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The interaction effect of attentional bias and attentional control on dispositional anxiety among adolescents

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Research has shown that children and adolescents with attentional control deficits tend to have high anxiety and exhibit threat-related selective attentional bias. This study aimed to investigate how positive and negative attentional biases would interact with attentional control on dispositional anxiety. One hundred and twenty participants aged 18 years of age or younger participated in a visual dot-probe task to measure their attentional bias and completed psychological questionnaires to measure their trait anxiety, and attentional control. Mean reaction times to the probe in milliseconds were used to measure attentional bias. Overall, our participants showed a bigger tendency towards attending to positive emotional stimuli than to negative emotional stimuli. Adolescents with high dispositional anxiety showed poorer attentional control. Regression analyses showed that attentional control interact with negative attentional bias to affect anxiety. For participants with high attentional control, higher negative attentional bias was associated with lower trait anxiety. Trait anxiety was not related to negative attentional bias for participants with low attentional control. Positive attentional bias showed no significant relationship with dispositional anxiety, either alone or in interaction with attentional control. Theoretical and clinical implications of the findings are also discussed.

According to attentional control theory (Eysenck, Derakshan, Santos, & Calvo, 2007), salient components of attentional control include inhibitory control and attentional set-shifting. Inhibitory control is related to the ability to successfully suppress task-irrelevant information, whereas attentional set-shifting describes the ability to flexibly allocate attention between relevant task demands (Berggren & Derakshan, 2013). It has been argued that low levels of effortful control (including attentional control) are one of the two important aetiological factors in child psychopathology, which include internalizing (e.g., anxiety and depression) and externalizing (e.g., delinquency and attention-deficit/hyperactivity disorder) symptoms (the other factor is high emotionality) (Muris & Ollendick, 2005; Nigg, 2006). In the context of anxiety, numerous empirical evidence has shown that anxiety as a personality trait is negatively related to an individual's ability to control attention voluntarily (Berggren & Derakshan, 2013; Derryberry & Reed, 2002; Eysenck & Derakshan, 2011; Osinsky, Gebhardt, Alexander, & Hennig, 2012). For instance, Derryberry and Reed (2002) showed a negative correlation between the two constructs, that is, individuals with higher dispositional anxiety tend to exhibit lower attentional control ability. Similarly, both the studies of Bishop (2009) and Muris, de Jong,

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and Engelen (2004) found that children's self-reported anxiety levels were negatively associated with self-reported attentional control. Furthermore, Pacheco-Unguetti, Acosta, Lupiáñez, Román, and Derakshan (2012) used angry, happy, and neutral faces as emotional distractors in a go/no-go task in two experiments, and demonstrated that the adverse effects of anxiety on attentional control were greatest for angry faces. These studies generally demonstrated that attentional control deficits primarily affect processing efficiency (e.g., reaction time of a task) while not adversely affecting performance effectiveness (e.g., number of incorrect responses) (Berggren & Derakshan, 2013; Eysenck & Derakshan, 2011). Furthermore, they also suggested that distractors with a negative valence seemed to exert a greater effect on attentional control than positive or neutral distractors (Basanovic & MacLeod, 2016).

Cognitive theories also propose that cognitive bias plays a key role in anxiety problems (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007; Mathews & MacLeod, 2005). Consistent with this proposition, many studies have shown that anxious individuals demonstrate negative attentional bias towards emotionally threatening stimuli (Bar-Haim *et al.*, 2007; Derryberry & Reed, 2002; Pérez-Edgar *et al.*, 2010; Weeks, Heimberg, Rodebaugh, & Norton, 2008), and this tendency was observed whether the stimuli were perceived consciously or subliminally (Bar-Haim *et al.*, 2007). A recent study by Basanovic and MacLeod (2016) provided further insight into this relationship. The researchers observed that there are two possible mechanisms to explain the relationship between anxiety and attention to negative stimuli. The first mechanism is related to attention goal setting. It proposes that anxious individuals, when compared to less anxious individuals, have a higher tendency to set attentional goal towards negative stimuli, leading to higher vigilance towards these stimuli. The second mechanism is related to attention goal execution and suggests that anxious individuals are less able to direct their attention away from negative stimuli when compared to less anxious individuals. In an experiment to test the relative importance of these two mechanisms, the researchers found that the goal setting mechanism, but not the goal execution mechanism, was significantly related to higher vigilance towards negative stimuli among anxious individuals (Basanovic & MacLeod, 2016). In other words, when compared to less anxious individuals, anxious individuals are more likely to set goals that focus on negative stimuli rather than to experience greater difficulty in shifting their attention away from negative stimuli. Because the goal-setting mechanism is important in the formula, other contextual variables (e.g., presence or absence of emotional stimuli, and task relevancy and irrelevancy) should be taken into consideration in formulating the relationships among anxiety, attentional control, and attentional bias.

