Ageing and thought suppression performance: Its relationship with working memory capacity, habitual thought suppression and mindfulness

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Abstract

A study investigated how the ability to suppress thoughts in the laboratory was affected by type of thought suppressed (positive, negative, neutral), participants' age and working memory capacity (WMC). Linked variables (Use of thought suppression, social desirability, and mindfulness) were measured to assess whether they modified susceptibility to thought intrusion.

Younger, middle aged and older adults suppressed three different valenced thoughts in a counterbalanced order for 5-minutes per thought. Participants then completed a WMC task and questionnaire measures of the linked variables.

Valence had no effect on intrusions. WMC was positively related to intrusions; higher WMC corresponded to greater intrusions. Age was negatively related to intrusions; with increasing age intrusions decreased. Hierarchical regression showed only age and backward digit span (WMC) significantly predicted intrusions. The relationship between WMC and intrusions was not moderated by age. WMC and age both independently predict level of intrusion, and no synergistic effect was found.

Keywords: Ageing, Intrusive thoughts, Working memory capacity, Thought suppression

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Intrusive thoughts are a familiar experience for almost all individuals (Rachman & de Silva, 1978; Radomsky, Alcolado, Abramowitz, Alonso, Belloch, Bouvard, et al. 2014; Uleman & Bargh 1989; Wegner 1989). Furthermore, as these thoughts are frequently unwanted, a common reaction is the use of thought suppression as a means of removing them from awareness (Wenger, 1994; Wenzlaff & Wegner, 2000).

However, research has demonstrated that suppressing thoughts can often cause them to subsequently intrude more frequently; a phenomenon termed the post-suppression rebound effect (Wegner, Schneider, Carter & White, 1987). In addition, some studies have shown an increase in intrusions about the concept one is trying to suppress during active suppression, termed the immediate enhancement effect (Lavy & van den Hout, 1990); although this effect appears to be rarer (Abramowitz et al., 2001). Therefore, using thought suppression often results in counterproductive consequences. Most of the subsequent thought suppression research has explored the dimension of post-suppression rebound effects. Therefore, early thought suppression research focused almost exclusively on examining the boundary conditions of the classic post-suppression thought rebound and demonstrating its robustness (Abramowitz, Tolin, & Street, 2001; Magee, Harden, & Teachman, 2012; Wenzlaff & Wegner, 2000). However, recently there has been a burgeoning of interest in thought suppression and behaviour. For example, Erskine and colleagues, among others, have demonstrated that if one avoids thoughts about specific behaviours, they subsequently come to undertake those behaviours to a greater degree following suppression (Denzler, Förster, Liberman, & Rozenman, 2010; Erskine, 2008; Erskine & Georgiou, 2010; Follenfant & Ric, 2010; – See Erskine & Georgiou, 2011 for a review).

Despite this volume of work, one aspect of thought suppression that has received little attention concerns why levels of thought intrusion during active suppression vary between individuals (Wenzlaff & Wegner, 2000) and which factors may account for this variability,

such as working memory capacity, intelligence, and valence (Brewin & Beaton, 2002; Brewin & Smart, 2005; Wenzlaff & Wegner, 2000). For example, in most thought suppression studies individuals are commonly asked to sit quietly in a room while verbalising all of their thoughts for a period of about 5 minutes; critically they are also simultaneously asked not to think about a certain concept, classically a white bear which is viewed as a neutral target for most individuals. The rates of intrusive thoughts are recorded during this period, e.g. Erskine & Georgiou (2010). Across studies, Wegner et al. (1987) and Wenzlaff and Wegner (2000) demonstrate that the average number of intrusive thoughts during active suppression is found to be approximately 1 intrusion per minute in young adult samples (however, the variability in intrusion between individuals is very high). In addition, intrusions during active suppression have yet to be studied in older samples. Intrusion frequency has been the most widely investigated variable in thought suppression research, although some studies have investigated intrusion duration (Koster, Rassin, Crombez & Näring, 2003; Lambert, Hu, Magee, Beadel, & Teachman, 2014) and behaviour (Erskine, Georgiou, & Kvavilashvili, 2010). The current study sought to assess intrusion frequency during active suppression as the outcome measure of interest. In addition, it is worth noting that virtually all thought suppression studies to date have been conducted using samples of young adults, whereas the current study will examine intrusions across the lifespan. The present study will therefore investigate the impact of ageing, working memory capacity and other associated variables on the susceptibility to intrusive thoughts during active suppression.

Despite the average level of intrusion during active suppression usually being around one thought per minute (Wenzlaff & Wegner, 2000), it is clear that there is a large variability in the number of thought intrusions during active suppression across individuals. Some participants report few intrusions during active suppression and others report considerably more. The extent to which these can be viewed as dependent on individual differences

remains largely unanswered. Some studies have started to examine this question, with two key studies conducted by Brewin and colleagues (Brewin & Beaton, 2002; Brewin & Smart, 2005).

