Can training change attentional breadth? Failure to find transfer effects

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Abstract

Recently, there is increasing interest in the causal relationship between attentional breadth and emotion regulation. To test this causal relationship, attentional breadth needs to be manipulated stringently. The aim of the current research was to establish whether visual attentional breadth could be manipulated through experimental training procedures. We conducted two single-session training experiments and one multiple-session training experiment, all of which contained pre- and post-training assessments to test the direct transfer effects of training on attentional breadth construed in different measures. For the first single-session training (Experiment 1), no training effects were found to transfer to the subsequent attentional breadth measures in terms of global-local processing preference. For the second single-session training (Experiment 2) and the five-day training (Experiment 3) which combined both trainings from Experiment 1 and 2, there were some indications that attentional breadth can be decreased, but there was no evidence that it could be increased neither in terms of global-local processing preference nor in terms of scope of visual perception. Bayesian analysis confirmed the null-hypothesis of no increase in attentional breadth through delivery of these training procedures. Therefore, our findings do not support the hypothesis that training variants of the Global-Local attentional breadth task or of the visuospatial attentional breadth task can stably alter attentional breadth in healthy students. Possible explanations and implications are discussed.

Keywords: visual attention; attentional scope; emotion regulation; single-session training; multiple-session training

Introduction

A growing literature suggests that attentional breadth plays an important role in emotion regulation (Lutz, Slagter, Dunne, & Davidson, 2008), mental wellbeing and psychopathology. Specifically, previous studies have related broad attentional breadth to positive mood (Derryberry & Tucker, 1994; Rowe, Hirsh & Anderson, 2007), improved self-regulation (Hanif et al., 2012), enhanced resilience to stress (Fredrickson, 2004), and increased cognitive flexibility (Olivers & Nieuwenhuis, 2005; Zmigrod, Zmigrod, & Hommel, 2015). In contrast, narrowed attentional breadth has been related to negative emotions (Fenske & Eastwood, 2003; Gable & Harmon-Jones, 2008), attention capture by negative stimuli (Gable & Harmon-Jones, 2012), increased anxiety (Derryberry & Tucker, 1994), and high levels of rumination (Grol, Hertel, Koster, & De Raedt, 2015). Given the distinctive theorized influence of attentional breadth in psychopathology (e.g., Whitmer & Gotlib, 2013), it is important to establish the causal nature of any observed relationship between attentional breadth and the above constructs. A wide variety of research has investigated whether variation in emotion can causally impact on attentional breadth, by investigating the influence of emotional states on attentional breadth (Derryberry & Tucker, 1994; Grol & De Raedt, 2014; Hüttermann & Memmert, 2015; Rowe et al., 2007; Vanlessen, De Raedt, Koster, & Pourtois, 2016). In contrast, less research has examined whether attentional breadth can be experimentally manipulated, which is necessary to observe its influence on other psychopathological factors such as resilience and rumination. Hence, it is vitally important to establish whether attentional breadth can be directly manipulated using experimental training procedures.

Several studies have sought to modify attentional breadth using amended versions of the Global-Local task. For example, in an ERP study, Gable and Harmon-Jones (2012) used the Global-Local task to induce a global or local processing preference on a trial-by-trial basis before exposing participants to disgust-evoking and neutral pictures. Specifically, they asked participants first to identify either the global or the local letter presented in a visual display, and then measured the relative degree to which attention was captured by disgusting and neutral images. The results showed that when participants were induced to process global letters, rather than induced to process local letters, they showed reduced N1 amplitude towards disgust pictures, suggesting that inducing greater attentional breadth reduced processing of this negative information. Other studies have aimed to induce a more sustained change in attentional breadth using training variants of the Global-Local task. For example, Hanif et al. (2012) sought to induce differences in attentional breadth using such a modified Global-Local task. During this task, a set of hierarchical shaped stimuli were presented and participants were required to always identify either the global shape (broad training) or the local shape (narrow training). These two groups showed differences in self-regulation after exposure to this attentional breadth manipulation, as measured by the time spent squeezing a handgrip exerciser, which reflects individuals' efforts to regulate negative feelings experienced during the task. These results are consistent with the possibility that manipulation of attentional breadth can causally influence self-regulation.

However, an important limitation of these earlier studies is that, because no measures of attentional breadth were taken, it remains unknown whether or not the training procedures served to modify attentional breadth as intended. Unless it is first confirmed that the manipulation exerted the required impact on attentional breadth, these studies therefore permit no strong conclusion concerning the causal influence of attentional breadth on emotion regulation. Indeed, prior literature provides no strong basis for assuming that attentional breadth can be modified using such training procedures.

In addition, it is also relevant to note that these previous studies only construed attentional breadth in terms of global-local processing. In fact, attentional breadth has been conceptualized in a variety of different ways in the literature, resulting in the lack of a single overarching definition of the construct. For instance, some investigators have operationalized attentional breadth as scope of visual perception (McConkie & Rayner, 1975) or breadth of visuospatial attention (Rowe et al., 2007), while others have operationalized it in terms of variation in the degree to which processing favors global versus local aspects of hierarchical stimuli (Fredrickson & Branigan, 2005; Kimchi & Palmer, 1982). Other researchers have construed attentional breadth as the breadth of information that can be held and manipulated in working memory (Whitmer & Gotlib, 2013). It is not clear yet whether the impact of experimental manipulations that influence one type of attentional breadth transfer to also affect other types of attentional breadth. Therefore, it would be appropriate to consider whether an intended training procedure can modify alternative types of attentional breadth, for example, when this is construed in terms of visuospatial attentional scope (cf. Vanlessen et al., 2016).

Current Studies

The aim of the present research was to establish whether attentional breadth can be changed through training procedures that specifically and directly manipulate attentional breadth and, if so, whether the attentional effect of these manipulations would be evident on assessment tasks that construe attentional breadth in multiple ways. To address limitations of previous research, we used more stringent study designs (see Table 1 for details), in which we directly tested whether attentional breadth training exerted a significant impact on attentional breadth. For this purpose, we performed two single-session attentional breadth manipulation studies (Experiments 1 & 2), each containing an adequate control condition and a pre- and post-training assessment of attentional breadth (i.e., global/local tendency vs. size of visual perception). In a third experiment we used a multiple-session, multiple training task approach in order to maximize the potential to modify attentional breadth and also to provide insight into sustained effects of attentional breadth training (Experiment 3).

