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# The Effect of Mindfulness on Cognitive Reflection and Reasoning

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## Abstract

**Objectives:** Cognitive decoupling (the ability to distinguish supposition from belief and run thought experiments) is considered one of the key mechanisms in mindfulness, cognitive reflection, and reasoning. Therefore, the present study examined whether a brief mindfulness exercise that explicitly encourages cognitive decoupling can increase cognitive reflection and reasoning. **Methods:** A total of 156 first and second-year undergraduate students were randomly allocated to either a mindfulness or control condition, before listening to a 15-minute audio recording. The mindfulness audio was a recording of the leaves on a stream exercise that focussed on how to dissociate from thoughts (decentring), whereas the control audio was a recording of a book prologue. Cognitive reflection and reasoning were measured through the expanded cognitive reflection test and a syllogistic reasoning test, both of which encourage an incorrect automatic response rather than a correct rational response. The five-facet mindfulness questionnaire-short form and the rational-experiential inventory were also administered as trait measures of mindfulness and thinking style (intuitive or rational), respectively. **Results:** The results showed no significant difference between the mindfulness and control conditions on either of the cognitive tests. However, there was a significant positive correlation between trait mindfulness and trait rationality ($r = 0.56$). Further analyses showed that the mindfulness subscales of observing, describing, detaching, and acting mindfully were all significant predictors of trait rationality. **Conclusions:** Trait mindfulness and trait rationality are moderately associated, although more research is required to determine whether mindfulness training can increase cognitive reflection and reasoning.

**Keywords** Mindfulness · Meditation · Decentring · Cognitive reflection · Reasoning

## Introduction

Mindfulness is an ancient Buddhist practice that involves paying attention in a particular way: on purpose, in the present moment, and non-judgementally (Kabat-Zinn, 1994). Mindfulness can be cultivated through regular meditation practice whereby attention is focused on the present moment and is gently but firmly guided back whenever the mind drifts off. As the ability to stay present improves, the true nature of thoughts and concepts becomes more apparent; thoughts are recognized as transient mental events that rise and fall (Bishop et al., 2004), whereas concepts are seen as a projection of thoughts and beliefs onto a mental image or physical object (Nisker, 1998). Therefore, cultivating a mindful disposition allows for each moment to be observed more fully, the present moment to be experienced more deeply, and situations to be perceived with greater clarity (Titmuss, 2014). This runs counter to the reactive and habitual mind states that are so pervasive in everyday life, many of which lead to unhealthy behaviours and untimely consequences (Titmuss, 2014).

From the Buddhist perspective, our lives are lived through a limited state of consciousness, simulating an extended dream as opposed to full conscious awareness or wakefulness (Kabat-Zinn, 1994). Accordingly, mindfulness involves learning to wake up from this extended dream by cultivating an ever-deepening conscious awareness of moment-to-moment experience. Neurological studies have shown there are at least four brain regions correlated with both meditation and consciousness: the insula, the anterior cingulate cortex, the posterior cingulate cortex, and the prefrontal cortex (Manuello et al., 2015). Furthermore, the practice of meditation has been found to result in both structural and functional alterations within neural networks that promote and maintain consciousness, although these alterations are more likely to be observed in long-term meditators than beginners (Manuello et al., 2015). As conscious awareness of moment-to-moment experience deepens, this lays the foundation for the development of metacognition – a conscious awareness of the constant changing of perceptions, sensations, emotions, and thoughts as represented in consciousness (Jankowski & Holas, 2014). This allows the individual to reflect and comment on the various mental states that are presently being experienced (Fleming et al., 2012). Consequently, mindful awareness is regarded as the highest level of metacognition as it incorporates all consciously accessible phenomena and cognitive processes in the present moment (Jankowski & Holas, 2014).

Dual process models of cognition differentiate between two modes of cognitive processing, often referred to as Type 1 and Type 2. The defining characteristic of Type 1 processing is autonomy; these processes occur fairly rapidly, have a high capacity due to occurring in parallel, and do not require working memory resources. In

contrast, Type 2 processes are fairly slow, have a limited capacity due to being sequential, and do require access to working memory resources (Evans & Stanovich, 2013). It has also been proposed that one of the defining features of Type 2 processing is cognitive decoupling or 'the ability to distinguish supposition from belief and to aid rational choices by running thought experiments' (Evans & Stanovich, 2013, p. 236). Therefore, cognitive decoupling appears to be a fundamental mechanism through which reasoning occurs. Although Type 1 and Type 2 processes are distinguished in all dual process models of cognition, the way in which these processes are thought to interact differs significantly across models. According to the default interventionist model, Type 1 processes provide a rapid and intuitive default response, while Type 2 processes monitor and override this default response when it is recognised as inaccurate (Evans & Stanovich, 2013). As stated by Mega and Voltz (2014), the capacity of Type 2 processes to monitor and override Type 1 processes is achieved through the process of cognitive decoupling; a re-representation of the Type 1 process is formed and manipulated through metacognition, allowing the individual to consciously determine the best course of action. As the resources required for Type 2 processes are severely limited, it is proposed that the majority of behaviour will accord with the intuitive default response, only being overridden by Type 2 processes when the present task is perceived as difficult or novel (Evans & Stanovich, 2013).

