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# Previous mindfulness experience interacts with brief mindfulness induction when reducing stimulus over-selectivity

Short title: Mindfulness and over-selectivity.

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## Abstract

The current study examined the effects of a brief mindfulness induction on over-selectivity. Participants were randomly assigned to a mindfulness, unfocused attention (relaxation), or no-intervention group. Participants experienced their designated intervention for 10min, and they underwent simultaneous discrimination training (AB+ CD-) followed by an extinction test (AvC, AvD, BvC, BvD). Levels of mindfulness were measured by the Toronto Mindfulness Scale, and participants were asked about their previous experience with mediation and mindfulness practice. Mindfulness reduced over-selectivity, and previous levels of mindfulness-experience identified by a single question moderated this effect, with mindful-experienced participants showing less over-selectivity. Both findings have some practical utility in the ongoing investigation of the possible use of mindfulness in medical settings.

**Keywords**: mindfulness; previous mindfulness-experience; over-selectivity; medical diagnosis.

In situations where a great deal of information has to be imparted or assimilated at one time, there is the likelihood of some of that information being missed (Anton, Mulji, Howley, Yurco, Tobben, Bean, & Stefanidis, 2017; Fox, Park, & Lang, 2007; Mack & Rock, 1998; Reed & Gibson, 2005; Schofield, Creswell & Denson, 2015; Sweller, 1988). Under some conditions, such a phenomenon has been termed 'stimulus over-selectivity' (see Dube, 2009, Ploog, 2010, for reviews), and bears a resemblance to inattentional blindness (Mack & Rock, 1998; Schofield et al., 2015). Over-selective responding is worse when the cognitive capacity of the individual is challenged by a clinical disorder (Dube, Farber, Mueller, Grant, Lorin, & Deutsch, 2016; Kelly, Leader, & Reed, 2015; Reed, Broomfield, McHugh, McCausland, & Leader, 2009; Stromer, McIlvane, Dube, & Mackay, 1993; Wayland & Taplin, 1985; Wilhelm & Lovaas, 1976). However, it can also occur for typically developing individuals who are elderly (Kelly, Leader, & Reed, 2016), or under conditions of emotional or cognitive stress (Drew, Vo, & Wolfe, 2013; Groden, Cautela, Prince, & Berryman, 1994; Maserejian, Link, Lutfey, Marceau, & McKinlay, 2009).

Important real world examples of only a subset of the available information coming to control behaviour (over-selection) include when individuals are given information by medical professionals (Beeney, Bakry, & Dunn, 1996; Hall & Walton, 2004; Osborne & Reed, 2008), which can be a major concern relating to treatment compliance, adherence, and concordance (Hall & Walton, 2004; Swar, Hameed, & Reychav, 2017; Varshney, 2014). This latter issue has important medical and financial implications for health services, where critical information relating to the diagnosis or treatment can be missed by patients and medical practitioners during consultations (e.g., Braido, Lavorini, Blasi, Baiardini, & Canonica, 2015; Drew et al., 2013; Osborne & Reed, 2018; Polonsky, & Henry, 2016; Quigley & Reed, 2017).

A number of solutions have been proposed for dealing with issues of diagnostic over-selectivity during consultations, including the use of relaxation and mindfulness procedures for patients prior to and during treatment consultations (see Kuyken et al., 2015; Vaughn, & Flanders, 2016). Mindfulness has been suggested to improve attention to currently available information and to reduce distractions (Brown & Ryan, 2003; Kabat-Zinn, Jha, Krompinger, & Baime, 2007; Lipworth, Burney, & Sellers, 1987). It has a long history as a therapeutic intervention (Bishop et al., 2004; van Vugt et al., 2018) for a variety of psychological problems (e.g., Kabat-Zinn et al., 1987; Winnebeck, Fissler, Gärtner, Chadwick, & Barnhofer, 2017). Importantly, in the current context, Levy, Jennings, and Langer (2001) and Quigley and Reed (2017) reported that more items were recalled and recognised by individuals undergoing mindfulness during informationally-challenging situations. Additionally, Schofield et al. (2015) demonstrated that a brief mindfulness induction increased detection of unexpected distracters, when load was high due to visual tracking.

