Mindfulness (2019) 10:234–244
https://doi.org/10.1007/s12671-018-0964-6

ORIGINAL PAPER

Mechanisms of Mindfulness in Those with Higher and Lower Levels of Autism Traits

Phil Reed [1]

Published online: 1 June 2018

Abstract
The effects of brief mindfulness induction on a central trait of autism spectrum disorder (over-selective attention) were examined in order to assess whether different mechanisms act in those with lower and higher levels of autism traits, and determine which intervention may be most appropriate for individuals with different sets of symptoms. Two hundred and 24 *volunteer* participants (110 male; 114 female) were assessed for levels of autism traits (autism quotient; AQ), anxiety and depression (Hospital Anxiety and Depression Scales), and mindful awareness (Toronto Mindfulness Scale). They were randomly assigned to mindfulness, relaxation, or no-intervention groups. After three 10-min sessions, held on alternate days, participants underwent simultaneous discrimination training between two two-element compound stimuli (AB+ CD−), followed by an extinction test (AvC, AvD, BvC, BvD) to determine the amount of over-selectivity present. Levels of depression, anxiety, and mindfulness were re-assessed. Participants with greater autism traits demonstrated greater over-selectivity, than those with lower autism traits. Mindfulness reduced over-selectivity, and did so independently of the level of AQ displayed by the participants. For lower scoring AQ participants, mindfulness worked more effectively than relaxation. In contrast, for participants with higher AQ scores, there was little difference between the impact of mindfulness and relaxation. The latter group displayed no improvement in mindful awareness. Mindfulness induction can be effective, but may work through different mechanisms for those with higher and lower autism traits, and consideration should be given as to whether this intervention may be the most suitable in all cases where autism traits are present.

Keywords Mindfulness · Brief-induction · Over-selectivity · Autism quotient · Anxiety · Relaxation

Mindfulness has been suggested as an intervention beneficial for a range of emotional problems, such as depression (Hofmann and Gómez 2017; Spek et al. 2013; Winnebeck et al. 2017) and anxiety (Hoge et al. 2017; Hofmann and Gómez 2017; Kiep et al. 2015); as well as improving aspects of cognitive functioning, such as attention (Chesin et al. 2016; Morrison and Jha 2015) and memory (Zeidan et al. 2010). Positive impacts have been claimed for a range of populations, including individuals with clinical problems (see Cachia et al. 2016, Hofmann and Gómez 2017, for reviews), and those with problems of a non-clinical nature who are affected by issues, such as performance or test anxiety (Cho et al. 2016), memory problems (Zeidan et al. 2010) and attentional difficulties (McHugh et al. 2010).

However, there are also suggestions that the widespread usage of mindful techniques may not be fully supported by the literature (Van Dam et al. 2018). In some cases, this is claimed because mindfulness may be less effective than other available treatment procedures for some subsets of a population (see Arch and Ayers 2013, for a discussion). In other cases, because mindfulness may be actually damaging to the individuals (Briggs and Killen 2013). Importantly for clinical practice, these concerns arise, in part, as it is not fully established which populations may be able to benefit from mindful techniques (Arch and Ayers 2013; Van Dam et al. 2018). Similarly, it is not established precisely how mindful techniques produce their effects, and it is far from clear that mindfulness works through the same mechanism for different groups of individuals. This latter consideration is also important for clinical practice, as understanding the mechanisms of action of any intervention can help to

✉ Phil Reed
p.reed@swansea.ac.uk

1 Department of Psychology, Swansea University, Singleton Park, Swansea SA2 8PP, UK

develop and refine that intervention and tailor it for usage in particular cases.

One set of individuals who have received contemporary research effort with regard to the effectiveness of mindfulness, and who straddle both the clinical and non-clinical population, is those scoring high in autism traits (Cachia et al. 2016; Higuchi et al. 2017; Singh et al. 2011). A number of reports have suggested that mindfulness does impact beneficially on this population along some dimensions of their functioning (Kiep et al. 2015; Spek et al. 2013). Current evidence is suggestive for a positive impact on reducing rumination (de Bruin et al. 2015; Kiep et al. 2015) and anxiety (Spek et al. 2013; see Cachia et al. 2016, for a review). However, the picture with regard to other emotional problems associated with this population is not so clear (see de Bruin et al. 2015; Spek et al. 2013).

Importantly, it has not been established which, if any, of the many of the central cognitive aspects of autism apectrum disorder (ASD), such as attentional problems, are helped by mindfulness (see de Bruin et al. 2015). Neither has it been established, whether any such impacts are actually a direct effect of mindfulness or due to its impact on other areas of functioning, such as anxiety, which then helps with the symptoms under investigation (cf. Maisel et al. 2016, for a related discussion). While emotional problems, such as anxiety and depression, are clearly important issues for those with higher functioning ASD (Posserud et al. 2016; Reed 2016), and those with high levels of autism traits who are non-clinical (Reed et al. 2016; Towbin et al. 2005), they are not a diagnostic criteria for ASD (DSM-5; APA 2013).

A further difficulty about making judgments about the impact of mindfulness for those with high levels of autism traits is that many reports do not include control groups to isolate specific effects of mindfulness, relative to other nonspecific aspects of a very complex intervention (e.g., relaxation). For example, both de Bruin et al. (2015), and Singh et al. (2011), had only a before and after measure of rumination, and Spek et al. (2013) compared a group with mindfulness to a waiting list control. Given the impact of mindfulness on anxiety-related issues for ASD (de Bruin et al. 2015; Kiep et al. 2015; Spek et al. 2013) and the relatively high levels of anxiety reported by those with high-functioning ASD (MacNeil et al. 2009; Reed 2016), it is unclear whether mindfulness has its impact through specific mindfulness-related mechanisms or through some of the associated nonspecific process involved, like relaxation (see Arch and Craske 2006; Maisel et al. 2016; Van Dam et al. 2018).

Research with individuals with ASD has not reported universally positive results in regard to the mindful-specific mechanisms responsible for improvements produced through mindfulness interventions. Although de Bruin et al. (2015) reported a reduction in rumination after mindfulness training, they noted no greater mindful awareness in those participants. Lee and Orsillo (2014) noted that both mindfulness and relaxation produced improvements with an emotional Stroop task compared to a control group. Indeed, it may be important that mindfulness sometimes does not work as well as other forms of talking therapy for those with high levels of anxiety (Arch and Ayers 2013), although the degree to which this finding generalises across functioning areas and populations is not clear (cf. Arch and Craske 2006).