The potential for mindfulness to reduce the influence of Type 1 processes and increase the influence of Type 2 processes on behaviour has recently been proposed by Kang et al. (2013). Specifically, they argue that mindfulness increases the activation of Type 2 processes through four specific mechanisms: awareness, attention, focus on the present, and acceptance. Awareness refers to the conscious awareness of one's present moment experience including both internal events (e.g. bodily sensations, thoughts and emotions) and external events (e.g. sights and sounds); attention refers to the focus of attention being directed specifically at these internal and external events; focus on the present moment involves the focus of attention being directed at the events occurring in each moment; and non-judgemental acceptance involves allowing each event to enter conscious awareness, without being judged as good or bad, desirable or undesirable, important or trivial (Germer et al., 2005). As mindfulness is cultivated, individuals start to realize that thoughts are simply transient mental events that continually rise and fall from conscious awareness (Kang et al., 2013). This realization leads to the creation of mental distance from present thoughts (cognitive decoupling), allowing individuals to become more aware of how they intuitively react to various internal and external events. As a result, individuals are able to respond to the event from a conscious level rather than an unconscious level. This potential salutary effect has also been acknowledged by Mellinger

(2010) who stated 'In Buddhist psychology, mindfulness is considered the method for cultivating the ability to perceive reality accurately, so the cognitions and feelings of a person who attains mindfulness would represent a very sound basis for arriving at truth through rational thinking' (p. 220).

One of the advantages of using mindfulness as a means of increasing cognitive reflection and reasoning is that mindfulness has also been associated with reduced anxiety and depression (Schreiner & Malcolm, 2008), an increased ability to deal with stressful events (Donald et al., 2016), and increased self-esteem (Pepping et al., 2013). In relation to reasoning and rationality, a recent study found a positive association between facets of mindfulness and critical thinking – a higher order cognitive process that involves analysing and evaluating evidence in the absence of bias and prior knowledge – which was fully mediated by the inhibition element of executive function (Noone et al., 2016). This study was followed-up with a randomized controlled trial which found that a 6-week mindfulness intervention and a 6-week sham meditation intervention both significantly increased mindfulness and critical thinking; however, there was no significant difference between the interventions on either of these measures (Noone & Hogan, 2018). Although the randomized controlled trial employed a fairly intensive mindfulness intervention, the potential for brief mindfulness interventions to influence cognition has also been confirmed by previous research (Hopthrow et al., 2017; Weger et al., 2012). Furthermore, a recent study has shown that even a brief five-minute computer-mediated mindfulness practice can significantly increase state mindfulness compared to a control condition (Mahmood et al., 2016).

As a mindful state can be cultivated through practice, this study explored whether a brief mindfulness exercise would increase cognitive reflection and reasoning (through an increase in cognitive decoupling) as measured by the ECRT and a syllogistic reasoning test. Based on the findings discussed above, this study builds on previous research in several ways. Firstly, as there is evidence that as little as 5-minutes of meditation can increase state mindfulness and have a positive effect on cognition, this study examined whether a brief mindfulness exercise would also improve cognitive reflection and reasoning. Secondly, the mindfulness condition involved listening to the 'leaves on a stream' exercise as it specifically encourages cognitive decoupling by teaching participants how to dissociate from thoughts in the present moment. Thirdly, this study measured cognition through the Expanded Cognitive Reflection Test (ECRT) and a syllogistic reasoning test as both distinguish between Type 1 and Type 2 processes. Lastly, following research evidence that sham meditation can also increase state mindfulness, this study employed a book-listening control as a comparison condition. It was expected that: (1) the brief mindfulness

exercise would lead to improved performance on the ECRT and the syllogistic reasoning test; (2) the brief mindfulness exercise would have a greater effect on individuals who were predominantly intuitive thinkers due to a greater increase in cognitive decoupling; (3) trait mindfulness would be positively associated with trait rationality; and (4) trait mindfulness would be positively associated with both the ECRT and the syllogistic reasoning test.

## Method

### Participants

The eligibility criteria stated that all participants must be at least 18 years old, first- or second-year undergraduate students, and fluent in English. An a priori calculation using G*Power indicated that 156 participants would be required to achieve a 0.8 level of power and detect an effect size (Cohen's d) of 0.4 with alpha set at 0.05. A small to medium effect size was selected as successful brief mindfulness interventions have shown a range of effect sizes (0.28 to 0.89) (Mahmood et al., 2016). A total of 168 first- and second-year undergraduate students were recruited for the main study in order to account for exclusions. Overall, nine participants had previously completed one or both of the cognitive tests; one had previously read an article on the ECRT; one had a technical issue with the audio recording; and one completed the study without consulting the researcher. This left a final sample size of 156 participants including 125 females and 31 males; the mean age of the sample was 19.33 years (SD = 2.93). Participants received either the assigned number of course credits or a £5 payment for taking part, as well as the extra financial reward earned during the study. Ethical approval for the study was granted by the Psychology Department Research Ethics Committee at City, University of London.

### Procedure

Each participant completed the study on a computer located in a sound-proof cubicle and was alone for the duration of the study. The participants initially completed four questions relating to demographics and personal characteristics, before they were randomly assigned to either the mindfulness or control condition which was done automatically through Qualtrics survey software. The corresponding audio recordings were then played through the computer speakers and participants could only start the next section once the recording had played through to the end. After the recording had finished, the participants in the mindfulness condition were also asked to complete a brief manipulation check. The second part of the study involved completing the ECRT followed by the syllogistic reasoning test; prior to completing the tests, all the participants were informed they would receive a

financial reward based on their performance. Specifically, they were told they would earn points for each question they answered correctly within a specified time frame and the points earned would be totalled at the end of the study to determine the overall financial reward, up to a maximum of £4. This ensured that the participants were motivated to give the correct answers as quickly as possible, balancing the motivation for Type 1 versus Type 2 processing. On completion of the cognitive tests, participants were asked to complete both the FFMQ-SF and the REI-R before they were debriefed. The study took approximately 40 minutes to complete.

