A Review of Gamified Cognitive Bias Modification Interventions for Psychiatric Disorders

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Abstract

Introduction

Automatic biases, such as that of attentional biases, avoidance and interpretative biases have been purported to be responsible for several psychiatric disorders. The advances in gamification has transformed the nature of conventional cognitive bias modification interventions. Gamification has been considered mainly to address one of the core challenges of conventional interventions, that of motivation to train; these tasks tend to be highly repetitive, with a need for multiple training sessions. Whilst a prior review has provided insights into potential gamification strategies that could be applied for bias interventions, there remains a lack of a systematic evaluation of the gamified cognitive bias modification interventions in the literature. This is needed to understand the overall effectiveness of a gamified approach for cognitive bias modification and to inform future research that seeks to integrate gamification technologies into existing conventional bias modification interventions.

Methods

To identify the relevant articles for the current review, the following search terminologies were used: ("cognitive bias" OR "attention bias" OR "interpret* bais" OR "approach bias" OR "avoidance bias") AND ("training" OR "modification" OR "practice" OR "therapy") AND ("gamification" OR "game elements" OR "game" OR "gaming" or "game mechanics"). PubMed, MEDLINE, PsycINFO, Scopus. Databases were searched systematically from 2000 onwards. Articles were included if they described a gamified cognitive bias modification task and included participants with underlying psychopathological symptoms. Data was systematically extracted from the identified articles and a qualitative synthesis was performed.

Results

Four studies evaluated a gamified cognitive bias modification intervention. Two studies included participants with anxiety symptoms, one with affective symptoms, and one with alcohol problems. Gamified interventions were based on the conventional visual probe task in three studies, and the attentional visual search task in the last study. The gaming elements incorporated into the task included that of animations, sounds, feedback, points scoring system for response time and difficulty. Out of the four identified studies, two studies have reported their gamified intervention to be effective.

Conclusions

Our review is the first to systematically synthesise the evidence for gamified cognitive bias modification intervention. There results arising from our current review should be considered in the future design and conceptualization of gamified cognitive bias modification interventions.
Introduction

Automatic biases have been posited to be involved in the psychopathologies of several psychiatric disorders, including anxiety and alcohol and tobacco disorders (1-5). Cognitive biases include attention, approach/avoidance and interpretative biases, and these biases can be retrained. Modification of these automatic biases could be achieved with tasks such as the visual-probe task (which involves the repeated pairing of probes with neutral stimulus) (6); the approach/avoidance task (which involves presenting the salient stimulus in a push-away format) (7); and lastly cognitive bias modification for interpretation (which involves training individuals to disambiguate ambiguous scenarios in a positive way) (8). Prior reviews have synthesised the evidence for cognitive bias modification (Cristea et al. (2016) (9) & Jones et al. (2017) (10)). In Cristea et al. (2016) (9)'s review, 25 trials involving participants with alcohol and tobacco disorder were identified, and they found bias modification to be effective for attentional and approach biases, with an effect size of 0.60 (Hedge G). Jones et al. (2017) reviewed meta-analyses and reported that cognitive bias modification was effective for anxiety disorders, with effect sizes ranging from 0.13 to 0.74 (10). They reported the effect sizes of cognitive bias modification for depressive disorders ranged between 0.35 to 0.85, and for appetitive disorders (defined to include eating disorders and addictive disorders) ranged from 0.003 to 0.36 (10).

Most conventional cognitive bias modification interventions have been delivered in the laboratory, but in recent years, with rapid advances in technologies, web technologies have been increasingly adopted. In Wiers W et al. (2015)'s study (11), they administered an attention control training and approach bias retraining intervention for 136 participants with problem drinking and reported a reduction in drinking across all the intervention groups. Similarly, William A et al. (2015) harnessed the potential of web-technologies for the delivery of an online cognitive bias modification training and reported it being effective in reducing depressive and distress symptoms (12). In addition to web-technologies, mobile technologies are also being used to transform the delivery of bias modification interventions. It has been reported that a mobile application could help in improving insomnia symptoms (13).