Mindfulness may have potential to deal with important real-wold issues, such as are involved in diagnosis (Kuyken et al., 2015; Vaughn, & Flanders, 2016). However, a critical practical limitation to the employment of mindfulness concerns the length of time that such a procedure may need to work. Moreover, it is unclear whether it would be effective for all individuals (van Dam et al., 2018) or whether it should be targeted at those most likely to benefit (Reed, 2018). Additionally, the answers to these questions must be operationalised within very-brief periods for busy medical professionals, who themselves are prone to missing important information under stressful conditions (Drew et al., 2013; Kannampallil, Jones, Patel, Buchman, & Franklin, 2014; Varshney, 2014).

The former issue regarding time has been addressed by a number of investigations that have found brief-mindfulness induction, of the order of 5-10 minutes, can be effective in improving function and attention (Arch & Craske, 2006; Lee & Orsillo, 2014; Schofield et al., 2015), even when delivered in single session (McHugh, Simpson & Reed, 2010; Reed, 2018). However, very little is known about which individuals will benefit most from such brief procedures (van Dam et al., 2018), and whether any markers are readily available to identify such individuals, especially those that could be obtained rapidly prior to a consultation – such as their previous experience of mindfulness or meditation techniques.

Experimentally, over-selectivity has been researched using simultaneous discrimination tasks (Lovaas, Schreibman, Koegel, & Rehm, 1971; Reynolds & Reed, 2011). Participants are trained (through trial-and-error) to select a complex stimulus involving at least two elements (AB+) over an alternative two-element compound (CD-). Once discriminative control is established by the AB+ stimulus, the elements from the reinforced compound (AB) are presented individually in extinction along with an element from the non-reinforced compound (i.e., AvC, AvD, BvC, and BvD). The element from the reinforced compound that is responded to most (either A or B) is identified in order to assess independent control of responding.

Although over-selectivity has been found to be reduced by mindful procedures in a variety of populations (e.g., Dube et al., 2016; Groden et al., 1994; Kelly et al., 2015; Stromer et al., 1993; Wayland & Taplin, 1985) it is unclear whether this effect is moderated by any factors, such as previous experience of meditation or mindfulness, which could be ascertained by a simple question relating to the issue. The aim of the current study is to explore whether such easily-identified previous experience of mindfulness techniques impacts on the effectiveness of a brief mindfulness procedure to reduce over-selectivity. The results of such an investigation may help to determine the practicality of employing such procedures in diagnostic situations.

# Method

## Participants

One hundred and eighteen participants (56 male, 62 female) were recruited from the general public (40; 34%) and university students (78; 66%). The study was advertised through notices on boards for ongoing studies throughout the University, including on noticeboards for societies promoting mindfulness techniques. The mean age of participants was 25.19 (SD ± = 6.98; range = 18 - 49) years. No payment or course-credit was given to the participants. Participants under the age of 18 years were not allowed to participate for ethical reasons, and those over the age of 55 years were not allowed to participate on the basis of previous research showing different levels of over-selectivity occur in older individuals (Kelly et al., 2016). Participants who had a history of self-reported psychiatric problems were not allowed to participate (i.e. any self-reported psychiatric conditions that were diagnosed by a health professional). 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.

## Materials

***Toronto Mindfulness 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 had an internal reliability (α) of .87 for this study.

***Compound and Elemental Stimuli.*** Stimuli used during the procedure included 8 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., Reynolds & Reed, 2011). In all phases, each symbol appeared in black and measured approx. 5cm × 5cm (see Figure 1).