**Audio Recordings**

The mindfulness condition involved listening to a 15-minute audio recording of the 'leaves on a stream' exercise which was recorded by the first author (Hayes & Smith, 2005). This exercise encourages the listener to imagine leaves floating down a slow-moving stream and to place each thought that arises onto one of the leaves before letting it drift off. This exercise shows participants how to dissociate from thoughts in the present moment, allowing these thoughts to be observed rather than experienced. Consequently, participants cultivate a greater awareness of thoughts in the present moment and start to perceive them as transient mental events that come and go. In comparison, the control condition was a 15-minute audio recording of the prologue from The Lord of the Rings and concerned the life and times of Hobbits (Tolkien, 2005). A book-listening control was chosen as prior research has found this to be a reliable control condition (Johnson et al., 2013).

**Measures**

Demographic information and personal characteristics were measured through a brief questionnaire which consisted of four questions concerning age, gender, sleep, and present-moment awareness. Sleep was measured by asking participants to state the total number of hours they had slept the night before the study; this was measured as acute sleep deprivation has previously been found to have a negative impact on cognitive performance (Alhola & Polo-Kantola, 2007). Level of alertness in the present moment was measured using a 7-point Likert scale ranging from 'Extremely alert' to 'Extremely unalert'; this was measured as substances such as caffeine have been shown to improve cognitive performance by increasing alertness and vigilance (Smith, 2002).

Cognitive reflection was measured using the Expanded Cognitive Reflection Test (ECRT) which is a brief 7-item test developed by Toplak et al. (2014). This measure is based on dual process theory and has been developed specifically to distinguish between Type 1 (automatic) and Type 2 (conscious) processes. Each question has a

mathematical basis and has been designed to elicit an automatic response that is incorrect; for example, one of the questions is 'A bat and a ball cost £1.10 in total. The bat costs a pound more than the ball. How much does the ball cost?'. The intuitive response to this question is 10p whereas the correct response is actually 5p. In order to obtain the correct response, the individual is required to reflect on the question consciously and run thought experiments using Type 2 processes. As each question can be answered incorrectly (scoring 0) or correctly (scoring 1), this test yields a binomial-distributed score from 0-7 depending on the number of correct answers given, but can be fully modelled as seven Bernoulli-distributed responses clustered within each participant. There is evidence to support the validity of the ECRT as previous research has shown that this test is a substantial unique predictor of rationality (Toplak et al., 2014). This finding has also been confirmed by a more recent examination of the psychometric properties of the ECRT (Šrol, 2018).

Syllogistic reasoning is a measure of deductive reasoning ability and involves deciding whether a conclusion is true or false based on two premises. The automatic response is to focus on the believability of the conclusion rather than whether it follows logically from the premises, often referred to as belief bias. Syllogisms may be presented in four different formats based on the validity and the believability of the conclusion: (1) valid and believable; (2) valid and unbelievable; (3) invalid and believable; or (4) invalid and unbelievable. The syllogistic reasoning test involved completing a total of 12 syllogisms developed by the researcher through a pilot study with three in each of the four formats described above (see supplementary materials). As the syllogism must present a conflict between the validity and believability of the conclusion in order to distinguish between Type 1 and Type 2 processing, only the six syllogisms that presented this conflict were included in the data analysis. For example, one of the syllogisms presented was 'No bears are arctic dwellers, some polar bears are arctic dwellers, therefore, some polar bears are not bears'. Although this syllogism is valid, it presents a conflict to the reader because the conclusion is unbelievable. Each syllogism presented can be answered incorrectly (scoring 0) or correctly (scoring 1), yielding six responses clustered within each participant that can be summarized as a score from 0-6, and fully modelled via inferential statistics. The effect of belief bias on syllogistic reasoning performance has previously been confirmed by Evans et al. (1983).

The FFMQ-SF is a 24-item questionnaire that measures trait mindfulness through five components: observing, describing, acting with awareness, non-judgement, and non-reactivity (Bohlmeijer et al., 2011). Each item is measured on a 5-point Likert scale from 'Strongly agree' to 'Strongly disagree'. The observing subscale consists

of four items ($\alpha$ for the present study = 0.62) , whereas the describing subscale ($\alpha$ = 0.79), acting with awareness subscale ($\alpha$ = 0.75), non-judgement subscale ($\alpha$ = 0.74), and the non-reactivity subscale ($\alpha$ = 0.75) all consist of five items. Bohlmeijer et al. (2011) confirmed the validity and replicability of the questionnaire by cross-validating with an independent sample of participants.

The REI-R is a 40-item questionnaire that is composed of two parts; the 20-item Need for Cognition Scale (NCS) and the 20-item Faith in Intuition Scale (FI) (Pacini & Epstein, 1999). This questionnaire measures the extent to which trait thinking style is rational (NCS) or intuitive (FI); each item is measured on a 5-point Likert scale from 'Strongly agree' to 'Strongly disagree'. The NCS is comprised of the 10-item rational engagement subscale ($\alpha$ for the present study = 0.79) and the 10-item rational ability subscale ($\alpha$ = 0.80). The FI is comprised of the 10-item experiential engagement subscale ($\alpha$ = 0.79) and the 10-item experiential ability subscale ($\alpha$ = 0.81). The validity and reliability of the REI-R has been confirmed in two separate studies by Pacini and Epstein (1999).

Participants in the mindfulness condition were also required to complete a manipulation check to determine adherence to the mindfulness exercise. This involved giving a brief description of the exercise, rating the extent to which the exercise had been followed, and rating the extent to which they had noticed their thoughts; both ratings were completed on a 5-point Likert scale from 'Not at all' to 'All of the time'.

### Data Analyses

It was initially planned to examine the hypotheses using ANOVA (hypothesis 1 and 2) and multiple regression analysis (hypothesis 3 and 4); running multiple regression would allow for the contribution of each of the five mindfulness subscales to be determined (hypothesis 3 and 4). However, as the ECRT and syllogistic reasoning test scores were both found to have a severe positive skew that was unresponsive to data transformation, it was determined that a series of generalised linear mixed models would be the most appropriate way to examine hypothesis 1, 2 and 4.

