The effect of mindfulness on extinction and behavioral resurgence

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Abstract In the present experiments, we investigated the effects of mindfulness on behavioral extinction and resurgence. Participants received instrumental training; either they received FI training ([Experiment 1](#)), or they were trained to emit high rates and low rates of response via exposure to a multiple VR yoked-VI schedule prior to exposure to a multiple FI FI schedule in order to alter their rates of responding learned during [Experiment 2](#). Participants were then exposed to either a focused- (mindfulness) or an unfocused-attention induction task. All participants were finally exposed to an extinction schedule in order to determine whether a mindfulness induction task presented immediately prior to extinction training affected extinction ([Experiment 1](#)) and behavioral resurgence ([Experiment 2](#)). During the extinction phase, the rates of responding were higher in the control group than in the mindfulness group, indicating that the mindfulness group was more sensitive to the contingencies and, thus, their prior performance extinguished more readily ([Experiment 1](#)). Moreover, rates of response in the extinction components less precisely reflected previous training in the mindfulness group, suggesting less resurgence of past behaviors after the mindfulness induction ([Experiment 2](#)).

Keywords Operant conditioning · Schedule of reinforcement · Human learning

Human behavior maintained by schedules of reinforcement has sometimes been found to be insensitive to the

contingencies that are in operation, and this finding is sometimes related to behavior being under the control of previously established verbal rules, rather than the currently operating reinforcement contingencies themselves (e.g., Hayes, Brownstein, Haas, & Greenway, 1986a; Hayes, Brownstein, Zettle, Rosenfarb, & Korn, 1986b; Matthews, Catania, & Shimoff, 1985; Shimoff, Matthews, & Catania, 1986). It is suggested that either through exposure to the direct verbal instructions associated with the task (e.g., Harzem, Lowe, & Bagshaw, 1978), or as a result of forming their own verbal rules during exposure to the previous reinforcement contingency (e.g., Hayes, Brownstein, Haas and Greenway 1986a), humans behave in accordance with these established verbal rules, rather than with the new reinforcement contingency, which can produce contingency-inappropriate behavior (see Shimoff et al., 1986). One example of this lack of sensitivity to the current contingency is noted when contingencies change from reinforcement to extinction; under these circumstances, human behavior is often insensitive to this change in schedule, and responding continues long after it is effective in producing reinforcers (e.g., Hayes, Brownstein, Zettle, Rosenfarb, & Korn, 1986b; Shimoff et al., 1986).

This lack of sensitivity to the current contingencies, revealed through numerous studies of basic human conditioning, has been related to a number of clinically relevant situations, such as anxiety (e.g., Eifert & Forsyth, 2005), depression (e.g., Williams, Duggan, Crane, & Fennell, 2006), and cognitive decline in old age (e.g., Finucane, Alhakami, Slovic, & Johnson, 2000). An important step in further investigating these contingency insensitivity effects that have been derived from the basic learning field and integrating them with evidence-based interventions would be to develop experimental *proof-of-concept* data relating to interventions that are suggested to be effective in overcoming

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contingency insensitivity effects in human conditioned behavior that may be based on language.

Recent trends in behavior therapy have seen the development of a number of language-based interventions, such as dialectical behavioral therapy (Dimeff & Linehan, 2001), acceptance and commitment therapy (Hayes, Strosahl, & Wilson, 1999), and techniques based on mindfulness (Grossman, Niemann, Schmidt, & Walach, 2004; Hayes et al., 1999). These techniques have been used in a wide variety of situations—for example, diabetes self-management (Gregg, Callaghan, Hayes, & Glenn-Lawson, 2007), pain tolerance (Kingston, Chadwick, Meron, & Skinner, 2007), and reduction of prejudice (Lillis & Hayes, 2007). Several studies have shown the efficacy of such procedures, relative to more traditional cognitive behavioral interventions (e.g., Zettle & Hayes, 1986; Zettle & Raines, 1989).