This lack of evidence for the specific impact of mindfulness in a population with high-functioning ASD, including those scoring high on autism traits but without a formal clinical diagnosis (i.e., those high on the broad autistic phenotype), contrasts with a range of studies for other populations that have shown an impact of mindfulness relative to relaxation. For example, Arch and Craske (2006) demonstrated a positive impact of a brief mindfulness training programme on anxiety, over and above the effects of relaxation, for a group with anxiety disorder. Similarly, McHugh et al. (2010) noted greater improvements in performance on an attentional over-selectivity task for older individuals. Over-selectivity occurs when one aspect of the environment controls behaviour at the expense of other equally salient and/or important aspects of the environment (see Dube 2009; Kelly et al. 2015). This latter task may be of particular importance to the ASD population, as they are known to display very high levels of over-selectivity and narrowed attention (Kelly et al. 2015).

Thus, it may be that mindfulness produces benefits across a range of populations, but may do so through different mechanisms. In those with lower anxiety levels, mindfulness may impact directly on a range of cognitive and emotional domains (Zeidan et al. 2010). However, for those with higher anxiety, which may include those with high-functioning ASD (MacNeil et al. 2009), mindfulness may work to reduce anxiety through some nonspecific aspect of the intervention, and this impacts levels of functioning (Lee and Orsillo 2014; Maisel et al. 2016). Certainly, in terms of over-selectivity, it is known that increasing levels of cognitive (Groden et al. 1994) and psychological (Reed and Gibson 2005) stress increases over-selectivity responding. Given this, a reduction in anxiety may serve to reduce over-selective attention—and it may be that this reduced anxiety, rather than some specific mindful mechanism is responsible for improvements in performance.

The current study aimed to explore these possibilities with regard to the impact of mindfulness on over-selective attention. The level of autism traits was measured in a volunteer sample, along with their levels of anxiety, depression, and mindfulness before and after a brief mindfulness intervention (modelled on that employed by Arch and Craske 2006). Based on previous literature, it was predicted that mindfulness would reduce over-selective responding in those with lower autism traits, compared to relaxation and a no-intervention control, but both relaxation and mindfulness would work to reduce over-selectivity in those with higher autism traits. It was also predicted that mindful awareness would not increase after the mindfulness intervention in the group with higher autism traits as much as in the former groups, but anxiety (being higher to start with) would reduce in the relaxation and mindfulness interventions for those with higher autism traits. This pattern of results would suggest that mindfulness works through different mechanisms for different groups of individuals.

Method

Participants

Two hundred and 24 *volunteer* adult participants (110 male; 114 female) were recruited from the general public and university students. The study adopted an exclusion criterion of anybody currently or previously in receipt of a diagnosis or treatment for a psychological problem, including ASD, which was specified on the advert for the study, and through self-report at the start of the study. No payment or course-credit was given to the participants. Participants had a mean age of 24.50 (± 6.02 SD; range = 18 to 49) years. Participants under the age of 18 years were excluded for ethical reasons, and those over the age of 55 years were excluded on the basis of previous research showing different levels of over-selectivity occurs in older individuals (McHugh and Reed 2007). Participants who had a history of self-reported psychiatric problems were excluded, as were those who reported that they had previously engaged in meditation or mindfulness techniques, as pilot studies had shown that previous meditational experience overwhelms any experimental manipulations. A priori power analysis (G*Power; Faul et al. 2007) for the overall analysis of variance (ANOVA) indicated that this was sufficient sample size to detect medium effect sizes. Ethical approval was given by the Ethics Committee of the University Psychology Department in which this research was conducted, and all participants gave fully informed consent to their participation.

Procedure

Participants were randomly assigned to one of three groups: mindfulness ($n = 74$), relaxation ($n = 74$) and control ($n = 76$). Each participant completed all parts of the study separately, in a small, quiet, dimly lit experimental room. During the first session, participants completed the AQ, HADS and TMS by hand, and then experienced their exercise (mindfulness or relaxation) or sat in the room for 10 min. They then returned twice for additional sessions, each 2 days after the preceding the session, during which they experienced their assigned exercise. Immediately after the exercise on the third session, the participants were presented with the experimental procedure via a Dell Latitude E6540 laptop (display size: 15.5″), programmed in E-Prime®. After this, they completed the HADS and TMS again.

Interventions There were two separate exercises—a relaxation (unfocused attention) induction (relaxation) and a focused attention induction (mindfulness) that were based on the exercises used by Arch and Craske (2006), and which have been shown to remediate over-selectivity in non-clinical populations (McHugh et al. 2010). Each exercise was delivered by a recording of a female voice, who was clinically qualified, and lasted 10 min. Participants experienced three sessions of their allotted exercise, each separated from one another by 1 day, making the study last 5 days in total. This procedure was based on the brief-mindfulness intervention constructed by Lee and Orsillo (2014) for cognitive flexibility. The exercises were completed alone by the participants while sitting in a dimly lit small room, and they were encouraged to practice the exercises at home in between the sessions.

Mindfulness (Focused Attention) Induction The instructions for the mindfulness induction were "*Focus your attention on your breathing. Notice the sensation of breathing air in. Notice the sensation of breathing air out. As you breathe air into your body, fill your mind with the thought 'just this one breath'. As you breathe air out of your body, fill your mind with the thought 'just this one exhale.*" Whenever any other thoughts came into the participants' minds, they were instructed to try and push them aside, and continue to focus only on their breathing patterns.

Relaxation (Unfocused Attention) Induction The participant instructions for the exercise were "*Let your mind wander freely amongst thoughts about past and present future events. Start by allowing your mind to roam. Don't try to focus on your thoughts; just let them drift without hesitation. There is no need to focus on anything in particular. Allow yourself to think freely. Try not to focus on any one thing. Just let your mind wander.*"

Experimental Training Phase Training commenced with the instructions "*Please select one of the two stimuli presented as soon as 'respond now' appears on the screen. You will be given feedback indicating whether you selected the correct or incorrect stimulus. Your aim is to select the correct stimulus.*" All participants were then presented with two simple discrimination tasks consisting of the compound stimuli (AB vs. CD; EF vs. GH). For each participant, the stimuli used as the elements (A, B, C, etc.) was constant throughout the experiment, but the assignment of stimuli as these elements differed across participants to avoid any effects being the results of overall differences between the actual physical stimuli. Two separate discrimination tasks were presented, as this has been shown to induce higher levels of over-selectivity in non-clinical populations than one such discrimination task alone (Reed and Gibson 2005). The two tasks were interspersed, so that compound stimulus AB appeared on the screen paired with compound stimulus CD, intermixed with trials of EF paired with GH (see Fig. 1 to demonstrate an AB vs. CD trial). Trials from each discrimination task (AB vs. CD and EF vs. GH) were randomly intermixed.