Given the similar nature of Experiments 1 and 2 (i.e., both were single-session manipulations exploring effects of attentional breadth training on a Global-Local assessment task), these first two experiments will be presented together, after which Experiment 3 will be presented. In contrast to previous research (Hanif et al, 2012; vanDellen, Sanders, & Fitzsimons, 2012), the present series of studies will serve to establish whether or not attentional breadth can be directly manipulated using previously employed and novel candidate training procedures, delivered in either single-session or multiple-session format.

Experiment 1-2

In Experiment 1, we employed the modified Global-Local task as our candidate training procedure targeting global/local processing style, but we now examined the impact of this procedure on attentional breadth, using a Global-Local attentional breadth assessment task. This task measures individuals' attentional preference while processing information that exhibits both global and local features. Provided the absence of training-induced changes on the transfer task, in Experiment 2 we adopted an alternative candidate training approach, now targeting visuospatial breadth of attentional processing. For this purpose, we developed and tested an innovative visuospatial training task either to induce a gradually broadening of attention, or to induce narrow breadth of attention. To examine whether any impact of this new visuospatial training on attentional breadth also would be evident on assessment tasks based on alternative conceptions of attentional breadth, we again took the Global-Local assessment measure of attentional breadth after the training procedure.

Methods

Participants.

Forty-five (Experiment 1) and sixty (Experiment 2) undergraduates[1] were randomly assigned to either broad or narrow breadth training groups. Participant characteristics for each experiment are described in Table 2.

Material.

All the assessment and training tasks were programmed using the E-PRIME 2 software package (Psychology Software Tools Inc., 2007). Black stimuli were presented against a white background on a 17 inch (Experiment 1) or 19 inch (Experiment 2) computer screen.

Questionnaires.

Depression. Depressive symptoms were assessed with the Beck Depression Inventory-II (BDI-II; Beck, Steer, & Brown, 1996), to ensure training groups did not differ in depression levels before training commenced. The BDI-II contains 21 items, scored on a four-point scale (0-3), and measures the occurrence and severity of depressive symptoms over the past two weeks.

Positive and negative affect. To ensure that training groups did not differ in either positive or negative affect, they completed the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988), which is a brief measure containing 20 items that assess both positive affect (PA) and negative affect (NA). Participants completed the state version in which they had to rate the extent to which they were currently experiencing a certain affective state on a 5-point scale. The Dutch translation of the PANAS has shown good psychometric properties (Peeters, Ponds, & Vermeeren, 1996).

Attentional breadth assessment task.

In both experiments, before and after the candidate attentional breadth training procedure participants' attentional breadth was assessed using the standard Global-Local Navon Letter task (Navon, 1977). The total number of trials was 32 in Experiment 1, whereas in Experiment 2 the number of trials in both the pre- and post-training assessment was doubled to 64 trials, to increase power to pick up potential training effects. On each trial, a black fixation cross was presented in the center of the screen for 500 ms. Then, 1 of 8 global-local Navon figures was presented. The target letter in each figure was either T or H. On each trial, only one of these two letters was presented, either as a local shape (e.g., the global letter L made up of little T's) or as a global shape (e.g., the global letter H made up of little F's). Participants had to indicate whether the presented target letter was a T or an H, as quickly and accurately as possible, by pressing one of two keys on a standard AZERTY keyboard. Thus, a local trial was the one in which the target letter was the local feature, whereas a global trial was the one in which the target letter was the global feature. All Global-Local figures were written in upper-case letters (Times New Roman). Global letters were either global T's composed of local F's or L's, or global H's composed of local F's or L's, whereas Local letters were either local T's forming global F's or L's, local H's forming global F's or L's. In line with Hanif et al. (2012), each global letter encompassed a horizontal visual angle of 6.2 ° and a vertical angle of 14.3 °, whereas each local letter encompassed a horizontal visual angle of 1.1 ° and a vertical angle of 1.4 °. 50% of the trials were figures with a global target, 50% with a local target. The target remained on the screen until response. The inter-trial interval was 2000 ms.

Attentional breadth training tasks.

Global-Local training. In Experiment 1, we endeavored to manipulate attentional breadth using a modified version of the abovementioned Global-Local task (Navon, 1977). Specifically, we exposed participants to one of the two training variants of this task, each delivering 160 trials. One variant was designed to encourage broadening of attention by delivering 80% global versus 20% local trials, and the other variant was designed to encourage narrowing of attention by delivering 80% local versus 20% global trials.

Participants were required either to only respond to the global trials (the global training group) or only respond to the local trials (the local training group). Thus, participants had to respond to the 80% of trials delivered in the required attentional breadth processing mode and did not respond to the 20% delivered in the alternative attentional breadth mode. Although training variants of the Global-Local task has been used in many previous studies with the intention of manipulating attentional breadth, there has been no uniform format for such training variants. For example, Gable and Harmon-Jones (2012) primed their participants with this task on a trial-by-trial basis whereas Hanif et al. (2012) asked their participants to always identify either the global shape or the local shape during manipulation. We decided to an 80% vs 20% ratio to encourage participants to focus as required on most trials with the occasional trials of the alternative attentional mode to reduce boredom during the task.

Visuospatial training. In Experiment 2, we developed and tested a new candidate procedure to manipulate attentional breadth. This procedure was delivered in either of two conditions designed to differentially modify attentional breadth: one intended to train broadened attention by improving attentional acuity across a wide visual angle, and the other intended to train narrowing of attention by employing the reverse contingency. Because previous research has shown that narrowed attentional breadth is related to decreasing mental well-being, here in the narrow training group, participants were only trained by improving the attentional acuity in a fixed visual angle instead of narrowing their initial attentional breadth. Participants were instructed to maintain their gaze on the center of the screen throughout the experiment and to use a chinrest to control the viewing distance. On every trial, a black fixation cross was presented in the middle of the screen. After 500 ms, while the fixation cross stayed on the screen, six letters (randomly chosen T's and H's; all uppercase, Calibri, 18) were briefly and simultaneously shown on screen for 100 ms. These six letters were positioned at different distances from the center of the screen, located on six of the 24 positions arranged on eight points around the circumference of three invisible circles (see Figure 1). More specifically, one of the six letters was presented randomly at one of the eight positions on the circle the closest to fixation (radius circle = 50 pixels), four of the six letters were presented at the circle on medium distance from fixation (radius circle = 150 pixels) and one of the six letters was presented randomly at one of the eight positions on the circle the furthest from fixation (radius circle = 250 pixels). Depending on the training condition, participants were required to identify either the letter closest (narrow attention group) or furthest (broad attention group) from the center of the screen. This way, participants in each of the two training groups were required to adopt either a narrow or broad attentional focus, respectively, to optimally perform the task. In the broad attention group, whenever accuracy level on a block of trials was above 80%, the radius of the imperceptible circles increased by 20 pixels to encourage the further broadening of attention. Otherwise, the maximal eccentricities stayed at the last level, when participants' performances were below 80%. In the narrow attention group, the radius remained constant across all blocks. The trials were presented in eight blocks of 32 training trials and four manipulation check trials, each block separated by a short break. In the manipulation check trials, a set of six different letters were presented with the same random configurations and presentation time as the training trials. However, on these trials, individuals were instructed to identify as many letters as possible. This allowed us to examine whether the letters that were best identified were those presented closest, middle distant or furthest from the center of the screen. Narrower attention will be indicated by a heightened tendency to identify the letters close to the screen center, whereas broader attention will be indicated by a more even probability of identifying letters distributed across the full breadth of the display.