In particular, mindfulness training has attracted growing attention in both psychology and neuroscience (e.g., Fletcher & Hayes, 2005; Kabat-Zinn, 2003) and has gained positive outcomes in many clinically related areas (McHugh, Simpson, & Reed, 2010; Smith, 2004; Teasdale, Segal, & Williams, 1995). Mindfulness training involves an attempt to produce a “continuous attention to ongoing current subjective experience” (Ortner, Kilner, & Zelazo, 2007). As a result, it has been suggested to produce greater sensitivity to the currently operative contingencies and to reduce behavioral control exerted by previously established rules (Hayes et al., 1999; Kabat-Zinn, 2003). Given these considerations, mindfulness training would seem a suitable candidate to explore in the current context of improving human sensitivity to current schedule control.

Typically, mindfulness training is implemented over a number of sessions (Shapiro, Schwartz, & Bonner, 1998). However, the effect of mindfulness processes has been demonstrated in experimental laboratory studies, using untrained *mindfulness mediators*, after inductions as short as 10 min (e.g., Arch & Craske, 2006; Broderick, 2005; Roemer & Orsillo, 2003). For example, Arch and Craske (see also McHugh et al., 2010) compared a short “focused-attention” induction procedure involving “mindfulness” of breath instructions with an unfocused-attention task constructed to relax the participant and noted that participants in the focused-attention induction demonstrated more positive responses to stimuli currently present in the environment (for similar positive results using short laboratory-based inductions, see also Broderick, 2005; McHugh et al., 2010). Since this form of training has been suggested to generate greater attention to stimuli in the current environment, the present series of experiments utilized such a 15-min focused-attention (mindfulness) induction in the context of human schedule behavior following a change of contingency. It was predicted that any insensitivity to

current contingencies demonstrated by human participants could be overcome through exposure to mindfulness interventions.

In summary, in the present set of experiments, we attempted to explore the impact of mindfulness training on human conditioned behavior—particularly in contexts where it has been suggested that human behavior may be insensitive to current contingencies. It was predicted that, since mindfulness is taken to increase attention to the current contingencies and to lessen control by previously established verbal rules, participants who received a mindfulness induction would have lower levels of insensitivity to current contingencies than would those experiencing unfocused-attention tasks.

Experiment 1

Experiment 1 employed a simple conditioning-then-extinction procedure in order to determine whether mindfulness training would enable participants to learn more rapidly to switch from one contingency (reinforcement) to another (extinction). The conditioning task employed was a fixed interval (FI) schedule. This schedule was chosen because it is often employed in studies of human schedule sensitivity (see Bentall, Lowe, & Beasty, 1985; Lowe, Beasty, & Bentall, 1983). This was followed by either a brief mindfulness induction or an unfocused-attention treatment session. The latter procedure was adopted to control for the general effects of verbal instructions during the period intervening between the conditioning and extinction phases and because it is thought to control for general relaxation effects (see Arch & Craske, 2006; McHugh et al., 2010). Finally, the participants were exposed to an extinction schedule to test the impact of the intervention on sensitivity to the new schedule (extinction was chosen because it has often been used as a transfer test schedule in such contingency sensitivity experiments; see, e.g., Hayes, Brownstein, Haas, & Greenway, 1986a). It was predicted that human behavior would extinguish at a quicker rate during transition to an extinction schedule following mindfulness training, as compared with the participants who receive the unfocused-attention induction.

Method

Participants and apparatus

Nineteen adults (8 males, 11 females), with an age range of 21–24 years (mean = 20.4 ± 3.7), took part in this study. All participants were volunteers, with no history of psychiatric problems; they received no payment for their participation and were naïve as to the purpose of the experiment. The

experiment was ethically approved by the Swansea University Psychology Department Ethics Committee. The experiment was conducted on and the data collected by an HP Pavilion tx 2000 tablet laptop.

Procedure

The broad outline of the phases in [Experiment 1](#) (and [Experiment 2](#)) can be seen in Fig. 1. For [Experiment 1](#), this procedure involved an initial phase of conditioning on an FI schedule, followed by either a brief mindfulness induction or a control treatment session and, finally, exposure to an extinction schedule to test the impact of the intervention on sensitivity to the new schedule.

