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Online visual search attentional bias modification for adolescents with heightened anxiety and depressive symptoms: A randomized controlled trial



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ABSTRACT

Anxiety and depression, which are highly prevalent in adolescence, are both characterized by a negative attentional bias. As Attentional Bias Modification (ABM) can reduce such a bias, and might also affect emotional reactivity, it could be a promising early intervention. However, a growing number of studies also report comparable improvements in both active and placebo groups. The current study investigated the effects of eight online sessions of visual search (VS) ABM compared to both a VS placebo-training and a no-training control group in adolescents with heightened symptoms of anxiety and/or depression ($n = 108$). Attention bias, interpretation bias, and stress-reactivity were assessed pre- and post-training. Primary outcomes of anxiety and depressive symptoms, and secondary measures of emotional resilience were assessed pre- and post-training and at three and six months follow-up. Results revealed that VS training reduced attentional bias compared to both control groups, with stronger effects for participants who completed more training sessions. Irrespective of training condition, an overall reduction in symptoms of anxiety and depression and an increase in emotional resilience were observed up to six months later. The training was evaluated relatively negatively. Results suggest that online ABM as employed in the current study has no added value as an early intervention in adolescents with heightened symptoms.

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Anxiety and depression are highly prevalent disorders in youth and have enduring negative consequences for social and academic functioning and mental health (Woodward & Fergusson, 2001). Since adolescence is a period of increased vulnerability for the development of these disorders, as well as a period of increased brain plasticity, prevention and early intervention are particularly important in this age group (Crone & Dahl, 2012; Haller, Cohen Kadosh, Scerif, & Lau, 2015). In order to reach a larger number of at-risk adolescents, low-barrier and low-cost interventions are necessary. Online cognitive training, like Attentional Bias Modification (ABM) training, could be such a candidate intervention, as adolescents would be able to complete the intervention 24/7 and without the help of a therapist.

Attentional bias modification training was first developed to test the causal role of an attentional bias for negative information in emotional vulnerability (MacLeod, Rutherford, Campbell,

Ebsworthy, & Holker, 2002). Earlier research had already provided a large body of evidence for cross-sectional and prospective relations between such an attentional bias and emotional vulnerability or emotional disorders (for reviews, see Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & Van Ijzendoorn, 2007; Cisler & Koster, 2010; Platt, Waters, Schulte-Koerne, Engelmann, & Salemink, 2016; Puliafico & Kendall, 2006; van Bockstaele et al., 2014). Biases in attention also affect later stages of information processing, like interpretation and memory (Everaert, Duyck, & Koster, 2014), and thus seem to be a core process underlying negative cognitions in anxiety and depression.

As manipulating attentional bias indeed led to changes in emotional responding, a growing body of research has focused on ABM as a potential intervention to reduce or prevent psychopathology such as anxiety and depression (Woud & Becker, 2014). These studies have provided mixed results, ranging from large reductions in clinical symptoms of anxiety to null-findings on both attentional bias and emotional outcome measures (for meta-analyses, see Cristea, Kok, & Cuijpers, 2015; Heeren, Mogoșe, Philippot, & McNally, 2015; Linetzky, Pergamin-Hight, Pine, &

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Bar-Haim, 2015; Mogoşe, David, & Koster, 2014). Important to note is that most null-findings on cognitive and emotional outcomes occur. That is, when no change in attentional bias has been obtained, emotional effects are generally also absent, while a successful manipulation of attentional bias tends to result in a change in at least some emotional outcome measures (MacLeod & Clarke, 2015; MacLeod & Grafton, 2016). This seems to suggest that manipulating attentional bias could be an effective intervention to reduce emotional vulnerability, but that the optimal paradigms and circumstances for changing attentional bias have yet to be found.

The most promising findings have been obtained in adult samples with (sub)clinical social anxiety, mainly in studies where training was performed in the laboratory (Linetzky et al., 2015; Mogoşe et al., 2014). As noted before, one of the great advantages of ABM compared to traditional (face-to-face) interventions is the possibility to deliver the training via the internet. However, attempts to employ ABM online have been less successful in changing attentional biases and symptomatology (e.g., Boettcher, Berger, & Renneberg, 2012; Carlbring et al., 2012), and more research on this delivery method is necessary (Mogoşe et al., 2014). It has been argued that online studies perform worse, due to a lack of experimental control or lack of social exposure (Boettcher et al., 2013; Kuckertz et al., 2014). However, a recent study directly comparing in-lab ABM training with training at home found no differences between active and placebo groups in both settings (Carleton et al., 2015), suggesting that the online environment is not the sole explanation for recent null findings.

Compared to the adult literature, ABM research in adolescents is relatively scarce, and studies up till now have also provided mixed evidence (for a meta-analysis, see Cristea, Mogoşe, David, & Cuijpers, 2015; for a review see Lowther & Newman, 2014). That is, changes in attentional bias are often observed, but effects on mental health seem inconsistent or limited. However, note that most studies included in this meta-analysis and review focused on clinical samples. Given the increased vulnerability but also plasticity during adolescence, research on prevention or early intervention is particularly relevant here (Crone & Dahl, 2012; Haller et al., 2015). Two studies on ABM as an early intervention for adolescents with heightened levels of social anxiety, did not find beneficial effects on attentional bias or social anxiety compared to placebo (Fitzgerald, Radwon, & Dooley, 2016; Sportel, de Hullu, de Jong, & Nauta, 2013). Note that these studies, as well as most studies included in the meta-analysis and review mentioned above, used a dot-probe training paradigm.

The dot-probe training (MacLeod et al., 2002) is the most often used ABM paradigm. Here, participants have to respond to a probe that replaces a neutral or positive stimulus that is paired with a negative stimulus, thus encouraging less attention to negative information. However, findings in youth samples have been mixed (Cristea et al., 2015b) and subjective evaluations are quite negative, as participants experience the task as boring and miss a clear rationale (Beard, Weisberg, & Primack, 2011). The visual search training is an alternative paradigm, in which participants have to search for the only positive stimulus (e.g. smiling face) amongst a grid of multiple negative stimuli (e.g. rejecting faces) (Dandeneau & Baldwin, 2004). This task aims to train both engagement with positive information and disengagement from negative information. It could be considered a more explicit task, as strategic search processes seem to be involved. This could make the task more intuitive and potentially more engaging for participants. However, the precise mechanisms assessed and trained with the visual search task compared to the dot probe task are still largely unknown.