If there is a relationship between anxiety and negative attentional bias, it is of both theoretical and clinical importance to understand whether there is also a relationship between anxiety and positive attentional bias. In other words, it is important to know whether the anxiety is related only to threatening stimuli or to emotional stimuli (irrespective of valence) in general (Ruiz-Caballero & Bermúdez, 1997). Theoretically, it is possible that an opposite (negative) relationship exists between anxiety and positive attentional bias: Less anxious individuals might show more positive attentional bias, as they are able to shift attention from threatening to positive information as a coping strategy to control their anxiety level (Derryberry & Reed, 2002). This proposition is partly supported by an early study using dot-probe tasks to investigate the relationship between attentional bias and anxiety among undergraduate students (Pishyar, Harris, & Menzies, 2004). It was reported that participants with low social anxiety showed a positive attentional bias towards positive faces. The reverse (i.e., an attentional bias away from

positive faces) was observed among participants with high social anxiety. Visu-Petra, Tincas, Cheie, and Benga (2010) used emotional facial expression (angry/happy/neutral) in an 'odd-one-out' task which required participating children to distinguish the odd face from two other identical distractors and remember its location. The children with high anxiety had significantly worse performance than those with low anxiety on trials containing happy faces (p = .06). Taylor, Bomyea, and Amir (2011) also founded that individuals with higher social anxiety exhibited a diminished attention to positive stimuli. Recently, in a randomized control trial, Waters *et al.* (2015) used an enhanced visual search paradigm (Dandeneau, Baldwin, Baccus, Sakellaropoulo, & Pruessner, 2007) to conduct attentional bias modification training on positive stimuli among 31 children with childhood anxiety disorders. Compared with the children in the waitlist control group (n = 28), the training group showed a significant reduction in symptoms post-intervention, although no pre- and post-training change in positive attentional bias was found. Other studies, however, found inconsistent results. In three studies, Waters and colleagues used visual dot-probe tasks to investigate attentional bias among children with different levels of anxiety severity (Waters, Henry, Mogg, Bradley, & Pine, 2010; Waters, Mogg, Bradley, & Pine, 2008). Overall, their findings showed that participants had similar attentional biases towards positive and negative stimuli (e.g., happy vs. angry faces) and these findings tended to apply to participants with different levels of severity of anxiety. In contrast, it has been pointed out that experiments using refined versions of both the Stroop test and visual dot-probe tasks have confirmed that anxiety-prone individuals have attentional bias towards negative stimuli rather than a general bias towards emotional stimuli irrespective of valence (Basanovic & MacLeod, 2016). It is less clear whether anxious individuals are more, less, or equally likely to preferentially direct attention towards positive stimuli (Taylor *et al.*, 2011), especially when both positive and negative attentional biases are taken into consideration. In other words, it is necessary to clarify whether negative attentional bias would exert the same or different effect on anxiety when positive attentional bias is controlled, and vice versa. One of the goals of this study was to investigate the relative roles of positive and negative attentional biases in affecting anxiety, especially when attentional control is taken into consideration (Derryberry & Reed, 2002).

Dispositional anxiety, attentional control, and attentional bias

The above review suggested that a complicated situation would result if one takes anxiety, attentional control, and attentional bias all together into consideration. The two systems of attention proposed by Corbetta and Shulman (2002) may help to describe the situation. According to the researchers (Corbetta & Shulman, 2002), two attentional processes can be distinguished: a bottom-up, stimulus-driven process for detection and attentional holding of salient information, and a top-down, goal-directed process for preparation and regulation of attention. It is further proposed that attentional bias is more related to the stimulus-driven process, whereas attentional control is more related to the goal-directed process (Schafer *et al.*, 2015; Taylor, Cross, & Amir, 2016). Anxiety disturbs the balance between these two systems such that the stimulus-driven process (i.e., attentional bias) is more influential than the goal-directed process (i.e., attentional control) in the cognitive process (Eysenck *et al.*, 2007). Other researchers suggested that attentional bias and attentional control interact to affect anxiety (Petersen & Posner, 2012; Schafer *et al.*, 2015). For instance, an influential study by Derryberry and Reed (2002) found that anxiety had a positive association with negative attentional bias only among individuals with low

attentional control, that is, attentional control moderated the relationship between anxiety and attentional bias. Similar findings were obtained in later studies (Susa, Pitică, Benga, & Miclea, 2012; Taylor, Bomyea, & Amir, 2010), providing further support for the interaction effect between attentional bias and attentional control on anxiety.

The above studies focus almost exclusively on negative attentional bias. To date, there is a dearth of empirical research on positive attentional bias and its relationship with attentional control. It is not clear whether positive attentional bias has a negative, positive, or insignificant relationship with dispositional anxiety when attentional control is taking into consideration. Another goal of this study was to examine the positive attentional bias interaction with attentional control on anxiety, especially when negative attentional bias is taken into account.

The present study

The present study was concerned primarily with relations between attentional bias, attentional control, and trait anxiety. It focussed on anxiety as a personality dimension in a normal, rather than clinical, population with anxiety disorders. Unlike many previous studies comparing anxious versus less anxious participants, this study examined the phenomenon among non-anxious normal adolescents under 18 years of age. Because of this, it did not categorize participants into high versus low anxiety groups but treated trait anxiety as a continuum in the analysis. Given the high prevalence of anxiety disorders among youths (Southam-Gerow & Kendall, 2000) and the large body of literature supporting the cognitive biases underlying individuals with an anxious trait (see the literature review above), identifying the nature of these biases would be helpful in developing interventions to prevent anxiety symptoms. The visual dot-probe paradigm was used to measure positive and negative attentional biases, and attentional control and other psychological constructs were measured by self-reported psychometric inventories, similar to previous studies (Derryberry & Reed, 2002; Muris *et al.*, 2004). The major goal of the present study was to examine the moderation effect of attentional control on the relationship between attentional bias and dispositional anxiety among normal adolescents. It was expected that attentional control would act as a moderator on the relationship between negative attentional bias and anxiety (Derryberry & Reed, 2002). Similarly, the present study also examined the role of positive attentional bias in the above relationships. Drawing references from the past literatures on attentional bias and attentional control (Derryberry & Reed, 2002; Schafer *et al.*, 2015), this study hypothesized two possible patterns of relationship with positive attentional bias. One possibility is that attentional control would act as a moderator on the relationship between positive attentional bias and anxiety, with a stronger negative relationship between positive attentional bias and anxiety in students with lower attentional control. Another possibility is the moderating effect of attentional control is only shown in negative attentional bias but not in positive attentional bias (i.e., there is no significant moderation effect of attentional control in the relationship between positive attentional bias and anxiety).