Brewin and Beaton, (2002) investigated the relationships between intrusions during active suppression and expression (actively thinking about a concept) and individual difference measures in a young adult sample. For example, they report significant negative correlations between intrusions occurring during suppression and working memory capacity and fluid intelligence. They also examined the relationships between thought expression and working memory and fluid intelligence but found no significant relationships. However, there are issues with the study that limit its generalisability, for example the mean number of intrusions reported during a five minute active suppression period was 15.53 (SD = 11.27), which is much higher than the usual frequency reported across studies and suggests that an immediate enhancement effect may have occurred (however in the absence of a control condition one can only speculate). The study provides no explanation for the heightened level of intrusions in the suppression group and therefore limits the conclusions that can be drawn from the data. Another issue with the study of Brewin and Beaton (2002) concerns the mean fluid intelligence scores reported (Raven's matrices M = 53.66, SD = 4.59) suggesting that the average participant had a corresponding IQ score of 119. Once again, this value is very high relative to the average European IQ range (95 – 100; Gelade, 2008) and it is above one standard deviation from the general population mean. This is potentially problematic as IQ is positively related to working memory capacity and this may affect the levels of thought intrusions (Ackerman, Beier, & Boyle, 2005). It is of course possible that the reason for the high level of intrusions reported by Brewin and Beaton (2002) concerns the sample participants having higher IQ's than the average population IQ and also higher working memory capacity, although this would require further study. Finally in relation to the results

for their expression condition, interpretation of this is compromised by the fact that their expression group scores were all from participants expressing after prior suppression. Given that these participants should have been experiencing thought rebound (Wegner et al., 1987) it is again difficult to say that this group's performance would represent a pure measure of expression performance.

A follow-up study by Brewin and Smart (2005) also investigated working memory capacity and thought intrusion and reported a negative relationship between intrusions during active suppression and working memory capacity ($r = -.23$) again in a young adult sample. Indicating that as working memory increased intrusions decreased. This is in line with Brewin and Beaton (2002) but the size of the correlation is much diminished. The work of Brewin and colleagues is instructive as it suggests that there is a negative relationship between working memory and suppression ability.

A study by Nixon, Flood & Jackson (2007) also investigated the extent to which thought suppression may be an ability that varies between individuals in a sample of young adults. Critically, they measured participants' suppression ability; defined as the number and duration of intrusions experienced during active suppression. Participants that experienced fewer intrusions were classed as 'good' suppressors and those that experienced many were classed as 'poor' suppressors. Nixon and colleagues had participants suppress three types of thought; a personally relevant negative autobiographical memory, a novel traumatic event and the classic neutral thought - white bear. Furthermore, all participants were assessed on measures of working memory capacity and crystallised intelligence. Results indicated that good suppressors reported lower intrusions during active suppression across all three types of thoughts in contrast to poor suppressors who had more intrusions across all three thoughts. This suggests that suppression ability was stable across subsequent suppression periods and even when suppressing different thoughts. Of relevance to the current work, those classed as

good suppressors showed no difference in working memory capacity or intelligence from those classed as poor suppressors.

In a similar study, Klein and Boals (2001) report that unwanted thought intrusions regarding a negative experience were negatively correlated (r=-.22) with working memory performance. However, the measure of intrusions used was the Impact of Events Scale (Horowitz, Wilner & Alvarez, 1979) which measures both intrusions but also frequency of attempted avoidance of these intrusions. As a sum score was created, this measure confounds avoidance and intrusion. The authors suggested that individuals with higher levels of avoidant thinking (attempted thought avoidance) reported reduced working memory capacity in young adults.

It has long been posited that keeping busy (or filling cognitive capacity in the current view) is a good method of inhibiting unwanted intrusive thoughts or reducing mind wandering (Smallwood & Schooler, 2006). It is therefore suggested that the amount of information being processed in working memory at any one particular time point may determine the level of other thought intrusions. If one conceptualises working memory as a having a limited capacity store, a larger capacity would potentially allow more intrusions to occur. Furthermore, even if some capacity was "occupied" by current ongoing tasks, for individuals with higher working memory capacity, unused resources may therefore be available, allowing for the processing of intrusive thoughts. This explanation can be seen as analogous to perceptual load theory of attention (Lavie & Tsaal, 1994) whereby increasing the perceptual load of task relevant processing reduces the level at which task irrelevant distracters are processed, based on the finite resources available. This explanation would suggest that individuals with higher working memory capacity would be more susceptible to thought intrusions given their increased capacity.

In addition, the type of information being processed in working memory (e.g. visual or auditory, valence) may also have an impact on the level of intrusions (Teasdale, Proctor, Lloyd & Baddeley, 1993) but this may be independent of the amount of information currently processed in working memory.

Task Unrelated Thoughts

Another related research domain concerns the extent to which individuals experience thoughts that are unrelated to the current on-going task, another form of thought intrusion. These have been termed - task unrelated thoughts (Giambra, 1989, 1995), stimulus independent thoughts (Antrobus, 1968), intrusive thoughts (Brewin, 1996) or mind wandering (Smallwood, Beach, Schooler & Handy, 2008; Wegner, 1997). Unintended mind wondering and thought intrusions resulting from thought suppression can both be conceived of as unintended thought.

Despite differences in terminology, recent models of mind wandering have tried to integrate the findings into the framework of executive models of attention, with the basic assumption that mind wandering consumes executive resources, reducing performance in the primary task (Smallwood & Schooler, 2006). Following a similar logic, it is probable that highly demanding tasks consume executive resources to such a degree, that they reduce the likelihood of experiencing task unrelated thought intrusions (Klein & Boals, 2001; Kvavilashvili & Mandler, 2004). This process may underlie why keeping busy at times of distress is helpful in terms of reducing unwanted intrusive thoughts (Giambra, 1989). However, this may depend on the type of distraction one chooses to employ with results indicating that focused distraction aids successful suppression more effectively than choosing multiple unfocused distracters (Wegner et al., 1987; Wegner, 2011).