In several studies with this paradigm (Dandeneau & Baldwin, 2004; 2009; Dandeneau, Baldwin, Baccus, Sakellaropoulou, & Pruessner, 2007), positive effects have been observed on

attentional bias, self-esteem and both self-report and physiological indices of stress-reactivity, but in a dysphoric sample, a single session had no effect on attentional bias (as assessed with the dot-probe task) or mood state (Kruijt, Putman, & van der Does, 2013). Visual search training has also been employed in youth samples, and reductions in attentional bias and anxiety were observed in a small sample of unselected adolescents (de Voogd, Wiers, Prins, & Saleminck, 2014). In a recent large scale online RCT in unselected adolescents, visual search training also led to a large reduction in attentional bias, but here no effects on emotional functioning were observed compared to placebo (de Voogd, Wiers, et al., 2016). As in several (online) studies of dot-probe ABM (e.g. Boettcher et al., 2012; Carlbring et al., 2012), a significant reduction in symptoms was observed, but both in the active and placebo condition. In contrast, in two studies in clinical samples, positive effects on anxiety have been observed in the visual search training specifically (Waters, Pittaway, Mogg, Bradley, & Pine, 2013; Waters et al., 2015), though note that only one of these studies included an active control group (Waters et al., 2013). These findings suggest that visual search ABM might be particularly suited for youth already high in symptomatology.

Improvements in both active ABM and placebo groups could be interpreted in various ways. First, it might simply reflect an effect of time, thus indicating a natural decline in symptoms or regression to the mean (cf. Sportel et al., 2013). Second, it could also reflect placebo effects, that is, demand effects, or effects of positive expectations and increased attention. Third, and probably most intriguing, the placebo condition used in such studies might unintentionally also be an effective training. For example, emotional effects might also be obtained with neutral or even attend-negative training, probably by increasing attentional control (cf. Chen, Clarke, Watson, MacLeod, & Guastella, 2015; Heeren, Mogoşe, McNally, Schmitz, & Philippot, 2015; Klumpp & Amir, 2010). However, mere practice effects might also explain these improvements (Heeren, Coussemont, & McNally, 2016). To disentangle the effects of a placebo training and of time alone, long-term studies including both a placebo and a no-training control group are essential.

Finally, it is important to assess which cognitive processes are affected by ABM. According to the combined cognitive bias hypothesis (Everaert, Koster, & Derakshan, 2012; Hirsch, Clark, & Mathews, 2006), negative biases in information processing, like attentional bias, but also interpretation and memory biases, may influence each other and interact in predicting emotional problems. For example, it has been found that attentional biases operate during the interpretation of ambiguous information, with negative biases in the latter predicting depressive symptoms (Everaert, Grahek, & Koster, 2016). The extent to which ABM is able to also affect other cognitive processes might thus be an important factor in fostering (durable) change in emotional vulnerability. A previous study on dot probe ABM has shown positive effects on interpretation bias (White, Suway, Pine, Bar-Haim, & Fox, 2011), but another study did not find a relation between individual differences in change in attentional bias and change in interpretation bias (Everaert, Mogoşe, David, & Koster, 2015). Both studies employed single-session training and the latter did not observe an attentional bias effect at the group level. Whether multi-session ABM, or visual search ABM in general, could affect other cognitive processes is still unknown.

In the current study, adolescents with heightened symptoms of anxiety and depression were randomized to eight online sessions of either visual search or placebo training, or to a no-training control group. Primary outcomes of anxiety and depressive symptoms, and secondary outcomes of self-esteem, perseverative negative thinking, and social-emotional and behavioral problems were

assessed pre- and post-training and at three and six months follow-up. Furthermore, short-term effects on attentional bias, interpretation bias, and stress-reactivity were assessed. First, we hypothesized that, compared to both placebo and no-training control, visual search (VS) training would reduce attentional bias. Second, we hypothesized that, compared to both control groups, VS training would reduce anxiety and depression, and improve emotional resilience as assessed with secondary measures. Third, we expected that a change in attentional bias would generalize to interpretation bias (White et al., 2011). Fourth, we examined moderators of training effects. That is, we expected larger effects on attentional bias, and anxiety and depression in participants who completed more training sessions (Beard, Sawyer, & Hofmann, 2012; de Voogd, Wiers et al., 2016; Hakamata et al., 2010), and larger effects on anxiety and depression in participants with a stronger attentional bias at baseline (Kuckertz et al., 2014). Finally, we explored how participants experienced the training and whether perceived training condition would influence results.

1. Methods

This study was approved by the ethics committee of the psychology department of the University of Amsterdam, carried out in accordance with the World Medical Association Declaration of Helsinki, and registered in the Dutch trial register with number NTR4850¹ (<http://www.trialregister.nl/trialreg/admin/rctview.asp?TC=4850>).

1.1. Participants

Participants were recruited from four secondary schools in the Netherlands between September 2014 and February 2015, and all follow-ups were completed by October 2015. Inclusion criteria for the study were: students in the 1st to 6th grade of a regular (all levels except for special education) high school (aged 11–19); and a score > 16 on the Screen for Child Anxiety Related Emotional Disorders (SCARED) and/or > 7 on the Children's Depression Inventory (CDI).² Also, informed consent from both the adolescent and a parent was required (passive for screening and active for the study). After screening 1153 adolescents for symptoms of anxiety or depression, 540 adolescents were invited for the study based on the inclusion criteria. Informed consent was obtained from 121 adolescents and their parent and they were randomly allocated to one of the three parallel conditions at the point when they registered themselves online (see Fig. 1 for the flow diagram). Randomization was stratified by school and gender, and determined by a computerized procedure written by a programmer independent of the study. Both participants and test assistants were blind to allocation. Participants who missed the first assessment were excluded ($n = 13$). The remaining 108 participants (66.7% female, mean age 14.45 years, $SD = 1.53$) were included in intention-to-treat analyses

¹ Please note that the trial registration contains information about six arms involving 300 participants. Participants were initially recruited from four schools and randomized into three of the arms (the current study); in a second phase participants were recruited from a different set of four schools and randomized into the other three arms. Although the two phases are registered in one registry entry, they are treated as two separate studies as the recruitment, sampling, and randomization were independent of one another. Results from the other three arms (the second phase) are reported elsewhere (de Voogd, de Hullu et al., 2016).