Methods

Participants

One hundred and twenty Grade 9 students from three secondary schools in Hong Kong participated in this study. All participants were Chinese with no known history of

developmental psychopathology or other psychological disorders. Seventy-one students (59.2%) were born in Hong Kong, 46 students (38.3%) were born in Mainland China, and the remaining three students (2.5%) were born elsewhere. All participants could read Chinese and had normal or corrected-to-normal vision. The majority (n = 111, 93.3%) were right-handed. There were 66 boys (55.0%) and 54 girls (45.0%) with a mean age of 15.16 years (SD = 1.33 years; range, 13–18 years). The wide age range resulted from some students being new immigrants from Mainland China, and they had enrolled in a lower form to better adjust to the education system and curriculum of Hong Kong.

Procedures

Written parental and student consent was obtained through the participating schools first. The experiments for each school were conducted on different days in a university laboratory for psychological experiments with 9–10 students in each group. First, a research assistant with an educational background in psychology and two students in the psychology Master's programme explained the purpose of the study and the procedures to the participants before commencing the tasks. Participants were informed again that participation was voluntary and that they could withdraw from the study at any time without any negative consequences.

The experiment consisted of two parts: a computerized task and a pen-and-paper task consisting of a set of psychometric inventories. Two groups of five participants entered the laboratory each time, and all participants completed both parts. To counterbalance the order of the two parts, one group completed the psychometric inventories first, and the other group completed the computerized task first. A 5-min break was taken between the two tasks to avoid fatigue. Upon completion of the experiment, a completion certificate and a souvenir memo pad worth £1.34 (HKD16) were given to each participant as a small token of appreciation for their participation.

The experiment

Apparatus and stimulus

The visual dot-probe paradigm (MacLeod, Mathews, & Tata, 1986) adopted in the present study was based on studies by Brosan, Hoppitt, Shelfer, Sillence, and Mackintosh (2011) and Chan, Ho, Law, and Pau (2013). The visual dot-probe task was conducted in a well-lit, quiet laboratory room with no external distractions. The task was presented on a desktop computer with a 17-inch colour monitor with a pixel density of 95.78 PPI. E-Prime 2.0 software (Schneider, Eschmann, & Zuccolotto, 2002) was used to deliver the stimulus, control the experiment, and record the response accuracy and latency. Reaction time was recorded using a number pad. Before the experiment began, each participant was instructed to place the index finger of his or her dominant hand on the centre white key (i.e., the '5' key between the '4' and '6' keys) on the number pad. The participant was further instructed to use his or her index finger to press the corresponding key after he or she saw an arrow appear and to place his or her index finger back on the centre white key after each trial. The experiment consisted of eight practice trials (eight neutral–neutral pairs) and three blocks of 264 test trials, with each block comprising 88 negative–neutral pairs, 88 neutral–neutral picture pairs, and 88 positive–neutral pairs. The picture pairs were presented in random order within the respective blocks. Distractor tasks were inserted between the three blocks. Participants were asked to watch a short movie

selected from the Brusspup Channel on YouTube (https://www.youtube.com/user/brusspup). Two movies of 55 and 108 s in duration were selected with one movie each shown between the three blocks. The order of these three blocks was counterbalanced across participants. Each trial was run in the following sequence. First, a black fixation cross (4 pixels wide, subtending 0.62 × 0.62 degree) was displayed in the centre of the screen for 1,000 ms. Second, a picture pair consisting of a neutral picture and an emotional (positive or negative) picture located approximately 13 cm apart (measured from their centres) was displayed in the top and bottom halves of the screen, respectively, for 500 ms based on the study of Bradley, Mogg, and Lee (1997) and a previous study conducted among Chinese breast cancer patients (Chan *et al.*, 2013). Each picture was unframed and subtended 14.8 (*W*) × 11.1 (*H*) degrees. Third, the two pictures disappeared from the screen. Fourth, the probe, in the form of a small arrow ('<'or '>') appeared in the centre of the area where one of the pictures was previously located. Each participant could press either the '4' (to indicate '<') or '6' (to indicate '>') key on the number pad to indicate the direction (either pointing left or pointing right, respectively) of the arrow as quickly as possible. A response from the participant would clear the screen, and the next trial would begin after 1,000 ms (Figure 1).

The picture stimuli comprised 384 pictures (88 positive, 88 negative, and 208 neutral pictures) selected from two sources. A majority of the pictures (92%) were from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008). Because pictures in IAPS represent almost exclusively Western scenarios and faces, another 30 (8.0%) pictures were selected from a previous study (Chan *et al.*, 2013), which involved the faces of Chinese volunteers aged 20–60 years portraying different emotions (happy, sad, and neutral). The inclusion of a small percentage of Chinese faces helped to improve the ecological validity of the stimuli (Waters *et al.*, 2008) and they should not affect the overall validity of the stimuli used in this study. All of the images were digitized, made monochromatic, and sized at 512 × 384 pixels. Four university graduate students rated the entire set of faces independently on happiness and sadness scales ranging from 1 (no emotion) to 7 (extreme emotion), and categorized the faces as sad or happy according to the research guidelines (Gotlib, Krasnoperova, Yue, & Joormann, 2004).

