of connections and brain pathways, due to the brain's neuroplasticity. Consequently, these alterations in the brain can lead to positive changes in the individual's behaviour and feelings (Canadian Agency for Drugs, 2014; Niv, 2013; Sitaram et al., 2017; White et al., 2017). Neurofeedback has been used as a complementary and alternative treatment to several mental disorders and has been showing potential for the treatment of anxiety (Gomes et al., 2016; Marzbani et al., 2016; Omejc et al., 2019), revealing improvements in individuals with this pathology (Banerjee & Argaez, 2017; Mennella et al., 2017; Moradi et al., 2011; Simkin et al., 2014). However, despite the positive results and the lack of side effects, this approach can be less intuitive, and its common visual applications are simple (e.g.: moving bidimensional bars), which is demotivating and less challenging. So, to make the neurofeedback training more appealing, several studies have evaluated the possibility of combining neurofeedback with video games (Connolly et al., 2014, p. 496; Wang et al., 2018).

Serious games are video games that are not used exclusively for entertainment and have been showing great potential in changing the player's thoughts and behaviours (Fitzgerald & Ratcliffe, 2019; Granic et al., 2014; Lau et al., 2017). Besides, these games are being used more in anxiety-related treatments, proving to be a success (Barnes & Prescott, 2018; Scholten et al., 2016). In particular, biofeedback games that measure the physiology of the players, and adapt the game (e.g.: difficulty, the mechanics of the game) incentivizes them to keep a desirable physiology state (Wang et al., 2018). Thus, given the defying nature of these games, they can be an advantage for neurofeedback training, monitoring the behaviour of the patients, leading them to reach small goals, aiming for the acquisition of self-regulation competencies, as well as using learned behaviours in their daily lives (Schuurmans et al., 2018).

Along with these approaches appears virtual reality (VR), which has been more prominent in last years, revealing itself as a powerful tool in the development of realistic and immersive virtual environments, that evoke emotions, allowing to explore and train the emotion regulation competences (Colombo et al., 2019; Hadley et al., 2019). Its applicability has been prominent in the treatment of anxiety (Anderson et al., 2013; Carl et al., 2019; Oing & Prescott, 2018; Tarrant et al., 2018), and its integration with biofeedback constitutes a very promising line of research (Colombo et al., 2019), since associating VR with neurofeedback games can improve current techniques. However, the development of these games is expensive (Wang et al., 2018) and involves a big array of theoretical-practical knowledge, which is perhaps why this is a less explored area, thus the low quantity of published articles about this.

Finally, considering the percentage of individuals who suffer from anxiety disorders, there is an urgent need to create more effective and attractive interventions, such as games that use neurofeedback and VR. Therefore, the existence of a set of guidelines that help with the process of game elaboration is fundamental. So, this study aims to determine the best preconditions and requirements for the development of a game, using VR and neurofeedback, intended to improve emotional self-regulation competencies.

2. The research

To answer the defined objective, two studies were performed. Study 1 aimed to analyse and map out the characteristics of serious games available that use neurofeedback and could be used in anxiety disorders treatment. Study 2 was developed to ascertain the specialists' perspective about the most relevant preconditions and requirements integrating a game using VR and neurofeedback, destined to train emotional self-regulation competencies, in individuals with anxiety disorders.

2.1. Study 1: literature revision (scoping review)

2.1.1. Method

2.1.1.1. Study design. A scoping review, oriented by the methodology proposed by the *Joanna Briggs Institute for Scoping Reviews* (Peters et al.,