Participants selected one of the compounds when 'Respond Now' appeared on the screen by clicking the mouse cursor on one of the compounds. The 'Respond Now' instructions appeared after the trial had been presented for 2 s. 'Correct' or 'Incorrect' then appeared on the screen immediately after a response, and the next trial commenced. Thus, one compound in each task (e.g., AB and EF) was always reinforced in the presence of the other compound (e.g., CD and GH) for that task. The positions of the stimuli were randomised, with the correct stimulus appearing on the left for approximately 50% of the trials, and on the right for approximately 50% of the trials. If participants did not respond within 1.5 s (to keep the length of each trial relatively constant), the next trial commenced, and the response was scored as incorrect.

Training continued until the participant selected each correct compound consecutively five times (e.g., AB was selected five consecutive times, and EF was also selected five consecutive times). Once five consecutive, correct trials had been completed for one compound (e.g., AB vs. CD), trials for this discrimination task ceased, and only trials for the remaining task (e.g., EF vs. GH) continued until five consecutive correct responses for this task were also given.

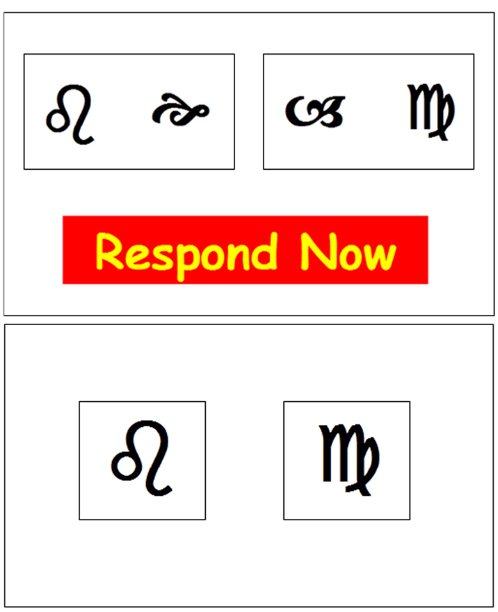

Fig. 1 An example of the compound stimuli used during the training phase, followed by an example of the elemental stimuli used during the testing phase

Test Phase Immediately after completing the training phase, the test phase instructions appeared on the screen. Participants were instructed "*Please select one of the two pictures presented. The computer will not tell you whether you are correct or incorrect.*" All participants were then presented with one stimulus from the previously reinforced compound (e.g., A or B; or E or F) paired with a stimulus from the previously punished compound (e.g., C or D; or G or H). Each combination (A vs. C, A vs. D, B vs. C, B vs. D, E vs. G, E vs. H, F vs. G, F vs. H) was presented five times. Thus, there were 40 trials in total. Participants were required to select one of the stimuli using the mouse cursor. They were provided with no feedback, and each trial appeared on the screen immediately after a response had been given. Participants were given 1.5 s to respond, as in the training phase, and, if no response was made, then neither element was scored as having been selected (this never occurred).

Measures

Autistic Spectrum Quotient Questionnaire AQ (Baron-Cohen et al. 2001) measures levels of autism traits. The questionnaire consists of 50 items. The test–retest reliability of the scale is .70 (Baron-Cohen et al. 2001), and the internal consistency (Cronbach α) is .82 (Austin 2005). There are sub-scales; however, there is some debate about the appropriate factor solution for the AQ, and the reliabilities of the sub-scales are uncertain (Austin 2005; Hurst et al. 2007). Given these concerns, only the overall AQ score was employed.

Hospital Anxiety and Depression Scale HADS (Zigmond and Snaith 1983) is a self-assessment questionnaire regarding levels of anxiety and depression. It contains seven items for anxiety and seven for depression over the past week. These scales give scores ranging from 0 to 21; 0–7 = 'normal'; 8–11 = 'mild'; 12–14 = 'moderate'; and 15+ = 'severe'. It has an internal reliability (α) of .84 for anxiety and .82 for depression (Bjelland et al. 2002).

Toronto Mindfulness Scale Toronto mindful scale (Lau et al. 2006) consists of 13 statements about how participants feel towards their thoughts during a mindfulness session. The items are scored on a 5-point Likert scale (0–4; 0 = not at all in agreement; and 4 = very much in agreement. It has an internal reliability (α) of .95 (Lau et al. 2006).

Compound and Elemental Stimuli Stimuli used during the procedure included eight abstract pictorial symbols taken from various fonts from Microsoft Word 2010 (Wingdings, Wingdings 2 and Symbol). Stimuli were either presented as a compound for training or an elemental stimulus during testing. Participants received different symbols for each stimulus to control for saliency effects. Additionally, the symbols have been successfully used in previous research using a similar over-selectivity paradigm with no evidence of differing a-priori salience (e.g., Reed et al. 2012). In all phases, each symbol appeared in black and measured approx. 5 cm × 5 cm (see Fig. 1).

Data Analyses

The over-selectivity data were analysed in a number of ways. Initially, data were organised into the percentage of times that the most-selected and least-selected stimuli were chosen during test. Two-way repeated-measures analysis of variances (ANOVA) were performed on these data with condition and stimulus type (most vs. least) as factors. It is reasonable to suggest that such an analysis will tend to produce a difference between the most and least-selected stimulus, and is not intended to show that there is over-selectivity per se, but that there is a difference in the relative amount of difference between the most and least-selected stimulus according to the condition. However, recognition of potential problems in using the above analysis, has led to additional analysis of the data using binomial theory (Reynolds and Reed 2011). In this test, data were explored to test whether the distribution of the most and least-selected stimuli is statistically greater than would be expected by random chance around an average probability of selection of the two stimuli; thus, indicating whether the difference from this expected level of choice differs from what would be expected if this were just random variation around a mean probability. In the absence of any a priori method of assessing what the mean probability of choosing a stimulus is, the combined mean of choice for A and B at test was employed, and the discrepancy from this mean tested according to binomial theory. Only one discrepancy for each condition will be tested, as the two values (most-selected and least-selected) are symmetrical around the mean.

Results

Table 1 shows the group-means for anxiety (HADS-A), depression (HADS-D), and mindfulness (TMS), before and after the interventions. These sample means are displayed for those participants who scored lower and higher in terms of their autism traits scores (AQ) in order to enable an initial analysis of the potential impact of autism traits on the effects of the interventions. For the initial analyses, the sample was split into lower and higher autism traits using a median split on the AQ variable. This produced a set of lower scoring autism participants ($n = 133$, mean = 10.35 ± 2.71; range = 3–15), and a set of higher scoring autism quotients participants ($n = 91$, mean = 20.10 ± 4.43; range = 16–39).