Measures

Attentional control

The Attentional Control Scale (ACS; Derryberry & Reed, 2002; Judah, Grant, Mills, & Lechner, 2014) is a 20-item self-report questionnaire that measures the abilities to

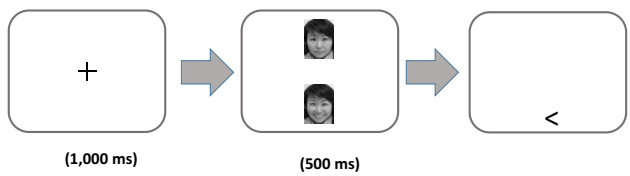

Figure 1. Presentation sequence of each trial in the visual dot-probe task. After a black fixation cross appeared in the middle of the screen for 1,000 ms, two pictures stimuli appeared simultaneously, one on top of another, for 500 ms. Then, an arrow probe replaced the picture until the participant identified the direction of the arrow by pressing the response button on the number pad. The screen then cleared and a new trial began after 1,000 ms.

maintain attention (focusing), and to redirect attention from one task to another (shifting). Items are scored on a 4-point scale, with 0 = never, 1 = sometimes, 2 = often, and 3 = always. After recoding inversely formulated items, an ACS total score (ACS Total) can be computed by summing across items. Higher scores reflect higher levels of attention control. We used the translation and back-translation procedures of the World Health Organization (2011) to develop the present Chinese version of the ACS (ACS-C). Cronbach's reliability alpha including all 20 items was .68. One item (item 18: *When a distracting thought comes to mind, it is easy for me to shift my attention away from it*) had a translation error and was subsequently removed. The final 19-item ACS-C had a Cronbach's coefficient alpha of .70 and was comparable to the English version of the ACS.

Trait anxiety

The study adopted the Trait Anxiety Scale of the Chinese version of the State-Trait Anxiety Inventory (STAI) (Form Y) (Shek, 1993). The trait anxiety scale (Spielberger, 1983) assesses one's persistent tendency to experience anxiety. All 20 items are rated on a 4-point scale from 'almost never' to 'almost always'. Nine items with reversal scores were recorded. A Trait Anxiety Score (STAI Trait) was computed by summing the item scores, with higher scores indicating greater anxiety. Considerable evidence attests to the construct and concurrent validity of the scale (Spielberger, 1983). Cronbach's coefficient alpha of the present sample was .84.

Demographic questionnaire

A self-designed demographic questionnaire was used to obtain personal information, including school attended, age, gender, place of birth, vision, and handedness.

Data analysis

Data preparation

Analyses were based on mean reaction times to probes in milliseconds (ms). Trials with errors or with extremely short (<200 ms) or extremely long (more than 2,000 ms) reaction times were excluded from subsequent analyses (Glinder, Beckjord, Kaiser, & Compas, 2007). To minimize the influence of outliers within subjects, response latencies that were more than two standard deviations above each subject's mean were discarded (Bradley *et al.*, 1997). Eight hundred and twenty of 31,680 trials (2.59%) were outliers. The maximum number of participants in each trial excluded for the above-mentioned reason was 5 (4.16%). Mean reaction times were first calculated for positive and negative trials. The difference between mean the response time for incongruent trials (probe appeared on the neutral stimulus) and congruent trials (probe appeared on the emotional stimulus) was then calculated separately for the positive and negative trials. Two scores were obtained according to this strategy.

Positive Attentional Bias Index (ABI Positive) measures participants' tendency to attend to positive stimuli. A positive value of ABI Positive indicates an attentional bias towards positive stimuli, whereas a negative value indicates an attentional bias away from positive stimuli (or towards neutral stimuli).

Negative Attentional Bias Index (ABI Negative) measures participants' tendency to attend to negative stimuli. Similar to the above, a positive value of ABI Negative indicates

an attentional bias towards negative stimuli, whereas a negative value indicates an attentional bias away from negative stimuli (or towards neutral stimuli).

It is of interest to examine the distribution of participants in each group, in particular how many of them exhibited both positive and negative attentional biases. Participants were thus categorized into positive and negative attentional bias groups according to the following procedures.

Positive attentional bias group

Participants with an ABI Positive greater than zero were categorized into the positive attentional bias group. These participants had, on average, a shorter reaction time for congruent trials (probe appeared on the positive stimuli) than for incongruent trials (probe appeared on the neutral stimulus).

Negative attentional bias group

Similarly, participants with an ABI Negative greater than zero tended to react faster when the probe appeared on the negative stimuli than on the neutral stimuli. They were classified into the negative attentional bias group.

Moderation effect

The following regression analyses were used to examine the moderation of attentional bias (*X*) on trait anxiety (*Y*) by attentional control (*M*).

1. All variables were mean-centred by gender (Hayes, 2013) because there were gender differences in ACS Total and STAI Trait scores.
2. Two interaction terms were calculated next: ABI Positive × ACS Total and ABI Negative × ACS Total.
3. A hierarchical regression analysis was conducted first with STAI Trait as the dependent variable. Three predictor variables including ACS Total, ABI Positive, and ABI Negative were entered in Step 1, and the two interaction terms above were entered in Step 2. This analysis allowed us to examine the relative importance of positive versus negative attentional bias in affecting anxiety.
4. To further examine the relations among the variables, separate analyses were then conducted for positive attentional bias and negative attentional bias. The PROCESS macro for SPSS developed by Hayes (2013) was used to conduct these analyses.