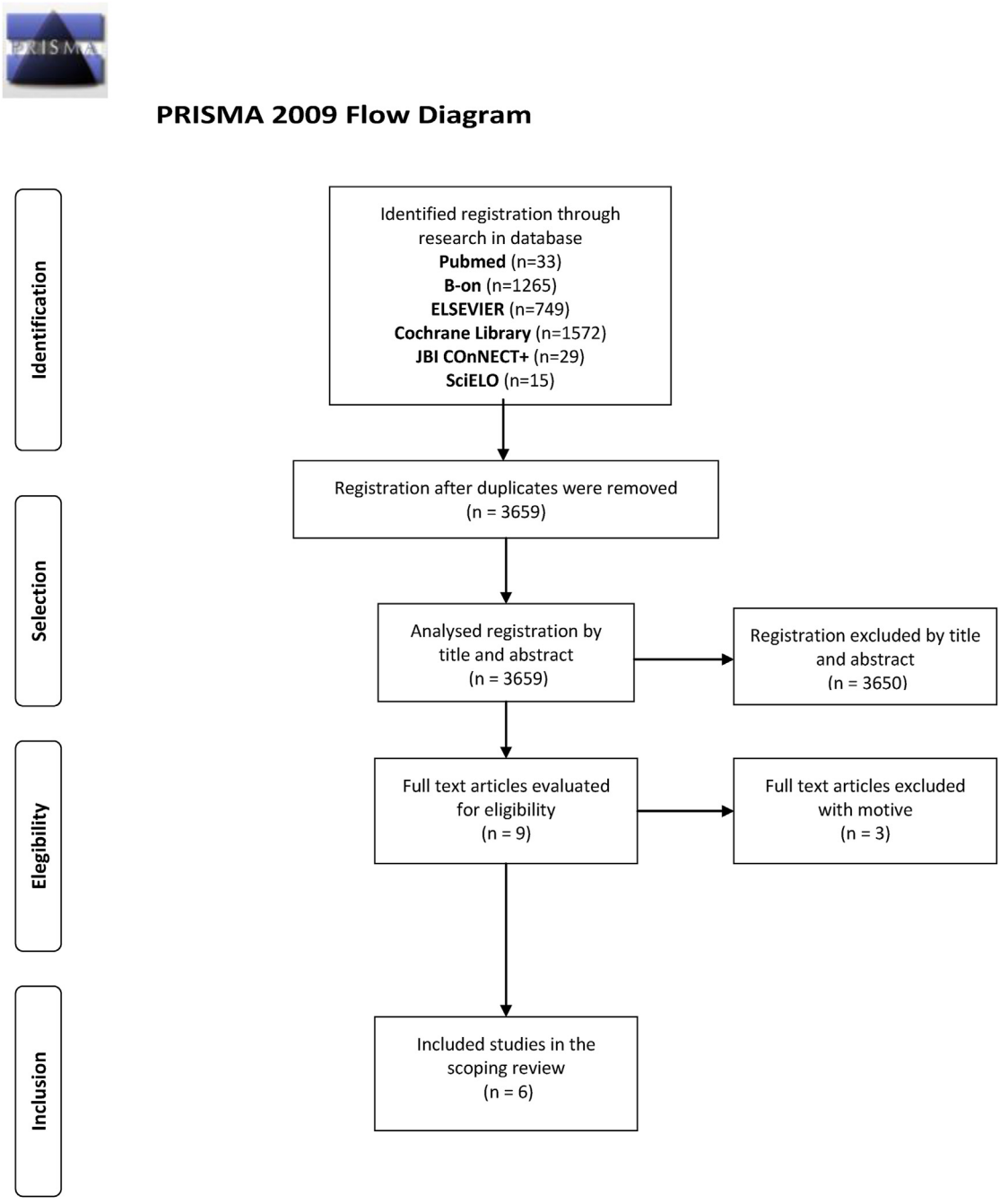

Fig. 1. PRISMA 2009 flow diagram.

2015, 2017), was conducted to answer the following questions: Which are the serious games already developed, that incorporate the neurofeedback practice, and can be used in the treatment of anxiety/stress disorders?; What are the main characteristics of the performed intervention with these games?; What are the results obtained in each intervention?

2.1.1.2. Inclusion and exclusion criteria. Based on the PCC strategy (Peters et al., 2017) (Participants, Concept and Context) all type of studies that: a) participants were individuals with some anxiety/stress disorder or healthy individuals; b) were centred on the development/implementation of a serious game with neurofeedback associated, that could be used in the treatment of anxiety/stress disorders; c) approached any type of context (all the clinical and geographic configurations, since for this aspect no restrictions were defined), were included in this scoping review. Studies in which participants had an anxiety disorder in comorbidity with other clinical situations were excluded from this scoping review.