Phase 1: Initial conditioning The phase commenced with participants clicking on a button in the center of the computer screen marked “Start Experiment,” after which the following instructions appeared:

You will shortly see a circle in the centre of the screen. When you see this circle you must press the spacebar to earn points. Try to earn as many points as possible. You must press either quickly or slowly in order to earn points. You must work out what rate of pressing makes you the most points.

Following this, a circular black symbol (diameter = 5 cm), appeared in the center of the top half of the computer screen, and a 5 × 5 cm box with “points” written above it

(initially set at 0) appeared in the center of the bottom half of the screen. The participants were then free to press the space bar to earn points and responded on an FI 15-s schedule for 2 min. The reinforcers (the addition of 10 points to the participants point total displayed in the “points” box on the screen) were delivered for the first space bar press after 15 s had elapsed from the time that the previous reinforcement was delivered. These points were totaled and displayed in the “points” box. After the 2-min trial was completed, the black symbol and the “points” box disappeared, and there was an intertrial interval of 1 s. Then the symbol and the “points” box (reset to 0) reappeared on the screen, and the participants could resume responding on the FI 15-s schedule. This initial training continued until the participant had completed 16 FI trials.

Induction: Focused (mindfulness) versus unfocused attention Following initial training, participants were randomly assigned to either the focused- or the unfocused-attention group, and they were given the appropriate 15-min induction procedure. Participants remained in the experimental room, which was darkened, and they were told to close their eyes while the experimenter provided them with the relevant instructions for each induction (see [Appendix 1](#) for the focused-attention instructions and [Appendix 2](#) for the unfocused-attention instructions).

Phase 2: Extinction Immediately following the induction task, the lights were raised, and the participants were

Fig. 1 An overview of the basic experimental procedures in [Experiment 1](#) and [Experiment 2](#)

instructed to attend to the computer screen again. They were given the following instructions on the screen:

You will shortly see a circle in the centre of the screen again. When you see this circle you must press the space bar to earn points. Try to earn as many points as possible. You must press either quickly or slowly in order to earn points. You must work out what rate of pressing makes you the most points.

The black symbol appeared on the screen, along with the “points” box (set to 0), as described for Phase 1. During the extinction phase, there was one 120-s trial. During this period, responses were recorded but had no programmed consequences.

Results and discussion

Figure 2 shows the rates of response across the 16 FI trials for the group that was to experience mindfulness induction and the group that was to experience the unfocused-attention control. These data show that, over the course of training, the response rates of the two groups came together, so that, by the end of training the rates of responding were highly similar. A two-factor analysis of variance (ANOVA) with group (to experience mindfulness vs. to experience control) as a between-subjects factor and trial as a within-subjects factor, was conducted on these data. This analysis revealed a statistically significant main effect of trial, $F(15, 255) = 3.02, p < .001$, but neither the main effect of group nor the interaction between the factors was significant, $F_s < 1$.

Figure 3 shows the mean response rates during the last session of FI training (Phase 1) and during extinction (Phase 2) for both the mindfulness and control groups. Inspection of these data shows little difference between the rates of response for the two groups at the end of FI training, as would be expected. However, during extinction, responding

Fig. 2 Results from Experiment 1. The response rates from the 16 trials of FI training for both groups of participants

Fig. 3 Results from Experiment 1. The response rates on the last trial of the FI schedule and during extinction for the control and mindfulness groups (bars = standard error)

for the group that received mindfulness training decreased, but that of the control group showed an increase, and the latter group responded more often than the mindfulness group. A two-factor mixed model ANOVA with group as a between-subjects factor and phase as a within-subjects factor was conducted on these data and revealed no statistically significant main effects, $F_s < 1$. The interaction approached statistical significance, $F(1, 17) = 3.80, p < .07$. Simple effect analyses revealed no statistically significant simple effect of group for Phase 1 (conditioning), $F < 1$, but a statistically significant simple effect (one-tailed) of group during Phase 2 (extinction), $F(1, 17) = 3.38, p < .03$.