² The cut-off scores were based on our previous study in a sample of 681 unselected adolescents, where 50% of adolescents scored above these values (de Voogd, Wiers et al., 2016). For the first two schools, we initially invited only adolescents scoring >25 on the SCARED or >11 on the CDI, but inclusion criteria (and information letters, see procedure) were adapted in December 2014 as response rates were low, possibly due to fear of stigmatization.

(VS training: $n = 38$, VS placebo: $n = 32$, Control: $n = 38$). This sample size provided 80% power to detect a Condition \times Time interaction effect size of $f = 0.21$ at an alpha of 0.05. Groups did not differ on demographic characteristics, baseline scores on outcomes measures, or number of assessments completed, all p 's > 0.140, except for baseline perseverative negative thinking, $F(2,107) = 4.32$, $p = 0.016$ (see Tables 1 and 2). Adding baseline PTQ scores as a covariate to our analyses, did not change the results.

1.2. Training task

The VS training (de Voogd et al., 2014; based on; Dandeneau et al., 2007) consisted of four blocks of 36 trials, in which participants had to find and select the only smiling face in a 4×4 grid of negative emotional faces (angry, fearful, and sad). Faces were presented until a response was given and a new trial started once the participants moved the mouse cursor over a fixation cross in the center of the screen. In case of an erroneous response the trial was repeated after feedback. A progress bar indicated how many trials were left in each block and participants received feedback on their performance (points based on RTs) during short breaks between blocks. At the end of each session, points of this and, if applicable, previous session(s) were presented in a graph. Face stimuli (height 149, width 117 pixels) were randomly drawn from two sets (counterbalanced over participants) of 36 adolescent faces (18 happy, six fearful, six angry and six sad faces) from the NIMH Child Emotional Faces Picture Set (NIMH_ChEFS, Egger et al., 2011; for stimuli selection, see de Voogd et al., 2014).

The VS placebo training was almost identical to the VS training, but here participants had to find and select the only 5-petaled flower in a 4×4 grid of 7-petaled flowers (Dandeneau et al., 2007).

1.3. Cognitive outcome measures

The Emotional Visual Search Task (EVST, de Voogd et al., 2014) was used to assess attentional bias. This task was comparable to the VS training task, such that participants had to find and select the only face with a distinct emotional expression in a 4×4 grid of emotional faces. However, here the task consisted of two blocks of 36 trials: one with a happy target amongst negative distractors, and one with a negative target (angry, fearful, or sad face) amongst positive distractors (happy faces). The order of blocks was counterbalanced over participants. The same stimulus set as during training was used at the pre-training assessment, and a new set was presented at post-training assessment. An attentional bias index was computed by subtracting the average RT for selecting negative faces from the average RT for selecting positive faces, with higher values indicating a negative attentional bias.

The Recognition Task (Mathews & Mackintosh, 2000) was used to assess interpretation bias. Participants read short three-line ambiguous scenarios, in which the last word was missing. This word was presented as a word-fragment, which participants had to complete, followed by a comprehension question about the scenario. After presentation of eight scenarios, titles of these scenarios were presented again in random order, once with a negative interpretation and once with a positive interpretation, also in random order. Participants rated the extent to which the interpretation corresponded to the scenarios on a 4-point scale. Scores for positive interpretations were subtracted from scores for negative interpretations, with higher values indicating a negative interpretation bias.

1.4. Primary outcome measures

Anxiety and depressive symptoms were assessed with the

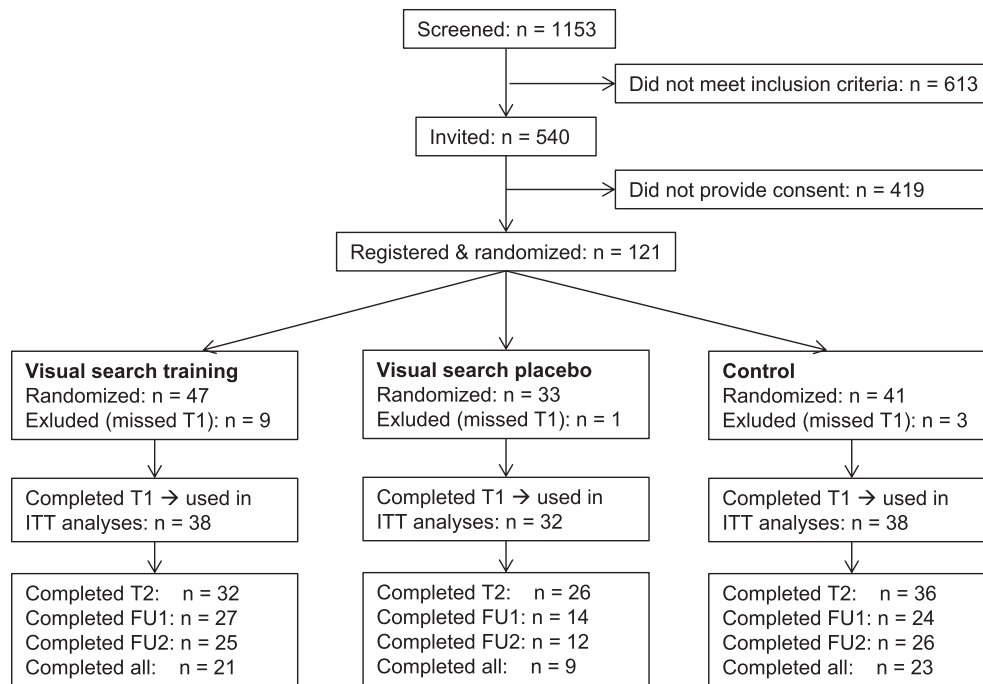


Fig. 1. Flow chart.

T1 = pre-assessment; T2 = post-assessment; FU1 = 3 months follow-up; FU2 = 6 months follow-up; ITT = intention-to-treat.

Table 1
Demographic characteristics per condition.

	VS training (n = 38)	VS placebo (n = 32)	Control (n = 38)
Age, mean (SD)	14.73 (1.57)	14.31 (1.51)	14.29 (1.50)
Female, N (%)	24 (63.2)	21 (65.6)	27 (71.1)
Sessions completed, mean (SD)	5.74 (2.76)	4.81 (3.64)	NA

* = $p < 0.05$.