2.1.1.3. Search procedure. During December 2019, searches were performed in the following electronic databases: B-on, PubMed, ELSEVIER, Cochrane Library, JBI COnNECT+, and SciELO. The key search terms were: (((neurofeedback) AND ((video games) OR (computer games) OR (serious games) OR (neurofeedback games))). The use of advanced search strategies allowed a restriction on the years of publication for the 2010–2020-time interval and language restriction to English, Spanish, French and Portuguese. The reference lists of retrieved articles were also searched to find other relevant studies.

The inclusion of the articles for the revision and data analysis was carried out by two independent reviewers. The disagreements between

Table 1
Answers to the revision questions presented by the study.

Authors	Game's name	Game's objective	Game's mechanism	Sample	Intervention protocol	Results
Coenen, Scheepers et al. , 2019 (Coenen et al., 2020)	"Daydream"	Increase player's relaxation or concentration, producing more brain activity α or β.	According to the player's state of mind, a change of the landscape presented on the screen occurs, which serves as feedback for the player to help obtain the desired mental state. If the player's desired mental state reverts, he will come to a lower level, with the previous landscape appearing again.	14 healthy male individuals, with ages between 20 and 44 years old.	5 assessments for 2 weeks (each assessment consisted in playing the 2 conditions of the relaxation/ concentration game for 20 min, 10 min per condition.)	There was no increase in the relaxation or concentration of the players.
Kovacevic, Ritter et al. , 2015 (Kovacevic et al., 2015)	"My virtual dream"	Explore the participant's ability to learn fast how to control their brain states[a] (brain activity α or β) in a complex environment.	The player receives positive visual feedback (more particles, more shine) every time the counter exceeds a positive limit. In case the opposite happens, the player receives negative visual feedback (less particles, less shine).	523 participants, 314 female and 209 males, with ages between 18 and 89 years old.	29 sessions for one night (12 h), being the total duration of the game was 6,5 min.	Subtle brain activity modifications, approximately 1 min after the beginning of the game; 3/5 of the participants showed pronounced neurofeedback beta learning through concentration blocks[b], and the others showed the opposite effect.
Murdoch(2019)	"Kevin's nightmare"	Help the players to develop or to improve their meditation skills.	If the player manages to relax, he will receive positive feedback (the traps will become easier to avoid and locked doors will open), delaying the nightmare duration.	The game was not validated.	The game was not validated.	The game was not validated.
Schone-veld, Malmberg et al. 2016 (Schoneveld et al., 2016)	"MindLight"	To give children a new resource to train, in a fun way, reducing anxiety clinical techniques.	The more relaxed the players are, the shinier the light in Arty's helmet will be, the only source of light in the house. Threats also become less scary. In contrast, when players get anxious, the light dims and threats become less visible, and thus scarier.	136 children with elevated anxiety symptoms, with ages between 8 and 13 years old.	5 sessions of 1 h, 2 times a week (the control group had access to a different game). 3 assessments were made: before the intervention, after the intervention and a follow up after 3 months.	Child- and parent-reported significative global reduction of anxiety, however the magnitude of improvements did not differ between conditions, as expected.
Lim, Sourina et al. , 2015 (Lim et al., 2015)	"Multitask in Neurofeedback Driving" (MIND)	Multi-tasking training and capability testing (including multi-tasking with neurofeedback condition - training protocols as EEG alpha, potency relation teta/ beta).	When the player is comfortable with the tasks and reaches the desired mental state, the game increases the car's speed to give a challenge to the player. If the desired mental state is not reached, the game reduces the car's speed to make the game less demanding.	The game was not validated, but the authors suggest a sample of 5 groups of participants.	The game was not validated, but the authors suggest an intervention of 1 month (2 sessions of 1 h per week).	The game was not validated.
Verkijika and Wet. (2014)	"Math-Mind game"	Anxiety reduction connected to mathematics.	The game gives visual feedback to the player when anxiety levels increase, in the attempt of trying to help control them. At the same time, advice on how to control math anxiety for the next task is given.	36 children with ages between 10 and 16 years old, allocated in 2 different groups (high anxiety group/ low anxiety group).	2 sessions per participant (in 2 separate days). During each session, the participants each played 2 levels of the game 2 times.	The analysis recovered showed that math anxiety can be trained and reduced with the use of the presented game.