The literature reviewed so far supports the notion that intrusive thoughts both during active suppression and unrelated to the current task, may be subject to individual differences in cognitive capacity, and possibly the type of thought that is suppressed. Regarding the type of thought that is suppressed, previous evidence suggests that personal relevance and valence makes no difference to the level of intrusion both during and subsequent to thought suppression. However, these effects have not been examined in older adult samples.

Ageing and intrusive thoughts

There are good theoretical and empirical reasons to believe that ageing may also effect levels of intrusions. For example, older adults have been shown to have impaired inhibitory control compared to younger adults, particularly during effortful and demanding processing (Hasher & Zacks, 1988; Maylor, Schlaghecken & Watson, 2005; Sweeney, Rosano, Berman, & Luna, 2001). Furthermore, it is widely accepted that working memory declines with age albeit mediated by the speed of other mental operations (Salthouse & Babcock, 1991). In addition, there is evidence that older adults may allocate greater resources to carrying out everyday tasks where they report concentrating more (Kvavilashvili & Fisher, 2007). This suggests that older adults might find they require greater effort during a thought suppression task than younger adults, possibly resulting in different levels of thought intrusions. However, few studies have investigated intrusions and ageing but those that have will now be reviewed.

Giambra (1989) reported five studies which examined the experience of task unrelated thoughts and age. In all studies there was a negative relationship between age and task unrelated thoughts such that with advancing age participants experienced fewer task unrelated thoughts. Brose and colleagues investigated intrusive thoughts, age, stress and affect in daily life over a period of 100 days. Results indicated that intrusive thoughts

increased on days when participants reported higher stress. Furthermore, of most relevance to the current research, older adults experienced fewer intrusive thoughts than younger adults (Brose, Schmiedek, Lövden, & Lindenberger, 2011).

With regards to intrusive thoughts during active suppression and ageing, Magee and Teachman (2012) designed a study where older and younger participants were asked to either suppress or monitor (no instruction on thought manipulation, but monitoring for intrusions) a personally relevant negative thought "I hope my friend is in a car accident" in the laboratory. After a practice period half of the participants suppressed this thought for 4 minutes and half merely monitored their thoughts. All participants recorded the frequency and duration of target thought intrusions. After this period all participants gave ratings of their effort on suppression. Finally all participants had another 4 minutes to monitor their thoughts and report intrusion frequency and their duration. The study also took measures of affect while experiencing intrusive thoughts. In addition, the study allowed the authors to examine everyday intrusive thoughts via checklists and the effects of age. This is important as older adults have been hypothesised to have better emotion regulation skills than younger adults (Carstensen, 1995; Urry & Gross, 2010) and this may mean less susceptibility to intrusive thoughts in everyday life. Results from Magee and Teachman (2012) indicated that in the laboratory there was no difference in the frequency of thought intrusions in young or older adults during or following suppression. Thus, older adults had equivalent thought suppression performance to younger participants and were no more or less likely to experience intrusive thoughts in the monitoring period following suppression than younger adults. The results for intrusion duration were similar to the results found for frequency. In contrast, older adults experienced more positive affect when experiencing intrusive thoughts than younger adults. Furthermore, the older adults reported experiencing less intrusive thoughts in everyday life than younger adults. Overall, these findings suggest that there is no difference in intrusion

rates in the laboratory between young and old, but older adults report fewer intrusions in an everyday context.

In one of the only other studies to investigate thought suppression performance and ageing, a multilevel modelling approach was used across a number of thought suppression sequences (Lambert, Smyth, Beadel, & Teachman, 2013). Results indicated that older adults experienced less thought intrusion and less thought recurrence than younger adults across all time periods and across repeated suppression attempts. In addition, they experienced less suppression difficulty than younger adults (see also Beadel, Green, Hosseinbor & Teachman, 2013). However, this study did not assess the impact of working memory capacity.

Therefore, the present study was designed to investigate the impact of ageing, working memory capacity and other associated variables (mindfulness, habitual thought suppression and social desirability) on the susceptibility to intrusive thoughts (of different valences) during active suppression, within one experiment. Previous work has indicated that susceptibility to intrusive thoughts generally (Giambra, 1989) and under thought suppression conditions (Lambert, et al., 2013), may decrease with age. Not only are there a limited number of previous studies, but critically, working memory capacity was not examined, which is also known to decrease with age (Salthouse & Babcock, 1999). Investigating working memory and susceptibility to intrusions within the same paradigm is important as it is clear that these variables change in similar ways with increasing age and one may influence the other. The other associated variables were included for the following reasons. Firstly research has indicated that dispositional mindfulness and the use of thought suppression are negatively correlated, meaning that more mindful individuals report using thought suppression less frequently (see Erskine, Ussher, Cropley, Elgindi, Zaman, & Corlett, 2012; Erskine, Rawaf, Grice, & Ussher, 2015). Secondly, as individuals often improve on a domain with repeated practice (Logan, & Klapp, 1991) the extent to which one reports intrusions

during active suppression may be linked to how frequently one uses thought suppression in everyday life. Therefore a measure of habitual thought suppression (The White Bear Suppression Inventory – Wegner & Zanakos, 1994) was also included. Finally, social desirability (Marlow Crowne Social Desirability Scale - Crowne & Marlow, 1964) was included speculatively to observe whether it had any impact on the level of intrusions reported as some participants may have had intrusions but been reticent to report these.