Screen for Child Anxiety Related Emotional Disorders (SCARED, Birmaher et al., 1999) and the Children's Depression Inventory (CDI, Kovacs, 1985), respectively. Internal consistency for the primary outcome measures was good to excellent in the current sample, SCARED $\alpha = 0.93$, and CDI $\alpha = 0.89$.

1.5. Secondary emotional outcome measures³

Self-esteem, perseverative negative thinking, and social-emotional and behavioral problems were assessed with the Rosenberg Self-Esteem Scale (RSES, Rosenberg, 1965), the Perseverative Thinking Questionnaire (PTQ, Ehring et al., 2011), and parent report on the total difficulties scale of the Strengths and Difficulties Questionnaire (SDQ-P, Goodman, 1997).

Stress reactivity was assessed by recording emotional responses to an anagram stress task (de Voogd, de Hullu et al., 2016; cf.; MacLeod et al., 2002). Participants were presented with 15 anagrams, that had to be solved within 30 s by typing in the correct word. A new anagram was presented after responding or when the 30 s were expired. Some of the anagrams were easy to solve, but most were extremely difficult (range from 6 to 14 letters). Participants were told that the anagrams would be reasonably easy and

that performance was related to intelligence. Before and after the stress task, participants rated to what extent they felt sad, nervous, anxious, enthusiastic, happy or relaxed, using a visual analogue scale. Scores were combined into a negative and positive mood scale respectively.

Internal consistency for the secondary emotional outcome measures was adequate to excellent in the current sample (RSES $\alpha = 0.88$, PTQ $\alpha = 0.95$, SDQ-P $\alpha = 0.74$, positive mood $\alpha = 0.72$, negative mood $\alpha = 0.74$).

1.6. Evaluation questionnaire

An evaluation questionnaire was administered to the VS training and VS placebo group, assessing participant experiences with the training. Questions were related to clarity of instructions and aim of the training, enjoyment, difficulty, concentration, learning experiences, satisfaction, and willingness to train again or recommend the training to friends. Participants were also told here that there had been a 'real' and 'fake' training, and had to indicate in which training condition they thought they had been.

1.7. Procedure

An information letter about the screening was sent to adolescents and parents of participating classes and they could indicate via school or the principal investigator if they did not want to participate in the screening (passive consent). The screening was

³ In order to be able to assess cost-effectiveness, we also included questionnaires on quality of life (EQ-5D-Y, self-report) and health related costs (parent-report), but these data are not included in the current manuscript.

Table 2
Outcome measures per condition.

Condition	Outcome measure ^a	T1 ^b pre-assessment		T2 post-assessment		FU1 3 months follow-up		FU2 6 months follow-up	
		M	SD	M	SD	M	SD	M	SD
		VS training n = 38	EVST bias index	516.52	1060.73	-1870.32	1363.49	-	-
	EVST RT positive	4181.12	1222.62	2600.46	774.17	-	-	-	-
	EVST RT negative	3664.59	739.25	4470.78	1545.05	-	-	-	-
	SCARED	26.61	13.62	23.19	13.00	19.22	12.96	19.04	16.62
	CDI	14.32	7.44	11.78	7.07	9.93	6.62	8.32	7.22
	RSES	26.87	4.94	29.19	4.88	30.30	4.02	31.16	5.11
	PTQ	42.05	13.31	36.69	13.41	36.41	14.19	33.28	16.20
	SDQ-P	9.27	5.64	8.45	5.68	8.56	5.43	7.04	4.17
	Positive mood	187.69	58.10	187.16	66.77	-	-	-	-
	Negative mood	52.34	54.13	49.00	50.53	-	-	-	-
	REC-T	-0.20	0.89	-0.61	0.85	-	-	-	-
VS placebo n = 32	EVST bias index	531.25	1088.26	123.80	744.38	-	-	-	-
	EVST RT positive	4193.56	1131.70	3559.69	525.44	-	-	-	-
	EVST RT negative	3662.31	855.94	3435.90	878.72	-	-	-	-
	SCARED	25.00	16.74	19.69	16.32	23.71	19.72	24.67	18.61
	CDI	11.50	8.11	8.85	6.42	8.57	8.87	10.92	8.35
	RSES	28.69	6.40	30.27	6.05	31.36	5.73	30.00	5.67
	PTQ	35.06	12.00	31.38	14.01	33.64	16.84	33.33	14.39
	SDQ-P	10.00	6.60	7.88	5.19	7.76	4.70	7.75	5.80
	Positive mood	201.12	54.49	182.31	70.11	-	-	-	-
	Negative mood	45.50	56.32	51.35	50.27	-	-	-	-
	REC-T	-0.34	0.72	-0.28	0.76	-	-	-	-
Control n = 38	EVST bias index	705.44	911.71	254.04	731.12	-	-	-	-
	EVST RT positive	4255.47	949.07	3849.04	920.41	-	-	-	-
	EVST RT negative	3550.04	729.47	3594.99	750.24	-	-	-	-
	SCARED	28.71	12.85	27.53	12.81	25.72	13.14	22.58	11.57
	CDI	12.71	7.62	12.22	9.26	11.25	9.30	9.04	7.15
	RSES	27.16	5.25	27.33	5.83	28.27	5.74	28.77	5.90
	PTQ	43.25	12.00	40.94	13.54	39.96	12.67	37.00	14.23
	SDQ-P	9.03	5.45	6.73	4.01	6.66	3.60	6.71	3.73
	Positive mood	178.50	59.84	178.72	56.88	-	-	-	-
	Negative mood	71.17	70.20	77.28	73.20	-	-	-	-
	REC-T	-0.31	0.79	-0.40	0.82	-	-	-	-

^a EVST = Emotional Visual Search Task; SCARED = Screen for Child Anxiety Related Emotional Disorders; CDI = Children's Depression Inventory; RSES = Rosenberg Self-Esteem Scale; PTQ = Perseverative Thinking Questionnaire; SDQ-P = Strengths and Difficulties Questionnaire (Parent); REC-T = Recognition Task.