Just as technology has transformed the mechanism of delivery of cognitive bias modification intervention, advances in gamification has transformed the nature of conventional cognitive bias modification interventions. Gamification is defined as the use of game-design features in a non-gaming context (14), while serious games refer to games that are intentionally designed and built specifically for education, training, or for behavioural modification (15). These technologies have been adopted in healthcare and some evaluated. Currently, most of these gamified interventions are used in chronic disease rehabilitation and mental health (16), with the most common gamification technique provision of feedback. Lumsden J et al. (2016) synthesised the evidence for gamification for cognitive assessment and training. The authors reported gamification helped improve engagement in the short and longer term and made the task more attractive. Other studies have found increased self-empowerment (16) and improved existing skills sets (16). More recently, Lau HL et al. (2017) (15), in their review, reported that serious games could help to improve psychiatric symptoms with an effect size of 0.55.

Gamification has been considered for cognitive bias modification interventions. Wouter J et al. (2015) (17) reviewed how gamification might help address one of the core challenges of conventional interventions, that of motivation to train; these tasks tend to be highly repetitive, with a need for multiple training sessions. Wouter J et al. (2015) (17) highlighted several potential gamification strategies and explored how they have been used in some studies. The gamification approaches used include that of the addition of gaming elements to existing tasks; the transformation of a conventional task into a serious game; identification of an underlying theory of the intervention and developing a game; the addition of a full gaming approach to a conventional task; both intrinsic and extrinsic combination and lastly, the use of over the shelf entertainment games. Whilst this review provides a timely insight into how gamification strategies have been adapted for bias modification interventions,
it was not a systematic review with a database search. Since Wouter J et al. (2015)’s review of application of cognitive bias modification in cognitive bias modification intervention, there has been other research reporting of the evaluation of gamified variant of an attention bias modification task, for example, that of Dennis TA et al. (2014) (18) which sought to determine the effectiveness of the gamified intervention for anxiety. However, to date, there is a lack of a systematic evaluation of the gamified cognitive bias modification interventions in the literature. This is needed to understand the overall effectiveness of a gamified approach for cognitive bias modification and to inform future research that seeks to integrate gamification technologies into existing conventional bias modification interventions.

The primary aim of this review is to review the application of gamification to cognitive bias modification for psychiatric disorders. Its secondary aim is to identify the gamification elements used for cognitive bias modification and to synthesize the evidence for the effectiveness of gamification when applied to cognitive bias modification interventions. Effectiveness of the gamification elements will be assessed by whether the gamified intervention resulted in changes in biases, if the gamified intervention resulted in improvement in secondary outcomes (for example, improvements in anxiety or depressive scores or reduction in the absolute amount of alcohol consumed) and lastly, if there have been any motivational improvement.

**Methods**

**Search Strategy**

To identify the relevant articles for the current review, the following search terminologies were used: (“cognitive bias” OR “attention bias” OR “interpret* bias” OR “approach bias” OR “avoidance bias”) AND (“training” OR “modification” OR “practice” OR “therapy”) AND (“gamification” OR “game elements” OR “game” OR “gaming” or “game mechanics”). PubMed, MEDLINE, PsycINFO, Scopus. Databases were searched systematically from 2000 onwards, as before the date, there were limited computer-based interventions. When full-text access was not available, the original authors were contacted for their articles.

**Inclusion and Exclusion Criteria**

Articles were included if they (a) described a cognitive bias modification intervention in the form of a gamified-like task, (b) included participants assessed to have underlying psychopathological symptoms (such as depressive, anxiety or addictive symptoms). Articles were excluded if they (a) were opinion pieces, review articles or design documentation; (b) utilised an intervention utilised from an existing over the shelf game. Only English language articles were included.

**Screening & Data Extraction, Sorting and Selection**

All the articles identified using the search strategy were downloaded and imported into a reference manager (Endnote X8). The articles were screened based on their titles and abstracts by two independent authors, MWBZ and JY. Full copies of the shortlisted articles were then evaluated against the inclusion and the exclusion article and any disagreement resolved by a discussion with the third author (GS).

For relevant articles, the following data were extracted:

1. Publication details: author(s), study year and country in which the study was conducted
2. Study design (observational or experimental design)
3. Sample size
4. Type of sample (treatment seeking or community sample)
5. Demographics of sample (mean age, gender proportion)
6. Psycho-pathological symptoms of participants and the methods of ascertaining psychiatric symptoms
7. Details of gamified cognitive bias modification intervention (mechanics of game-play and the conventional cognitive bias modification intervention that the gamified task was based on)
8. Primary Outcomes & Secondary Outcomes: Effectiveness of gamified cognitive bias modification intervention and any changes in psychiatric symptoms
Data Integration & Synthesis
A qualitative synthesis of the evidence extracted from the articles was performed. Due to the heterogeneity in the outcomes reported, it was not appropriate to conduct a meta-analytical synthesis.