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Figure 1 about here

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**Interventions**

There were two separate exercises – an 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, who was clinically-qualified, and lasted 10 min.

***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 unfocused attention 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.*”.

Participants in the control condition were asked to wait in the cubicle for 10min, and could anything that they wanted during this time. Participants had any possessions that they brought with them in the cubicle, so could potentially have used mobile phones, etc.

**Procedure**

Participants were randomly assigned to one of three groups: mindfulness (*n* = 39), unfocused attention (*n* = 39); and control (*n* = 40). Each participant completed all parts of the study separately, in a small, quiet, dimly lit experimental room. Participants experienced their exercise (mindfulness or unfocused attention) or sat in the room for 10min. Immediately after the exercise, the participants were presented with the experimental procedure via a Dell Latitude E6540 laptop (display size: 15.5”), programmed in E-Prime®. During this part of the study, participants sat approximately 75cm from the screen. After this, they completed the Hospital Anxiety and Depression Scales (HADS – which was taken and not analysed), and the Toronto Mindfulness Scale (TMS), again.

***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.*”. If participants asked how to make this decision, they were told to learn which stimulus to select through the feedback provided. All participants were then presented with two simple discrimination tasks consisting of the compound stimuli (AB vs CD; EF vs GH). 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 & 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 Figure 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 physical mouse cursor on one of the compounds. The '*Respond Now*' instructions appeared after the trial had been presented for 2s. '*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 1.5s, the next trial commenced, and the response was scored as incorrect.

The presentation of each discrimination task (i.e., AB vs CD and EF vs. GH) continued until participants selected the correct compound on 5 consecutive occasions. The training ceased when this condition was met in both discrimination tasks. Once 5 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 5 consecutive correct responses for this task were also given.

***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 5 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. There was no 1.5s response window.

Immediately after the over-selectivity task the participants completed the TMS, and they were asked: "*Have you practiced mindfulness or meditation in the last three months?*".

**Overselectivity Analysis**

Data were organised into the percentage of times that the most-selected and least-selected stimuli were chosen during the test. 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 for each participant, 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 combined mean most-selected (e.g., A and E) and least-selected (e.g., B and F) mean was then calculated. A difference score (most minus least) was calculated, and a two-way between-subjects analysis of variance (ANOVA) was performed on these data, with condition (mindful, relax, control), and experience (naïve versus experienced) as factors.

Of course, analysing such data 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 the above considerations, analysis of the data also 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. 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. In the absence of any *a priori* method of determining the probability of choosing a stimulus, the mean probability of choosing A/E and B/G was first calculated (Reynolds & Reed, 2011). Given this probability, the binomial equation was used to obtain the probability of choosing all possible combinations of A and B (or E or F) over C or D (or G or H) on 20 trials. The probability of choosing a reinforced compound stimulus was set at the mean probability of choosing A/E and B/G stimuli in a particular condition. Then, the probability of obtaining 20 A/E, and zero to 20 B/G; the probability of obtaining 19 A/E, and zero to 19 B/G; etc., were calculated, and put in a 20 x 20 contingency table. The contents of this table were then multiplied by a 20 x 20 table that contained the absolute A/E minus B/G difference score for each combination. The resulting 20 x 20 table contained the expected frequency of obtaining each possible A/E minus B/G difference resulting from all possible combinations of A/E and B/G frequencies. The sum of the values in this table (multiplied by 20) provided an estimate of the most minus least selected difference, in percentage terms, expected by random variation of selection of A/E and B/G stimuli. Paired t-tests were then used to test this sum against the obtained data, in order to investigate whether significant over-selectivity occurred in the average participant in the sample.

## Results

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Figure 2 about here

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Figure 2 shows the group-mean mindfulness scores, as measured by the TMS, for the three groups (control, relaxation, and mindfulness) for the naïve and experienced groups.

Inspection of these data reveals that for both naïve and experienced groups, experienced mindfulness was highest in the mindful group, but this was especially pronounced for the mindful-experienced group.