Note: α – alpha; β – beta.
[a] Explore the players' ability to relax (increased alpha brain activity) or increase their concentration (increased beta brain activity) according to the objective of the game.
[b] 3/5 of the participants were able to learn to increase their concentration (increased beta brain activity).

the reviewers were resolved by a third author.

2.1.1.4. Results. 3.663 papers were identified by the search terms used in the main literature search. Of these, 4 articles were excluded because they were duplicates, and 3.650 did not comply with the defined inclusion criteria. Of the following 9 articles, after reading the full text, 3 were also excluded for not complying with the inclusion criteria, determining the inclusion of the following 6 articles in this scoping review. The study flow diagram is presented in Fig. 1.

According to the detailed analysis made to the included studies, it is possible to respond to the questions raised by the revision. We identified 6 serious games already developed that incorporate the neurofeedback practice, and may be used in the treatment of anxiety disorders: "Daydream" (Coenen et al., 2020); "My virtual dream" (Kovacevic et al., 2015); "Kevin's nightmare" (Murdoch, 2019); "Mindlight" (Schoneveld et al., 2016); "MIND" (Lim et al., 2015); and "Math-Mind game" (Verkijika & Wet, 2014).

Generally, all of them present appealing game designs, involving game narratives, several tasks and challenges, which sometimes are organized by levels. The 6 games incorporate neurofeedback practices, such as EEG data that reach the game's mechanism and influence the course of the game. In all 6 games, the player receives positive visual feedback (e.g. traps easier to get through), every time the desired brain state is achieved. However, if the opposite happens, the player receives negative visual feedback (e.g. new obstacles appear). These games require EEG headsets. In every game, the use of this equipment is referred to, varying only the brand: "Neurosky"; "Emotiv EPOC"; "Muse".

Intervention protocols among games differ greatly, since the number of sessions varies from 1 to 5, and only the game "Mindlight" (Schoneveld et al., 2016) alludes to the performance of a follow-up after 3 months.

In general, positive results were achieved in each intervention. However, the game "Daydream" (Coenen et al., 2020) was the only one that did not register favourable effects, since both brain activity alpha (α) and brain activity beta (β) were not improved, in other words, there was no increase in the relaxation or concentration of the players. Two of the games were not validated ("Kevin's nightmare" (Murdoch, 2019) and "MIND" (Lim et al., 2015)), and consequently it is not possible to analyse if the intended results were achieved. All of the remaining games were validated and tested on healthy individuals or with anxiety disorders. In the table that follows (Table 1), the main characteristics of the 6 studies included, as well as the answers to the questions raised by the revision presented by the study, can be observed.

2.1.2. Discussion of results

With this scoping review, we intended to analyse and map out the serious games' characteristics using neurofeedback in the treatment of anxiety disorders. We identified 6 serious games with these attributes: "Daydream" (Coenen et al., 2020); "My virtual dream" (Kovacevic et al., 2015); "Kevin's nightmare" (Murdoch, 2019); "Mindlight" (Schoneveld et al., 2016); "MIND" (Lim et al., 2015); and "Math-Mind game" (Verkijika & Wet, 2014). Of these 6 games, only Mindlight" (Schoneveld et al., 2016) and "Math-Mind game" (Verkijika & Wet, 2014) were specifically developed and tested for the treatment of anxiety disorders. The 2 games were tested on children, and both revealed effectiveness in anxiety reduction. This data meets what is approached in the literature about neurofeedback training (Gomes et al., 2016; Marzbani et al., 2016; Omejc et al., 2019), and its contribution to the treatment of anxiety disorders is corroborated. In the treatment of children with anxiety disorders, it is crucial to adjust the type of interventions according to their age, and we should seek more appealing therapies (Fovet et al., 2017), given the low acceptance of treatment in these age groups (Tozzi et al., 2018). The junction of neurofeedback training with serious games shows a big potential to revolutionize treatments in the mental health field, since it can contribute to an increase in patients' motivation, leading to more satisfactory results (Wang et al., 2018).