Results
The pre-defined search strategy identified 1008 citations from four bibliographic databases; after duplicate articles were excluded, 970 records were screened, and of these 962 were excluded as not relevant to the topic of interest. Eight full-text articles were downloaded for further evaluation against both the inclusion and exclusion criteria. Four citations were excluded as they did not fulfil the inclusion criteria, leaving four articles for the qualitative synthesis. Figure 1 provides an overview of the study selection process. Table 1 provides an overview of the characteristics of the selected studies.

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Characteristics of Identified Studies
Two of the four studies identified involved participants with anxiety symptoms (Dennis TA et al., 2014 & Dennis-Tiwary et al., 2016) (18, 19). One involved participants with alcohol-related problems (Boendermaker et al., 2016) (4) and one, participants with affective symptoms (Pieters EK et al., 2017) (20). All studies were experimental, randomized controlled design, recruiting participants from Universities with mean age of the participants in their twenties. All the studies were conducted in a western setting. Two studies came from the United States, one from the Netherlands and another from Belgium. None of the studies used a structured clinical interview in ascertaining symptomatology or diagnosis, but relied on validated questionnaires (State-Trait Anxiety Inventory (Dennis TA et al., 2014; Dennis-Tiwary et al., 2016) (18, 19), the Mood and Anxiety Symptoms Questionnaire (Pieters et al., 2016) (20) and the Alcohol Use Questionnaire and the Alcohol Use Disorders Identification Test (AUDIT) questionnaire (Boendermaker et al., 2016)) (4). Three studies have based their gamified intervention on the visual probe task, and one on the attentional visual search task. Gaming elements integrated into these tasks included animations, sound effects, reward points, time pressure and levels of complexity.

Characteristics of Gamified Cognitive Bias Modification Intervention
Two studies (Dennis TA et al., 2014 & Dennis Tiwary et al., 2016) (18, 19) used the same application for their intervention, a gamified attention bias modification application based on the conventional dot-probe task. The gamification elements included that of animated characters, a system for points scoring and sound effects. Two animated characters would appear on the screen simultaneously, then both disappearing into a hole. One character would cause a path of grass to rustle behind and participants undertaking the intervention were asked to trace the path of the grass. Based on the author’s description of the gamified intervention, four different sounds were played, and different rewards were given depending on the participants’ accuracy and speed. The lowest pitch sound and red jewel would be played and awarded for slow response or responses that were least accurate; a medium pitch sound and purple jewel would be played and awarded for moderate speed and accuracy; and lastly a high pitch sound with a gold jewel would be played and awarded if fast and accurate. There was also a feedback sound for incorrect responses. There were two variants of the gamified intervention; 25 minutes of training along with 20 minutes or rest, or 45 minutes of training with no rest. Points were accumulated as the intervention progressed, and feedback was given immediately on completion.

Pieters et al. (2016) (20) used a gamified application for cognitive bias modification for anxiety symptoms, based on the conventional visual attention task. The game required participants to tap on smiling faces, with smiling faces making up 60% of the faces and disgust faces the remaining 40%. Once the participant has tapped on the smiling face, the face bounced up for a short distance and become untappable for 0.5 to 1 second. The participants were instructed to prevent the smiling faces
from falling down the screen by tapping on them. Points were awarded, to incentivise game-play. A point was awarded for tapping the smiling face the first time, and five points if the same smiling face is tapped a second time. There was negative scoring with the lost of three points if a smiling face was not tapped and fell off the screen.

Boendermaker et al. (2016) (4) used a “Shot game” for attention bias modification, based on the conventional visual probe task. The gamified intervention included a reward system, as well as graphics, animations, sound effects, time pressure and levels. Their game resembled a slot machine, with a coin-based reward system. Like the conventional task, participants were required to identify the probe that replaced the position of the alcohol or neutral image. There were bonuses for participants who responded rapidly, and they were given access to new levels in the game.