Inspection of Table 1 for the anxiety scores shows that participants with higher autism scores had greater levels of anxiety than those who had lower autism scores. In neither autism group did the control condition produce a strong reduction in anxiety. There was, however, a reduction in anxiety in both the relaxation and the mindfulness conditions, which was greater in size for the higher autism group. A three-factor mixed-model analysis of variance (ANOVA) with intervention group and AQ group as between-subject factors, and anxiety before and after as a within-subject factor, was conducted on these data and revealed no significant main effect of intervention group, $F(2,218) = 1.93$, $p = .148$, $\eta^2_p = .017$[95% CI = .000–.060], but there were significant main effects of AQ level, $F(1,218) = 21.10$, $p < .001$, $\eta^2_p = .088$[.029–.165], and anxiety before-after, $F(1,218) = 131.33$, $p < .001$, $\eta^2_p = .376$[.279–.460]. There were significant interactions between intervention group and anxiety before-after, $F(2,218) = 54.61$, $p < .001$, $\eta^2_p = .334$[.233–.418], AQ level and anxiety before-after, $F(1,218) = 43.42$, $p < .001$, $\eta^2_p = .166$[.085–.253], but not intervention group and AQ level, $F < 1$, $\eta^2_p = .005$[.000–.038], but there was a significant three-way interaction, $F(2,218) = 13.09$, $p < .001$, $\eta^2_p = .107$[.038–.183].

Table 1 Mean (standard deviation) for psychological variables before and after the study for the lower and higher autism trait groups

	Control		Relaxation		Mindfulness	
	Before	After	Before	After	Before	After
Lower AQ						
Anxiety	6.58 (2.67)	6.86 (2.67)	6.28 (2.81)	5.77 (2.97)	6.33 (3.19)	5.44 (3.23)
Depression	3.00 (2.69)	3.21 (2.49)	4.27 (2.46)	4.22 (2.22)	3.47 (2.43)	3.53 (2.79)
Mindfulness	24.63 (7.75)	24.72 (7.61)	25.33 (6.25)	25.69 (6.42)	24.20 (5.81)	35.51 (5.73)
Higher AQ						
Anxiety	8.88 (3.66)	9.09 (4.07)	8.78 (4.21)	6.20 (4.05)	9.48 (4.08)	7.58 (4.38)
Depression	3.91 (2.21)	5.69 (3.06)	4.59 (2.50)	6.55 (2.43)	5.65 (3.27)	5.69 (3.06)
Mindfulness	22.52 (8.07)	20.27 (7.79)	22.83 (8.62)	22.66 (8.23)	23.03 (4.87)	22.76 (3.56)

To further analyse the three-way interaction, separate two-factor mixed-model ANOVAs (intervention group × anxiety before-after) were conducted for each AQ level group, as recommended by Howell (1997). For the lower AQ level group, this analysis revealed a significant main effect of anxiety before-after, $F(1,130) = 16.70$, $p < .001$, $\eta^2_p = .114[.031–.220]$, but not of intervention group, $F(2,130) = 1.04$, $p > .30$, $\eta^2_p = .016[.000–.070]$. There was a significant interaction between the two factors, $F(2,130) = 7.84$, $p < .001$, $\eta^2_p = .108[.022–.206]$. Simple effect analyses conducted on anxiety before-after for each intervention-condition revealed no significant change for the control group, $F(1,130) = 2.98$, $p > .30$, $\eta^2_p = .022[.000–.094]$, but significant reductions in anxiety for the relaxation, $F(1,130) = 18.31$, $p < .001$, $\eta^2_p = .124[.037–.231]$, and mindfulness, $F(1,130) = 30.76$, $p < .001$, $\eta^2_p = .191[.083–.305]$, groups. For the higher AQ level group, this analysis revealed a significant main effect of anxiety before-after, $F(1,88) = 115.80$, $p < .001$, $\eta^2_p = .568[.429–.662]$, but not of intervention group, $F(2,88) = 1.15$, $p > .30$, $\eta^2_p = .025[.000–.105]$. There was a significant interaction between the two factors, $F(2,88) = 41.98$, $p < .001$, $\eta^2_p = .488[.330–.591]$. Simple effect analyses conducted on anxiety before-after for each intervention-condition revealed no significant change for the control group, $F < 1$, $\eta^2_p = .011[.000–.087]$, but significant reductions in anxiety for the relaxation, $F(1,88) = 120.89$, $p < .001$, $\eta^2_p = .579[.441–.670]$, and mindfulness, $F(1,88) = 66.78$, $p < .001$, $\eta^2_p = .432[.276–.549]$, groups.

Inspection of Table 1 for the depression scores shows that participants with higher autism scores had slightly greater levels of depression than those who had lower autism scores. In neither autism group did any of the interventions produce a strong reduction in depression. A three-factor mixed-model ANOVA (intervention group × AQ level × depression before and after) conducted on these data revealed a significant main effect of intervention group, $F(2,218) = 5.32$, $p < .01$, $\eta^2_p = .047[.005–.106]$, depression before-after, $F(1,218) = 25.17$, $p < .001$, $\eta^2_p = .103[.039–.183]$, and AQ level, $F(1,218) = 19.19$, $p < .001$, $\eta^2_p = .081[.025–.156]$. There were significant interactions between intervention group and depression before-after, $F(2,218) = 9.52$, $p < .001$, $\eta^2_p = .080[.021–.151]$, AQ level and depression before-after, $F(1,218) = 17.07$, $p < .001$, $\eta^2_p = .073[.020–.146]$, but not intervention group and AQ level, $F(2,218) = 1.04$, $p > .30$, $\eta^2_p = .009[.000–.043]$. There was a significant three-way interaction, $F(2,218) = 13.61$, $p < .001$, $\eta^2_p = .111[.041–.188]$.

A two-factor mixed-model ANOVAs (intervention group × depression before-after) conducted for the lower AQ level group revealed no significant main effect of depression before-after, $F < 1$, $\eta^2_p = .004[.000–.049]$, or intervention group, $F(2,130) = 2.49$, $p = .087$, $\eta^2_p = .037[.000–.109]$, nor interaction between the two factors, $F < 1$, $\eta^2_p = .006[.000–.039]$. For the higher AQ level group, this analysis revealed significant main effects of anxiety before-after, $F(1,88) = 36.87$, $p < .001$, $\eta^2_p = .295[.145–.429]$, and intervention group, $F(2,88) = 3.52$, $p < .05$, $\eta^2_p = .074[.000–.182]$, and a significant interaction between the two factors, $F(2,88) = 19.73$, $p < .001$, $\eta^2_p = .310[.149–.435]$. Simple effect analyses conducted on depression before-after for each intervention-condition revealed no significant change for the control group, $F(1,88) = 3.27$, $p = .07$, $\eta^2_p = .034[.000–.137]$, a significant increase in depression for relaxation, $F(1,88) = 71.54$, $p < .001$, $\eta^2_p = .449[.294–.563]$, and no change for mindfulness, $F < 1$ (.02), $\eta^2_p = .001[.000–.009]$.