Therefore, in the present study, adults between the ages of 17 and 85 were invited to the laboratory for a study on thought control and personality. They were asked to suppress three different thoughts over three successive 5-minute periods. These thoughts varied in valance (positive, negative and neutral) and were presented in a counterbalanced order. Participants were also assessed for their working memory capacity via forwards and backwards digit span measures, their habitual use of thought suppression, dispositional mindfulness and social desirability. It was predicted that susceptibility to intrusive thoughts would decline with age, and that valence would have no significant effects. In view of the previous work of Brewin and colleagues it was also predicted that there would be a negative correlation with working memory and intrusions. However, this negative correlation would suggest that reduced working memory capacity would lead to increased intrusions, something contradicted by the previous ageing literature showing reduced intrusion in older adults who are known to have lower working memory capacity. Given the mixed nature of the previous literature it is hard to anticipate how age and working memory will interact with regards to thought intrusion during active suppression. Other variables were included as they have been previously linked to thought suppression but specific predictions were not made. This study represents the first to our knowledge to examine intrusions during active suppression across the adult lifespan and working memory in the same study. This will enable examination of the possible interactive effects of age and working memory on thought intrusions during

active suppression.

Method

Participants

Ninety-eight participants were recruited from staff, former staff, colleagues and students at a London university and were aged 17 to 85 years. The mean age was 37.55 (SD = 20.15, skewness = .78), with 53 males and 45 females. 55.1% of the sample (n = 54) were aged below 30 years, 27.6% of the sample (n = 27) were ages of 30 and 60 years, and 17.3% of the sample (n = 17) were above 60 years. All participants were not receiving psychiatric treatment, were fluent in English, and did not report any of the following health issues – vision, hearing, mobility, memory, mental health and stroke. Participants were paid £10 for their time. Ethical approval was granted by the local research ethics committee.

Design

A correlational design was used. Examining associations between the following variables: thought intrusions frequency during active suppression for three different valence thoughts (positive – love; negative – disease; neutral – white bear); age; working memory (digit span - forward and backward); tendency to suppress thoughts in everyday life (WBSI); social desirability (Marlow Crowne); and Mindfulness (MAAS).The different valenced thoughts were chosen as white bear is the most frequently used target in previous research and is seen as a neutral thought (Wenzlaff & Wegner, 2000). Love and disease were chosen as positive and negative targets respectively. These were deliberately chosen so that the thought suppressed would be standardised across all participants. Previous studies have had participants disclose their own intrusive thoughts and then suppress that, however this has the

disadvantage that participants all suppress different thoguhts making comparisons complex. While it is appreciated that not all participants may see love as positive or disease as negative over multiple participants it was felt that any individual differences would even out with love being mostly seen as positive and disease mostly negative.

Measures

Auditory Digit Span Task: Forward and Backward (Wechsler 1981; 1997)

Span tasks assess the capacity to retain information in verbal working memory. The standard digit span task requires participants to repeat a sequence of verbally presented digits, in the same order (forward) or the reverse order (backward). The number of digits started at 1 and progressively increased by one until the participant successively failed two trials of the same digit span length. A presentation rate of approximately one digit per second is maintained throughout digit span tests. Recognisable or memorable digit patterns were avoided (e.g. even numbers). The greater the number of correctly reproduced digits is indicative of greater working memory capacity.

Marlow Crowne Social Desirability Scale (MC – Crowne & Marlow, 1964)

A thirty-three item questionnaire measuring defensiveness/social desirability, including statements such as 'I'm always willing to admit it when I make a mistake' and 'I have never intensely disliked someone'. Each item is scored as true or false, with scores ranging from 0 to 33 (higher scores identify those individuals with greater levels of defensiveness). Chronbach's alpha if found to be high at .88 (Crowne & Marlow, 1964).

The White Bear Suppression Inventory (WBSI - Wegner & Zanakos, 1994).

A fifteen-item questionnaire measuring the tendency to suppress thoughts in everyday life. Statements include 'I have thoughts that I cannot stop' and 'I always try to put problems

out of my mind'. Items are scored on a 5-point Likert scale ranging from 'Strongly disagree' (1) to 'Strongly agree' (5). The total score is calculated by summing the 15 items. Scores range from 15 to 75, with higher scores indicating greater use of thought suppression. Reported Chronbach's alpha range from .87 to .89 (Wegner & Zanakos, 1994).

Mindful Attention Awareness Scale (MAAS - Brown & Ryan, 2003).

A 15-item scale measuring the ability to remain in the present, attentive and aware of present moment experience. Items are rated on a 6-point Likert scale (ranging from 'almost always' to 'almost never') depending on how relevant participants find each statement. It assess how often one feels disconnected from the present, pre-occupied, inattentive or on autopilot. Items include *"I find myself doing things without paying attention*", *"I tend to walk quickly to get where I'm going without paying attention to what I experience along the way"* and *"I find myself listening to someone with one ear, doing something else at the same time"*. Higher scores indicate greater levels of mindfulness. (Cronbach's alpha are consistently above .80, Brown & Ryan, 2003)

Procedure

Participants were tested individually. The study was introduced to them as an investigation of people's ability to control their thoughts and how age and personality may influence this. Prior to the start of the study, participants were informed of the tasks that they would be completing, and then were asked to provide consent.