^b Note that for positive and negative mood, T1 and T2 refer to pre- and post-stressor mood respectively, both assessed at the post-assessment session.

completed under supervision during regular school hours in a computer classroom. Adolescents fulfilling the inclusion criteria received another information letter inviting them for the study. The aim of the study was explained as 'investigating a training to make adolescents more resilient to stress and negative emotions, like feeling anxious or down'. At first, adolescents were told that they had heightened levels of 'negative feelings' and thus might profit from the training (n = 23). After lowering cut-off scores (see footnote 2), we removed this information and explained that adolescents would be randomly selected and invited to participate (n = 85). When both adolescents and one of their parents provided written informed consent, they were invited for the first assessment (T1, three to five weeks after screening). Assessment consisted of the EVST, REC-T, and the questionnaires and took place in group format in a computer classroom after the last school lesson,⁴ under supervision of one or two research assistants. The eight online training sessions were performed at home during the following four weeks. Each session started with instructions stressing the importance of creating a quiet environment for at least 20 min (e.g., turning music and phones off, closing web pages and not being distracted by others). Participants could complete the sessions whenever they wanted, but were encouraged to complete each new session within two days. A new session became available

twice a week, and was announced by e-mail and text message. Reminder e-mails were sent after two and five days, and participants who had not trained for more than seven days were contacted once by telephone, offering technical assistance when needed. After four weeks, the post-training assessment (T2) took place at school, again after the last lesson. T2 was almost identical to T1, but here the questionnaires were followed by the anagram stress task. After debriefing about the aim of the stress task, participants completed the evaluation questionnaire. Three and six months after T2 (FU1 and FU2), participants received an e-mail and text message to invite them to the online follow-up questionnaires.⁵ Non-responders were contacted by e-mail after two weeks, and by telephone after three weeks. Parents also received an e-mail to complete their questionnaires at T1, T2, FU1 and FU2 and were sent reminders after one and two weeks. Participants were compensated with vouchers and participation in a lottery, with the amount of compensation based on the number of training and assessment sessions completed (it ranged from 5 to 15 euro).

1.8. Data analyses

For the EVST, incorrect trials (1.6% at T1, 1.4% at T2), corrections of incorrect trials, and trials with RTs more than 2 SDs from the

⁴ Due to scheduling difficulties, for some adolescents, the assessment took place during school hours.

⁵ Due to a technical error, five participants received the questionnaires of FU1 six weeks too early, but excluding these data did not change results.

individual's mean for the positive and negative blocks separately (2.2% at both T1 and T2), were removed before computing the attentional bias index (de Voogd et al., 2014).

To study differences in outcome measures between conditions and time points, we conducted regression analyses with the factorial predictors Condition and Time, and their interactions. We assumed that missing data were missing at random, and therefore performed mixed regression analyses (using IBM Statistical Package for Social Sciences 20), taking into account all available data, without excluding participants with missing data at specific time points (cf. Mallinckrodt et al., 2003; Verbeke & Molenberghs, 2000). For all outcome measures, we tested a mixed model with Participant as the grouping variable and Time as a repeated measure variable, using maximum likelihood estimation. The factor Time had two levels for EVST, REC-T and mood scales (T1 and T2), and four levels for SCARED, CDI, RSES, PTQ, and SDQ-P (T1, T2, FU1, and FU2). With regard to the covariance between time points, we have verified (based on AIC and BIC criteria) whether these were structured according to compound symmetry, or first order autoregressive, or whether these were unstructured.

To test our hypotheses that VS training would reduce attentional bias, interpretation bias, and symptoms of anxiety and depression, and increase resilience, the basic model for all outcome measures included the factors Condition, and Time, and their interactions. Parameters were excluded from the model in a backward elimination procedure based on AIC and BIC criteria and significance levels. To test the moderating role of number of sessions completed and baseline attentional bias, and to explore the effect of the condition participants thought they were in, separate models were tested including Condition, Time, the moderator of interest, and their interactions. The effects of interest in these analyses were the three-way interactions between Condition, Time, and potential moderator.

Bonferroni-Holm correction was applied to control for Type I errors related to the number of outcome measures. Effects with $p < 0.05$ that did not survive this correction were defined as marginal. Statistics of the original and final models for all hypotheses can be found in Table 3, and Table 4 shows the relevant parameters estimates (with T1 and the VS training group as reference categories).

2. Results

2.1. Preliminary analyses

At baseline (T1), a significant attentional bias for negative information was found, as indicated by an attentional bias index (RT for positive faces – RT for negative faces) significantly larger than zero, $t(107) = 6.02$, $p < 0.001$. Attentional bias was not significantly correlated with anxiety or depression at T1, $r = 0.13$, $p = 0.19$, and $r = 0.03$, $p = 0.73$ respectively. Of all emotional measures, only PTQ scores were significantly correlated with attentional bias at T1, $r = 0.23$, $p = 0.016$.

On average, participants who received training completed 5.31 training sessions ($SD = 3.20$). The VS training and VS placebo group did not differ in the number of training sessions completed, $t(57.04) = 1.18$, $p = 0.243$, or the number of days between first and

last training session, $t(60) = -0.18$, $p = 0.856$. In total, 60% of the participants who received training completed at least one session a week for four weeks (23 in the VS training group and 19 in the VS placebo group).⁶

2.2. Attentional bias and primary outcome measures

Our first hypothesis, that attentional bias would be more reduced in the VS training group compared to the VS placebo training and Control group, was confirmed by a significant Condition \times Time interaction effect, $p < 0.001$ (see Table 3), indicating a significantly larger reduction in attentional bias from pre- to post-assessment in the VS training group, compared to both the VS placebo and Control group (see Table 4).⁷

Our second hypothesis, that VS training, compared to the VS placebo and Control group, would also reduce anxiety and depressive symptoms, was not confirmed, as no significant Condition \times Time interactions were observed (see Table 3). Only significant main effects of Time were observed, both p 's < 0.001 , indicating a general reduction of symptoms over time (including FU), with significant differences between T1 and all other time points (see Table 4).

Exploratory analyses on the relation between change in attentional bias and change in anxiety or depressive symptoms (see Table 5 for descriptives), revealed no significant correlations, all p 's > 0.519 . When restricting the analysis of training effects to participants for whom a reduction in attentional bias was observed ($n = 68$), results were comparable to our main analyses, except for a marginal Condition \times Time interaction for anxiety, $F(6, 51.30) = 2.55$, $p = 0.031$. However, no significant differences between specific time points or conditions were observed.