Procedure.

Written informed consent was obtained at the beginning of the experiment after which participants completed the BDI-II and PANAS questionnaire. They then completed the pre-assessment. Due to the different nature of the assessment tasks, participants were seated approximately 60 cm from the screen in Experiment 1 and 30 cm from the screen in Experiment 2. Next, participants were randomly assigned to one of the two training groups and completed the corresponding version of the Global-Local training task in Experiment 1, or the visuospatial training task in Experiment 2. Immediately following this training procedure, the attentional breadth assessment task was re-administered, after which participants were fully debriefed. The experiments were approved by the local ethical committee of the Faculty of Psychology at Ghent University and participants received reimbursement.

Results

Participant characteristics.

Participants were excluded from the analyses either because their performance accuracy was not above chance (n = 2 in Experiment 1), because their mean RT deviated more than 2.5 SDs from the sample mean during the pre-training assessment (n = 2 in Experiment 1; n = 1 in Experiment 2), or because they failed to complete both pre- and post-training assessments (n = 2 in Experiment 1). Participants also were excluded if their depressive symptoms met or exceeded a moderate level of depression, indicated by a BDI-II score greater than or equal to 20 (n = 3 in Experiment 2; for criteria, see Beck et al., 1996). Accordingly, six participants were excluded from Experiment 1 and four participants from Experiment 2.

Table 2 presents mean scores and standard deviations on all self-report measures for the final samples (Experiment 1: n = 39; Experiment 2: n = 56) assigned to each of the two training groups. In both experiments, there were no significant differences between the two training groups in terms of the negative and positive affect scales of the PANAS, BDI score or pre-training assessment (all *t*s < 1).

Impact of training on attentional breadth assessment[2].

For the Global-Local assessment task in each experiment, trials on which participant did not respond correctly were excluded (< 6.1 %), as were trials in which a participant's RT deviating more than 2.5 SDs from that participant's mean RT for this particular trial type (< 2.9 %). The remaining RT data (see Table 3 for details) were subjected to a mixed-design ANOVA, with assessment time (pre- vs. post-training) and trial type (global vs. local) as within-subject factors and training group (broad vs. narrow) as a between-subjects factor. A three-way interaction involving assessment time, trial type and group was expected, indicating training related changes in attentional breadth. For Experiment 1, results showed a significant main effect of assessment time, $F(1, 37) = 32.40$, $p < .001$, partial $\eta^2 = .47$, a marginally significant main effect of trial type, $F(1, 37) = 3.41$, $p = .07$, partial $\eta^2 = .08$, and a significant interaction effect between assessment time and trial type, $F(1, 37) = 11.45$, $p < .01$, partial $\eta^2 = .24$ (other *F*s < 2.52, *ps* > .12, partial $\eta^2 s < .06$). Further analysis revealed that whereas at pre-training assessment responses on global trials (*M* = 678, *SD* = 115) was significantly faster than on local trials (*M* = 733, *SD* = 159). $F(1, 38) = 10.85$, $p < .01$, partial $\eta^2 = .22$, response times to global trial (*M* = 624, *SD* = 103) and local trial (*M* = 615, *SD* = 88) no longer differed significantly at post-training assessment, $F(1, 38) = 0.43$, $p = .52$, partial $\eta^2 = .01$. However, of greatest important to the central issue under consideration, there was no evidence of the expected three-way interactions, $F(1, 37) = 0.04$, $p = .84$, partial $\eta^2 = .001$, that would indicate the success of the intended training manipulation in altering breadth of attention.

For Experiment 2, results showed a significant main effect of assessment time, $F(1, 54) = 69.73$, $p < .001$, partial $\eta^2 = .56$, a significant main effect of trial type, $F(1, 54) = 9.67$, *p*

< .01, partial $\eta^2 = .15$, and a significant three-way interaction of assessment time, trial type, and training group, $F(1, 54) = 6.51$, $p < .05$, partial $\eta^2 = .11$ (other *F*s < 1.32, *ps* > .26, partial $\eta^2 s < .02$). Further investigation of this three-way interaction showed that the two-way interaction of trial type and time was not significant in the broad training group, $F(1, 28) = 1.08$, $p = .31$, partial $\eta^2 = .04$, while this interaction was significant in the narrow training group, $F(1, 26) = 6.26$, $p < .05$, partial $\eta^2 = .19$. Specifically, in the narrow training group, response times to global trials at pre-training assessment ($M = 688$, $SD = 148$) was significantly faster than to local trials ($M = 736$, $SD = 152$), $t(26) = 3.83$, $p = .001$, $d = 0.75$. However, at post-training assessment, there was no significant difference in response times between global trials ($M = 624$, $SD = 120$) and local trials ($M = 635$, $SD = 117$), $t(26) = 0.71$, $p = .48$, $d = 0.14$, indicating a narrowing effect of attentional breadth in the narrow training condition.

In summary, the two training groups in Experiment 1 did not show any significant differences in the performance to global or local trials after Global-Local training. There was a significant narrowing effect in the narrow training group after visuospatial training in Experiment 2 but no broadening effect was found in the broad training group. Thus, the broad training in both Experiment 1 and 2 did not exert the expected broadening impact on attentional breadth.

Discussion

In these first two experiments, we attempted to manipulate attentional breadth using a single-session Global-Local training procedure (Experiment 1), and a single-session visuospatial training procedure (Experiment 2). Experiment 1 used a modified Global-Local training task in which the proportion of global versus local trials was manipulated, with the intention of inducing a group difference in attentional breadth. However, results showed that the training conditions did not differentially influence attentional breadth. These results call into question Hanif et al. (2012)'s assumption that the impact on emotional regulation, which they observed to result from their single-session Global-Local training procedure, was mediated by training induced change in attentional breadth. Unlike Hanif et al. (2012), the present study directly examined whether this procedure serves to alter attentional breadth, and found no evidence that the Global-Local training can lead to significant differences between broad and narrow training groups.