Following this, participants completed each of the measures starting with the digit span tasks (forward and backward). In order to standardise the order and rate of presentation, the experimenter used a pre-recorded sequence of numbers. Subsequent to this, participants were required to complete the three separate thought intrusion tasks, one for each of the three

valenced targets (positive, negative and neutral). As part of the intrusion task, participants were instructed to verbalise their thoughts alone in the room whilst trying not to think about the target provided.

Prior to the thought suppression task, participants were given a three-minute practice session for verbalising their thoughts. The participant was given the following instructions: 'Please verbalise all of your thoughts out loud for three minutes. There are no restrictions on what you can think about'. It was emphasised that they had to continuously verbalise their thoughts and that no justification or explanation was required. The digital voice recorder was then turned on and the experimenter left the room. After the three minutes were over, the experimenter returned to the room and turned off the digital recorder.

For the experimental thought suppression tasks, participants were asked to continue verbalising their thoughts aloud for three separate five-minute periods. Each session involved the participant attempting to suppress their thoughts about a particular valenced target word whilst continuously verbalising their stream of consciousness. The participants were asked to make a tally on a sheet provided each time they happened to think about or mention the thought they were supposed to suppress. At the beginning of each session the experimenter turned on a digital voice recorder and said 'Begin' and then left the participant alone in the room. After the five minutes, the experimenter returned to the room, switched off the digital recorder and then asked the participant to stop verbalising their thoughts. To ensure the participants understood the instructions and also to ensure the elimination of any bias, the same instructions were read to each participant before each timed session. The order of valenced sessions was randomised for each participant to avoid bias.

Verbalisation Instructions

"I would like you to continue thinking aloud for a further five minutes, but this time, please try to avoid thinking about (target word: either positive – love; negative – disease; neutral – white bear). Each time you think about (target word), or talk about (target word), please make a tally."

Following this, participants completed three questionnaire based measures including: Marlow Crowne; Mindfulness; WBSI. Each questionnaire commenced with instructions on how to complete them so no further instructions from the experimenter were required. On completion of the study participants were debriefed and then paid £10 for their participation.

Results

Following descriptive analysis of the data, 5 participants had frequencies of intrusive thoughts that were more than 2.5 standard deviations above the mean. These participants were removed from the data set as they were extreme cases. Therefore, the final data set included 93 participants (50 males & 43 females). Participants' mean scores on the measures collected are displayed in Table 1.

Analysis of intrusion valence

Level of intrusions across the three valenced conditions (love, white bear, disease) were examined, using a single factor repeated measures ANOVA, which showed no significant differences, $F(2, 184) = 2.20$, $p = .11$, $\eta_p^2 = .02$ (sphericity assumed). As the level of intrusions across valences did not differ, a principal component analysis was conducted to assess the possibility of a reduced number of components related to intrusion. The analysis showed that all three types of intrusions loaded significantly on a single factor which accounted for 75.95% of the variance, with an Eigenvalue of 2.28 (Bartlett Test of Sphericity

$p < .001$ & Kaiser-Meyer-Olkin Measure of Sampling Adequacy = .73). All three of the intrusion variables had factor loadings over .85. A new principal component score was created from the analysis labelled Principal Component Score of Intrusions (PCS-I), which was used as the dependent variable in all further analyses.

Hierarchical Regression Analysis

The first analysis examined the correlation matrix for the measures collected which contained several notable findings (See Table 2). Intrusions (PCS-I) negatively correlated with age (-.44) and for both measures of working memory capacity (forwards .37 & backwards .36 digit span). As expected age was negatively and significantly associated with reduced working memory capacity. The two measures of working memory capacity (forward and backward digit span) were only moderately correlated at .43 and therefore these were not reduced to a single composite working memory measure.

The next series of analyses sought to predict intrusions during active suppression from their significant correlates. For the regression analysis, the assumptions of linearity, independence of errors, homoscedasticity, unusual data points and normality of residuals were met.

A three-stage hierarchical multiple regression was conducted using intrusions as the dependent variable and significant correlates as predictors (Age, WBSI, MAAS, Marlow Crowne, and forwards and backwards digit spans). As Age and working memory capacity were considered as the key theoretical predictors, these were entered into Block 1. However, as backward digit span also measured working memory capacity, this was entered into Block 2 to assess further contribution to the model. Finally Block 3 contained all other significant correlates with intrusions (WBSI, MAAS, & Marlow Crowne). Regression statistics are reported in Table 3.

The hierarchical multiple regression revealed that at Stage one, Age and forward digit span contributed significantly to the regression model, F (2,90) = 14.91, $p < .001$) and accounted for 24.9% of the variation in intrusion. In Stage 2, introducing backward digit span explained an additional 3.5% of variation in intrusions and this change in R^2 was significant, F (1,89) = 4.32, $p = .041$. Adding WBSI, MAAS, & Marlow Crowne to the regression model explained an additional 4.6% of the variation in intrusions but this change in R^2 was not significant, F (3,86) = 1.95, $p = .13$. Durbin Watson = 1.37, VIF's ranged between 1.15 and 1.47 across all predictors. Standardised residuals were normally distributed and less than 5% of cases had standardised residuals over 2. Cook's distance values were less than .75 for all cases.