Inspection of Table 1 for the mindfulness scores shows that, for the lower autism group, the control and relaxation conditions did not produce a change in mindfulness, but there was an increase in mindfulness for the mindfulness condition. There was no increase in mindfulness for the higher autism group in any of the conditions. A three-factor mixed-model ANOVA (intervention group × AQ level × mindfulness before-after) conducted on these data revealed significant main effects of intervention group, $F(2,218) = 4.55$, $p < .05$, $\eta^2_p = .040[.002–.097]$, mindfulness before-after, $F(1,218) = 129.00$, $p < .001$, $\eta^2_p = .391[.274–456]$, and AQ level, $F(1,218) = 22.03$, $p < .001$, $\eta^2_p = .092[.032–.169]$. There were significant interactions between intervention group and mindfulness before-after, $F(2,218) = 251.82$, $p < .001$, $\eta^2_p = .698[.633–.743]$, AQ level and mindfulness before-after, $F(1,218) = 355.19$, $p < .001$, $\eta^2_p = .620[.543–.677]$, but not intervention group and AQ level, $F(2,218) = 2.06$, $p = .136$, $\eta^2_p = .018[.000–.062]$, but there was a significant three-way interaction, $F(2,218) = 177.16$, $p < .001$, $\eta^2_p = .619[.541–.675]$.

A two-factor mixed-model ANOVA (intervention group × mindfulness before-after) conducted for the lower AQ level group revealed significant main effects of mindfulness before-after, $F(1,130) = 880.52$, $p < .001$, $\eta^2_p = .871[.832–.896]$, intervention group, $F(2,130) = 7.94$, $p < .001$, $\eta^2_p = .109[.023–.201]$, and a significant interaction between the two factors, $F(2,130) = 788.97$, $p < .001$, $\eta^2_p = .924[.899–.938]$. Simple effect analyses conducted on mindfulness before-after for each intervention condition revealed no significant change in mindfulness for the control group, $F < 1$ (.16), $\eta^2_p = .001[.000–.039]$, or the relaxation group, $F(1,130) = 2.41$, $p = .244$, $\eta^2_p = .018[.000–.086]$, but a significant increase in the mindfulness group, $F(1,130) = 2481.03$, $p < .001$, $\eta^2_p = .950[.934–.960]$. For the higher AQ level group, this analysis revealed a significant main effect of mindfulness before-after, $F(1,88) = 13.77$, $p < .001$, $\eta^2_p = .135[.029–.268]$, but not of intervention group, $F < 1$, $\eta^2_p = .006[.000–.077]$, but there was a significant interaction between the two factors, $F(2,88) = 8.11$, $p < .001$, $\eta^2_p = .156[.034–.281]$. Simple effect analyses conducted on mindfulness before-after for each intervention-condition revealed a significant reduction for the control group, $F(1,88) = 33.72$, $p < .001$, $\eta^2_p = .277[.129–.411]$, but no significant change for the relaxation group, $F < 1$, η^2_p = .002[.000–.056], or the mindfulness group, $F < 1$, η^2_p = .005[.000–.071].

Trials to Criterion During Discrimination Training

Participants in the control group took a mean 18.01 (± 2.91) trials during training to reach the criterion for choosing AB and EF, those in the relaxation group took 18.76 (± 4.16) trials, and those in the mindfulness group took 17.72 (±2 .77) trials. An ANOVA revealed no statistically significant main effect of group, $F(1,221) = 1.91$, $p > .1$, η^2_p = .008 [95%CI = .000–.048]. There were no significant correlations between trials to criterion and autism quotient, $r = -.035$, $p > .60$; anxiety before, $r = -.013$, $p > .80$; anxiety after, $r = -.006$, $p > .9$; depression before, $r = -.050$, $p > .40$; depression after, $r = -.089$, $p > .10$; mindfulness before, $r = .028$, $p > .60$; or mindfulness after, $r = .004$, $p > .60$.

Most vs. Least-Selected Elements During Test (Over-Selectivity)

The mean percentage times that the most-selected and least-selected stimuli were chosen from reinforced compounds AB and EF during the test were calculated. The number of times that the individual elements of each previously reinforced element (A or B and E and F) were calculated. The element that was selected more times from each compound, was designated the ‘most-selected’ element; providing a most-selected (e.g., A) and least-selected stimulus (e.g., B) from AB, as well as a most-selected (e.g., E) and least-selected stimulus (e.g., F) from EF. The mean most-selected (e.g., A and E) and least-selected (e.g., B and F) mean was then calculated.

Figure 2 shows the group-mean percentage times that the most- and least-selected stimuli were chosen for the three groups (control, relaxation, and mindfulness) for the lower and higher autism participants in those groups. Inspection of these data reveals that there was a large differences between the most- and least-selected stimuli in the control group for both the higher AQ and lower AQ groups. For the relaxation groups, there was a difference between the most- and least-selected stimulus for the lower scoring AQ group, but not for the higher scoring AQ group. For the mindfulness group, there was little most versus least difference for either AQ group.

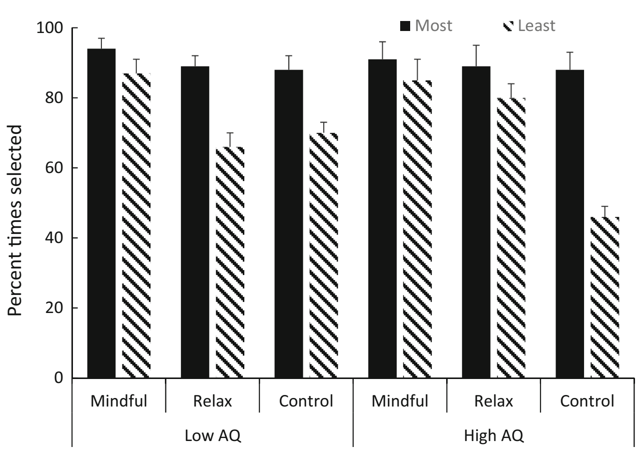

Fig. 2 Percentage times most and least-selected elements were chosen for each group at test

A three-factor mixed-model analysis of covariance (ANCOVA) with group and AQ as between-subject factors, stimulus as a within-subject factor, and anxiety-, depression-, and mindfulness after as covariates (i.e., these scores at the time of testing) was conducted on these data. This analysis revealed a significant main effect of group, $F(2,215) = 16.84$, $p < .001$, η^2_p = .135[.056–.216], stimulus, $F(1,215) = 17.51$, $p < .001$, η^2_p = .075[.021–.150], but not AQ, $F < 1$, η^2_p = .001[.000–.002]. There were significant interactions between group and AQ, $F(2,215) = 10.26$, $p < .001$, η^2_p = .087[.025–.160], stimulus and group, $F(2,215) =$ 68.82, $p < .001$, η^2_p = .390[.289–.471], but not stimulus and AQ, $F <= 1$, η^2_p = .001[.000–.068], but there was a significant three-way interaction, $F(2,215) = 33.89$, $p < .001$, η^2_p = .236[.144–.327].