In Experiment 2, we developed and tested an innovative alternative candidate attentional breadth training task. We found a narrowing effect after training in the narrow training group. However, in line with the results of Experiment 1, we again did not observe any broadening effect of the broad training on the subsequent measure of attentional breadth. Although speeded responding was observed at post-training assessment relative to pre-training assessment across both groups in Experiment 1 and 2, this likely represents a practice effect. It is possible that the training only induced participants to use the expected attentional breadth in one specific task (e.g., the training task) but stopped using this attentional set after training. For example, a recent study using Bayesian tests on two replication experiments about the $GLOMO^{sys}$ Model found no evidence that global priming of the Global-Local task can influence individual's performance in a subsequent rating task (Field, Wagenmakers, Newell, Zeelenberg, & van Ravenzwaaij, 2016). Indeed, this may be a drawback of training attentional processes within a single context. Therefore, to increase the chance of attentional breadth training transferring to different contexts, we combined two different candidate attentional breadth training tasks in Experiment 3. Furthermore, we substantially increased exposure to the training manipulation, by extending this across multiple sessions. Specifically, in Experiment 3 participants were required to perform five training sessions of two different training tasks over a period of one week.

Experiment 3

This experiment was designed to optimize the prospect of successfully inducing change in attentional breadth, by using a five-day combined training procedure in which participants were required to complete two different candidate training tasks each time (i.e., the modified Global-Local task and the visuospatial training task). Following completion of this five-day training procedure, in addition to examining its impact on attentional breadth using the Global-Local assessment task employed in Experiments 1 and 2, we also used an alternative visuospatial attentional breadth assessment task that has previously proven sensitive to change in attentional breadth (Bosmans, Braet, Koster, & De Raedt, 2009; Grol et al., 2015). By using these alternative measures of attentional breadth, in the form of Global-Local processing and of visuospatial attention, it becomes possible to assess whether training-induced change in the type of attentional breadth measured by the Global-Local task transfers to affect the type of attentional breadth assessed by the visuospatial assessment task.

Methods

Participants.

Seventy-three individuals participated in Experiment 3 and were randomly assigned to two training groups. The sample size in experiment 3 was based on the consideration that one would expect at least a moderate effect size (f = .25) for such an extensive training on close transfer (on a highly similar task). This would require a total sample size at least of n = 54 (based on G-power with α = .05 and $(1-\beta)$ = .95). Here we oversampled because we expected some drop out of participants during multiple-session training procedure. Attentional breadth was assessed both before and after a 5 day procedure intended to induce differential change in attentional breadth. In line with the procedure followed in Experiment 1 and 2, participants were excluded either because their mean RT deviated more than 2.5 SDs from the sample mean during the pre-assessment (n = 2), or because their depressive symptoms met or exceeded a moderate level of depression, indicated by a BDI-II score greater than or equal to

20 (*n* = 6; for criteria, see Beck et al., 1996). An additional nine participants completed only the pre-training assessment, and consequently were excluded from the study. Characteristics of the remaining 56 participants, who completed the whole procedure, are presented in Table 2.

Material.

Both of the attentional breadth training tasks and the Global-Local assessment task were programmed using the E-PRIME 2 software package (Psychology Software Tools Inc, 2007). The visuospatial attentional breadth assessment task was programmed using Inquisit software package (Millisecond Software LLC., Seattle, WA, USA).

Questionnaires. Measures of depressive symptoms (BDI-II; Beck et al., 1996) and positive and negative affect (PANAS; Watson et al., 1988) were identical to those employed in Experiment 1 and 2.

Assessment tasks. As in Experiment 2, attentional breadth was measured using the 64-trial version of Global-Local Navon Letter task (Navon, 1977).

Additionally, in order to test whether the effect of attentional breadth training would transfer to another task which measures attentional breadth in a different manner, we also delivered an established visuospatial attentional breadth assessment task (Bosmans et al., 2009). This task was recently used for measurement of attentional breadth on self-related information in people with different levels of rumination, since rumination has been considered to be associated with self-focus attention (Grol et al., 2015). During this assessment, a self- (“ME”) or other-related (“LR”) word was presented 68 ms in the central area of the screen surrounded by 16 gray dots arranged in two concentric circles in one of which a black smaller circle target appeared simultaneously with the word and gray dots. Participants were required to identify the central word (ME vs. LR) as well as to localize the position of the small black target. In close trials the positions of the target were in the smaller one of the two concentric circles whereas in far trials the positions of the target were in the larger (outer) one of the two concentric circles. Participants performed 16 practice trials and 182 test trials, during which the stimulus displays were presented for 250 ms in the first eight practice trials and then were presented 68 ms in the following eight practice trials and during all the test trials. In previous studies, as Attentional Narrowing index (ANI = accuracy of the close trials – accuracy of the far trials) has been calculated to assess the attentional breadth, and this has been shown to be an effective index that reveals variation in attentional breadth (Bosmans et al., 2009; Grol et al., 2015). Accordingly, we too used this method by computing attentional breadth using the Attentional Narrowing Index, where higher ANI scores indicate a more narrow attentional breadth and lower ANI scores indicate more broad attentional breadth.

Training tasks. The two training tasks (i.e., the Global-Local training and visuospatial training) were similar to the variants employed in the first two experiments. For the Global-Local training, people in the attentional broadening training group were instructed to only focus on and respond to the letter in the global form whereas people in the attentional narrowing training group were asked to only focus on and respond to the letter in the local form. On each trial of both training tasks, if the participants' response was incorrect, an error message was then presented for 500 ms. Participants were required to perform both tasks each day, and were instructed to switch the order of the two tasks across successive days. There were 160 trials in the Global-Local training and 288 trials in the visuospatial training, and each training session could be completed in around 20-30 minutes.

Procedure.

After signing informed consent, participants completed the visuospatial attentional breadth task and the Global-Local task as pre-training assessment of their attentional breadth. In line with the specific requirements of the visuospatial attentional breadth assessment task

(Bosmans et al., 2009; Grol et al., 2015), participants were seated at 27 cm from a 19 inch CRT screen during pre- and post-assessment. Participants then filled out the questionnaires (BDI-II, PANAS). Subsequently, participants were randomly assigned to one of the two training groups (broad or narrow) which were scheduled to include five training sessions at home within a period of one week. During each session, participants were required to complete both the visuospatial training and the Global-Local training in random order. Every participant was given an instruction manual which included all the information and requirements regarding the home training. In the manual, they were asked to concentrate on the training tasks and to read the instruction of each task carefully. They were also asked to record the date and order in which they performed the training tasks at home. After home-training, they returned to the lab where the experimenter collected the data of the training tasks and checked the accuracy rate of each day to see whether they performed the training tasks as instructed. At the same time, participants completed the post-training assessment (cognitive transfer tasks and questionnaires) after which they were fully debriefed. This experiment was approved by the local ethical committee of the Faculty of Psychology at Ghent University and participants were reimbursed.