A two-factor between-subject analysis of variance (ANOVA) with group (mindful, relax, and control) and experience (naïve and experienced) was conducted on these data. This analysis revealed significant main effects of group, $F(2,112) = 18.30$, $p < .001$, $\eta^2_p = .246[.112\text{-}.362]$, and experience, $F(1,112) = 29.46$, $p < .001$, $\eta^2_p = .208[.089\text{-}.331]$, and a significant interaction between the factors, $F(2,112) = 2.92$, $p = .050$, $\eta^2_p = .050[.000\text{-}.135]$. Simple effect analyses revealed a small-sized significant difference between the groups for the mindful-naïve participants, $F(2,112) = 4.35$, $p = .035$, $\eta^2_p = .072[.003\text{-}.167]$. Subsequent Tukey's Honestly Significant Difference (HSD) tests revealed pairwise differences between the mindful and control group, $p < .05$. No other pairwise differences were significant. For the mindful-experienced participants there was a large-sized significant simple effect of group, $F(2,112) = 18.68$, $p < .001$, $\eta^2_p = .250[.116\text{-}.366]$. Subsequent Tukey's HSD tests revealed pairwise differences between the mindful group and both the relaxation and control groups, *p*s < .05. No other pairwise differences were significant. Simple effects conducted between the naïve and experienced groups, revealed significant differences in mindfulness for the mindful group, $F(1,112) = 23.39$, $p < .001$, $\eta^2_p = .173[.063\text{-}.294]$ and control, $F(1,112) = 10.67$, $p < .001$, $\eta^2_p = .087[.014\text{-}.196]$ groups, but not for the relaxation group, $F(1,112) = 1.91$, $p > .30$, $\eta^2_p = .017[.000\text{-}.090]$.

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Figure 3 about here

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The top panel of Figure 3 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 naïve and experienced groups. There were larger differences between the most- and least-selected stimuli in the control group than in the mindful group, and for the mindfulness-naïve group, indicating greater levels of over-selectivity. These data can be seen more clearly in the bottom panel of Figure 3, which shows the mean difference between the most- and least-selected stimuli for each of the three groups for the naïve and experienced participants.

A two-factor between-subject ANOVA (group x experience) conducted on these data revealed significant main effects of group, $F(2,112) = 8.08$, $p < .001$, $\eta^2_p = .126[.027\text{-}.249]$, and experience, $F(1,112) = 12.55$, $p < .001$, $\eta^2_p = .101[.020\text{-}.213]$, but no significant interaction between the factors, $F < 1$, $\eta^2_p = .018[.000\text{-}.075]$. Subsequent Tukey's HSD tests revealed pairwise differences between the mindful and control group, $p < .05$. No other pairwise differences were significant.

In order to determine whether there was a statistically significant difference in the level of choice for the stimuli, compared to deviation from the level of choice expected by chance, the random model based on the binomial equation provided the necessary difference between the over-selected and under-selected stimuli in 20 choices (Reynolds & Reed, 2011). The expected differences for the naïve group were 16% for the mindful condition, 17% for the relax condition, and 18% in the control condition. For the experienced group, these scores were: 14% for the mindful condition, and 15% for the relax and control conditions. Paired t-tests were performed to compare the obtained differences and the expected differences based on chance. For the naïve group, these indicated no significant difference from chance for the mindful condition – i.e. there was no over-selectivity, $t(17) < 1$, $d = .05$; no significantly greater than chance difference in the relax condition, $t(16) = 1.05$, $p = .153$, $d = .36$; and a significantly greater than chance difference in the direction of overselectivity in the control condition, $t(23) = 5.07$, $p < .001$, $d = 1.05$. For the experienced group, there was no significant difference from chance for the mindful condition – i.e. no over-selectivity, *t*(20) = 1.76, *p* = .09, *d* = .38; no significant difference from chance for the relax condition – i.e. no over-selectivity, *t* < 1, *d* = .01; and a significantly greater than chance difference in the direction of overselectivity in the control condition, *t*(18) = 1.93, *p* < .05, *d* = .46.