The other studies included in this revision have variants that can be used for the treatment of anxiety disorders, although they do not report developed games specifically for that end. In the case of "Daydream" (Coenen et al., 2020), one of its variants aimed to promote the participants' relaxation, which can be used in the treatment of anxiety disorders. The game "My virtual dream" (Kovacevic et al., 2015), aimed to explore the participants' ability to control their brain states, including relaxation, which can be used for anxiety reduction. The game "Kevin's nightmare" (Murdoch, 2019) aimed to help players to develop/improve their meditation abilities, and since this is one of the alternative treatments for anxiety (Saeed et al., 2010; Zeidan et al., 2014), it becomes viable for individuals who suffer from this pathology. Lastly, the game "MIND" (Lim et al., 2015) focused on the training and testing of multitasking ability. However, different training protocols could have been used, including the type used for anxiety such as alpha protocol (Marzbani et al., 2016), and that is why it was included in this revision.

Since it is not relevant for a scoping review, the methodologic quality of the studies included was not analysed, but some limitations should be mentioned. The lack of validation of some games ("Kevin's nightmare" (Murdoch, 2019) and "MIND" (Lim et al., 2015)), the small sample size ("Math-Mind game" (Verkijika & Wet, 2014) and "Daydream" (Coenen et al., 2020)), the lack of reference of which assessment instruments used ("My virtual dream" (Kovacevic et al., 2015)), and the lack of follow-ups ("Daydream" (Coenen et al., 2020), "My virtual dream" (Kovacevic et al., 2015), and "Math-Mind game" (Verkijika & Wet, 2014)) should be considered as limitations. It is also important to note that, in all games, the intervention protocols used included a reduced number of sessions, which may impact the consistency/reliability of results. In fact, according to the literature, the required number of sessions to obtain significant clinical results varies according to the treated condition and case. However, reports point to 10 to 80 sessions (Askovic et al., 2017; Cheon et al., 2016; Dias, 2010; Marzbani et al., 2016). So, games should be tested again, performing a larger number of sessions to guarantee reliability.

The games "Kevin's nightmare" (Murdoch, 2019) and "MIND" (Lim et al., 2015) were not validated, so we cannot conclude their efficacy. The rest were tested and presented positive results, except for "Daydream" (Coenen et al., 2020). However, these results should be interpreted carefully since they are not fully reliable and significant. The conclusions cannot be considered valid evidence for supporting or rebutting the games' efficacy. Thus, the unfavourable results, such as in "Daydream" (Coenen et al., 2020), cannot be interpreted as an indicator for the low efficacy of the game. The same happens with positive results, which also should not be considered as representative of high efficacy. This data reinforces the importance of validating developed games and testing stringently its efficacy, especially before implementing them in clinical or therapeutical programs (Coenen et al., 2020). According to Kato (Kato, 2012), to assess if a serious game reaches the intended results, it is necessary to perform a high-quality assessment, so she elaborated a set of guidelines. These suggest the execution of randomized controlled trials that include an adequate number of participants, as well as control groups; the use of objective and standardized assessment instruments, along with self-report measures; and the monitoring and description of potential negative side effects. The publication of every result obtained is advised, even when the effects are non-existent or negative. Otherwise, the developed meta-analysis on this theme will have the tendency to show only the positive results. Actually, there is a discrepancy between the quick changes in the technological world and in the time necessary to develop and assess this type of games, which leads often to the public release without the execution of formal empirical tests (Shah et al., 2018).