Results

Participant characteristics.

Participant characteristics are shown in Table 2. There were no significant differences between the two training groups on any of the self-report measures (all *t*s < 0.82) or pre-assessment task performance (all *t*s and *F*s < 1).

Impact of training on attentional breadth assessment[3].

Training-related changes on the Global-Local assessment task. During data preparation, trials on which participants responded incorrectly were discarded (< 4.9%). Furthermore, trials with RTs 2.5 SDs or more above a participants' own mean RT were also excluded (< 2.8%). To determine whether the training influenced performance on the Global-Local assessment task, we conducted a mixed ANOVA with assessment time (pre- vs. post-training) and trial type (global vs. local) as within-subject factor and training group (broad vs. narrow) as a between-subjects factor on RT (see Table 3 for details) as dependent variable. This revealed a significant main effect of assessment time, $F(1, 54) = 46.33$, $p < .001$, partial $\eta^2 = .46$, a marginally significant main effect of trial type, $F(1, 54) = 3.70$, $p = .06$, partial $\eta^2 = .06$, and a significant interaction effect between assessment time and trial type, $F(1, 54) = 8.35$, $p < .01$, partial $\eta^2 = .13$. Importantly, we found a significant interaction effect between trial type and training group, $F(1, 54) = 8.26$, $p < .01$, partial $\eta^2 = .13$, and a significant three-way interaction involving assessment time, trial type and training group, $F(1, 54) = 9.20$, $p < .01$, partial $\eta^2 = .15$ (other Fs < 0.99, $ps > .32$, partial $\eta^2 s < .02$). Further investigation of this three-way interaction revealed that its nature was as follows. Whereas the two-way interaction of trial type and time was not significant in the broad training group, $F(1, 28) = 0.01$, $p = .91$, partial $\eta^2 < .001$, this interaction was significant in the narrow training group, $F(1, 26) = 14.64$, $p < .01$, partial $\eta^2 = .36$. Specifically, in the narrow training group, there was no significant difference between the response times at pre-training assessment on the global trials ($M = 697$, $SD = 138$) and the local trials ($M = 719$, $SD = 157$), $t(26) = 1.34$, $p = .19$, $d = 0.26$. However, at post-training assessment, response times on local trials ($M = 568$, $SD = 84$) were faster than on global trials ($M = 610$, $SD = 111$), $t(26) = 3.18$, $p < .01$, $d = 0.67$, suggesting a narrowing effect of attentional breadth in the narrow training condition.

Training-related changes on the visuospatial attentional breadth assessment task. An average of 3.41% of the trials was discarded from further analysis due to incorrect reporting of the center word. We performed a mixed ANOVA with Time (pre- vs. post- training) and word (ME vs. LR) as within-subject factors and training group (broad vs. narrow) as a between-subjects factor on Attentional Narrowing Index as dependent variable. We found a significant main effect of time, $F(1, 54) = 4.46$, $p < .05$, partial $\eta^2 = .08$, indicating a decrease of visuospatial attentional breadth from pre-assessment (*M* = .40, *SD* = .17) to post-assessment (*M* = .45, *SD* = .17). However, there was no group related main effect or interaction effect, *F*s < 2.30, *ps* > .14, partial $\eta^2 < .04$. Therefore, the two training conditions did not exert a differential impact on visuospatial attentional breadth.

Discussion

In an attempt to determine whether a cognitive training procedure could modify attentional breadth, we used a five-day procedure with two training tasks in Experiment 3. We again failed to observe any evidence that the broad training condition served to broaden attentional breadth. However, on the Global-Local assessment task, we found a training-congruent effect for the narrow training group, reflected by their speeded responding compared to the broad training group on the local trials at post-training assessment. The results, therefore, suggest that our multiple-session training procedure cannot be adopted to broaden attention beyond the prior preference of an individual. Instead, the narrow training manipulation did result in the desired effects although the impact of this training was observed only on the Global-Local assessment measure of attentional breadth. In order to determine the strength of support for the null-hypothesis that these procedures designed to modify attentional breadth did not induce a generalized change in attentional breadth in Experiment 1 and a specific broadening impact on attentional breadth in Experiment 2 and 3, we went on to conduct complementary Bayesian analyses.

Bayesian Comparison of the Null and Experimental Hypotheses

The reported series of failures to reject the null-hypothesis cannot be taken as compelling evidence that these attentional training procedures do not impact attentional breadth. That is, when using a Frequentist approach, failures to reject the null-hypothesis are inconclusive; they indicate only lack of evidence for the alternative hypothesis but do not allow estimation of evidence for the null-hypothesis (Kruschke, 2011; Mulder & Wagenmakers, in press). In contrast, a Bayesian approach allows comparison of evidence between different models as it relies on likelihood ratios, allowing us to accumulate evidence in favor of the null-hypothesis (Jeffreys, 1961).[4]

To determine how confident we can be that attentional breadth was not successfully broadened using the one- or multisession attentional breadth training, we re-analyzed our attentional breadth assessment data using two-sided Bayesian *t*-tests. The analysis was performed via JASP 0.7.1 (Love et al., 2015), using a Cauchy distribution as a prior (e.g., Wetzels, Matzke, Lee, Rouder, Iverson, & Wagenmakers, 2011).

We first performed independent samples *t*-tests with change in Global preference score (Global preference = mean RTs of local trials – mean RTs of global trials) throughout training as dependent variable (Δ Global preference = post-Global preference – pre-Global preference), and also with the change in Attentional Narrowing Index score computed in Experiment 3 as dependent variable (Δ ANI = post-ANI – pre-ANI). For the change in Global preference, a more positive score reflects training-induced broadening of attention whereas a negative score reflects training-induced narrowing of attention. On contrary, for the change in ANI, a more positive score reflects training-induced narrowing attention whereas a negative score reflects training-induced broadening attention. Results of our first experiment indicate that a single session of Global-Local training does not affect Global preference scores: the data are respectively 3.156 times more likely to occur under the null-hypothesis than under the alternative hypothesis (see Table 4). In contrast, the visuospatial training task showed more potential in modifying attentional breadth. That is, in Experiment 2 – in which a single session visuospatial training procedure was used – evidence for change in Global preference favored the alternative hypothesis with 3.743. Similarly, in Experiment 3, in which a multi-training and multi-session approach was employed including the visuospatial training procedure, there was strong evidence for change in Global preference scores following one week of training. The results favored the alternative hypothesis with 10.517. In contrast, the analyses of ANI scores were in support of the null-hypothesis, ranging from anecdotal to substantial strength of evidence.