These data suggest that mindfulness training produced greater extinction than did unfocused-attention training. There are, of course, a number of potential explanations for this effect, based both on mindfulness processes and on other potential factors. It should be noted that the test session in this study was very short. However, given the novelty of this finding and its potential to serve as proof of concept, prior to discussion of these factors, it was thought prudent to attempt to replicate and extend these data.

Experiment 2

Another phenomenon of relevance to the focus of the present topic (not exclusively associated with humans) is the reappearance of an apparently absent behavior in the current repertoire of an individual, when the occurrence of more recent behaviors are challenged, either by low levels of reinforcement or by extinction. This phenomenon is known as behavioral resurgence (e.g., Cleland, Foster, & Temple, 2000; Epstein, 1983, 1985; Reed & Morgan, 2006, 2007), and it has been demonstrated to occur in human participants (see Bruzek, Thompson, & Peters, 2009; Doughty, Cash, Finch, Holloway, & Wallington, 2010; Pettenger, Pavlik,

Flora, & Kontos, 1988; Reed & Clark, 2011; Sajwah, Twardosz, & Burke, 1972).

Resurgent responses sometimes have proven to be useful, for example, in problem-solving responses; if one response fails, it often is useful to revert to previously successful responses. However, since such behaviors also have significance for many clinically relevant behavioral patterns, such as depression, drug dependence, and externalizing behaviors (see, e.g., Bouton, 2002; Doughty, Reed, & Lattal, 2004; Reed & Clark, 2011; Williams et al., 2006), it has been thought important to develop experimental analogues of the effect in order to study the factors that impact resurgence more fully, and such experimental analogues are helpful in the present context of investigating the impact of manipulations such as mindfulness that are specifically designed to limit intrusions from previous learning into current performance (see Hayes et al., 1999; Kabat-Zinn, 2003).

Reed and Morgan (2007) investigated whether resurgence of behavior during extinction depended on previously established rates of response (see also Doughty et al., 2004; Doughty, da Silva, & Lattal, 2007). In this within-subjects study, rats were trained on a multiple schedule comprising two different schedules of reinforcement that are known to produce two particular and different rates of responding: a variable ratio (VR) schedule, where reinforcement is related to the number of responses made and which produces higher rates of response, and a VI schedule, where only responses following the passage of time are reinforced and which is known to produce lower rates of response (see Dack, McHugh, & Reed, 2010, for a similar demonstration in humans). Once these two distinguishable rates of responding emerged for the two levers, the schedules of reinforcement were altered in Phase 2. Responding to both levers was reinforced by the same FI schedule, in order to produce a rate of response that was different from that produced in Phase 1 but was the same across the two FI levers. After this, the rats' responding was put into extinction to see the resurgent patterns of behavior; response rates in extinction became greater in the component previously associated in Phase 1 with the higher rate of response (VR), despite there being no difference in response rate between the components at the end of Phase 2.

In *Experiment 2*, our aim was to exploit this methodology (Reed & Morgan, 2007) for human participants and to investigate whether mindfulness training would reduce this resurgence effect, as well as making the participants who had undergone this procedure more sensitive to the shift to the extinction contingency. In addition to the impact on sensitivity to extinction, as in *Experiment 1*, it has been suggested that the automaticity with which conditioned schedule performances are executed can be modified by means of a mindfulness intervention, whereby attention is brought to the present behavioral response (Didonna, 2009). Applying a mindfulness intervention in measuring posttraining performance in extinction

may provide insight into how the bringing of awareness to the environmental contingencies might influence conditioned (resurgent) behavior that is potentially under the control of a prior history of reinforcement. In particular, it was predicted that, relative to an unfocused-attention control, the behavior of participants undergoing mindfulness would extinguish faster and would show less evidence of resurgence.

Method

Participants and apparatus

Thirty adults (8 males, 22 females), with an age range of 21–60 years (mean = 39.7 ± 13.03) participated. All participants were volunteers, with no history of psychiatric problems, received no payment for their participation, and were naïve as to the purpose of the study. The study was approved by the Swansea University Psychology Department Ethics Committee. The experiment was conducted on and the data were collected by an HP Pavilion tx 2000 tablet laptop. The study was conducted in a quiet room, free from distraction.