To further analyse the three-way interaction, separate two-factor ANCOVAs (AQ × stimulus, with depression, anxiety, and mindfulness—after as covariates) were conducted for each group. For the control group this analysis revealed significant effects of AQ, $F(1,71) = 12.56$, $p < .001$, η^2_p = .150[.029–.299], and stimulus, $F(1,71) = 25.16$, $p < .001$, η^2_p = .262[.108–.410], and a significant interaction between stimulus and AQ, $F(1,71) = 18.62$, $p < .001$, η^2_p = .208[.063–.358]. Simple effect analyses conducted on the most vs. least stimulus difference for the lower AQ group revealed a significant difference, $F(1,72) = 15.73$, $p < .001$, η^2_p = .179[.046–.329], and a much greater difference for the higher scoring group, $F(1,72) = 300.73$, $p < .001$, η^2_p = .808[.723–.854].

For the relaxation group this analysis revealed a significant effect of AQ, $F(1,69) = 6.43$, $p < .05$, η^2_p = .085[.003–.224], no significant main effect of stimulus, $F < 1$, η^2_p = .009[.000–.099], but a significant interaction between stimulus and AQ, $F(1,69) = 15.88$, $p < .001$, η^2_p = .187[.049–.340]. Simple effect analyses conducted on the most vs. least stimulus difference for the lower AQ group revealed a significant difference, $F(1,72) = 115.78$, $p < .001$, η^2_p = .617[.471–.707], and a much lower difference for the higher scoring group, $F(1,72) = 15.73$, $p < .001$, η^2_p = .179[.046–.329].

For the mindfulness group this analysis revealed a significant main effect of stimulus, $F(1,69) = 6.40$, $p < .05$, η^2_p = .085[.003–.224], but no significant effect of AQ, $F<$

1, η^2_p = .001[.000–.085], or interaction between stimulus and AQ, $F(1,69) = 3.96$, $p > 0.05$, η^2_p = .054[.000–.182].

Most vs. Least-Selected Elements During Test (Over-Selectivity)

The analysis above will produce a numeric difference between the most- and least-selected stimuli, and this analysis will not show that there is over-selectivity per se. Given this consideration, further analysis of the data was undertaken, based on binomial theory, to determine whether the deviation in the times that the most-selected and least-selected stimuli were chosen was statistically greater than would be expected by random chance around an average probability of selection of the two stimuli (Reynolds and Reed 2011). This analysis was undertaken to indicate whether the difference from the level of choice that would be expected if both stimuli had the same probability of being chosen was statistically significant—i.e., whether there was absolute over-selectivity, as opposed to relative differences in stimulus selection. Paired t tests were then used to test this sum against the obtained data, in order to investigate whether significant over-selectivity occurred in each of the groups.

Control Group The criteria level for over-selectivity, calculated using the Reynolds/Reed methods (above), for this group was 18.23, and a paired t test between the actual differences and this criterion value revealed a statistically significant difference from chance, $t(75) = 5.51$, $p < .001$, $d = .63$, suggesting over-selectivity occurred for this group. Participants were categorised into those who demonstrated over-selectivity (i.e., had a difference score of greater than the criterion value) and those who did not. A logistic regression was conducted with anxiety (HADS-A), depression (HADS-D), mindfulness (TMS) after the intervention, and the AQ scores, as predictors, and the binary categorisation (0 = no over-selectivity; 1 = over-selectivity) as the outcome. This revealed a significant regression, $-2LL = 61.54$, $X^2(4) = 28.06$, $p < .001$. There were significant relationships between the autism quotient and presence of over-selectivity, with more autism traits meaning a greater chance of over-selectivity (*odds ratio* = 1.444, $p < .001$), but not between the presence of over-selectivity and anxiety (*odds ratio* = .923, $p > .50$), depression (*odds ratio* = 1.064, $p > .60$), or mindfulness (*odds ratio* = 1.080, $p = .074$).

Relaxation Group The criteria level for over-selectivity, calculated using the Reynolds/Reed methods (above), for this group was 15.78, and a paired t test between the actual differences and this criterion value revealed no statistically significant difference from chance, $t < 1$, $d = .02$, suggesting no overall level of over-selectivity for this group. A logistic regression, conducted with the psychological variables as predictors, and the binary categorisation (0 = no over-selectivity; 1 = over-selectivity) as the outcome, revealed a significant regression, $-2LL = 66.00$, $X^2(4) = 25.72$, $p < .001$. There was a significant negative relationships between autism quotient and the presence of over-selectivity (*odds ratio* = .828, $p < .05$), and a significant positive relationship between anxiety (β = 1.273, $p < .05$), and mindfulness (β = 1.139, $p < .05$), but not between depression (*odds ratio* = .731, $p = .194$).

Mindfulness Group The criteria level for over-selectivity, calculated using the Reynolds/Reed methods (above), for this group was 8.10, and a paired t test between the actual differences and this criterion value revealed no statistically significant difference from chance, $t(73) = 1.73$, $p > .08$, $d = .24$, suggesting no over-selectivity was present. A logistic regression also revealed no significant prediction by these variables to the presence of over-selectivity, $-2LL = 98.39$, $X^2(4) = 2.89$, $p > .50$.

Discussion

The results demonstrated that without any form of intervention (mindfulness or relaxation), participants with higher levels of autism traits demonstrated greater over-selectivity than those with lower autism and anxiety scores. This finding is novel with respect to AQ scores, but is consistent with previous findings for those with ASD (Kelly et al. 2015; Leader et al. 2009), and also replicates previous findings that have shown greater levels of anxiety or stress associated with over-selective responding (Groden et al. 2005). The finding that those with higher AQ scores perform similarly to those with clinical-ASD also extend the suggestion that ASD could be regarded as a broad phenotype with traits distributed across the population (Couteur et al. 1996; Reed et al. 2011).

The mindfulness intervention removed a tendency to over-select, and did so independently of the level of AQ displayed by the participants. This suggests that mindfulness may well be a useful intervention in this regard, and further substantiates previous findings that have shown its effectiveness for some populations (Hofmann and Gómez 2017). This also suggests that mindfulness may be effective in dealing with some of the core symptoms of ASD. However, the current results also suggest that the mechanisms through which such a mindfulness intervention works could differ between those with lower and higher levels of autism traits. Considering the data from the lower scoring AQ participants, it is apparent that the mindfulness intervention worked much more effectively than the relaxation (unfocused attention) intervention in terms of reducing over-selective responding. This is in line with previous studies that have compared mindfulness with relaxation for a population without ASD (Arch and Craske 2006; McHugh et al. 2010).