Given the evidence for differential training effects on Global preference scores in Experiments 2 and 3, in line with the above presented results, we then continued with paired samples *t*-tests to explore within-subject effects of training on Global preference in the broad / global and the narrow / local training condition separately (see Table 5). This yielded substantial evidence that undergoing one session of broad training (cfr. Experiment 2) or multiple sessions of broad / global training (cfr. Experiment 3) did *not* foster a Global preference (i.e., the evidence favored the null-hypothesis by a factor of 3.104 and 5.037 respectively), whereas undergoing one session of narrow training or multiple sessions of narrow / local training reduced the Global preference of participants (i.e., the evidence favored the alternative hypothesis by a factor of 2.733 or 44.705 respectively). Evidence for attentional narrowing was strongest for the multi-method multiple session approach (Experiment 3).

General Discussion

In the current research program, we conducted two single-session training experiments (Experiments 1 and 2) and one multiple-session training experiment in which training approaches from Experiments 1 and 2 were combined (Experiment 3) with the aim of determining whether attentional breadth could be manipulated through these training procedures. Our results showed no evidence that attentional breadth training can be used to broaden attention. Specifically, we did not find any congruent changes in Global-Local task performance (Experiments 1-3) or sustained effects on the visuospatial attentional breadth assessment task (Experiment 3). Therefore, the current study provides no evidence that training variants of the Global-Local task and/or the visuospatial task can lead to significant increase in attentional breadth in broad training group, assessed using the Global-Local assessment task or the visuospatial assessment task. This was true regardless of whether single-session or multiple-session (five days) training approaches were employed. Importantly, the Bayesian analysis confirmed the null-hypothesis of no increase in attentional breadth through delivery of these training procedures.

When reflecting on the possible explanations for the present results, we first need to consider the validity and reliability of the measures and research approach in our study. It seems unlikely that our assessment measures were inadequate. We used the Global-Local task (in all three experiments) and a well-established visuospatial attentional breadth assessment task (in Experiment 3). The Global-Local task is the most frequently used task to assess attentional breadth (e.g., Fredrickson & Branigan, 2005) and the visuospatial attentional breadth assessment task has been used in previous research as well (e.g., Bosmans et al., 2009; Grol et al., 2015). Might it be the case that we employed inappropriate attentional breadth training procedures? We used the Global-Local training task (in Experiments 1 and 3) and a new visuospatial training task (in Experiments 2 and 3). Importantly, the Global-Local training task has been used in previous studies that have sought to manipulate attentional breadth. This manipulation has previously shown to influence attentional bias to negative information (Gable & Harmon-Jones, 2012) and emotion regulation (Hanif et al., 2012; vanDellen et al., 2012). However, these studies typically lack manipulation check procedures, which do not allow to draw conclusions on the causal influence of attentional breadth on these far transfer measures. With regard to our novel visuospatial training task, the manipulation check trials in Experiments 2 and 3 suggest successful online manipulation of attentional breadth during training.

It is important to consider whether our failure to detect any impact of training procedures on attentional breadth could be due to insufficient power. Again this seems unlikely to be the case, if we assume a medium effect size of f = .25 (Cohen, 1988), as post-hoc power calculations confirm that each experiment showed sufficient power to detect a potential impact of the training manipulation on attentional breadth, using the G*Power 3.1.9.2 software package (Faul, Erdfelder, Buchner, & Lang, 2009). The power (1 - β) to detect the training condition x assessment time two-way interaction effect of Global Preference Score on the assessment tasks was .87 in our first experiment, .95 in Experiment 2, and .96 in Experiment 3. However, if we conservatively assume a small effect size of f = .10 (Cohen, 1988), the power (1 - β) to detect the interaction effect of Global Preference Score on the assessment tasks was .23 in our first experiment, .31 in Experiment 2, and .31 in Experiment 3. These results suggest that all three experiments in the current study were sufficiently powered to detect medium effects but not small effects on the measures assessing attentional breadth. Thus, power considerations add weight to our conclusion that visual attentional breadth cannot be manipulated using the modified Global-Local task or visuospatial training task.

One important characteristic that differentiates our current study from previous ones is that we measured individuals' attentional breadth pre- and post-training, which in principle could provide stronger evidence that attentional breadth can be changed through training. However, even though the manipulation check showed that participants complied with the requirements of the training procedure, we did not find any subsequent broadening impact of these procedures on alternative measures of attentional breadth. Furthermore, after performing multiple training sessions, we only observed a decrease on the Global preference measure of attentional breadth following the narrow training condition. However, this effect was not found on the visuospatial measure of attentional breadth.

Perhaps there may not have been sufficient overlap between our training and assessment tasks. The definition of attentional breadth is often rather broad, so it is unclear which tasks provide an optimal assessment. In our study we included two different operationalizations of attentional breadth, the Global-Local and visuospatial training task, which may represent different kinds of attentional breadth. Global (or local) processing may reflect a high (or low) level of processing (Fujita, Trope, Liberman & Levin-Sagi, 2006; Hanif et al., 2012; van Dellen et al., 2012), whereas the target of the visuospatial attentional breadth training task pertains to the size of spatial perceptual attentional breadth. Though the narrowing effect in the Global-Local assessment task found in Experiment 2 and 3 which both included visuospatial attentional training may suggest a possibility that manipulation of visuospatial attention can be transferred to the global-local processing measurement, this was not the case for the broad training condition in these two experiments. Also, no transfer effect of multiple-session training was found in visuospatial assessment task. Hence, whether the effect of manipulation of one kind of attentional breadth can transfer to tasks that measure other kinds of attentional breadth should be further considered in future research.

As has been noted, some previous studies that found improvement of self-regulation after Global-Local training intended to modify attentional breadth, but failed to include any post-training assessment of attentional breadth (Hanif et al., 2012). Given the present findings, it seems unlikely that attentional breadth was actually modified in these previous studies. How then did these training procedures exert their influence on emotion regulation? One interesting possibility is that Global-Local training may instead have influenced cognitive flexibility, as greater cognitive flexibility is associated with enhanced self-regulation (Olivers & Nieuwenhuis, 2005). This was especially evident for the narrow training group, which started with global preference and was trained to switch to local preference. Thus, the effect of Global-Local training procedures on self-regulation observed in previous research (Hanif et al., 2012) could be due to increased cognitive flexibility instead of increased attentional breadth. Future research should consider combining both pre-and post-assessment tasks that measure attentional scope and cognitive flexibility.