Procedure

The overall outline of the procedure is displayed in Fig. 1. There was an initial conditioning phase in which individuals were exposed to a multiple VR VI schedule as employed in previous studies of resurgence (Reed & Morgan, 2007). The second phase involved further conditioning (reconditioning) with a multiple FI FI schedule to bring the rates established in Phase 1 together, as previously used in resurgence studies (Reed & Morgan, 2007). The participants then were given a mindfulness or an unfocused-attention control procedure, before being placed into extinction. A greater number of extinction trials were employed in *Experiment 2* than in *Experiment 1*, in part because there were greater numbers of conditioning trials in this experiment, as compared with *Experiment 1*, and partly to determine whether longer exposure to extinction would influence the results.

Phase 1: Initial conditioning (multiple VR VI) During Phase 1, all participants responded on a multiple VR-20 VI-yoked schedule. The phase commenced with participants clicking on a button in the center of the computer screen marked “Start Experiment,” after which the following instructions appeared:

You will shortly see a circle in the centre of the screen. When you see this circle you must press the spacebar to earn points. Try to earn as many points as possible. You must press either quickly or slowly in order to earn points. You must work out what rate of pressing makes you the most points.

Following this, a black or white circle (counterbalanced across the participants) appeared on the screen (as described in [Experiment 1](#)), and the participants responded on a VR-20 schedule for 2 min to earn points (as described in [Experiment 1](#)). After the VR schedule trial was completed, the symbol disappeared, there was an intertrial interval of 1 s, and then the other colored symbol appeared on the screen, and the participants had to resume responding on a VI schedule (the “points” box counter was reset to 0). The times at which the reinforcers were delivered on the preceding VR schedule became the successive intervals required for earning points on the VI schedule. After the VI trial, the participants experienced another VR trial, and then another VI schedule trial yoked the immediately preceding VR schedule. This training continued until the participant had completed four trials of each of the VR and VI pairs (i.e., eight trials in total), which were presented in alternation.

Phase 2: Reconditioning training (multiple FI, FI) On completion of Phase 1, all participants proceeded into Phase 2. Phase 2 involved responding on a multiple FI 15-s FI 15-s schedule. For Phase 2, participants were presented with the following instructions:

You will shortly see a circle in the centre of the screen. When you see this circle you must press the space bar to earn points. Try to earn as many points as possible. You must press either quickly or slowly in order to earn points. You must work out what rate of pressing makes you the most points.

The black and white circles that appeared on screen during this part of the experiment were displayed for 120 s each, alternating from white to black, over eight individual trials each. These *black* and *white* trials were identical to one another in terms of the FI contingency presented and were

presented in alternation (some participants starting with the black symbol and some with the white symbol).

Induction: Focused (mindfulness) versus unfocused attention Following Phase 2, participants were randomly assigned to either the focused- or the unfocused-attention group and cycled directly into a 15-min induction as described in [Experiment 1](#). Participants were told to close their eyes while the experimenter provided them with strategy-relevant instructions (see [Appendix 1](#) for the focused-attention instructions and [Appendix 2](#) for the unfocused-attention instructions).

Phase 3: Extinction Immediately following the induction task, participants were instructed as follows:

You will shortly see a circle in the centre of the screen again. When you see this circle you must press the space bar to earn points. Try to earn as many points as possible. You must press either quickly or slowly in order to earn points. You must work out what rate of pressing makes you the most points.

During the extinction phase, the trials alternated between presentations of the black and white circles, both lasting for 120 s until a total of eight trials were completed. The black and white symbols (for the previous VR and VI components) were presented randomly for each participant and did not appear in the same sequence for all participants.

Results and discussion

Figure 4 shows the group-mean response rates during Phases 1 and 2. Inspection of these data for Phase 1 shows an increase in rate across trials, with the VR schedule

Fig. 4 Results from [Experiment 2](#). Mean participants' response rates across Phases 1 and 2. On the left side of the figure, the data represent the mean number of responses that were emitted when the participants were exposed to the multiple VR, VI schedule during Phase 1. On the right side of the figure, the data represent the mean number of responses emitted during the multiple FI 15-s, FI 15-s schedule in Phase 2

coming to control a higher rate of responding than the VI schedule. These data were analyzed using a two-factor, repeated measures ANOVA with schedule (VR vs. VI) and trial as factors. This analysis revealed statistically significant main effects of schedule, $F(1, 29) = 15.87, p < .001$, and trial, $F(3, 87) = 3.45, p < .05$, but no significant interaction between the two factors, $p > .30$.