In addition to age and forward digit span, backward digit span also significantly added to explained variance in intrusions. However, in order to assess which of the two working memory capacity measures better predicted intrusions, a further hierarchal multiple regression was conducted with Age in Block 1 and both working memory measures in Block 2 using the forward selection regression equation (see Table 4 regression statistics). The analysis revealed that at Stage one, Age significantly contributed to the regression model, F (1,91) = 22.12, $p < .001$) and accounted for 19.6% of the variation in intrusion. Introducing forward and backward digit spans in Stage 2 explained an additional 6.8% of variation in intrusions and this change in R^2 was significant, F (1,90) = 8.26, $p = .005$. However, in Stage 2 only backward digit span was significant whereas forward digit span was not ($p = .11$). Durbin Watson = 1.38, VIF's ranged between 1.00 and 1.07 across all predictors. Standardised residuals were normally distributed and less than 5% of cases had standardised residuals over 2.

Moderation Analysis

In order to test how age might moderate the relationship between working memory and intrusions a moderation analysis was carried out. Working memory capacity and Age were centred and the working memory capacity-by-age interaction term was computed (Aiken & West, 1991). From the hierarchical analysis, backward digit span was found to be a better predictor of intrusions than forward digit span. Therefore, backward digit span was used as the measure of working memory capacity in the moderation analysis.

A moderation analysis was conducted to investigate whether the association between backward digit span and intrusions depends on age. The two predictors and the interaction were entered into a simultaneous regression model. The model was shown to be significant, $F(3,89) = 13.17$, $p < .01$) and account for 26.4% for the variance. Results indicated that the moderator Age (b = -.02, SEb = .004, $p < .001$) and the predictor backward digit span (b = .18, SEb = .06, $p = .002$) were both associated with intrusions. However, the interaction between backward digit span and age was not significant (b = -.001, SEb = .003, $p = .71$). For simple slopes see Figure 1.

Discussion

This study was designed to examine the relationships between susceptibility to intrusive thoughts when trying to suppress and a range of variables including: age, the type of thought suppressed, working memory capacity, suppression in everyday life, social desirability, and mindfulness. The results are clear and in line with hypotheses, showing that there was a reduction in intrusive thoughts with advancing age that was independent of other factors and was not affected by the type of thought, working memory or any of the other variables included in the present study. Furthermore, contrary to expectations there was an independent effect of working memory, such that greater working memory capacity predicted

greater intrusions irrespective of the other variables. Intrusions did not vary as a function of type of thought suppressed, and a composite intrusion variable was created. In regression analyses, the main predictors of intrusions were always age and working memory capacity. As the regression models contained the other theoretically relevant variables, but these were not significant, it suggests that once age and working memory capacity are accounted for the other variables do not explain any additional variance in intrusive thoughts. The results of moderation analyses demonstrated that the effects of working memory capacity on intrusive thoughts were not moderated by age. In particular, the moderation analyses showed that age and working memory were both independently predictive of intrusions but did not interact.

Several of the findings reported here require further investigation. For example, on the basis of Brewin and colleagues' previous work (2002, 2005) we hypothesised that there would be a negative relationship between working memory and intrusive thoughts. The present study found the opposite relationship. This is potentially explained by the use of different measures of working memory used across studies. Brewin used the OSPAN task whereas the present study used forward and backward digit span. While the digit span may be a more specific measure of capacity, the OSPAN may also measure other components of working memory such as the central executive (Colom, Rebollo, Abad, & Shih, 2006; Conway, Kane, Bunting, Hambrick, Wilhelm, & Engle, 2005). However, if one conceptualises working memory as a limited capacity store, then for those with greater capacity, more information can be processed. Furthermore, if involved in a moderately demanding task, an individual with low working memory capacity may be using all of their capacity having no working memory resources left for intrusions to occur. In contrast, a high working memory capacity individual completing the same moderately demanding task would have spare capacity allowing for potential task unrelated intrusions. This can be seen as analogous to models of selective attention (e.g. Lavie, Hirst, De Fockert, & Viding, 2004).

Furthermore, the literature of working memory and intrusions is mixed, with Brewin and colleagues (2002, 2005) reporting negative correlations, Nixon et al. (2007) finding that intrusions during active suppression are not related to working memory and the present study finding a positive relationship between working memory and intrusions.

An alternative possibility regarding the positive correlations between working memory and intrusions relates to the particular strategy participants use to suppress the thought. Thus, studies have examined the effect of different suppression strategies on intrusions during suppression and working memory capacity (Ju & Lien, 2016). The main finding was that participants using a focused breathing strategy during thought suppression reported significantly fewer intrusions than a group using a focused distracter condition where they focused on a blue sports car. Most importantly this study demonstrated that in the focused distraction condition there was a significant negative correlation ($r = -.32$) between thought intrusions and working memory capacity. In contrast, in the Focused breathing condition there was no significant correlation ($r=.10$). In the current study participants were not given any specific strategies to use while suppressing so it is difficult to know whether a particular strategy was favoured. An interesting avenue for future research concerns whether ageing modifies the type of suppressive strategies individuals choose to employ in consistent ways.

Importantly Rummel and Boywitt (2014) reported a study that demonstrated less mind wandering occured as task demands increased, as suggested by Smallwood and Schooler (2006). The study also examined the ability to flexibly engage in task unrelated thoughts, with the main finding that high working memory capacity individuals appeared better able to flexibly engage in task unrelated thoughts when situational demands are low but to reduce task unrelated thoughts when demands are high.