Results

Descriptive statistics

The means and SDs of all measures are shown in Table 1. Female students, when compared to their male counterparts, reported lower attentional control score, but higher trait anxiety. No gender differences were obtained for negative and positive attentional bias scores. Other demographic variables such age, handedness, and city of birth did not show significant effects on all variables.

It is worth noting that the mean ABI Positive and ABI Negative scores of this sample were 4.29 (SD = 32.63) and −5.02 (42.28), respectively, $t(120) = 2.13$, $p < .05$. The findings suggested that overall, adolescents in our sample had a significantly bigger

Table 1. Mean (*SD*) by gender

	Total (n = 120) *M* (*SD*)	Males (n = 66) *M* (*SD*)	Females (n = 54) *M* (*SD*)	*t*-Value
Psychometric inventories				
ACS-C Total	47.97 (6.66)	49.15 (6.65)	46.49 (6.43)	2.20*
STAI Trait	45.96 (8.51)	44.00 (8.75)	48.35 (7.63)	−2.87**
ABI Negative	−5.02 (42.28)	−4.11 (46.11)	−6.14 (37.48)	0.26
ABI Positive	4.29 (32.63)	5.33 (34.24)	3.03 (30.81)	0.38

Note. STAI Trait = Trait subscale score of the State-Trait Anxiety Inventory (Form Y); ACS-C Total = Attention Control Scale for Children; ABI Negative = Negative Attentional Bias Index; ABI Positive = Positive Attentional Bias Index.
**p < .01; *p < .05.

attentional bias towards positive than they had a bias towards negative. A 2 (attentional bias: positive vs. negative) × 2 (gender: male vs. female) repeated-measures analysis of variance obtained a significant attentional bias main effect: $F(1, 118) = 4.44$, $p < .05$. Neither the gender main effect, $F(1, 118) = 0.16$, $p > .1$, nor the interaction effect, $F(1, 118) = 0.001$, $p > .1$, was significant.

The Pearson product–moment correlation results showed that participants with a higher trait anxiety tended to report lower attentional control (trait anxiety and attentional control: $r = -.33$, $p < .01$). Neither positive nor negative attentional bias correlated with trait anxiety and attentional control. However, a positive correlation was obtained for ABI Positive and ABI Negative (Table 2).

Attentional bias group distributions

Sixty-three (52.5%; 33 males, 30 females) participants were classified as exhibiting positive attentional bias, whereas 50 (41.7%; 23 males, 27 females) were categorized into the negative attentional bias group. As expected, gender did not affect either the positive or negative attentional bias group distributions, positive attentional bias by gender: $\chi^2(1) = 0.37$, $p > .1$; negative attentional bias by gender: $\chi^2(1) = 2.801$, $p > .05$.

The following distributions existed among the participants: both positive and negative attentional bias (n = 27, 22.5%); positive attentional bias without negative attentional bias (n = 26, 30.0%); negative attentional bias without positive attentional bias (n = 23,

Table 2. Intercorrelation of variables (n = 120)

	ACS-C Total	STAI Trait	ABI Positive	ABI Negative
ACS-C Total	1	−.33**	.08	−.10
STAI Trait		1	−.10	−.08
ABI Positive			1	.20*
ABI Negative				1

Note. ACS-C Total = Attention Control Scale Total Score; STAI Trait = Trait subscale score of the State-Trait Anxiety Inventory (Form Y); ABI Positive = Positive Attentional Bias Index; ABI Negative = Negative Attentional Bias Index.
**p < .01; *p < .05.

19.2%); and neither positive nor negative attentional bias (n = 34, 28.3%). Chi-square analysis showed no significant difference in the distribution of group membership: χ^2 (1) = 0.08, $p > .1$ (Table 3).

Attentional bias group comparison

We examined whether attentional bias group differences, as measured by the visual dot-probe tasks, were present in the self-reported psychological measures. The results are shown in Table 4.

A significant difference in ACS score was obtained for negative attentional bias, $t(117) = 2.08$, $p < .05$. Participants with a negative attentional bias reported poorer attentional control when compared to those without such bias. No negative attentional bias group differences were found for trait anxiety. Furthermore, no group differences for all psychological variables were found for positive attentional bias.

Negative attentional bias versus positive attentional bias on anxiety by attentional control

Table 5 presents the results of the hierarchical regression analysis predicting trait anxiety score. In step 1, attentional control, negative attentional bias, and positive attentional bias could significantly predict trait anxiety, $F(5, 113) = 4.33$, $p < .001$. However, attentional control was the only significant individual predictor in the regression equation ($\beta = -.34$, $p < .0001$). Inclusion of the two interaction terms in step 2 did not significantly improve the predictive power of the regression equation: R^2 change = .03, $p = .118$. The overall equation was significant: $F(5, 113) = 4.33$, $p = .001$. Both the attentional control ($\beta = -.34$, $p < .0001$) and the attentional control $\times$ negative attentional bias interaction term ($\beta = -.67$, $p < .05$) were significant individual predictors in the final equation. Positive attentional bias did not predict trait anxiety, either alone ($\beta = -.24$, $p > .1$) or in interaction with attentional control ($\beta = -.16$, $p > .1$).

Separate analysis for negative attentional bias and positive attentional bias, respectively

The above analyses suggested that negative attentional bias, but not positive attentional bias, interact with attentional control to affect anxiety. We separated positive attentional bias and negative attentional bias in subsequent analyses and used the SPSS macro developed by Hayes (2013) to investigate the phenomenon further. This strategy allowed

Table 3. Positive attentional bias group by negative attentional bias groups

	Negative attentional bias group (%)		
	Yes	No	Total (%)
Positive attentional bias group			
Yes	27 (22.5)	**36 (30.0)**	63 (52.5)
No	**23 (19.2)**	34 (28.3)	57 (47.5)
Total	50 (41.7)	70 (58.3)	120 (100)

Note. Number (%) of participants with incongruent positive and negative attentional biases are highlighted in bold.