Inspection of the data from Phase 2 reveals that the response rate decreased from the end of Phase 1 and came to be similar in both components by the end of training. A two-factor, repeated measures ANOVA (schedule [previous VR vs. previous VI] $\times$ trial) was conducted on the data and revealed that the main effect of schedule approached significance, $F(1, 29) = 3.58, p < .08$, a statistically significant main effect of trial, $F(7, 203) = 3.48, p < .01$, and a statistically significant interaction between schedule and trial, $F(7, 203) = 5.19, p < .001$. Simple effect analyses revealed no statistically significant effect of schedule on any of the last four trials of training, all $F_s < 1$.

Figure 5 shows the group-mean rates of responding for each 2-min block of the extinction phase, for the components associated with the VR and VI schedules in Phase 1, for both groups. These data show that for the control group, initially, responding increased for both components but did so slightly more in the former-VR component, as compared with the former-VI component, although this was a relatively small effect. The mindfulness group showed little differentiation between the components during extinction and had lower rates of response in extinction than did the control group. These data were analyzed by a three-factor mixed-model ANOVA (group $\times$ component $\times$ trial), which revealed statistically significant main effects of group, $F(1, 28) = 7.52, p < .05$, and trial, $F(3, 84) = 18.78, p < .001$. The main effect of schedule approached statistical significance, $F(1, 28) = 3.34, p < .08$. None of the interactions were statistically significant, all $p_s > .20$.

To determine the level of resurgence, the rates of responding during the last FI component were subtracted from the rate of responding for the first extinction trial for each participant. Thus, this created two groups: those who experienced the component previously associated with the VR schedule first in extinction and those who experienced the component previously associated with the VI schedule first in extinction. This procedure was adopted to see levels of extinction straight after conditioning and uncontaminated by prior extinction training. The group mean change in response rates for the resultant four groups (mindfulness VR, $n = 8$; mindfulness VI, $n = 7$; control VR, $n = 5$; and control VI, $n = 10$) are displayed in Fig. 6. These data show that responding was higher in the control groups, as compared with the mindfulness groups, and that responding was higher in the VR than in the VI components. A two-factor between-subjects ANOVA (schedule $\times$ group) was conducted on these data and revealed statistically significant main effects of schedule, $F(1, 26) = 7.05, p < .01$, and group, $F(1, 26) = 3.86, p < .05$, but no statistically significant interaction between these factors, $F < 1$.

The difference between the rates of responding generated by the VR and VI schedules in the human participants in the present study reflect those previously seen in studies of nonhuman (Ferster & Skinner, 1957) and human (Reed, 2001) behavior. Moreover, the results for the control group reflected the findings of resurgence reported by Reed and Morgan (2007) for rat subjects. During the extinction phase, the effects of the prior learning history influenced resurgence; that is, responding to the component previously associated with a VR schedule was higher than that to a component previously associated with a VI schedule, despite there being no difference in the rate of responding between these components at the end of an interpolated training phase. These results suggest that the present

Fig. 5 Results from Experiment 2. The response rates on the last trial of the FI schedule and the first block of extinction for the control and mindfulness groups

Fig. 6 Results from [Experiment 2](#). The mean change in response rates on Phase 3 for participants in the control and mindfulness groups (bars = standard error)

procedures generated schedule-typical behavior in the human participants.