## Results

### Preliminary Analysis

A preliminary analysis showed that participants from both conditions were well matched on demographic and personal characteristics (see Table 1).

**Table 1**

*Characteristics of Participants as a Function of Condition*

| Characteristic | Mindfulness (n = 81) | Control (n = 75) |
|---|---|---|
| Age (Mean, SD) | 19.42 (3.60) | 19.23 (1.98) |
| Females (%) | 86.4 | 73.3 |
| Sleep – Hours (Mean, SD) | 7.06 (1.35) | 7.00 (1.34) |
| Alertness – 1-7 (Mean, SD) | 5.30 (1.10) | 5.31 (1.21) |
| FFMQ score – 1-5 (Mean, SD) | 3.02 (0.43) | 3.12 (0.44) |
| REI - Rational – 1-5 (Mean, SD) | 3.25 (0.52) | 3.38 (0.57) |
| REI - Intuitive – 1-5 (Mean, SD) | 3.45 (0.52) | 3.41 (0.50) |

The manipulation check showed that participants in the mindfulness condition reported following the instructions most of the time (3.88 out of 5, SD = 0.62) and also noticed their thoughts most of the time (3.95 out of 5, SD = 0.76). Both the state measures of thinking style – the ECRT and syllogistic reasoning test – were scored so that higher scores reflected a greater degree of cognitive reflection and reasoning. As initial tests of normality showed both of these measures to have a severe positive skew, a theoretically appropriate Generalized Linear Mixed Model (GLMM) and non-parametric tests were used to analyse the data.

A series of Spearman's Rho correlations showed no significant association between ECRT score and sleep, $r$ (155) = 0.00, $p$ = 0.981; no significant association between ECRT score and alertness, $r$ (155) = -0.04, $p$ = 0.640; and a significant association between ECRT score and time spent on the test, $r$ (155) = 0.35, $p < 0.001$. There was also no significant association between syllogistic reasoning score and sleep, $r$ (155) = -0.14, $p$ = 0.081; no significant association between syllogistic reasoning score and alertness, $r$ (155) = 0.01, $p$ = 0.906; and a significant association between syllogistic reasoning score and time spent on the test, $r$ (155) = 0.32, $p < 0.001$. Therefore, the more time participants spent on the ECRT and the syllogistic reasoning test, the more questions they answered correctly.

The descriptive statistics showed that participants in the mindfulness condition scored lower on the ECRT (mean = 1.19 out of seven, SD = 1.31) than participants in the control condition (mean = 1.33, SD = 1.50), a finding that was in contrast with the initial research hypothesis (see Figure 1). The descriptive statistics also showed that

participants in the mindfulness condition answered slightly more syllogisms correctly (mean = 1.85 out of six, SD = 1.76) than participants in the control condition (mean = 1.76, SD = 1.58), a finding that supported the initial research hypothesis (see Figure 2). However, it is important to note that the mode was 0 for both conditions on both tests.

**Figure 1**

*The Distribution of ECRT Scores in the Mindfulness and Control Conditions*

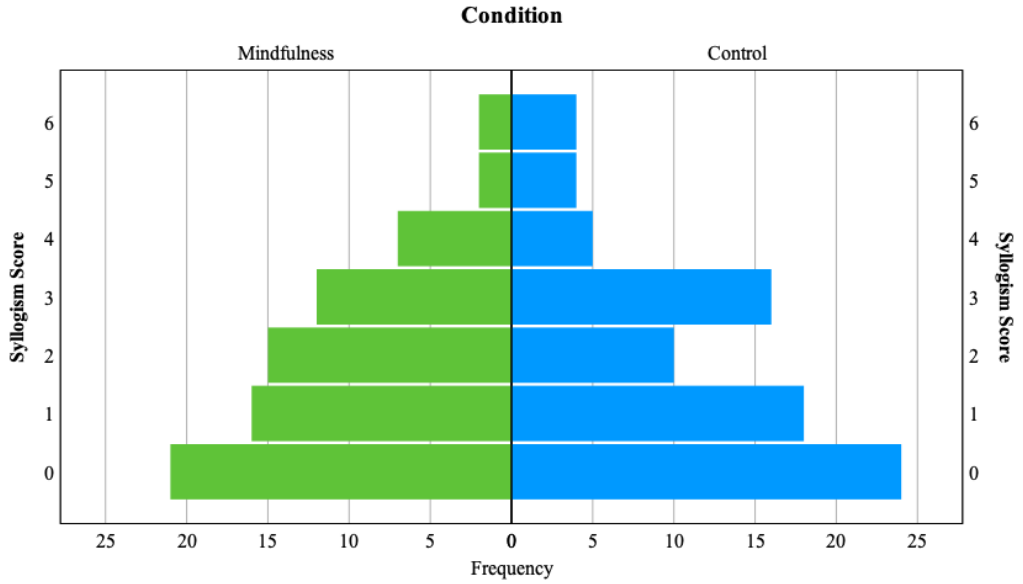
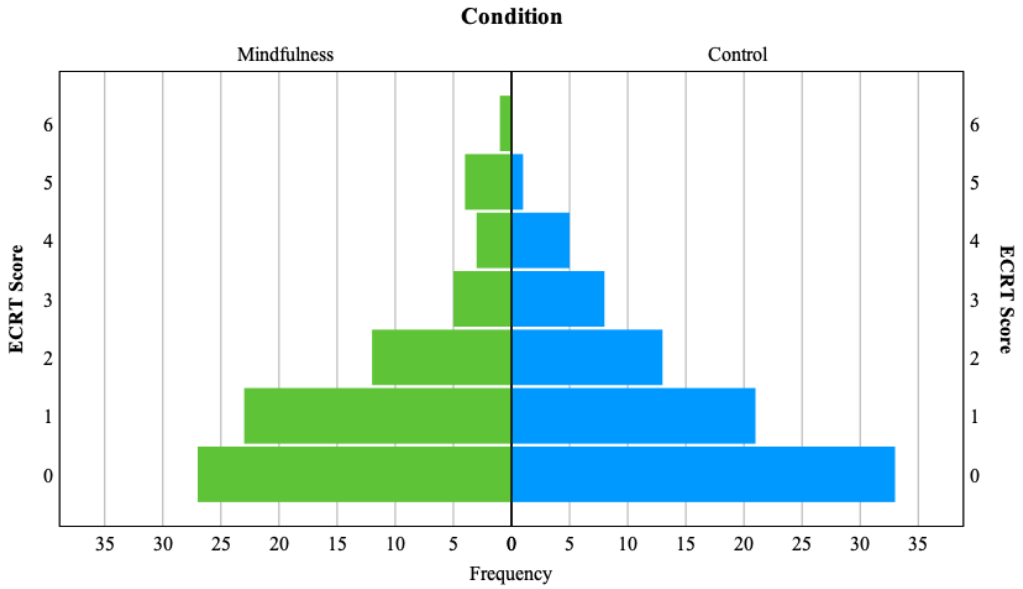