An alternative, but related, possibility is that the training procedures employed in these studies may have increased the flexibility of attentional breadth. According to theoretical models and empirical evidence in the visual attention domain, the field of focal attention could be seen as a single unitary focus that varies its size depending on task requirements (e.g., zoom lens model, Eriksen & St. James, 1986; Barriopedro & Botella, 1998; Muller, Bartele, Donner, Villringer, & Brandt, 2003), or as multiple foci attending to different places in a display simultaneously (e.g., Awh & Pashler, 2000; Cave, Bush, & Taylor, 2010). Notably, the mode of attentional deployment (as a changeable zoom lens or multiple foci) could even be altered within a task due to a simple change in the goals of the participants (Jefferies, Enns, & Di Lollo, 2014). Therefore, it may be that attentional breadth is highly malleable based on goals and context, such that individuals can easily modify their attentional breadth to meet task demands. In our experiments, participants were asked to keep using one dominant attentional deployment approach (i.e., using broad attentional breadth in the broad training group and narrow attentional breadth in the narrow training group), whereas in the assessment tasks no specific attentional deployment approach was required. Thus, participants may have adjusted their strategy between the training and assessment task in order to reach the optimal performance in the assessment tasks. Future research should consider using assessment tasks that do not require altering the size of attentional breadth in order to improve performance, such as the moving window task (McConkie & Rayner, 1975) which is proposed to measure perceptual attentional breadth in a natural reading context and the attention-demanding conjunction task (Hüttermann, Memmert, Simons, & Bock, 2013; Hüttermann, Memmert, &

Simons, 2014) which is an interesting paradigm that could give precise information concerning the shape and size of changes in attentional breadth.

This current study is the first to our knowledge that has systematically examined whether attentional breadth can be manipulated through the application of these candidate training procedures. The results of our studies have important implications for future research designed to investigate the potential causal impact of variability in attentional breadth by observing the consequences of systematically manipulating attentional breadth. The vague definition of attentional breadth, possibly overlapping with cognitive flexibility, and its flexible nature, suggests that we need to further specify whether and how attentional breadth may be involved in emotion regulation. However, the present demonstration that attentional breadth may be resistant to direct manipulation compromises the prospect of evaluating these refined theories by testing the predictions they generate concerning how induced change in attentional breadth will affect emotion regulation. Given the increasing interest in changing attentional breadth in psychopathology (Whitmer & Gotlib, 2013), instead of training people to exhibit differences in their average breadth of attention, future research could aim to increase individuals' capacity to flexibly change their attentional breadth based on the requirements of different tasks.

Of course, our study had some limitations. First, training effects were assessed by comparing two training groups. A no-training control group could have revealed additional information about different effects of attentional breadth training. Second, in the multiple-session training, participants conducted the training tasks at home using their own computer. This may have reduced the consistency of the training environment in ways that reduced training efficacy. Nevertheless, recent meta-analytical findings regarding cognitive training effects in the field of working memory training suggest that such training effects can be obtained regardless of whether training is administered in the lab or at home (Au, Sheehan, Tsai, Duncan, Buschkuehl, & Jaeggi, 2014). Third, although we instructed participants to always focus on the central fixation point, it is possible that they may have directed attention to other regions. However, given that the target letter was presented randomly at the eight positions on the outer circle, the best strategy for participants to adopt would be to focus on the central fixation point instead of moving eyes to some “expected” position before the appearance of the target, since the chance of the target appearing at one attended outer location is rather small (12.5%). Moreover, the target letter was presented for only 100 ms. The latency to execute a saccade exceeds this time, typically taking at least 150-175 ms (Rayner, 1998), and so our use of 100 ms target presentations precludes the possibility that participants shifted their attention to the target after its appearance.

Conclusion

We investigated whether attentional breadth could be changed through experimental procedures designed to directly modify attentional breadth. Our findings do not support the hypothesis that training variants of the Global-Local attentional breadth task or of the visuospatial attentional breadth task can broaden attentional breadth, as indicated by subsequent tasks that assess attentional breadth in terms of either global-local processing preference (Global-Local assessment task) or in terms of scope of visual perception (visuospatial assessment task). This was the case for both single-sessions consisting of individual training procedures and multiple-session manipulations using a combined training approach over a five day period. In Experiment 2 and 3, there were some indications that training a narrowing of attentional breadth may be possible, but there was no evidence that, even with this extensive and intensive training, it was possible to induce an increase in attentional breadth.

Footnotes

[1] In Experiment 1 and 2, due to the fact that previous studies where they tried to manipulate attentional breadth did not include a pre- and post-training measure of attentional breadth, we could not determine statistical power a priori.

[2] Experiment 1 and 2 also examined the attentional breadth training impact on attentional bias towards threat information using an attentional bias task at pre- and post-assessment. Since the training did not induce different attentional breadth between the two training groups, we did not find any differences between these two groups in the attentional bias task after training as well (these results are available upon request).

[3] Experiment 3 also investigated the influence of attentional breadth training on rumination using a rumination induction in the post-assessment (after those two attentional breadth assessment tasks) and measuring state rumination before and after the induction procedure. The results did not suggest effects on susceptibility to state rumination during a rumination induction procedure (these results are available upon request).

[4] As such, the Bayes Factor (BF) – i.e., the ratio of the probability of the data given one hypothesis compared to the probability of the data given another hypothesis – allows to draw conclusions concerning the *strength of evidence* for the alternative hypothesis [BF(10)] or the null-hypothesis [BF(01)] (Wagenmakers, 2007). To foster interpretation of strength of evidence, following cut-offs have been proposed: BF 1 = No evidence, BF 1 – 3 = Anecdotal evidence, BF 3 – 10 = Substantial evidence, BF 10 – 30 = Strong evidence, BF 30 – 100 = Very strong evidence, and BF > 100 = Extreme evidence (Jeffreys, 1961; Wagenmakers, Wetzels, Borsboom, & van der Maas, 2011).

Compliance with Ethical Standards

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Conflict of Interest: All the authors report no conflicts of interest.

Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and /or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent: Informed consent was obtained from all individual participants included in the study.

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Table 1

Schematic overview of the differences in the experimental procedures among experiments

	Experiment 1	Experiment 2	Experiment 3
GL pre-assessment	32 trials	64 trials	64 trials
AB pre-assessment	---	---	182 trials
GL training	160 trials (4:1) respond only to trained trial type	---	160 trials respond to trained trial type
AB training	---	AB training: 8 blocks of 32 training trials + 4 manipulation check trials	AB training: 8 blocks of 32 training trials + 4 manipulation check trials
GL post-assessment	32 trials	64 trials	64 trials
AB post-assessment	---	---	182 trials

Note: GL, Global-Local task; AB, attentional breadth.