The participants exposed to the mindfulness induction, however, did not display these resurgence results to the same extent as the group with the unfocused-attention control procedure. In contrast, they showed faster extinction and less increase in responding in the VR and VI components. These data replicate the general extinction effects noted in [Experiment 1](#); that is, mindfulness induction produced faster extinction than in the unfocused control. This effect was noted with a longer extinction procedure than in [Experiment 1](#) and suggests that the effect is not limited to short test regimes. One feature of the data that is in need of comment is that the control group did not extinguish fully even with the extended extinction procedure. This might suggest that it is unclear whether the points alone are functioning as reinforcers, given that their removal does not lead to a significant reduction in behavior in the control group. However, it should be noted that extinction does occur in the mindfulness group and does so in an orderly manner.

There was no suggestion of a resurgence effect in the mindfulness group. Of course, while insensitivity to extinction is often taken to reflect control by previous verbal rules, it is uncertain whether verbal control alone plays a role in resurgence. The potential for multiple mechanisms being active in mindfulness will be taken up in the [General Discussion](#) section, but, taken together, these data suggest that mindfulness may be a powerful tool in removing potentially harmful schedule insensitivity, however it is generated.

General discussion

The present experiments examined the effect of mindfulness versus unfocused attention on extinction and resurgence with the aim of exploring whether mindfulness would

produce less contingency insensitivity in humans. The findings demonstrated that a mindfulness induction increased the speed of extinction ([Experiments 1 and 2](#)) and also reduced levels of resurgence ([Experiment 2](#)). Taken together, these results indicate that mindfulness produced responding that was more sensitive to the currently operative contingencies. This offers some of the first experimental proof-of-concept data regarding the impact of mindfulness on human responding.

A number of alternative theoretical explanations concerning the effects of mindfulness on schedule performance seem possible, and two explanations, in particular, should be considered in this context. The first suggestion coheres both with the theory underlying approaches such as acceptance and commitment therapy (Fletcher & Hayes, 2005) and with the theory underlying some human insensitivity to schedules of reinforcement (Hayes, Brownstein, Zettle, Rosenfarb and Korn 1986b; Shimoff et al., 1986). This view suggests that mindfulness produces a suppression of the language (verbal rules) that can make behavior contingency insensitive. This would explain the current enhanced contingency sensitivity. It has also been suggested that enhanced focus on the current contingencies (i.e., remaining in the present; Kabat-Zinn 2003; McHugh et al., 2010) is a fundamental impact of mindfulness (Hayes et al., 1999; Kabat-Zinn, 2003). By allowing the participants to remain more focused on the present as a result of the mindfulness induction, both of the experiments reported here have shown that the individuals who participated in the mindfulness induction were more apt to have greater sensitivity to the current contingencies. In terms of learning theory, it may have been that participants develop attentional set as a result of the mindfulness induction, in which the salience of a particular stimulus dimension (e.g., the present), relative to other dimensions of stimuli (e.g., the past), is increased (see, e.g., Sutherland & Mackintosh, 1971). These two suggestions are not mutually exclusive but are in need of further experimental exploration.

However, the proof-of-concept data presented here also leave open a wide variety of additional potential theoretical explanations of the effects of mindfulness on human conditioned behavior. One potential explanation of the present mindfulness-induced results might be that the mindfulness induction functions as a concurrent cognitive load, or task, that prevents active retrieval of former events and reinforcement schedules. That is, it serves purely as an interfering task. However, this suggestion is made unlikely because the control group was exposed to an unfocused-attention induction that could also interfere in this same way but did not produce the same effects. Similarly, it may have been that lower response rates occur after a mindfulness induction because the participants simply were calmer. While it might be expected that both inductions would have produced this

effect (i.e., the breathing instructions in both conditions may have reduced heart rate, etc.), there are data from other studies that suggest that the effects of mindfulness and relaxation are different from one another. For example, Ditto, Eclache, and Goldman (2006) found that brain activity and cardiovascular effects were different between the two procedures, and Jain et al. (2007) found that while relaxation and mindfulness both reduced distress and foster positive mood states, only mindfulness reduced distractive and ruminative thoughts. Of course, these issues require further exploration.

It is worth noting that in many investigations concerning resurgence, resurgence is measured by the recovery of an originally trained response when a later-trained response undergoes extinction. However, in the present procedures, resurgence was conceptualized as an increase in the only measured response. The absence of resurgence in the mindfulness group had something to do with the potency of the extinction treatment in that condition on the only permissible response (i.e., the only measured response). It could be noted that the absence of this resurgence may be due, in part, to there not being different responses permissible to the participants. This limitation of the present study could be addressed in future research using a different design.