**Figure 2**

*The Distribution of Syllogism Scores in the Mindfulness and Control Conditions*



**The Effect of Mindfulness on Cognitive Reflection and Reasoning**

As the data violated the assumptions required for ANOVA, a Generalized Linear Mixed Model (GLMM) analysis was run to determine whether the mindfulness exercise would (1) lead to an improved performance on the ECRT and syllogistic reasoning test and (2) have a greater effect on individuals in the mindfulness group who scored higher on trait intuitive thinking. Two models were tested, one with the ECRT scores as the dependent variable and one with the syllogism scores as the dependent variable. Both models were run with a logistic link function and binomial noise as these are specifically applicable in studies where the dependent variable represents the sum of binary outcomes (Jaeger, 2008). The models included three fixed effects: mindfulness condition, intuition (i.e. score on the REI-R experiential scale) and the interaction of these variables. The model also included a random intercept in order to properly model the clustering of answers within participants. Fitting was performed using the MATLAB fitglme command and was based on maximum likelihood estimated using the Laplace approximation, with effects coding (and mean centring for REI-R). The first model showed no significant fixed effect of condition on ECRT score, $F$ (1, 152) = 0.30, $p$ = 0.584, as well as no significant interaction between condition and intuition, $F$ (1, 152) = 0.29, $p$ = 0.589. The unadjusted beta values for the first model are provided in Table 2. The second model also showed no significant fixed effect of condition on syllogism score, $F$ (1, 152) = 0.06, $p$ = 0.800, as well as no significant interaction between condition and intuition, $F$ (1, 152) = 0.32, $p$ = 0.574. The unadjusted beta values for the second model are provided in Table 3.

**Table 2**

*Generalized Linear Mixed Model for ECRT Score Based on Seven Responses Clustered Within Each of 156 Participants.*

| Parameter | Coefficient ($\beta$) | Standard Error | P value | 95% CI | |
|---|---|---|---|---|---|
| | | | | Lower | Upper |
| Intercept | -1.85 | 0.12 | < 0.001 | -2.09 | -1.61 |
| Condition | -0.07 | 0.12 | 0.584 | -0.31 | 0.17 |
| REI-R Intuition | -0.33 | 0.25 | 0.184 | -0.82 | 0.16 |
| Condition*REI-R Intuition | 0.13 | 0.25 | 0.589 | -0.35 | 0.62 |

**Table 3**

*Generalized Linear Mixed Model for Syllogistic Reasoning Score Based on Seven Responses Clustered Within Each of 156 Participants.*

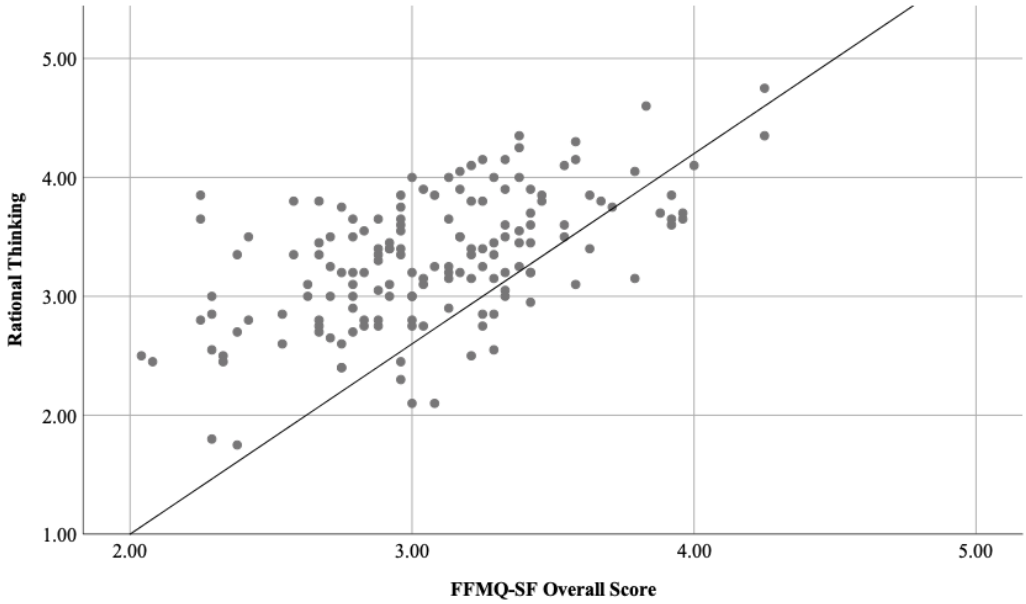
| Parameter | Coefficient ($\beta$) | Standard Error | P value | 95% CI | |
|---|---|---|---|---|---|
| | | | | Lower | Upper |
| Intercept | -1.12 | 0.13 | < 0.001 | -1.39 | -0.86 |
| Condition | 0.03 | 0.13 | 0.802 | -0.23 | 0.30 |
| REI-R Intuition | 0.18 | 0.26 | 0.480 | -0.33 | 0.70 |
| Condition*REI-R Intuition | -0.15 | 0.26 | 0.574 | -0.66 | 0.37 |