Table 4. Attentional bias group differences in attentional control and trait anxiety

	Negative attentional bias			Positive attentional bias		
	Mean (*SD*)			Mean (*SD*)		
	Yes	No	*t*-Value	Yes	No	*t*-Value
ACS-C Total	46.47 (6.97)	49.01 (6.27)	2.08*	48.27 (6.98)	47.63 (6.33)	−0.52
STAI Trait	46.28 (8.54)	45.73 (8.55)	−0.35	45.53 (8.67)	46.44 (8.39)	0.59

Note. ACS-C Total = Attention Control Scale Total Score; STAI Trait = Trait subscale score of the State-Trait Anxiety Inventory (Form Y).
*$p < .05$.

us to investigate the moderation effect of attentional control on the relationship between negative attentional bias and trait anxiety without taking positive attentional bias into consideration, and vice versa. The results are depicted in Table 6 below. Results similar to those of the previous regression analysis including the two types of attentional bias were obtained. For negative attentional bias, a (marginally) significant interaction effect was obtained ($p = .06$). A visual presentation of the moderation relationship is depicted in Figure 2. It is interesting to note that for adolescents with high attentional control (1 *SD* above mean), higher negative attentional bias was associated with lower trait anxiety (95% CI: −0.119 to −0.012, $p < .05$). On the other hand, for participants with low attentional control, negative attentional bias was not associated with trait anxiety (95% CI: −0.027 to 0.045, $p > .1$). Negative attentional bias and trait anxiety were marginally correlated for participants with moderate attentional control (95% CI: −0.058 to 0.002, $p = .066$). Again, positive attentional bias did not exert a significant effect on trait anxiety, either as an individual predictor or in interaction with attentional control.

Table 5. Hierarchical regression analysis to examine moderation of positive and negative attentional bias on trait anxiety by attentional control

	B	*SE B*	β	ΔR^2
Step 1				
ASC-C Total	−0.43	0.11	−.34**	.13**
ABI Negative	−0.02	0.02	−.11	
ABI Positive	−0.02	0.02	−.06	
$F(3, 115) = 5.65, p < .001$				
Step 2				
ASC-C Total	−0.44	0.12	−.34**	.03
ABI Negative	0.11	0.07	.54[a]	
ABI Positive	−0.06	0.07	−.24	
ABI Negative × ASC-C Total	−0.01	0.00	−.67*	
ABI Positive × ASC-C Total	0.00	0.00	.16	
$F(5, 113) = 4.33, p < .01$				

Note. ACS-C Total = Attention Control Scale Total Score; STAI Trait = Trait subscale score of the State-Trait Anxiety Inventory (Form Y); ABI Positive = Positive Attentional Bias Index; ABI Negative = Negative Attentional Bias Index.
*$p < .05$; **$p < .01$; [a]$p = .098$.

Table 6. Regression coefficients, standard errors, and model summary information for moderation of negative attentional bias and positive attentional bias, respectively, on trait anxiety by attentional control

	Coeff.	*SE*	*p*
Negative attentional bias			
ASC-C Total	−.43	2.38	<.001
ABI Negative	.09	0.06	.16
ABI Negative × ASC-C Total	−.01	0.00	.06
Constant	6.17	2.38	.01
$R^2 = .15$, $F(3, 115) = 6.85$, $p < .001$			
Positive attentional bias			
ASC-C Total	−.42	0.12	<.001
ABI Positive	−.02	0.06	.73
ABI Positive × ASC-C Total	.00	0.00	.97
Constant			
$R^2 = .12$, $F(3, 115) = 5.09$, $p = .002$			

Note. ACS-C Total = Attention Control Scale Total Score; STAI Trait = Trait subscale score of the State-Trait Anxiety Inventory (Form Y); ABI Positive = Positive Attentional Bias Index; ABI Negative = Negative Attentional Bias Index.

Discussion

The present study investigated attentional bias among a group of non-clinical adolescents in Hong Kong. First, it is interesting to note that as depicted in the result of *t*-test and Figure 3, our sample exhibited a bigger tendency towards attending to positive emotional

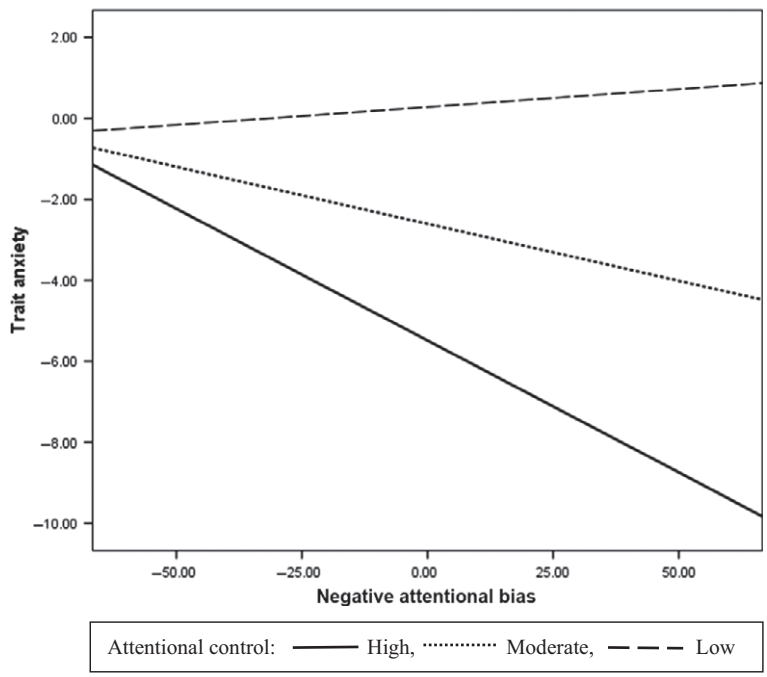

Figure 2. A visual representation of the moderation of the effect of negative attentional bias (*X*) on trait anxiety (*Y*) by attentional control (*M*).