2.3. Secondary emotional outcome measures

With regard to secondary measures of emotional functioning, our hypotheses were also not confirmed as no significant Condition \times Time interactions were observed (see Table 3). For self-esteem, and social-emotional and behavioral problems, only significant main effects of Time were observed, both p 's < 0.001 , indicating increased self-esteem and reduced social-emotional and behavioral problems over time. For perseverative negative thinking, the same pattern of significant reductions over time was observed, $p < 0.001$, but here a main effect of Condition was also observed, $p = 0.014$, indicating significantly lower PTQ-scores in the VS placebo group irrespective of time point.

In response to the stress task, no changes in positive and negative mood were observed (no significant main effect of Time), nor did training groups differ in mood change (no significant Group \times Time interaction effect).

2.4. Transfer to interpretation bias

Our third hypothesis, that ABM effects would generalize to interpretation bias was partly confirmed, as a marginal Condition \times Time interaction was observed, $p = 0.023$ (see Table 3), indicating an increase in positive interpretation bias in the VS training group from pre- to post-assessment compared to both the VS placebo and Control group (see Table 4). Change in attentional bias and change in interpretation bias were not significantly correlated, $r = 0.16$, $p = 0.125$.

⁶ Exploratory analyses were performed for this subgroup and the no-training control group, investigating training effects on our primary and secondary outcome measures. Results were comparable, except for a marginally significant Condition \times Time interaction for self-esteem scores, $F(6,64.07) = 2.93$, $p = 0.014$. The VS training group showed a larger increase post-training compared to the no-training control group, but no differences were observed compared to the VS placebo group or at follow-up.

⁷ This analysis was repeated after removing five (within-group) outlying individuals with regard to RTs and bias index at either T1 or T2, and results were comparable.

Table 3
Statistics of the original and final models.

Outcome measure	Model ^b	Model fit		Time		Condition		Condition * Time		Condition * Time * Moderator	
		AIC	BIC	F	df	F	df	F	df	F	df
EVST ^a	Condition * Time (CS)	3375.21	3401.68	68.09***	1,104.11	24.48***	2,106.33	25.51***	2,103.94	–	–
SCARED	Condition * Time (UN) * Sessions^c	2159.93	2191.30	49.30***	1,67.95	22.08***	1,67.87	20.84***	1,67.95	8.97**	1,71.06
	Condition * Time (UN)	2428.07	2511.72	16.74***	3,66.01	1.23	2,107.19	1.91 [†]	6,69.36	–	–
CDI	Time (UN)	2426.20	2479.43	16.62***	3,64.81	–	–	–	–	–	–
	Condition * Time (UN) * Baseline EVST	2442.30	2571.58	14.81***	3,65.46	0.97	2,105.06	2.13 [†]	6,68.10	0.66	6,66.14
	Condition * Time (UN) * Sessions ^c	1549.57	1636.09	11.47***	3,43.37	0.07	1,73.70	0.93	3,43.37	0.40	3,46.20
	Condition * Time (UN)	2050.41	2133.99	12.12***	3,77.19	0.64	2,104.57	1.74	6,81.17	–	–
RSES	Time (UN)	2045.59	2098.78	13.07***	3,73.85	–	–	–	–	–	–
	Condition * Time (UN) * Baseline EVST	2066.39	2195.56	11.29***	3,76.04	0.52	2,105.22	1.69	6,79.11	1.03	6,75.93
	Condition * Time (UN) * Sessions ^c	1267.58	1354.11	7.83***	3,56.88	0.93	1,67.79	2.86*	3,56.88	0.66	3,59.88
PTQ	Condition * Time (UN)	1834.72	1918.43	9.16***	3,62.78	1.49	2,107.83	1.43	6,94.47	–	–
	Time (UN)	1829.22	1882.49	9.71***	3,60.99	–	–	–	–	–	–
SDQ-P	Condition * Time (UN)	2387.95	2471.53	17.61***	3,78.36	3.12*	2,112.45	1.19	6,83.33	–	–
	Time + Condition (UN)	2382.87	2443.66	19.03***	3,74.49	4.64*	2,108.96	–	–	–	–
Positive mood	Condition * Time (CS)	1790.96	1844.48	7.52***	3,235.00	1.68	2,101.46	0.70	6,234.78	–	–
	Time (CS)	1782.42	1805.35	7.69***	3,234.18	–	–	–	–	–	–
Negative mood	Condition * Time (CS)	2043.66	2069.55	1.37	1,94.00	0.48	2,94.00	1.20	2,94.00	–	–
	Time (CS)	2038.99	2051.94	0.94	1,94.00	–	–	–	–	–	–
REC-T	Condition * Time (UN)	2060.40	2086.29	0.21	1,94.00	2.51 [†]	2,94.00	0.26	2,94.00	–	–
	Time (CS)	2057.80	2070.75	0.21	1,94.00	–	–	–	–	–	–
REC-T	Condition * Time (CS)	451.74	478.12	3.89 [†]	1,100.29	0.21	2,110.78	3.93*	2,100.16	–	–
	Time (CS)	451.44	464.64	4.41*	1,100.55	–	–	–	–	–	–

[†]p < 0.10, *p < 0.05, **p < 0.01, ***p < 0.001. Note that most p-values between p < 0.01 and p < 0.05 are non-significant after Bonferroni-Holm correction.

^a EVST = Emotional Visual Search Task; SCARED = Screen for Child Anxiety Related Emotional Disorders; CDI = Children's Depression Inventory; RSES = Rosenberg Self-Esteem Scale; PTQ = Perseverative Thinking Questionnaire; SDQ-P = Strengths and Difficulties Questionnaire (Parent); REC-T = Recognition Task; UN = Unstructured covariance; CS = Compound Symmetry covariance structure.

^b Bold print = final model, based on AIC and BIC criteria and significance of parameters. Italic = marginal model. Lower AIC and BIC values indicate better model fit. Note that moderation models were tested after testing general training effects on primary outcomes measures (SCARED and CDI).

^c VS training and VS placebo only.

Table 4
Parameter estimates.