**The Association Between Trait Mindfulness and Trait Rationality**

A forced entry multiple regression showed the association between the five subscales of the FFMQ-SF and trait rationality was moderate to strong (Multiple $R = 0.58$, $p < 0.001$) with the subscales accounting for 31% of the variance in trait rationality (Adjusted $R^2$) (see Figure 3). The data analyses showed that none of the subscales were intercorrelated (observing, VIF = 1.02; describing, VIF = 1.24; acting with awareness, VIF = 1.29; non-reactivity, VIF = 1.10; non-judgement, VIF = 1.28). The standardised coefficients for each of the five subscales were as follows: observing = 0.24, $p = 0.001$ (95% CI = 0.08 – 0.29); describing = 0.20, $p = 0.008$ (95% CI = 0.04 – 0.25); acting with awareness = 0.26, $p = 0.001$ (95% CI = 0.08 – 0.30); non-reactivity = 0.22, $p = 0.002$ (95% CI = 0.06 – 0.25); and non-judgement = 0.08, $p = 0.263$ (95% CI = -0.05 – 0.18). Therefore, it can be concluded that all subscales, except for the subscale of non-judgement, were positive predictors of trait rationality. A second forced entry multiple regression showed there was no association between the five subscales of the FFMQ-SF and trait intuition, (Multiple $R = 0.14$, $p = 0.707$).

**Figure 3**

*The Association Between Trait Mindfulness and Trait Rationality*




**Trait Mindfulness as a Predictor of Cognitive Reflection and Reasoning**

A GLMM analysis showed that, collectively, the five subscales of the FFMQ-SF significantly predicted ECRT score, $\Delta D$ (5) = 15.55, $p$ = 0.008. The analysis incorporated the five FFMQ-SF subscales individually (without mean centring), and is summarised in Table 4, showing untransformed $\beta$ values. In the main text that follows, the effects are instead described in terms of odds, i.e. the exponent of the log odds values described by the (logistic) model coefficient ($\beta$) values. Applying the model equation for the mean-average participant indicated baseline odds of success on the ECRT of 0.16, equating to a probability of success of 14% on each question. The results showed that the subscale of non-judgement was the only significant predictor of ECRT score, exp ($\beta$) = 1.75, $t$ (150) = 3.04, $p$ = 0.002. This suggests that a one-point increase in this component of trait mindfulness is associated with a 75% increase in the odds of correctly answering questions assessing cognitive reflection, which supports the research hypothesis. The (non-significant) results for the remaining four subscales were as follows: observing, exp ($\beta$) = 1.40, $t$ (150) = 1.88, $p$ = 0.062; describing, exp ($\beta$) = 0.92, $t$ (150) = -0.45, $p$ = 0.652; acting with awareness, exp ($\beta$) = 1.12, $t$ (150) = 0.65, $p$ = 0.519; and non-reactivity, exp ($\beta$) = 0.94, $t$ (150) = -0.37, $p$ = 0.711. A further GLMM analysis (Table 5) showed that, collectively, the five subscales of the FFMQ-SF were not significant predictors of syllogistic reasoning score, $\Delta D$ (5) = 4.77, $p$ = 0.445. The results for each of the five subscales were as follows: observing, exp ($\beta$) = 0.85, $t$ (150) = -0.89, $p$ = 0.375; describing, exp ($\beta$) = 0.82, $t$ (150)

= -1.06, $p$ = 0.289; acting with awareness, exp ($\beta$) = 0.84, $t$ (150) = -0.84, $p$ = 0.402; non-reactivity, exp ($\beta$) = 0.87, $t$ (150) = -0.79, $p$ = 0.432; and non-judgement, exp ($\beta$) = 1.01, $t$ (150) = 0.03, $p$ = 0.973.

**Table 4**

*Generalized Linear Mixed Model for Trait Mindfulness as a Predictor of ECRT Score Clustered Within Each of 156 Participants.*

| Parameter | Coefficient ($\beta$) | Standard Error | P value | 95% CI | |
|---|---|---|---|---|---|
| | | | | Lower | Upper |
| Intercept | -4.44 | 0.97 | < 0.001 | -6.35 | -2.53 |
| Observing | 0.34 | 0.18 | 0.062 | -0.02 | 0.69 |
| Describing | -0.08 | 0.17 | 0.652 | -0.42 | 0.27 |
| Acting with Awareness | 0.12 | 0.18 | 0.519 | -0.24 | 0.47 |
| Non-Reactivity | -0.06 | 0.16 | 0.711 | -0.38 | 0.26 |
| Non-Judgement | 0.56 | 0.18 | 0.002 | 0.20 | 0.93 |

**Table 5**

*Generalized Linear Mixed Model for Trait Mindfulness as a Predictor of Syllogistic Reasoning Score Clustered Within Each of 156 Participants.*

| Parameter | Coefficient ($\beta$) | Standard Error | P value | 95% CI | |
|---|---|---|---|---|---|
| | | | | Lower | Upper |
| Intercept | 1.07 | 1.07 | 0.316 | -1.03 | 3.18 |
| Observing | -0.17 | 0.19 | 0.375 | -0.54 | 0.21 |
| Describing | -0.20 | 0.19 | 0.289 | -0.58 | 0.17 |
| Acting with Awareness | -0.17 | 0.20 | 0.402 | -0.57 | 0.23 |
| Non-Reactivity | -0.14 | 0.18 | 0.432 | -0.49 | 0.21 |
| Non-Judgement | 0.01 | 0.21 | 0.973 | -0.41 | 0.42 |

**The Association Between Trait Rationality and Cognitive Reflection and Reasoning**

A series of Spearman's Rho correlations indicated a small positive association between the ECRT and trait rationality, $r = 0.22$, $p = 0.005$, as well as a small negative association between syllogistic reasoning score and trait rationality, ($r = -0.24$, $p = 0.003$). There was no association between ECRT score and syllogistic reasoning score ($r = 0.00$, $p = 0.966$).