In contrast, for the participants with higher AQ scores, it is apparent that there was little difference between the impact of the mindfulness and the relaxation interventions, and both produced less over-selectivity than the control condition. This is a novel finding with respect to the impact of mindfulness on over-selectivity—where in other groups mindfulness has produced a stronger reduction in over-selectivity than relaxation (Arch and Craske 2006). It is also novel with respect to the impact of mindfulness on a population with higher levels of ASD traits. Previous studies of this latter group often have lacked such a relaxation control (de Bruin et al. 2015; Singh et al. 2011). Although it has been shown that mindfulness works for a group with ASD, especially with regard to ritualistic behaviours (de Bruin et al. 2015; Kiep et al. 2015), it has not been shown that this effect is due to the specific effects of mindfulness, rather than to the possible effects of relaxation.

Thus, the current results suggest that mindfulness may well be beneficial with regard to reducing an over-focused attention in those with lower and higher levels of autism traits, but that it may well work through different mechanisms in each case. The precise mechanisms of this action will require further exploration. However, some tentative suggestions may be made on the bases of these data. Mindfulness reduced over-selectivity, better than relaxation, for the lower scoring AQ participants. This latter group showed higher levels of mindfulness after the mindful intervention than the other two intervention groups. Together, these findings suggest a specific mindful mechanism for these participants.

That those with higher levels of AQ showed no differential over-selectivity reduction in the mindfulness compared to the relaxation treatment, and also showed no higher levels of mindfulness after the mindfulness intervention than after the other interventions, suggests that the relaxation induced by the mindfulness condition may have been the key component of action for this group. That anxiety levels were higher in the higher AQ participants, might also suggest that this aspect was exerting a strong effect on their over-selectivity performance (Groden et al. 2005), and that any intervention that reduces anxiety may help this group to reduce over-selective attentional responses (see also Maisel et al. 2016, for a similar discussion). Indeed, anxiety has been shown to be reduced in groups with ASD traits (MacNeil et al. 2009).

Of course, these suggestions are speculative, and do not mean that mindfulness would not be effective for specific mechanisms in those with higher levels of autism traits who had lower levels of anxiety. Neither do the results suggest that the mindfulness intervention did not have specific effects in those with higher AQ, but that any specific effects were secondary to the general effects of anxiety reduction. These suggestions would need further experimentation to explore. It should also be noted that the current interventions were given over a relatively brief time period, certainly for a shorter time period than might be given in a clinical context. However, that brief interventions of a similar length have been successful in reducing clinically relevant symptoms (Arch and Craske 2006), and that even shorter mindful interventions have been successful in reducing over-selectivity in other populations (McHugh et al. 2010), suggests that time-alone is not a key factor in the impact of mindful interventions. None of the participants were drawn from a clinical population (in so far as they failed to report any current or previous psychiatric problems). This might mean that the current results may not generalise to those populations —this will require further exploration. However, mindfulness has been suggested as an important approach to tackle many non-clinical problems, and, to this extent, the current results are directly relevant. Finally, the degree to which these findings would generalise to populations with other cognitive or emotional problems, or who receive longer duration or greater numbers of mindfulness sessions, is also uncertain.

In summary, the current study demonstrated that over-selective responding is associated with higher levels of AQ and anxiety, and that it can be reduced by mindfulness interventions. However, it is unclear whether these mindfulness interventions impact over-selectivity through the same mechanisms in those with lower and higher levels of autism traits. It seems that mindfulness may initially act to reduce anxiety levels which are associated with over-selectivity, and then exert a more specific effect on attention.

Compliance with Ethical Standards

Conflict of Interest The author declare that they have no conflicts of interest.

Ethics Statement Ethical approval for this research was given by the Department of Psychology, Swansea University, Ethics Committee.

Informed Consent Statement All participants were given information about the study, told that they could withdraw at any point without giving a reason, and signed a consent form after receiving this information.

References

American Psychiatric Association (2013). Diagnostic and statistical manual of mental disorders (DSM-5®). American Psychiatric Pub.

Arch, J. J., & Ayers, C. R. (2013). Which treatment worked better for whom? Moderators of group cognitive behavioral therapy versus adapted mindfulness based stress reduction for anxiety disorders. *Behaviour Research and Therapy, 51*, 434–442.

Arch, J. J., & Craske, M. G. (2006). Mechanisms of mindfulness: Emotion regulation following a focused breathing induction. *Behaviour Research and Therapy, 44*, 1849–1858.

Austin, E. J. (2005). Personality correlates of the broader autism phenotype as assessed by the Autism Spectrum Quotient (AQ). *Personality and Individual Differences, 38*, 451–460.

Baron-Cohen, S., Wheelwright, S., Skinner, R., Martin, J., & Clubley, E. (2001). The autism-spectrum quotient (AQ): evidence from asperger syndrome/high-functioning autism, males and females, scientists and mathematicians. *Journal of Autism and Developmental Disorders, 31*, 5–17.

Bjelland, I., Dahl, A. A., Haug, T. T., & Neckelmann, D. (2002). The validity of the Hospital Anxiety and Depression Scale: an updated literature review. *Journal of Psychosomatic Research, 52*, 69–77.

Briggs, J., & Killen, J. (2013). Perspectives on complementary and alternative medicine research. *Journal of the American Medical Association, 310*, 691–692.

Cachia, R. L., Anderson, A., & Moore, D. W. (2016). Mindfulness in individuals with autism spectrum disorder: a systematic review and narrative analysis. *Review Journal of Autism and Developmental Disorders, 3*, 165–178.

Chesin, M. S., Benjamin-Phillips, C. A., Keilp, J., Fertuck, E. A., Brodsky, B. S., & Stanley, B. (2016). Improvements in executive attention, rumination, cognitive reactivity, and mindfulness among high-suicide risk patients participating in adjunct mindfulness based cognitive therapy: preliminary findings. *The Journal of Alternative and Complementary Medicine, 22*, 642–649.

Cho, H., Ryu, S., Noh, J., & Lee, J. (2016). The effectiveness of daily mindful breathing practices on test anxiety of students. *PLoS One, 11*(10), e0164822.

Couteur, A., Bailey, A., Goode, S., Pickles, A., Gottesman, I., Robertson, S., & Rutter, M. (1996). A broader phenotype of autism: the clinical spectrum in twins. *Journal of Child Psychology and Psychiatry, 37*, 785–801.

de Bruin, E. I., Blom, R., Smit, F. M., van Steensel, F. J., & Bögels, S. M. (2015). MYmind: mindfulness training for youngsters with autism spectrum disorders and their parents. *Autism, 19*, 906–914.

Dube, W. V. (2009). Stimulus overselectivity in discrimination learning. In P. Reed (Ed.), *Behavioural theories and interventions for autism*. New York: Nova.

Faul, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007). G* Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39*, 175–191.

Groden, J., Cautela, J., Prince, S., & Berryman, J. (1994). The impact of stress and anxiety on individuals with autism and developmental disabilities. In *Behavioral Issues in Autism* (pp. 177–194). Springer, Boston.