Outcome measure	Model	VS placebo ^a		Control		T2		FU1		FU2		T2 VS placebo		T2 Control	
		B	SE	B	SE	B	SE	B	SE	B	SE	B	SE	B	SE
EVST ^b	Condition * Time	14.72	238.31	188.91	227.87	-2386.18***	221.54	–	–	–	–	1978.82***	329.65	1937.37***	307.91
SCARED	Time	–	–	–	–	-3.21***	0.75	-4.92***	1.02	-7.46***	1.16	–	–	–	–
CDI	Time	–	–	–	–	-1.83***	0.46	-2.45***	0.56	-4.25***	0.74	–	–	–	–
RSES	Time	–	–	–	–	1.48***	0.41	2.10***	0.45	2.93***	0.56	–	–	–	–
PTQ	Condition + Time	-6.17*	2.88	2.21	2.74	-3.87***	0.80	-4.30***	0.99	-7.76***	1.11	–	–	–	–
SDQ-P	Time	–	–	–	–	-0.73*	0.33	-1.28***	0.34	-1.53***	0.36	–	–	–	–
REC-T	Condition * Time ^c	-0.14	0.19	-0.12	0.18	-0.43**	0.12	–	–	–	–	0.50**	0.19	0.35*	0.17

[†]p < 0.10, *p < 0.05, **p < 0.01, ***p < 0.001. Note that most p-values between p < 0.01 and p < 0.05 are non-significant after Bonferroni-Holm correction.

^a Reference categories for parameters estimates were the VS training condition and pre-training assessment (T1). T2 = post-training assessment; FU1 = 3 months follow-up; FU2 = 6 months follow-up.

^b EVST = Emotional Visual Search Task; REC-T = Recognition Task; SCARED = Screen for Child Anxiety Related Emotional Disorders; CDI = Children's Depression Inventory; RSES = Rosenberg Self-Esteem Scale; PTQ = Perseverative Thinking Questionnaire; SDQ-P = Strengths and Difficulties Questionnaire (Parent).

^c Note that this interaction was only marginally significant.

Table 5
Change in attentional bias, anxiety and depression scores.

Outcome measure ^a	Time ^b	VS training		VS placebo		Control	
		M	SD	M	SD	M	SD
EVST	T1-T2	-2382.26	1815.37	-406.78	1230.92	-433.72	726.27
REC-T	T1-T2	-0.44	0.88	0.08	0.66	-0.07	0.63
SCARED	T1-T2	-4.41	6.54	-5.65	8.88	-0.64	6.17
SCARED	T1-FU1	-6.22	8.68	-2.50	9.58	-4.48	6.65
SCARED	T1-FU2	-7.08	10.36	-8.33	8.71	-8.08	9.81
CDI	T1-T2	-2.91	3.96	-2.50	5.34	-0.50	3.97
CDI	T1-FU1	-2.74	4.18	-1.57	4.62	-2.96	5.21
CDI	T1-FU2	-4.72	5.90	-2.58	5.14	-5.15	6.79

^a EVST = Emotional Visual Search Task; REC-T = Recognition Task; SCARED = Screen for Child Anxiety Related Emotional Disorders; CDI = Children's Depression Inventory.

^b T1 = pre-training assessment; T2 = post-training assessment; FU1 = 3 months follow-up; FU2 = 6 months follow-up.

Table 6
Response to evaluation questionnaire in VS training and VS placebo group.

		VS training	VS placebo
The aim of the training was clear before I started	% Agree	43.8	32.0
	% Not agree	28.1	44.0
	% Neutral	28.1	24.0
I considered it important to participate in the training sessions	% Agree	43.8**	32.0
	% Not agree	6.3	48.0
	% Neutral	50.0	20.0
I enjoyed the training	% Agree	31.3	24.0
	% Not agree	31.3	44.0
	% Neutral	37.5	32.0
The training task was easy ^a	% Agree	78.1	76.0
	% Not agree	3.1	4.0
	% Neutral	18.8	20.0
The instructions on what to do in the training were clear	% Agree	81.3	76.0
	% Not agree	12.5	12.0
	% Neutral	6.3	12.0
I could easily concentrate on the training	% Agree	50.0	52.0
	% Not agree	21.9	21.0
	% Neutral	28.1	28.0
I think I learned to cope better with negative emotions and stress	% Agree	9.7	11.5
	% Not agree	51.6	61.5
	% Neutral	38.7	26.9
I am satisfied with the training	% Agree	81.3	72.0
	% Not agree	18.8	28.0
	% Agree	45.2	24.0
I would recommend the training to a friend who feels anxious or sad	% Not agree	54.8	76.0
	% Agree	41.9*	12.0
	% Not agree	58.1	88.0
Which version of the training do you think you got; the 'real' or 'fake' one?	'Real'	51.6 [†]	28.0
	'Fake'	48.4	72.0

[†] $p < 0.10$; * $p < 0.05$; ** $p < 0.01$ (group difference).

^a Recoded from 'The training task was difficult'. Note that some other questions were included in the questionnaire to evaluate the reward system and the intensity of the training. These data are not included in the current manuscript for reasons of conciseness, but can be requested from the first author.

2.5. Moderation of training effects

The effect of VS training on attentional bias was moderated by the number of training sessions completed (see Table 3), such that a larger difference between VS training and VS placebo was observed for participants who completed relatively many training sessions, $B = 367.94$, $SE = 122.88$, $p = 0.004$ (note that the VS training group is the reference category). Contrary to our expectations, training effects on anxiety and depression were not moderated by the number of training sessions completed nor baseline attentional bias, as no significant three-way interactions with these variables were observed, all p 's > 0.410 .

2.6. Evaluation questionnaire

Analyses of the evaluation questionnaire answers (Table 6) revealed more positive evaluations of the VS training compared to the VS placebo. That is, participants considered it significantly more important to participate in the training sessions, $\chi^2(2) = 13.89$, $p = 0.001$, and would more often train again in case of emotional problems, $\chi^2(2) = 6.08$, $p = 0.014$. Also, a difference that just fell short of significance was observed for the training condition participants thought they were in, $\chi^2(2) = 3.19$, $p = 0.074$, such that participants in the VS placebo group more often tended to think they had received a 'fake' training compared to those in the VS training group. Whether participants thought they were in the experimental or placebo group did not affect training efficacy, as no significant Condition x Time x Perceived condition interactions were observed, all p 's > 0.392 .