**The Association Between Cognitive Test Score and Speed of Processing**

Two Spearman's Rho correlations were run to examine (1) the association between ECRT score and the time taken to complete the test, and (2) the association between syllogistic reasoning score and the time taken to complete the test. The results showed a small to moderate association between ECRT score and the time taken to complete the ECRT which was significant, $r = 0.35$, $p < 0.001$. There was also a small to moderate association between syllogistic reasoning score and the time taken to complete the syllogistic reasoning test which was also significant, $r = 0.32$, $p < 0.001$.

## Discussion

The main aim of this study was to determine the effect of a brief mindfulness exercise on measures of cognitive reflection and reasoning. Overall, the results showed that the mindfulness exercise had no effect on cognitive reflection or reasoning; there was no difference between the mindfulness and control conditions on either the ECRT or the syllogistic reasoning test. The second aim was to determine whether the brief mindfulness exercise would have a greater effect on individuals who are predominantly intuitive thinkers due to a greater increase in cognitive decoupling. As the results showed no interaction between condition and trait intuition, this implies there was no greater benefit for the predominantly intuitive thinkers compared to the more rational thinkers.

One of the most surprising findings was the low scores on the ECRT and the syllogistic reasoning test for both conditions. As a recent meta-analysis found that males generally performed better than females on the Cognitive Reflection Test (CRT - the first three questions of the ECRT), the high percentage of females in this study may have contributed to the low scores obtained (Brañas-Garza et al., 2019). Specifically, the meta-analysis found that (1) males outperformed females on all three questions; (2) females were more likely to fail to answer any of the questions correctly (45% compared to 27%); and (3) males were more likely to answer all three questions correctly (25% compared to 12%). Furthermore, the differences between males and females persisted even after controlling

for test characteristics, such as monetary incentives and student samples. This gender difference has also been found for the ECRT, an effect that was attributed to differences in mathematical ability rather than differences in reasoning ability (Juanchich et al., 2019). Specifically, the authors found that both males and females were equally likely to engage in cognitive reflection, however, females were more likely to make mathematical errors due to higher levels of mathematics-related anxiety. Another recent study found that males also performed better than females on 22 syllogistic reasoning items; the average number of correct responses for male and female students was 15.04 and 13.93, respectively (Preiss et al., 2013). However, there is evidence that this may have been due to a slightly higher preference for rational processing among younger males compared to younger females (Sladek et al., 2010). As well as contributing to the low scores overall, these findings suggest that the higher percentage of females in the mindfulness condition may have confounded any effect of the mindfulness exercise on the ECRT and syllogistic reasoning scores.

The lack of effect found may also be accounted for by several alternative explanations. Firstly, the mindfulness exercise may have been too brief to have had any effect on cognitive reflection and reasoning. A systematic review of studies examining the effect of mindfulness on cognition showed that most involved attending a series of mindfulness sessions over several weeks or months (Chiesa et al., 2011). Furthermore, studies that have supported the effect of mindfulness over a shorter period of time have often utilised more intense mindfulness practices, such as retreats which involved meditating for up to 11 hours per day (Khoury et al., 2017). Despite this, research has also shown that shorter periods of mindfulness practice can lead to significant increases in state mindfulness (Mahmood et al., 2016). However, as the present study did not employ a measure of state mindfulness before and after the mindfulness condition, it cannot be stated whether the mindfulness exercise was successful in this respect. In relation to this, cognitive measures based on dual process theories comprise questions that are naturally dichotomous (the answers are either correct or incorrect) in order to distinguish between Type 1 and Type 2 processes. As this is also the case with the ECRT and syllogistic reasoning test, it could be argued that these tests are fairly insensitive to slight changes in cognitive reflection and reasoning. Therefore, it may be the case that a greater increase in mindfulness is required in order for any effects to be detected by these measures. Furthermore, as the ECRT only comprises seven questions, dividing this test into two shorter tests to measure cognitive reflection before and after the mindfulness exercise would further reduce the sensitivity of this measure.

Another factor that may have contributed to the lack of effect is the added time pressure to complete the ECRT and the syllogistic reasoning test in the least amount of time. Before starting the tests, each participant was informed they would receive a financial reward based on their performance; specifically, the participants were told that faster correct responses would result in a greater financial reward. The purpose of this reward was to balance the motivation to answer the questions automatically versus consciously, although the participants were not informed of the amount of time they had to answer each question. Therefore, it may be that the added time pressure inadvertently made the participants more reliant on Type 1 processes to complete both the ECRT and the syllogistic reasoning test, leading to an increase in the number of incorrect responses. This explanation is supported by research which examined the effect of experiential cues (cues related to Type 1 processes) on decision making under four levels of time pressure (Fraser-Mackenzie & Dror, 2011). The results showed that as the time pressure increased, participants became increasingly reliant on Type 1 processes to make decisions. The nature of the task may also have increased reliance of Type 1 processes as the default-interventionist model proposes that Type 2 processes only override Type 1 processes when the present task is perceived as being difficult or novel (Evans & Stanovich, 2013). Consequently, if the participants perceived both cognitive tests to be fairly easy then Type 2 processes will not have been activated.