Groden, J., Goodwin, M. S., Baron, M. G., Groden, G., Velicer, W. F., Lipsitt, L. P., & Plummer, B. (2005). Assessing cardiovascular responses to stressors in individuals with autism spectrum disorders. *Focus on Autism and Other Developmental Disabilities, 20*(4), 244–252.

Higuchi, Y., Inagaki, M., Koyama, T., Kitamura, Y., Sendo, T., Fujimori, M., et al. (2017). Emotional intelligence and its effect on pharmacists and pharmacy students with autistic-like traits. *American Journal of Pharmaceutical Education, 81*, 74.

Hofmann, S. G., & Gómez, A. F. (2017). Mindfulness-based interventions for anxiety and depression. *Psychiatric Clinics, 40*, 739–749.

Hoge, E.A., Bui, E., Palitz, S.A., Schwarz, N.R., Owens, M.E., Johnston, J.M., ... & Simon, N.M. (2017). The effect of mindfulness meditation training on biological acute stress responses in generalized anxiety disorder. *Psychiatry Research*.

Howell, D. C. (1997). *Statistical methods for psychology*. Boston: PSW-Kent.

Hurst, R. M., Mitchell, J. T., Kimbrel, N. A., Kwapil, T. K., & Nelson-Gray, R. O. (2007). Examination of the reliability and factor structure of the Autism Spectrum Quotient (AQ) in a non-clinical sample. *Personality and Individual Differences, 43*, 1938–1949.

Kelly, M. P., Leader, G., & Reed, P. (2015). Stimulus over-selectivity and extinction-induced recovery of performance as a product of intellectual impairment and autism severity. *Journal of Autism and Developmental Disorders, 45*, 3098–3106.

Kiep, M., Spek, A. A., & Hoeben, L. (2015). Mindfulness-based therapy in adults with an autism spectrum disorder: do treatment effects last? *Mindfulness, 6*, 637–644.

Lau, M. A., Bishop, S. R., Segal, Z. V., Buis, T., Anderson, N. D., Carlson, L., et al. (2006). The Toronto mindfulness scale: development and validation. *Journal of Clinical Psychology, 62*, 1445–1467.

Leader, G., Loughnane, A., McMoreland, C., & Reed, P. (2009). The effect of stimulus salience on over-selectivity. *Journal of Autism and Developmental Disorders, 39*, 330.

Lee, J. K., & Orsillo, S. M. (2014). Investigating cognitive flexibility as a potential mechanism of mindfulness in generalized anxiety disorder. *Journal of Behavior Therapy and Experimental Psychiatry, 45*, 208–216.

MacNeil, B. M., Lopes, V. A., & Minnes, P. M. (2009). Anxiety in children and adolescents with autism spectrum disorders. *Research in Autism Spectrum Disorders, 3*, 1–21.

Maisel, M. E., Stephenson, K. G., South, M., Rodgers, J., Freeston, M. H., & Gaigg, S. B. (2016). Modeling the cognitive mechanisms linking autism symptoms and anxiety in adults. *Journal of Abnormal Psychology, 125*, 692–703.

McHugh, L., & Reed, P. (2007). Age trends in stimulus overselectivity. *Journal of the Experimental Analysis of Behavior, 88*(3), 369–380.

McHugh, L., Simpson, A., & Reed, P. (2010). Mindfulness as a potential intervention for stimulus over-selectivity in older adults. *Research in Developmental Disabilities, 31*, 178–184.

Morrison, A.B., & Jha, A.P. (2015). Mindfulness, attention, and working memory. In *Handbook of mindfulness and self-regulation* (pp. 33–45). Springer, New York.

Posserud, M., Hysing, M., Helland, W., Gillberg, C., & Lundervold, A. J. (2016). Autism traits: the importance of "co-morbid" problems for impairment and contact with services. Data from the Bergen Child Study. *Research in Developmental Disabilities*.

Reed, P. (2016). *Interventions for autism: Evidence for educational and clinical practice*. Chichetser: Wiley.

Reed, P., & Gibson, E. (2005). The effect of concurrent task load on stimulus over selectivity. *Journal of Autism and Developmental Disorders, 35*, 601–614.

Reed, P., Lowe, C., & Everett, R. (2011). Perceptual learning and perceptual search are altered in male university students with higher Autism Quotient scores. *Personality and Individual Differences, 51*, 732–736.

Reed, P., Reynolds, G., & Fermandel, L. (2012). Revaluation manipulations produce emergence of underselected stimuli following simultaneous discrimination in humans. *Quarterly Journal of Experimental Psychology, 65*, 1345–1360.

Reed, P., Giles, A., Gavin, M., Carter, N., & Osborne, L. A. (2016). Loneliness and social anxiety mediate the relationship between autism quotient and quality of life in university students. *Journal of Developmental and Physical Disabilities, 28*, 723–733.

Reynolds, G., & Reed, P. (2011). The strength and generality of stimulus over-selectivity in simultaneous discrimination procedures. *Learning and Motivation, 42*, 113–122.

Singh, N. N., Lancioni, G. E., Singh, A. D., Winton, A. S., Singh, A. N., & Singh, J. (2011). Adolescents with Asperger syndrome can use a mindfulness-based strategy to control their aggressive behavior. *Research in Autism Spectrum Disorders, 5*, 1103–1109.

Spek, A. A., Van Ham, N. C., & Nyklíček, I. (2013). Mindfulness-based therapy in adults with an autism spectrum disorder: a randomized controlled trial. *Research in Developmental Disabilities, 34*(1), 246–253.

Towbin, K. E., Pradella, A., Gorrindo, T., Pine, D. S., & Leibenluft, E. (2005). Autism spectrum traits in children with mood and anxiety disorders. *Journal of Child & Adolescent Psychopharmacology, 15*, 452–464.

Van Dam, N. T., van Vugt, M. K., Vago, D. R., Schmalzl, L., Saron, C. D., Olendzki, A., et al. (2018). Mind the hype: a critical evaluation and prescriptive agenda for research on mindfulness and meditation. *Perspectives on Psychological Science, 13*, 36–61.

Winnebeck, E., Fissler, M., Gärtner, M., Chadwick, P., & Barnhofer, T. (2017). Brief training in mindfulness meditation reduces symptoms in patients with a chronic or recurrent lifetime history of depression: a randomized controlled study. *Behaviour Research and Therapy, 99*, 124–130.

Zeidan, F., Johnson, S. K., Diamond, B. J., David, Z., & Goolkasian, P. (2010). Mindfulness meditation improves cognition: evidence of brief mental training. *Consciousness and Cognition, 19*, 597–605.

Zigmond, A. S., & Snaith, R. P. (1983). The hospital anxiety and depression scale. *Acta Psychiatrica Scandinavica, 67*, 361–370.