Even though the results of "Daydream" (Coenen et al., 2019) do not possess enough credibility to prove its efficacy is reduced, it is important to highlight that this game, when compared to the rest, reveals an unappealing design, with a lack of challenges, avatars and engaging narrative. This may have made it monotonous for players, demotivating and pushing them away from the desired objectives. So, it is

recommended to test the efficacy of this game again, considering the above-mentioned guidelines, as well as the referred unfavourable aspects, since they may have an impact. In fact, according to literature, the gameplay of a serious game should be motivating and engaging. The game should present a large basis of new stimuli and situations, to captivate and maintain the player focused in the end objective (Carlier et al., 2020; Shah et al., 2018). Besides, the use of avatars can be a useful technique to promote personal domain, since the players usually identify with them, especially when these are self-representative or have a similar appearance. So, players tend to modify their behaviour, when confronted with situations in which their actions affect the avatar (Thompson, 2012). Considering this information, we concluded that, for the development of digital interventions in mental health, including serious games, it is necessary to consider several aspects, since existing guidelines are available (Shah et al., 2018).

Regarding "Mindlight" (Schoneveld et al., 2016), we can conclude the results were surprising since although good results on anxiety reduction emerged, there was no significant difference between the reduction caused by the game in the control group and the game "Mindlight" (Schoneveld et al., 2016). This result may have different explanations. The possibility of the neurofeedback game containing constant challenges to face fear, instead of having some entertaining free time, may have affected the flow state (where the individuals feel immersed in an activity), which may have affected the results. Another possibility of failure is the protocol choice and the electrode localization, which may not be ideal to treat anxiety.

Regardless of all the possible mentioned loopholes, and all the aspects that may need to be improved, serious games may be a great way to engage people in the treatment of anxiety disorders. It is fundamental to invest in this area, to improve the 6 already existing games and develop new ones, albeit the development of these games is quite expensive (Wang et al., 2018), complex, time-consuming, leading up to 3 years (Baranowski et al., 2016; Shah et al., 2018) and it requires specific equipment. Besides, the game designers need to fully comprehend the pathology to which the game is destined, as well as the theoretical foundations of the intervention (Bowers et al., 2011). Despite the already existing guidelines for the development of digital interventions, this revision allowed us to understand that these are not directed specifically for the development of serious games resourcing to VR and neurofeedback. So, the existence of a set of preconditions and requirements would be helpful, since that may help facilitate the developing process of these games, which motived us to carry out the study in that direction.

2.2. Study 2: specialists' perspective on the development of a serious game using VR and Neurofeedback

2.2.1. Method

2.2.1.1. Study design. An exploratory study was developed to describe the best requirements for the development of a serious game resourcing to VR and neurofeedback, aiming for the improvement of emotional self-regulation competencies, taking into account the specialists' perspective. This type of study was selected, since it allows to further study the meaning of the phenomenon, in the subjective perspective of who experiences it, in a specific context (Green & Thorogood, 2018; Ritchie et al., 2013).

2.2.1.2. Group of study. For the performance of the focus group, we defined the inclusion criteria as: to be professionals from different areas involved with the study theme, and present at least 1 year of professional experience. To fulfil the already established criteria, we resorted to an intentional sample from the professionals. The focus group was formed by eight professionals (one occupational therapist, one psychologist, one neurophysiologist, two neuropsychologists researchers, two computer sciences professors, and one mental health professor/researcher), 4

Table 2
Preconditions and requirements for the development of a serious game using VR and biofeedback (NF), in cases of anxiety disorders.