Studies that have examined age differences previously reported that when older and younger adults suppress a personally relevant negative thought in the laboratory there were no differences in intrusions (Magee & Teachman, 2012). However, the older adults appeared more positive regarding these intrusive thoughts than the younger adults and showed less intrusive thoughts in everyday life. In contrast, Lambert and colleagues (2013) found that when older and younger participants suppressed on multiple occasions, the older adults experienced less thought intrusion and less suppression difficulty than younger adults. In a study of naturalistic intrusions Brose and colleagues (2011) also find that older adults have fewer intrusions than younger adults.

Taken together the previous literature and the present findings suggest that performance on a suppression task may improve with age. The only previous study to report no difference in performance between younger and older adults used a very personally relevant negative intrusive thought, which may have altered the findings (Magee & Teachman, 2012). Importantly, the present study also included a range of variables that might contribute to, or account for this reduction in intrusions with age. In the present study several potential explanatory variables were examined, for example the WBSI measuring frequency of suppression in everyday life. One might assume that the more frequently one suppresses in everyday life the better one becomes as a result of practice or automaticity. However, the WBSI is associated with a range of psychological disorders which suggests that thought suppression may develop as a reaction to problems regarding intrusive thoughts as a coping mechanism (Erskine et al 2007; Purdon, 1999; Wegner & Zanakos, 1994). So participants high on the WBSI may be those with a susceptibility to intrusive thoughts in the first place. Importantly these data show that WBSI scores do not affect susceptibility to intrusion during active suppression. Furthermore, mindfulness and social desirability also did not significantly predict intrusions of any type in the regression models.

While the present findings are significant they need to be viewed in the light of some limitations. Firstly, while participants of varying ages were successfully recruited there were fewer of these at older ages due to the difficulty of getting them to attend the laboratory. A further limitation concerns the measure of working memory which was a simple capacity measure rather than a more complex working memory task such as OSPAN involving executive function as well.

Conclusions and future directions

The present findings suggest that ageing may reduce intrusive thoughts whilst actively suppressing, or at least enhance the ability to suppress them. This occurs through ageing itself but also through reductions in working memory capacity which the current study shows are independent of each other. Although the present findings show age to be a factor in reduced intrusions they do not provide an explanation regarding the mechanism underlying the reduction in intrusions with ageing. It is possible that as individuals age they discover more effective methods of suppression as a result of a lifetime of practice, alternatively ageing may influence a change in suppression method or strategy which has been shown to alter some of the relationships investigated (Ju & Lien, 2016). However this would require significant further study. It is therefore now important that studies seek to examine which specific components of ageing result in these reductions in intrusions from a mechanistic perspective. In addition the present study suggests that with advancing age the number of intrusive thoughts while actively suppressing goes down. In short, this would indicate that older adults are potentially better at suppressing thoughts. However, further studies would need to determine whether there are differences in levels of intrusions across age groups when under different mental control instructions, for example monitoring or expressing thoughts. It could be the case that older adults would demonstrate fewer intrusions irrespective of whether they were suppressing, monitoring or expressing. Therefore, showing that older adults may have

fewer thoughts in general in spite of the mental task conditions. Future research is necessary to examine these competing explanations. This study sought to establish whether there were independent or interaction (working memory and age) effects specifically for a suppression effect. The data seem to support the notion that these factors are indeed orthogonal. However, the authors acknowledge that the effects reported here, when compared to other effects such as monitoring or expression, may be different.

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Tables and Figures

Figure 1: Mean intrusions by working memory and Age. Values for the moderator (Age) and for the predictor (backward digit span) were mean centred (representing Medium) with ± one standard deviation from the mean representing Low and High).