Three studies delivered the gamified cognitive bias modification intervention using a mobile device, and Pieters EK et al. (2016) (20), used a computer.

**Reasons for Gamification**

Two studies described the reasons for inclusion of gamification. Boendermaker et al. (2016)’s (4) included gaming elements to potentially increase participants’ motivation to train via the intervention. The authors also sought to determine if the inclusion of gaming elements affected the effectiveness of the conventional visual probe task. Dennis TA et al. (2014)’s (10) were interested in whether the inclusion of gamification changed the effects of the attention bias modification.

**Primary and Secondary Outcomes**

Of the four studies, two (Dennis TA et al. (2014) & Dennis Tiwary et al. (2016) (18, 19)) reported the gamified variant of the cognitive bias modification intervention to be effective. Dennis TA et al. (2014) (18) reported that the long-training attention bias modification task resulted in reduced threat bias and difficulties that individuals had with disengaging from threat-related stimulus. There was also a corresponding reduction in the subjective and observed anxiety and stress. Similarly, the authors of the second paper (Dennis Tiwary et al. (2016)) (19)reported that the single session of gamified attention bias modification was effective in improving the performance of the attention bias modification task. However, the authors reported that there were differences in the gender, and the significant results were observed amongst females only. Contrary to the findings of Dennis TA et al. (2014) & Dennis Tiwary et al. (2016) (18, 19), Pieters et al. (2016) (20) reported that their “IMPACT” gamified intervention did not result in any reduction in attention biases and associated mood-related measures.

For the study involving participants with alcohol-related problems (Boendermaker et al. (2016)) (4), the gamified variant of the cognitive bias modification task did not reduce attention bias and failed to achieve a decline in overall alcohol consumption. Of importance, Boendermaker et al. (2016)’s (4) study was also the only study that investigated the effects of gamification and motivation of participants in using the training task. Boendermaker et al. (2016) (2) reported that motivation to train did not increase with the addition of gaming elements. In fact, participants assigned to receiving the gamified variant reported having lower motivation to continue the training task, as compared to participants assigned to other conditions.

**Discussion**

Our review is the first to systematically synthesise the evidence for gamified cognitive bias modification intervention. Of the four studies that evaluated a gamified cognitive bias modification intervention, two studies included participants with anxiety symptoms, one with affective symptoms, and one with alcohol problems. Gamified interventions were based on the conventional visual probe task in three studies, and the attentional visual search task in the last study. The gaming elements incorporated into the task included that of animations, sounds, feedback, points scoring system for response time and difficulty. Two publications discussed their rationale for gamification, one sought to determine if gamification enhances motivation, and the other to determine if the gamified attention
bias modification was as effective as conventional. Out of the four identified studies, two studies have reported their gamified intervention to be effective. Of significance, these two studies have used the same application and were from the same research group.

These four studies applied gamification across a variety of psychiatric disorders, anxiety, affective and addictive disorders. The conditions that gamified cognitive bias modification intervention target are like those targeted by conventional mobile-based cognitive bias modification interventions target. Zhang et al. (2018)’s review evaluated the published literature and reported that out of the eight identified studies, at least four studies used a mobile intervention to target anxiety-related disorders (anxiety and social anxiety disorders). Jones et al. (2017) in their review of meta-analyses included five meta-analyses that examined anxiety related outcomes. This demonstrates that anxiety conditions have been extensively investigated, and could account for there being studies applying gamification technique, to potentially increase the inherent effectiveness of existing conventional training tasks.

All identified studies have based their gamified intervention on the conventional cognitive bias modification intervention, which if of importance, as the conventional cognitive bias modification intervention is well-validated. Three studies based it on the conventional visual probe task, and one based it on attentional visual search task. Considering Boendermaker et al. (2015)’s recommended gamification techniques, it appears that all four studies have used “intrinsic integration with evidence-based training task as a basis”, given that all four studies have based their intervention on a conventional task, and gaming elements were then added on to the conventional task. By adopting intrinsic integration, this helps to make the task more engaging, which might increase the inherent levels of motivation to continue training. Unfortunately, we found no evidence that the adoption of “intrinsic integration” did lead to increased motivation to train, as only one study included motivation to train as an outcome measure, and in that study (Boendermaker et al., 2016), there was no improvements.