A Pearson correlation between the Toronto Mindfulness Scale and the difference between the most- and least-selected stimuli across all participants, revealed a significant negative correlation, *r* = -.546, *p* < .001. This indicates the higher the mindfulness score, the lower the level of over-selective responding.

## Discussion

The current study investigated whether easily-identified previous mindful-experience would impact the effectiveness of a brief-mindfulness procedure (or indeed any procedure) to reduce over-selectivity. The results demonstrated that the brief-mindfulness intervention reduced levels of over-selectivity, as indexed by the difference between the most- and least-selected stimuli, and did so relative to a relaxation control. These findings have been noted previously in a number of contexts (Arch & Craske, 2006; Lee & Orsillo, 2014), including over-selective responding (McHugh et al., 2010), and inattentional blindness (Schofield et al., 2015).

However, a novel finding was that this effect was influenced by the participants' previous experience of mindfulness techniques. Mindful-experienced participants showed a much greater reduction in over-selectivity than mindful-naïve participants across all of the treatments. There was no over-selective responding seen in either the mindful, or the relaxation, groups for those experienced in mindfulness. In contrast, for the mindfulness naïve group, only the mindful condition showed removal of over-selectivity, and this was a smaller reduction than that for the mindfulness-experienced group. Although the effect of this prior experience did not seem to be limited to enhancing only the effect of mindfulness procedures. The data also suggested that these effects were reflected in the levels of mindfulness experienced by the participants as a result of their session (see Reed, 2018).

These findings have some implications for the usefulness of mindfulness and relaxation in situations where complex information has to be conveyed in demanding situations, such as are involved in diagnosis (Kuyken et al., 2015; Vaughn, & Flanders, 2016). This can be a problem for medical staff, as well as for patients. For example, Drew et al. (2013) found that 83% radiologists performing a familiar detection task failed to see a very large gorilla inserted in the stimulus slide. That mindfulness helped improve control by all elements of the complex stimulus array presented, suggests that it may have some utility in improving the degree to which information is encoded during such circumstances (Kuyken et al., 2015; Levy et al., 2001; Quigley & Reed, 2017). However, it also suggests that this may be especially effective when the participant has had some previous experience of the technique. This latter finding provides information regarding whom mindfulness procedures may be effective with (van Dam et al., 2018), but also suggests that a simple question, easily asked in diagnostic situations, may help to identify those most likely to benefit from any such intervention. One issue that is worth noting and future study is the method for determining mindful experienced versus naïve participants. A criterion of having practised mindfulness in the last three months was chosen for this study, and there are there some limitations to this approach. For instance, if someone had only meditated once in the last three months, they would answer 'yes' to the question, putting them in the experienced group, but this person would generally not be greatly practiced in mindfulness. Despite this, differences between the groups were noted. A simple method like the current one could identify patients likely to benefit, could reduce the implementation of potentially wasteful procedures, and reduce stress on patients and staff.

Of course, these suggestions are speculative, and will need to be investigated in situ. 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 generalize to those populations – and 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. Neither do these data suggest that mindfulness would not be effective in those with no previous experience, but that these effects would be greater for mindful-experienced patients. It might be noted that the recruitment directly advertised mindfulness as being used in the study, and the sample might have been motivated to participate on that basis making them different from people who are not interested in mindfulness. The participants were also asked if they had previous mindfulness experience in the last three months at the end of the experiment. It is possible that some of them might have counted the mindfulness experienced in the study, and answered "yes", even though they had done no other mindfulness practice in the past 3 months. This should also be addressed in future studies. Finally, it should be noted that the sample size in each group (approximately 20) is relatively small.