Requirements	Verbatim Examples
1 - Conducting an initial assessment: carry out an initial assessment of the individual, before exposing him to the game situation, to ensure that he meets the necessary conditions for safe participation. This assessment should include self-report measures as well as the measurement of physiological signals (Maples-Keller et al., 2017; Scholten et al., 2016; Tarrant et al., 2018).	P1: *"(…) a more rigorous previous assessment of the person to understand the level she is, comparing to those stimuli that we are going to expose her to and may generate a fear or an anxiety catalyst response."* P8: "*In my perspective, I think it would make more sense if we set self-report measures before exposing the person (…)"/"(…) probably self-report scales that measure anxiety, and if reached a determined threshold, it could be motive for exclusion (…)".*
2 - Desensitization phase to VR environments: some VR users may have side effects both during and after the experience (sight problems, disorientation, balance disorders and nausea) (Dores et al., 2012), so there should be a prior exposure of the person to a neutral, non-anxiogenic environment so that there is habituation to VR environments. A prior and detailed presentation of the equipment and how the whole experience will take place must also be carried out.	P4: *"(…) the confrontation between the person and the scenario may go badly."/ "Because side effects may emerge during or after (…)".* P8: *"(…) to have a training and desensitization phase for the person in VR context before beginning the scenario."/"(…) prepping the environment without the stressor."/"It is an environment of getting used to the equipment."*
3 - Gradual stimulation and dynamic difficulty adjustment (DDA): physiological signals must be measured during the experiment, which allows the difficulty of the game to be adjusted automatically according to the performance of the individual, and also allows the anxiogenic stimuli to be introduced gradually, respecting the systematic desensitization process[a] [1](Missura, 2015; Sutoyo et al., 2015).	P4: *"(…)if it is automatized, I think it is easier to use a heart rate sensor, a breathing belt, of course also with neuronal signalling (…)"/"obtain that determined neuronal or heart rate threshold, (…) and go to the next level (…)"/" (…) so if you find that rhythm, go to the next level, I think it is perfectly automatized."* P2: *(…) in other words, the system could constantly be updating with information from those physiological signs, updating the environment's level of difficulty."*
4 - Creating realistic virtual environments: we must create realistic virtual environments to enhance the training of emotional self-regulation skills, and to enhance the generalisation of learning for everyday life (Kothgassner et al., 2019; Salkovskis et al., 2007; Weerdmeester et al., 2020; Zeng et al., 2018).	P2: "*I think that the main advantage of using virtual reality, (…) is the immersive degree of the experience (…)".* P1: *"(…) a multisensory stimulation (…) is going to enhance once again the exposure conditions and enhance this dimension of self-regulation (…)/"(…) very close exposure to natural conditions (…) it presumably will facilitate the learning generalization and transfer them into their daily lives."*
5 - Co-creation and customization of resources: we should consider the opinion of patients, and specialists in the area of anxiety disorders, to develop virtual scenarios suitable for each type of case, which is extremely relevant given the heterogeneity of anxiety disorders.	P4: *"(…) to do a focus group with patients with social anxiety before and understanding what are their fears, and then design personalized scenarios (…);* P2: *"(…) the methodology of the focus group would be interesting (…) or at least, an individually semi-structured interview methodology, or with three or four people with phobia (…) could bring important input for the environment's design."*
6 - Definition of the ideal duration of the game: these games should be short (in these games it is normal for people to feel tired after a short amount of time and consequently some adverse effects from VR may emerge), but since these incorporate biofeedback training (neurofeedback) they should be repeated/played throughout several sessions so significative clinical results are achieved, since literature points to 10 to 80 sessions (Askovic et al., 2017; Cheon et al., 2016; Dias, 2010;	P6: *"(…) that is why the duration time of these games is reduced, it should be even shorter. If the person is getting tired, they will end up not seeing results, they will be more exhausted than anything else."* P8: *"(…) it is necessary to verify the effect* 3 months *later, or the effect* 6 months *later."*; P4: "*I do not guarantee that things have maintained a month after, so a follow up is necessary."*

(*continued on next page*)

Table 2 (*continued*)

Requirements	Verbatim Examples
Marzbani et al., 2016). Besides, participants alerted of the necessity of performing a follow-up, to verify if the effect is maintained after the end of the sessions.	
7 - Need to ensure the possibility of game interruption at any moment: in a game like this, the chance of interruption, at any moment, needs to be assured. In other words, there has to exist a specific way that allows the player to communicate their intentions of suspending the game (e.g.: alarm button), in case they feel bad or experience some VR side effect (Kim & Kim, 2020).	P5: "*But there needs to be an alarm button, right?! If the person doesn't feel well, right?!*"/ "*I think so, there needs to exist an SOS (…)*" P4: *"(…) it is like in CAT scans, there is a button to get out, you could, for example, raise your hand, yes there needs to be an exit.*"