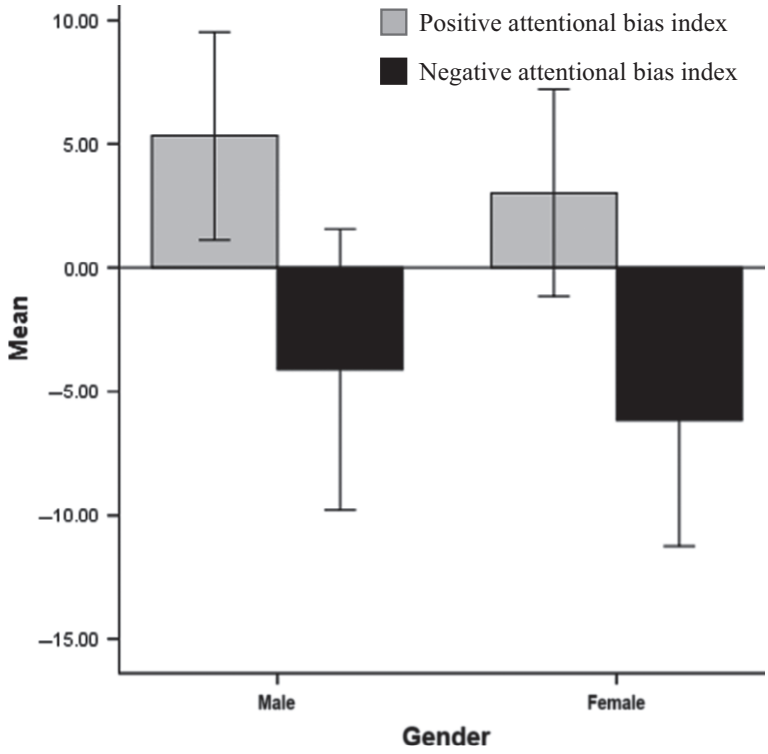

Figure 3. Positive and negative attentional biases by gender (n = 120). Error bars represent standard error to the mean.

stimuli than to negative emotional stimuli. This result was further supported by the attentional bias main effect in ANOVA, showing a higher positive attentional bias index than negative attentional bias index among the participants, $F(1, 118) = 4.44$, $p < .05$. Table 3 also reveals that a higher percentage of our participants had positive attentional bias without negative attentional bias (30.0%) as compared to those with negative attentional bias but without positive attentional bias (19.2%). Previous studies suggested a general tendency of negative attentional bias among all individuals (Mogg & Bradley, 1998; Waters, Lipp, & Spence, 2004) as such negative bias serves an adaptive survival function by helping an organism to avoid danger in the environment (Rozin & Royzman, 2001). Our results showed the contrary and found a tendency towards positive emotional stimuli among the adolescents in our sample. However, some other studies also failed to find a negative attentional bias among normal children and those with low anxiety (Waters *et al.*, 2008, 2010). For instance, Waters *et al.* (2008) did not find attentional bias towards emotional stimuli among both mildly anxious and non-anxious children although a significant negative attentional bias among highly anxious children was observed. An early study also showed that participants with low anxiety tended to show a positive attentional bias towards happy faces (Pishyar *et al.*, 2004). More relevant to our findings is another recent study conducted by Waters *et al.* (2010). These researchers found a positive attentional bias towards happy faces in both anxious and non-anxious children, but they suggested that replication of their findings is necessary. Our results provide support for the findings of Waters *et al.* (2010). However, the positive attentional bias among our sample could be explained from a cultural perspective. According to the socio-emotional

selectivity theory (Carstensen, Isaacowitz, & Charles, 1999), people have a tendency to pay selective attention to information that is meaningful to them and culture plays a salient role in defining meaningfulness of the information. A recent study also implied that task relevancy and irrelevancy, which can be influenced by culture, is an important factor related to attentional bias (Basanovic & MacLeod, 2016). A study using eye-tracking techniques to investigate attentional bias among Chinese participants in Hong Kong showed that younger people (47 years old or below) did not show attentional bias, whereas older people (57 years old or above) tended to exhibit a negative attentional bias (Fung *et al.*, 2008). No concrete explanation of their results was offered, but the researchers noted that Asian cultures are more interdependent and suggested that characteristics of Asian culture such as dialectical thinking might contribute to their results. It is also noted that the rapid economic development in China in the past decades might make our younger generation prone to paying more attention to positive stimuli and avoiding negative stimuli although this hypothesis needs further examination to confirm it. In sum, our findings illuminate our current understanding of attentional bias by replicating the finding of Waters *et al.* (2010) that a positive attentional bias exists among normal adolescents. More importantly, it shows that cultural factors should be taken into consideration in experiments involving emotional stimuli for attentional bias study. Of note, our study included 30 Chinese faces to increase the ecological validity of the stimuli.