In summary, a brief mindfulness intervention reduced levels of over-selectivity, and this effect was greater for mindful-experienced participants, which could be identified by a simple question. Both findings have some practical utility in the ongoing investigation of the possible use of mindfulness in medical settings.

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# Figure Captions

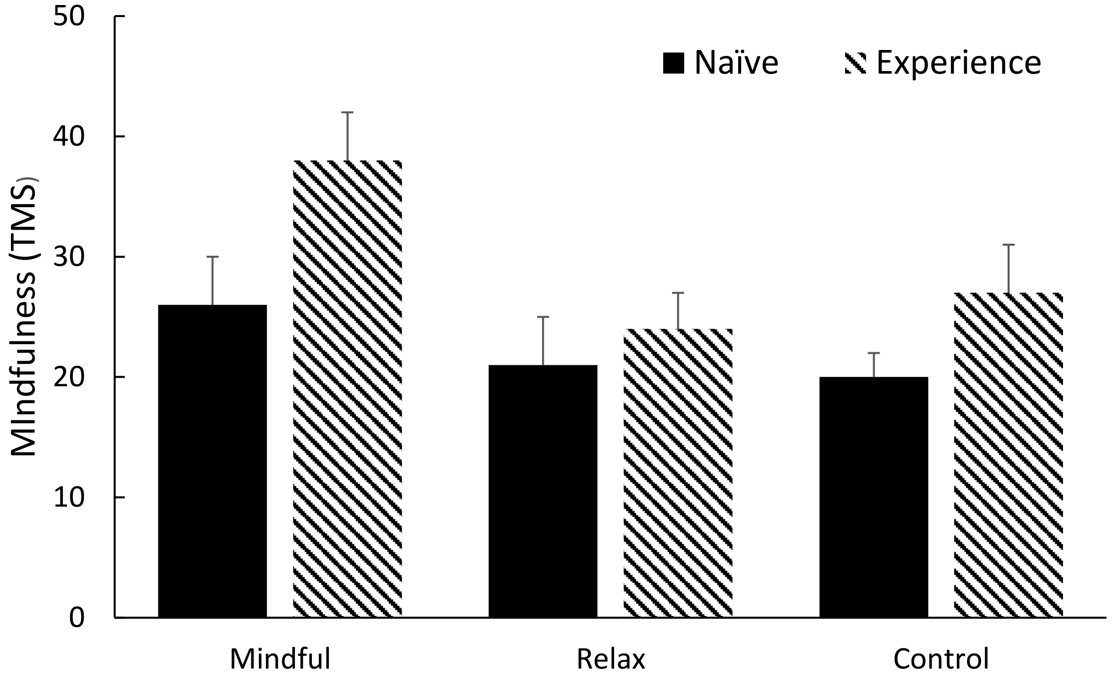
*Figure 1*: Example of over-selectivity stimuli (Stimuli AB).

*Figure 2*: Group-mean mindfulness scores (TMS) for the three groups (control, relaxation, and mindfulness) for the naïve and experienced groups. Error bars = 95% between-subject confidence intervals.

*Figure 3*: Top panel: Group-mean percentage times that the most- and least-selected stimuli were chosen for the three groups (control, relaxation, and mindfulness) for the naïve and experienced groups. Error bars = 95% between-subject confidence intervals. Bottom panel: Group-mean difference in the percentage times that the most- and least-selected stimuli were chosen for the three groups (control, relaxation, and mindfulness) for the naïve and experienced groups. Error bars = 95% between-subject confidence intervals.