3. Discussion

The aim of the current study was to test the short- and long-

term effects of online visual search attentional bias modification training compared to both placebo training and no-training in adolescents with heightened symptoms of anxiety or depression. Consistent with our first hypothesis, a large reduction in negative attentional bias was observed immediately after training in the VS training group compared to both the placebo and control group. Our second hypothesis, that VS training, compared to the two control conditions, would reduce primary outcomes of anxiety and depressive symptoms, and increase emotional resilience, was not confirmed, as no superior effects of the VS training on primary or secondary emotional outcome measures were found. That is, irrespective of condition, symptoms of anxiety and depression generally decreased and resilience increased over time. With regard to our third hypothesis on generalization of attentional bias change, a marginally significant corresponding effect on interpretation bias was observed. Contrary to our expectations, emotional training effects were not moderated by the number of training sessions completed or the relative strength of attentional bias at baseline.

For change in attentional bias, a moderating effect of the number of sessions completed was observed: participants who completed relatively more VS training sessions showed larger reductions in attentional bias. This corresponds to previous findings (de Voogd, Wiers et al., 2016; Hakamata et al., 2010) and suggests that multi-session training leads to an improvement in attentional bias that increases with the amount of training. However, as no correlations between attentional bias and anxiety or depressive symptoms were observed, nor between changes in these measures, one might wonder whether our assessment task accurately reflects the kind of information processing biases that are relevant to anxiety and depression in at-risk samples. Although adolescents in the current study on average displayed a negative attentional bias, which decreased following ABM training, it might not have been the most relevant target for this sample when aiming at symptom

improvement. Furthermore, the large change in attentional bias without corresponding emotional effects might have been related to the relatively explicit nature of the task, as participants were instructed to search for positive stimuli. Previous research has suggested that for emotional change to occur, a more positive bias should be acquired in an implicit way (e.g., Grafton, Mackintosh, Vujic, & MacLeod, 2014; but see; Nishiguchi, Takano, & Tanno, 2015).

Also, as the attentional bias assessment task closely resembled the training task, it is unclear whether training-related change would generalize to other measures of attentional bias or real life information processing. Some studies have observed effects of VS training on another measure of attentional bias, the dot-probe task (e.g. Dandeneau et al., 2007; Dandeneau & Baldwin, 2009), while others did not (e.g. de Voogd, Wiers et al., 2016; Kruijt et al., 2013). In the current study, a marginal effect on interpretation bias was observed, which suggests that some change in information processing beyond task-specific effects might have occurred. This is a promising finding, as according to the combined cognitive bias hypothesis, various cognitive biases interact in predicting emotional disorders (Everaert et al., 2012).

The observed general improvement in terms of anxiety and depressive symptoms and emotional resilience, resembles long-term patterns in previous ABM studies (de Voogd, Wiers et al., 2016; Sportel et al., 2013). An important strength of the current study is that ABM training was not only compared to a placebo training, but also to a no-training control group. Improvements in both training and placebo conditions could indicate the presence of demand effects or unintended active ingredients of the placebo training (cf. Enock, Hofmann, & McNally, 2014; Heeren et al., 2015a). However, as also no differences were observed compared to the no-training group, a natural decline in symptoms seems the most likely explanation.

In addition to the lack of efficacy of our training program, it was also evaluated relatively negatively. Only a minority of the adolescents would perform the training again or recommend the training in case of emotional problems, which seems to be related to low levels of enjoyment and the lack of a clear rationale, resembling previous reports about the dot-probe task (Beard et al., 2011). The placebo training received more negative evaluations than the VS training and marginally more participants in this group guessed that they were in the placebo group. Although this perception did not affect results, these differences are a limitation of our placebo task and might also explain the slightly higher (though non-significant) drop-out in this condition. The stimuli in the placebo condition differed considerably from the training task, and the absence of exposure to emotional faces might be considered another shortcoming of the placebo condition. However note that a previous study comparing both conditions to an exposure-control condition has shown that training effects were not due to mere exposure (Dandeneau et al., 2007). The high drop-out rates in all conditions are an important limitation of the current study, although these rates are not uncommon in longitudinal and online research (cf. Sportel et al., 2013; Yang, Zhang, Ding, & Xiao, 2016). The reduction in sample size reduced our power to detect differential training effects and might also have affected the representativeness of our results. A second limitation concerns the high variability in timing of the training sessions. Since participants of a previous study (de Voogd, Wiers et al., 2016) often requested to complete sessions they missed at a later moment, we decided to loosen the deadlines for training sessions in the current study. Although we still encouraged participants to complete a session within two days, several adolescents did not train for two or three weeks and then completed all sessions over the course of several days. It is yet unclear what an optimal spreading in training

sessions would be and what the consequences are of such massed versus spaced presentation (MacLeod & Clarke, 2015). However, based on the assumption that newly acquired information processing styles should be applied to daily experiences in order to have emotional effects (cf. Harmer, Goodwin, & Cowen, 2009), some separation of sessions seems important. However, note that exploratory analyses on the subset of participants (60%) that completed at least one training session a week for four weeks yielded comparable results. A related issue and limitation is the lack of experimental control that is inherent of online research. Although adolescents were instructed to create a quiet environment, the exact circumstances under which training was performed are unknown, and could have influenced concentration and engagement.

A third limitation concerns the choice of our stress task. As it appeared to be ineffective in eliciting a stress response, any differential effects in the training group were difficult to observe. Furthermore, this task might not have been the best match to the training task. As the visual search training involves social information, a more socially threatening stress task would have been more relevant (e.g. telling participants that their results will be shared). However, the group format of our assessments limited the possibilities for deception.

To summarize, the current study found no evidence for the efficacy of online visual search ABM in reducing anxiety or depression or increasing emotional resilience in selected adolescents. Compared to VS placebo training and a no-training control group, the VS training reduced negative attentional bias, especially when relatively many training sessions were completed, and tended to affect interpretation bias. However, improvements in emotional functioning were observed irrespective of condition and most likely reflect a natural decline in symptoms. The current results add to the growing number of null-findings on online applications of ABM in general (Mogoșe et al., 2014), and specifically in youth samples (Cristea et al., 2015b). The question remains whether the promising findings in controlled laboratory environments could be translated to real world interventions that profit from the advantages of online delivery.

Declaration of conflicting interests

The authors declare that there are no conflicts of interest.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at <http://dx.doi.org/10.1016/j.brat.2017.02.006>.

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