Table 2

Characteristics of participants at pre-training assessment

	Experiment 1		Experiment 2		Experiment 3	
	Training Group		Training Group		Training Group	
	Broad	Narrow	Broad	Narrow	Broad	Narrow
N	19	20	29	27	29	27
Age	23.16	23.10	22.00	23.04	22.38	22.48
Gender (F/M)	14/5	18/2	26/3	19/8	23/6	21/6
Questionnaires	M	M	M	M	M	M
	(SD)	(SD)	(SD)	(SD)	(SD)	(SD)
BDI-II	4.37	5.35	6.52	7.33	6.90	8.26
	(3.68)	(3.57)	(4.82)	(6.08)	(3.80)	(5.34)
PA state	31.05	31.95	32.45	30.63	34.55	33.81
	(6.42)	(4.70)	(5.76)	(4.86)	(4.69)	(5.65)
NA state	11.53	12.30	12.52	14.07	17.28	17.85
	(2.17)	(3.29)	(2.75)	(3.91)	(8.21)	(5.82)

Note: BDI-II, Beck Depression Inventory-II (BDI-II; Beck et al., 1996); PA and NA state, positive and negative affect (PANAS; Watson et al., 1988).

Table 3

Reaction time (ms) as a function of training group in Global-Local assessment task

Experiment	Time	Group	N	Global Trial		Local Trial	
				M	SD	M	SD
1	1	Broad	19	656	103	705	170
		Narrow	20	698	124	759	147
	2	Broad	19	625	117	613	100
		Narrow	20	623	92	616	77
2	1	Broad	29	685	128	707	156
		Narrow	27	688	148	736	152
	2	Broad	29	582	108	619	135
		Narrow	27	624	120	635	117
3	1	Broad	29	678	155	726	185
		Narrow	27	697	138	719	157
	2	Broad	29	589	104	638	130
		Narrow	27	610	111	568	84

Table 4
Experimental results and Bayesian independent samples t-tests

Experiment	Cognitive transfer Measure	Group (N)	M (SD)	Mean difference Cohen's *d*	*t*	*p*	Bayes factor BF(10) [BF(01)]
1	Δ Global preference	Broad (*n* = 19)	-60.32 (128.51)	0.06	0.20	.84	0.317 [3.156]
		Narrow (*n* = 20)	-67.81 (107.54)				
2	Δ Global preference	Broad (*n* = 29)	14.27 (74.06)	0.68	2.55	.01	3.743 [0.267]
		Narrow (*n* = 27)	-37.58 (78.04)				
3	Δ Global preference	Broad (*n* = 29)	1.55 (74.94)	0.81	3.03	.004	10.517 [0.095]
		Narrow (*n* = 27)	-64.22 (87.21)				
	Δ ANI self-related	Broad (*n* = 29)	.08 (.20)	0.42	1.54	.13	0.695 [1.439]
		Narrow (*n* = 27)	.01 (.13)				
	Δ ANI other-related	Broad (*n* = 29)	.048 (.19)	-0.02	0.10	.92	0.271 [3.688]
		Narrow (*n* = 27)	.053 (.21)				

Note: Δ-scores reflect increase in global preference for the Global-Local task and increase in attentional broadening for the visuospatial attentional breadth assessment task.

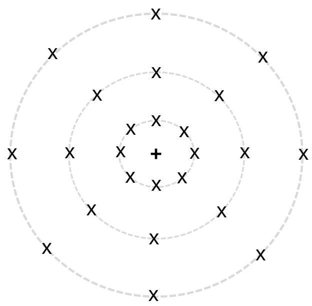
Table 5

Bayesian paired samples t-tests

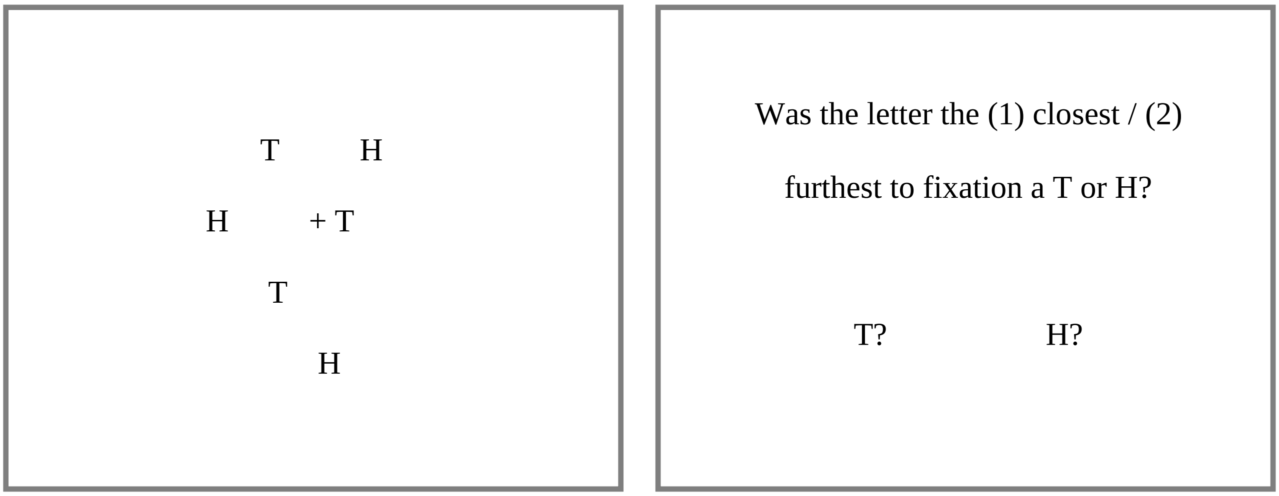
Training condition	Outcome	Mean difference			Bayes factor
		Cohen's *d*	*t*	*p*	BF(10) [BF(01)]
Experiment 2					
Global / Broad training	Global preference	0.19	1.04	.31	0.322 [3.104]
Local / Narrow training	Global preference	-0.48	-2.50	.02	2.733 [0.366]
Experiment 3					
Global / Broad training	Global preference	0.02	0.11	.91	0.199 [5.037]
Local / Narrow training	Global preference	-0.74	-3.83	.001	44.705 [0.022]

Figure 1. Visuospatial training task. a) all 24 possible positions, b) (1) narrow (2) broad training and c) manipulation check trial examples.

a)



b)



c)