A limitation of the present design that may also impact on the eventual theoretical explanation of these effects is that each assessment of contingency-appropriate behavior is a reduction in response rates (i.e., studying the transition to extinction). In other words, it is unclear whether mindfulness techniques would result in an increase in response rates during the transition to a schedule that should generate higher response rates (e.g., the transition from an FI schedule to a VR schedule). Moreover, it may be interesting in future research to perform more fine-grained analyses of the temporal patterning of responding during the resurgence test, in order to determine whether these behaviors are schedule specific.

In comparing the present mindfulness intervention with prior mindfulness interventions, several key findings have been replicated in terms of the clinical significance of limiting resurgence. For example, in the context of depression, Williams et al. (2006) examined the effectiveness of mindfulness in reducing relapse into suicidal thoughts and proclivities and suggested that mindfulness was central in breaking the ruminative cycles of suicidal thinking. Furthermore, Williams, Teasdale, Segal, and Soulsby (2000) found that mindfulness reduced negative autobiographical memory in depressed individuals, suggesting that mindfulness-based interventions could dramatically reduce the rate of relapse associated with depression. The link with the present experimental procedure is made by considering the suggestions of Reed and Morgan (2007), who found that resurgence appears most often after the transfer from a dense

schedule of reinforcement to a leaner schedule of reinforcement (see also Lieving & Lattal, 2003). If individuals who are deemed depressed in the current contingency (e.g., the present) not to be worthwhile (e.g., they experience a lean schedule), then it might be plausible to suggest that the individuals who are depressed are more likely to revert back to previous behaviors (e.g., past learning histories), resulting in a relapse of their depression. The fact that mindfulness impacts on both the clinical and laboratory explorations suggests that the current model may be viable to further explore this effect.

In sum, in the present study, we sought to investigate the effects of a mindfulness intervention on human conditioning. The findings suggested that human participants display patterns of resurgence on schedules of reinforcement similar to those noted in rats and that mindfulness training produces less resurgence and greater extinction than in controls. This suggests that the present experimental procedures are useful in the exploration of these issues and that mindfulness may have the potential to become a first-choice treatment against depression and its symptoms.

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Appendix 1. Mindfulness induction

Much of the emotional distress people experience is the result of thinking about upsetting things that have already happened or anticipating negative events that have yet to occur.

Distressing emotions such as anger, anxiety, guilt and sadness are much easier to bear if you only focus on the present – on each moment one at a time.

This is an exercise to increase your mindfulness of the present moment so that you can clear away any thoughts about past and future events.

Start by focusing on your breathing.

Don't try to change anything about your breathing, just notice the air moving in and out of your body.

Try to focus all your attention on your breathing.

Notice the sensation of breathing air in.

Notice the sensation of breathing air out.

As you breath 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".

Focus on the actual sensation of breath entering and leaving your body.

Just this one breath in.

Just this one exhale out.

If you notice that your awareness is no longer on your breath gently bring your awareness back.

Just this one breath.

Just this one exhale.

Continue focusing only on each breath in and each breath out, do not anticipate anything – even your next breath. Only focus on one breath at a time.

If anything else pops into your mind, push it aside and refocus your attention to each breath.

Continue focusing on each breath in and each exhale out until you hear the sound of the bell.

Appendix 2. Unfocused-attention induction

Much of the emotional distress people experience is the result of thinking about upsetting things that have already happened or anticipating negative events that have yet to occur.

Distressing emotions such as anger, anxiety, guilt and sadness are often brought to mind.

With this exercise let your mind wander freely amongst thoughts about past and 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.

Openly let your thoughts flow.

Continue to let yourself think freely.

There is no need to think of anything in particular.

Just let your mind wander.

Think about whatever comes to mind.

Let your thoughts drift.

Continue your flow of thoughts.

Continue to let your thoughts flow until you hear the sound of the bell.

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