The third aim of the study was to establish whether trait mindfulness was positively associated with trait rationality, as measured by the FFMQ-SF and the REI-R, respectively. The results showed a moderate to strong positive relationship which was found to be significant. Further analyses showed that this association was partly accounted for by four of the five FFMQ-SF subscales, namely observing, describing, acting mindfully, and non-reactivity; only the subscale of non-judgement showed no association with rationality. This is in line with a recent study which concluded that trait mindfulness appears to facilitate critical thinking performance; this study specifically found that the mindfulness subscale of observing was positively related to critical thinking, an effect which was fully mediated by the inhibition element of executive function (Noone et al., 2016). Furthermore, the subscale of non-reactivity was negatively associated with critical thinking which implies there may be mechanisms of mindfulness that have a detrimental effect on the ability to think critically. This finding suggests that rationality and critical thinking require different cognitive processes, although further research is required to determine the specific mechanisms through which these processes work. This will allow researchers to gain a deeper understanding of how mindfulness influences cognition and determine when mindfulness will have a positive or negative effect. However, it is also important to acknowledge the challenges in measuring mindfulness

and thinking style through self-report measures; one of the main issues with self-report measures of mindfulness is that individuals who are unfamiliar with the concept of mindfulness can easily misinterpret the items, leading to inconsistencies within studies (Bergomi et al., 2013).

The final aim was to establish whether the FFMQ-SF was positively associated with both the ECRT and the syllogistic reasoning test. The results showed a small positive association between the FFMQ-SF and ECRT score, implying that higher trait mindfulness was associated with greater cognitive reflection; this association was found to be significant and supports the initial research hypothesis. Further analyses showed that this association was accounted for by the subscale of non-judgement which was the only positive predictor of ECRT score; this suggests that having a non-judgmental attitude is positively associated with rationality. One explanation for this finding is that an incorrect intuitive response is partially due to an automatic judgement that is not questioned by the participant. However, the results also showed a trend toward a negative association between the FFMQ-SF and syllogistic reasoning score; this finding implies that lower trait mindfulness is associated with an increase in reasoning ability and opposes the initial research hypothesis. Further analyses showed that none of the FFMQ-SF subscales were significantly associated with syllogistic reasoning score. Overall, this finding suggests that the ECRT and the syllogistic reasoning test rely on different cognitive processes to answer the questions correctly. This is also supported by the positive (ECRT) and negative (syllogistic reasoning) associations with trait rationality, as well as the lack of association between the ECRT and syllogistic reasoning test. Overall, these findings support the argument that mindfulness may have a positive or negative effect on cognition depending on the nature of the task at hand (Noone et al., 2016).

**Limitations and Future Research**

There are several limitations that may have influenced the results of this study. Firstly, the high percentage of females in both groups is likely to have contributed to the low scores obtained for both the ECRT and the syllogistic reasoning test (Brañas-Garza et al., 2019). The higher percentage of females in the mindfulness condition may also have confounded any effect of the mindfulness exercise on the ECRT and syllogistic reasoning scores. Therefore, future research would benefit from employing different measures of cognitive reflection and reasoning. A more appropriate measure of cognitive reflection may be the 10-item verbal cognitive reflection test (CRT-V) which was recently developed by Sirota et al. (2018). The CRT-V has been found to be a valid and reliable measure of cognitive reflection with the mean around the centre point of the summation index; therefore,

this test is less prone to floor effects than the CRT and the ECRT. Furthermore, as this test is less associated with numeracy, men and women have been found to perform equally well on this measure (Sirota et al., 2018). In order to assess reasoning ability, future studies may be improved by administering the Halpern Critical Thinking Assessment (HCTA) which scores participants on five dimensions of critical thinking, including verbal reasoning (Schuhfried, n.d.). As well as being a more sensitive measure, this test would also (1) show whether improvements are specific to one or more dimensions of critical thinking, and (2) allow for critical thinking to be measured both before and after the mindfulness exercise. Secondly, the mindfulness exercise may have been too brief to have had any effect on state mindfulness. Although brief mindfulness interventions have been successful in previous studies, the present study employed a different mindfulness exercise which may have been less effective in the short-term; it could be argued that decentring from thoughts is a difficult skill to learn and therefore may take more time to develop. As previous research has shown that level of mindfulness is positively associated with mindfulness practice, future research would benefit from employing a more intense mindfulness practice over a longer period of time to ensure an increase in level of mindfulness (Carmody & Baer, 2008). Thirdly, the results may have been affected by the added time pressure to complete the ECRT and the syllogistic reasoning test in the least amount of time. In order to balance the motivation to answer the questions automatically versus consciously, the participants were told that faster correct responses would result in a greater financial reward at the end of the study. As previous research has shown that increasing time pressure increases reliance on Type 1 processes, future research may also be improved by testing participants without the added pressure of a time restriction (Fraser-Mackenzie & Dror, 2011).

**Author Contributions**

STF: designed and executed the study, performed part of the date analysis, and wrote the first draft of the manuscript. KY: assisted with the data analysis, wrote part of the results and edited the final manuscript. KT: collaborated with the design of the study and edited the final manuscript. All authors approved the final version of the manuscript for submission.

**Compliance with Ethical Standards**

**Ethical Approval**

All procedures performed in studies involving human participants were in accordance with the ethical standards of the British Psychological Society and with the 1964 Helsinki declaration and its later amendments or

comparable ethical standards. Ethical approval was granted by the Psychology Department Research Ethics Committee at City, University of London.

**Informed Consent**

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

**Conflict of Interest**

The authors declare that they have no conflict of interest.

**Data Availability**

The data for the study is available from the first author on request.

**Supplementary Materials**

Details of the pilot study.

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