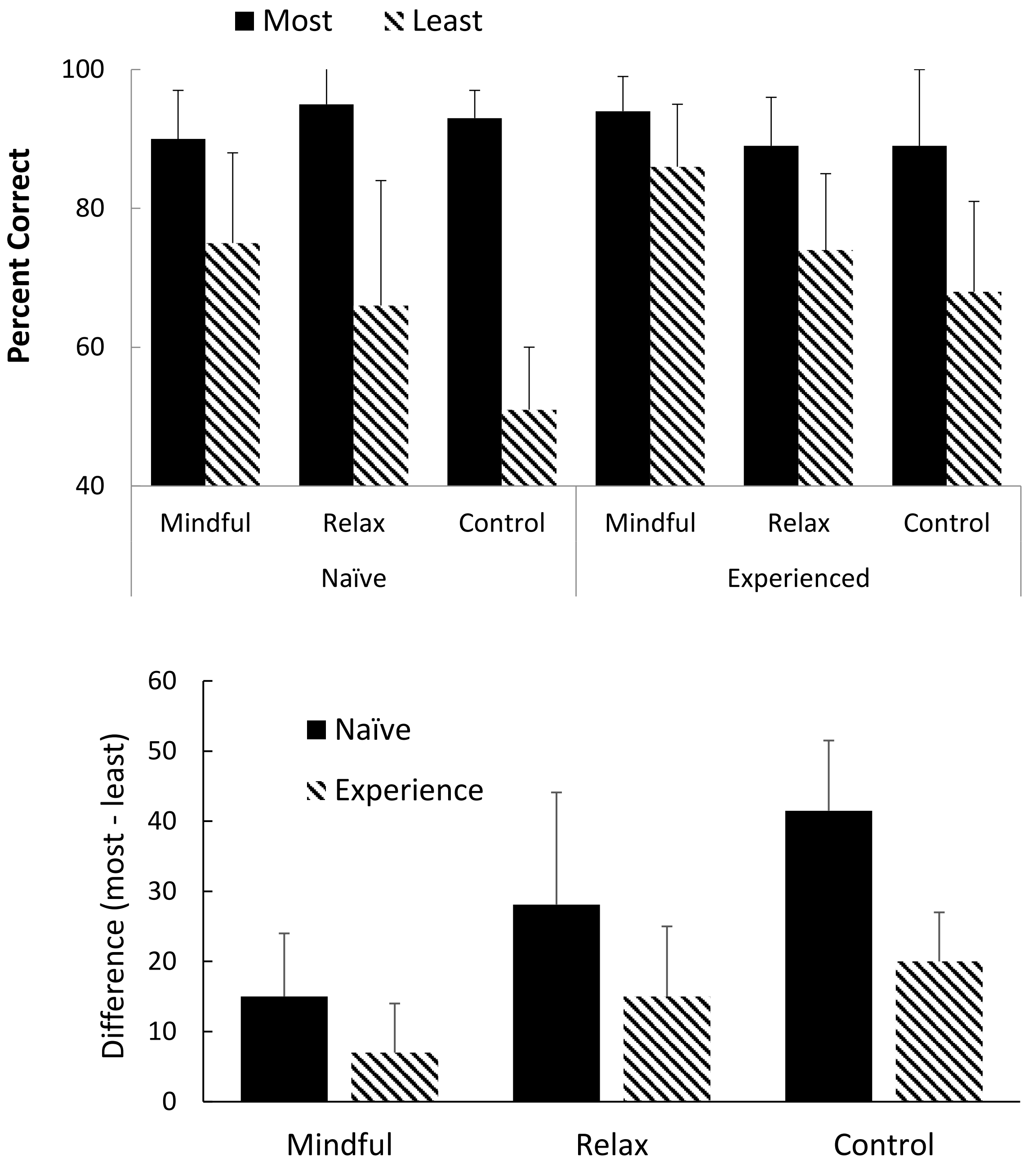
Figure 1

Figure 2



50
40
30
20
10
0
MIndfulness (TMS)
Naïve
Experience
Mindful
Relax
Control

Figure 3


Most
Least
Percent Correct
100
80
60
40
Mindful
Relax
Control
Mindful
Relax
Control
Naïve
Experienced
60
50
40
30
20
10
0
Naïve
Experience
Difference (most - least)
Mindful
Relax
Control