It is in the above context regarding our sample characteristics that we discuss the findings related to the main research questions of this study. First and foremost, a modest negative correlation was found between trait anxiety and attentional control ($r = -.33$). Consistent with the existing findings in both adults and children (Bishop, 2009; Derryberry & Reed, 2002; Muris *et al.*, 2004; Osinsky *et al.*, 2012; Pacheco-Unguetti *et al.*, 2012; Wood, Mathews, & Dalgleish, 2001), individuals with higher dispositional anxiety tend to exhibit lower attentional control. Furthermore, neither positive nor negative attentional biases showed a significant correlational relationship with trait anxiety. For a non-clinical and normal population such as our sample, the lack of a relationship between these two constructs has been reported in other studies (Waters *et al.*, 2008, 2010). As mentioned before, some theories have even argued that a negative attentional bias is common to all individuals as it may be beneficial to survival (Rozin & Royzman, 2001). It has also been argued that negative attentional bias but not positive attentional bias is significantly related to anxiety (Basanovic & MacLeod, 2016). The relationship between attentional bias and attentional control is more complicated. Correlational analysis showed that neither positive nor negative attentional biases were related to attentional control (Table 2). When we categorized participants into attentional bias groups, it was revealed that participants with a negative attentional bias had lower attentional control as compared to those without negative attentional bias (re Table 4). Perhaps there are qualitative differences between individuals with and without negative attentional bias that led to the present results, and this proposition should be investigated further. In contrast, positive attentional bias has no relations with attentional control in both a correlational linear relationship and categorical (with vs. without positive attentional bias) difference.

The major objective of the present study was to examine the interaction effect of attentional control and attentional bias on anxiety (Petersen & Posner, 2012; Schafer *et al.*, 2015) among normal adolescents. A significant negative attentional bias $\times$ attentional control effect on anxiety was obtained in the hierarchical regression analysis with both positive and negative attentional biases taken into consideration (Table 5). A marginal significant effect ($p < .06$) was also obtained when negative attentional bias was considered alone in the PROCESS analysis (Hayes, 2013). Hence, we also found that

attentional control moderates the relationship between negative attentional bias and anxiety (Derryberry & Reed, 2002). On the other hand, our results revealed that for adolescents with high attentional control, a lower trait anxiety is related to higher negative attentional bias. Our present result seems to contrast with existing findings which show a positive relationship between the two constructs (Bar-Haim *et al.*, 2007; Derryberry & Reed, 2002; Pérez-Edgar *et al.*, 2010; Weeks *et al.*, 2008). It has been shown that individuals exhibiting a perceptual attention to both positive and negative stimuli represent better functioning than those perceive only positive or negative stimuli *per se* (Cheng, Wong, & Tsang, 2006). Our results suggest that higher functioning participants with higher attentional control and lower trait anxiety would exhibit a balanced attention by setting attentional goal towards negative emotional stimuli to comply with the task demand. They may not need to set attentional goal towards positive stimuli as they have a tendency to attend to the positive. The positive correlation between negative and positive attentional biases provides some support to the above hypothesis (r = .20, Table 2). Our present result needs to be investigated further in other studies. Positive attentional bias did not interact with attentional control to affect anxiety. As participants did not set specific attentional goal either towards or away from positive emotional stimuli, leading to the result that positive attentional had no relations with anxiety and attentional control.

Because our sample consisted of non-clinical participants, it is not appropriate to generalize our results to clinical interventions for anxiety. However, our results support attentional control training such as mindfulness training (Kabat-Zinn *et al.*, 1992) as an effective intervention strategy for anxiety management and prevention. Regarding cognitive bias modification training, positive attentional bias training for anxiety management is now available, and some positive results have been attained (Taylor *et al.*, 2010, 2011; Waters *et al.*, 2015). Our present results, however, suggest that cognitive modification of negative attentional bias may be more important than modification of positive attentional bias, especially when the attentional bias modification training would increase attentional control. There may be additional benefits of positive bias modification training after reducing negative attentional bias and this possibility could be explored in future studies.

There are several limitations of this study. First, it used a self-reported inventory to measure attentional control. Thus, future studies could use behavioural measures of attentional control such as the antisaccade tasks (Eysenck & Derakshan, 2011) and the Wisconsin Card Sorting Task (Eysenck & Derakshan, 2011) and the Wisconsin Card Sorting Task (Caselli, Reiman, Hentz, Osborne, & Alexander, 2004). Child-specific versions of some scales such as the ACS for Children (Muris, Mayer, van Lint, & Hofman, 2008) and the State-Trait Anxiety Scale for Children (Spielberger, 1973) could also be used. However, some participants in our sample were beyond the age limits for the above scales, thus preventing us from using them in the current study. Second, some neutral picture stimuli were presented in more than one trial. This repeated presentation might have led to familiarity with the neutral stimuli and thus attracted the participants' attention and affected their response times (Christie & Klein, 1995). Finally, comorbid depressive symptoms might affect reaction time and the relationships among the variables (Susa *et al.*, 2012). Future studies could include depressive symptoms in their measures.

Conclusion

In summary, in a community (non-clinical) sample of Hong Kong adolescents, the current results showed that attentional control is an important factor in understanding anxiety.

Negative attentional bias plays a more important role than positive attentional in affecting anxiety. Most importantly, negative attentional bias interacts with attentional control to affect anxiety. In particular, for individuals with high attentional control, a negative attentional bias is associated with lower trait anxiety, whereas for individuals with low attentional control, no significant relationship between negative attentional bias and trait anxiety is shown. Positive attentional bias is not related to both attentional control and trait anxiety.

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