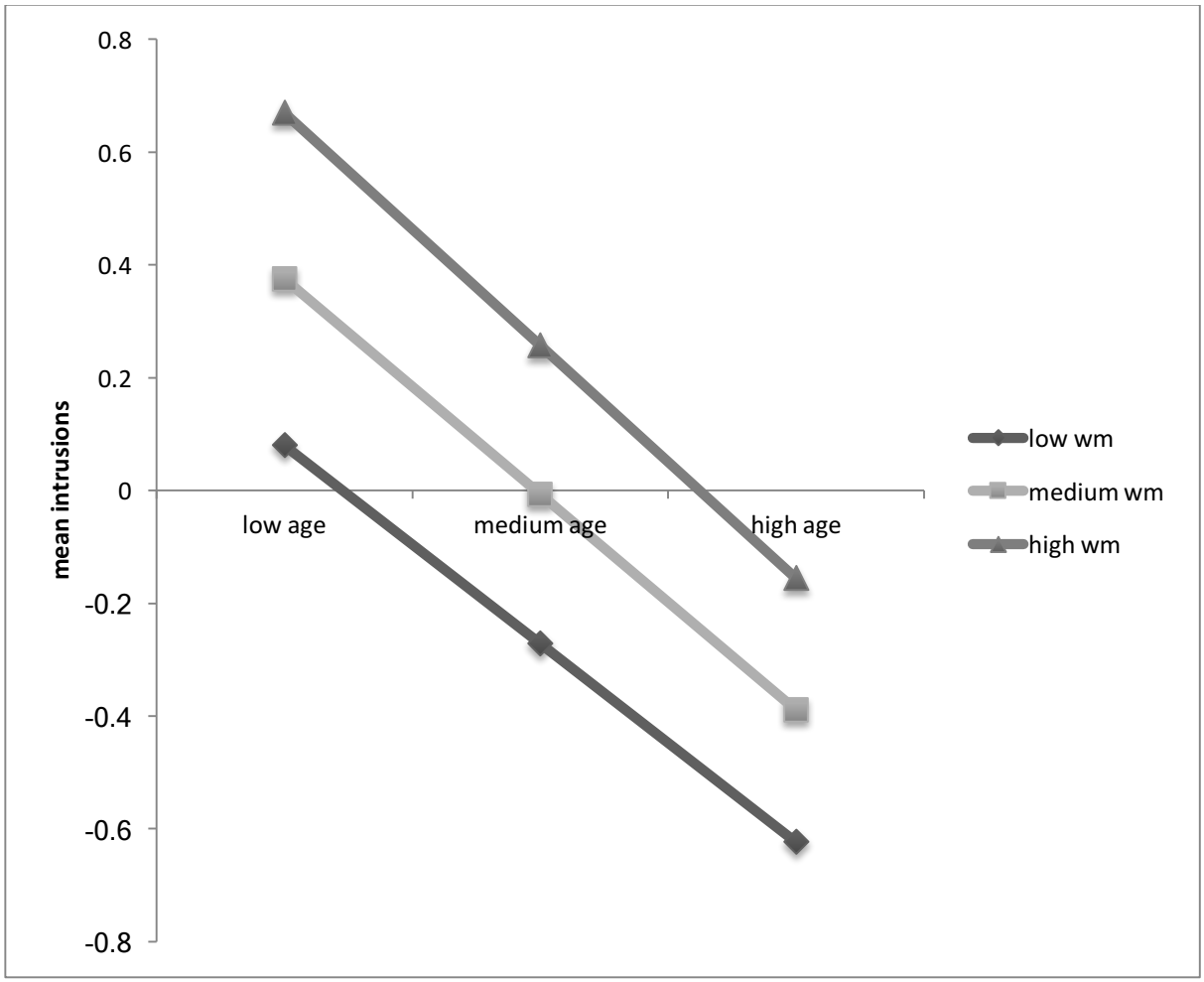

Table 1: Mean, standard deviation, minimum and maximum for variables measured.

	N	Min	Max	Mean	SD
WBSI	93	20	73	47.59	10.99
FDS	93	4	10	6.76	1.25
BDS	93	2	8	4.98	1.47
MC	93	6	37	17.46	5.69
MAAS	93	41	84	59.95	9.75
IntDis	93	0	14	4.29	3.25
IntWB	93	0	14	4.68	3.44
IntLove	93	0	16	4.92	3.64
Age	93	17	85	38.40	20.34

Key:

WBSI = White Bear Suppression Inventory; FDS = Forwards Digit Span; BDS = Backwards Digit Span; MC = Marlow Crowne Scale; MAAS = Mindful Attention Awareness Scale; IntDis = Disease Intrusions; IntWB = White Bear Intrusions; IntLove = Love Intrusions; Age = Age; PCS-I = Principal Component Score of Intrusions.

Table 2: Correlations between the continuous measures

	WBSI	FDS	BDS	MC	MAAS	IntDis	IntWB	IntLove	Age	PCS-I
WBSI	1									
FDS	-.03	1								
BDS	-.01	.43***	1							
MC	-.27**	-.09	-.23*	1						
MAAS	-.42***	-.05	-.16	.45***	1					
IntDis	.13	.39***	.25*	-.12	-.19	1				
IntWB	.21*	.34**	.39***	-.25*	-.20	.69***	1			
IntLove	.19	.26*	.31**	-.18	-.21*	.62***	.63***	1		
Age	-.02	-.36***	-.25*	.12	.18	-.34**	-.39***	-.43***	1	
PCS-I	.20*	.37***	.36***	-.21*	-.23*	.88***	.88***	.86***	-.44***	1

Key: * < .05; ** <.01; *** <.001

Table 3. Summary of Hierarchical Regression Analysis for Variables predicting PCS-I (Principal Component Score of Intrusions).

		b	*SE B*	*ß*	*p*
Stage 1	Constant	-.68	.63		.28
	Age	-.02	.005	-.35	.001
	Forward span	.20	.08	.25	.01
Stage 2	Constant	-.98	.64		.13

	Age	-.02	.005	-.33	.001
	Forward span	.13	.08	.17	.11
	Backward span	.14	.07	.21	.04
Stage 3	Constant	-1.41	1.10		.20
	Age	-.02	.005	-.32	.002
	Forward span	.14	.08	.18	.09
	Backward span	.13	.07	.19	.06
	WBSI	.02	.01	.18	.08
	Marlow Crowne	-.01	.02	-.05	.64
	MAAS	-.004	.01	-.04	.73

Table 4. Summary of Hierarchical Regression Analysis for Age, Forward and Backward digit spans predicting PCS-I (Principal Component Score of Intrusions).

		b	*SE B*	*ß*	*p*
Stage 1	Constant	.84	.20		.000
	Age	-.02	.005	-.44	.000
Stage 2	Constant	-.20	.41		.623
	Age	-.02	.005	-.38	.000
	Backward span	.18	.06	.27	.005