[a] To fight the symptoms related to anxiety disorders, one of the more effective treatment methods has been exposure therapy, which results from the practice of CBT. In exposure therapy, patients go through a process of systematic desensitization, where a series of systematic steps are applied to expose gradually the patient to an anxiety or fear-inducing stimulus, with the final objective of minimizing their intensive and aversive behaviour to the stimulus (Oing & Prescott, 2018).

females and 4 males, with ages between 21 and 60.

2.2.1.3. Data gathering method. The data gathering was performed through a focus group, which occurred on the online platform "using a script with semi-structured topics - D1 - Emotional Self-regulation Competences; D2 - Virtual Reality; D3 - Neurofeedback; and D4 – Serious games - developed based on the literature and main themes for which we intended to collect information. A test focus group was created, with participants who fulfilled the criteria of inclusion, to test the script's performance, and as well as to train the methodology.

Before the beginning of the focus group, which had an average duration of 100 min, the participants were reminded of the objective for the study performance and a verbal authorization was requested to audio record the discussion. Before the performance of the focus group (a week before), all of the participants signed the written informed consent and filled the form for sociodemographic data gathering, received, via e-mail.

2.2.1.4. Analytical process. In the analytical process, content analysis was used, which aims to analyse and interpret the collected data, classifying them into categories that aid in the speech's comprehension (Bardin, 2009; Bengtsson, 2016; Carlomagno & Rocha, 2016; Coutinho, 2014, p. 412). For this content analysis, the heuristic function was used, proposed by Bardin (2009), to increase the tendency for discovery.

In this study, the categories were outlined *a posteriori*, so the results emerged from the content analysis techniques (Bardin, 2009; Coutinho, 2014, p. 412). In the performed categorization, it was resorted to the triangulation of researchers, to ensure faithfulness in the results (Fortin, 1999). This was performed individually by two researchers, and when opinions diverged, a third researcher was consulted.

The described categories that are found in the results' section pertain to the studied theme and were created based on the approached topics in the course of the focus group. So, after the analysis of the transcribed interviews, two categories were established: Category 1: participants' general overview on anxiety disorders and emotional self-regulation competencies. This category was subdivided into two subcategories: subcategory 1.1.: anxiety disorders' characteristics considered by participants; and subcategory 1.2.: exploration of the relationship between anxiety disorders and emotional self-regulation competencies. Category 2 - necessary preconditions and requirements for the development/implementation of a serious game, using VR and biofeedback (neurofeedback), intended for anxiety disorders, and aiming for the improvement of emotional self-regulation competencies. This category was subdivided into 2 subcategories: subcategory 2.1.: VR and biofeedback integration in a serious game intended to the improvement of emotional self-regulation competencies in people with anxiety disorders; and subcategory 2.2.: participants' concerns and considerations/suggestions related to the applicability of a serious game, using VR and biofeedback (neurofeedback), in cases of anxiety disorders.

2.2.2. Results and discussion

After the interpretative task, it was possible to determine the preconditions and requirements most relevant for the development of a serious game with the characteristics mentioned. Thus, we present in the following table (Table 2) the preconditions and requirements that from the experts' point of view are crucial.

3. General conclusion

This study demonstrates that the use of serious games with virtual reality and neurofeedback, for the treatment of anxiety disorders although promising, is still quite incipient and emerging. Simultaneously, considering the methodological limitations identified in the studies included in this review, valid evidence of the effectiveness of this type of interventions is not yet possible to be assumed. Nevertheless, the literature review and the focus group discussion pointed out relevant requirements for the development of serious games with these characteristics and purpose, which may determine the success of this therapeutic approach.

Research ethics

Approved by School of Health Ethics Committee.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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