In keeping with the objectives of the review, we identified some of the common gaming elements that are incorporated in the published gamified interventions. The gaming elements incorporated included that of animations, sound effects, point-scoring systems, time pressure and levels. Hoffman et al. (2017)’s review, has proposed a taxonomy of gamification strategies that could be applied for the evaluation of gamification strategies in applications. The authors used the taxonomy and evaluated stress management applications. It was found that feedback (or performance-orientated strategies) were frequently used in the 62 evaluated applications. Like Hoffman et al. (2017)’s review, our findings also demonstrated that performance-orientated gamification strategies are used for some of the gamified applications (time pressure and levels in Boendermaker et al. (2016)’s study). Economic gamification strategies are more commonly used, with four studies reporting the usage of a point system. The differences in our findings, as compared to that for stress management applications, is not unexpected. Prior research highlighted the importance for designers to carefully consider the gamification techniques used, depending on the nature of the application and how gamification could affect user interaction. Thus, for cognitive bias modification interventions, incorporating feedback might be less feasible, as feedback usually involves a comparison to a set-standard or others’ performance. Digital rewards like points might be more tangible, both as an extrinsic motivator and as a surrogate indicator of how well one is performing on the task.

The existing evidence is inconclusive for gamified cognitive bias interventions effectiveness, as only two out of the four studies reported positive findings, there are several implications that arise from this review. Why gamification is only effective in some studies and not others need consideration of which gamification strategies to adopt in an intervention. The perspectives of patients and public is important in the design of gamified cognitive bias modification intervention informing us about what they feel might help make the application more engaging and what strategies, when applied, would result in both short and longer-term engagement. While only four studies are identified for this review, Zhang et al. (2018) have in their prior review highlighted that there are seventeen cognitive bias modification commercial applications on the application stores. It might be helpful to analyse the
gamification features in commercial cognitive bias modification applications and see if certain gamification features are associated with higher rates of downloads, a surrogate measure of acceptability. Also, a qualitative analysis of the feedback that individuals provide for the gamified commercial applications might be helpful for developers or healthcare professionals who are creating a new gamified intervention.

A major strength of the current review is that we identified systematically from the published literature, gamified cognitive bias modification interventions, and synthesized the evidence for their overall effectiveness. We also identified the gamification strategies that they have adopted. Our review will be of importance for future research seeking to design and evaluate gamified cognitive bias modification interventions, as it provides information about gaming elements that might render result in the intervention to be effective. Despite the strengths, there are some limitations. In the current review, we are limited to a qualitative synthesis, as a meta-analytical synthesis was not appropriate given the heterogeneity in the studies and the outcomes reported. Our synthesized results might have limited generalizability, as two studies used similar applications and tested the applications in a university sample.

Conclusions
By identifying gamified cognitive bias modification interventions in the published literature and synthesizing their evidence, our current findings has helped to bridge the gaps of the previous review. There results arising from our current review should be considered in the future design and conceptualization of gamified cognitive bias modification interventions.
Figure 1: Overview of Study Selection Process

1008 Citations identified based on Search Strategy

970 records after duplicates removed

970 records screened

962 citations excluded as they were of no relevance

8 Full-text articles assessed for eligibility

4 citations excluded
2 articles were on attribution error & confirmation bias
1 was a review article
1 article involved the delivery of a Go/Go-go task for alcohol-related memory bias

4 included in qualitative synthesis
<table>
<thead>
<tr>
<th>Study &amp; Country of Study</th>
<th>Study Design &amp; Sample Size</th>
<th>Types of Sample</th>
<th>Demographics of Sample</th>
<th>Psycho-pathological symptoms</th>
<th>Details of Intervention</th>
<th>Primary and Secondary Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dennis TA et al. (2014) (18) New York, United States of America</td>
<td>Randomised Controlled Study Total sample size =78</td>
<td>Adults recruited from an Introduction to Psychology Course at an urban University</td>
<td>Long training condition: mean age 22.3, 27 females, 11 males Short training condition: mean age 20.2, 28 females, 12 males</td>
<td>Anxiety symptoms</td>
<td>Gamified mobile application was based on the dot-probe task. Gamification elements included animated characters, points and sound effects. In the game-play, two animated characters, one with an angry expression and another with a neutral/mildly positive expression would appear. Thereafter, both would disappear into a hole, with one causing a path of grass to rustle. Participants traced the path of grass. Feedback was provided after each trial: red jewel/low pitch sound for slow response, poor accuracy; purple jewel/medium pitch sound for moderate speed &amp; accuracy; gold jewel/high-pitch sound for fast response &amp; accuracy. A high pitch sound was played for errors made. Points were accumulated as the intervention progress. The short and long version of the app involved 25 and 45 minutes of training respectively.</td>
<td>Long-training resulted in reduced threat bias and difficulties with disengaging. Both the short and long training resulted in reductions in subjective and observed anxiety and stress.</td>
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<td>Boendermaker et al. (2016) (4) Amsterdam, The Netherlands</td>
<td>Randomized Controlled Study Total sample size=96</td>
<td>Sample of undergraduate students recruited through the university laboratory’s website</td>
<td>Mean age 21.2 years, (68/96) 71% were females Gamified visual probe task (VPT-G) group: mean age 21.0, 23/33 were females Regular visual probe task (VPT-R) group: mean age 21.3, 22/30 were females Placebo version of Alcohol Problems</td>
<td>Participants were recruited if they consumed ≥ 5 standards glasses of alcohol on average per week for males; ≥ 4 for females. Participants were assessed by means of the Timeline Follow back (TLFB), adapted version of the Alcohol Use Questionnaire (AUQ), and the Alcohol Use Disorders Identification</td>
<td>Gamified mobile application was based on conventional visual probe task. The game elements included reward system, graphics, animations, and sound effects. The gamified intervention resembled that of a slot machine. Participants identified the position of the probe that replaced either the substance or neutral stimuli. Participants were rewarded for correct and fast responses (by means of time bonuses and special bonus trials) and new levels.</td>
<td>Decline in attention bias mainly in the regular visual probe training task. There was no decline in alcohol consumption after the training. Motivation to train decreased in all conditions. This implied that the training task did get boring over time. Participants in the game condition indicated a lower motivation to train as compared to other conditions.</td>
</tr>
<tr>
<td>Study Details</td>
<td>Experimental Design</td>
<td>Participants</td>
<td>Measures</td>
<td>Intervention</td>
<td>Results</td>
<td></td>
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<td>---------------</td>
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<td>Dennis-Tiwary et al. (2016) (19) New York, United States</td>
<td>Randomized Study</td>
<td>Adults recruited from an undergraduate research pool at an urban university in New York City, and through Craiglist</td>
<td>Mean age 20.6; 21/42 were females</td>
<td>Anxiety symptoms State-Trait Anxiety Inventory was used to screen participants. Participants were recruited if they scored +1 standard deviation above the mean for college students on trait anxiety.</td>
<td>Similar app as Dennis TA et al. (2014) A single session of gamified ABMT improved performance on anxiety-related stress task among females only.</td>
<td></td>
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<tr>
<td>Pieters et al. (2016) (20) Ghent, Belgium</td>
<td>Randomized Controlled Study</td>
<td>Undergraduate students</td>
<td>Experiment 1: Attend-positive group: mean age 23.9, 23/30 females Attend-negative group: mean age: 23.1, 25/28 females</td>
<td>Affective symptoms Assessed by the 30-item version of the Mood and Anxiety Symptoms Questionnaire (MASQ-D30), the Ruminative Response Scale (RRS), Gamified application based on Intrinsically Motivating Playable Attentional Control Training (IMPACT). Intervention based on conventional visual attention task. Game elements included feedback, time points, difficulty levels and sounds. Faces (either smiling or disgust) continuously descend from top to bottom of the screen. Participants were to prevent faces from reaching the bottom of the screen by clicking on the faces twice. Participants in the attend-positive condition were required to click on happy faces and ignore disgusted faces; while participants in the attend-negative condition were asked to click on disgusted faces and ignore happy faces. Immediate feedback was provided through time points. The task consisted of 15 rounds of 1min each. In the attend-positive condition, 60% of the faces were smiling and 40% were disgusted. This was reversed for the attend-negative condition.</td>
<td>No significant effect on measures of emotional attentional performance, or on self reported stress, anxiety and depression symptoms</td>
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**Table 1: Characteristics of Included Studies (n=4)**
References
