Cognitive dysfunction is the hallmark of Alzheimer’s disease (AD), but increasingly research has also focused on how emotion processing is affected by the disorder. Such studies have indicated that AD is associated with increased difficulties in decoding facial expressions of emotion (Henry et al., 2008), reduced memory for emotional events (Mori et al., 1999), as well as abnormalities in affective priming (Padovan, Versace, Thomas-Antérion, & Laurent, 2002). Further, there appears to be a breakdown in emotion response system coherence, whereby the affective and behavioral aspects of emotional experience may not be completely aligned. Thus, while subjective emotional experience appears to be unaffected by AD, subtle changes in the behavioral expression of emotion have been documented (Burton & Kaszniak, 2006; Smith, 1995).

Specifically, Burton and Kaszniak (2006) found that AD and control groups provided similar subjective ratings when viewing emotion-eliciting images, and these ratings were in the expected directions on dimensions of valence and arousal. However, although electromyographic recordings indicated that the two groups showed similar increases in responding over the corrugator supercilii (i.e., brow) muscle region in response to negatively valenced stimuli, when viewing positively valenced stimuli, only the control group had significantly increased activity in the zygomaticus muscle. As zygomatic activity is particularly implicated in positive expressive behaviors (i.e., smiling), this implies that although positive emotional experience is preserved, related behavioral expression may be disrupted. In a separate study, Smith (1995) also found that participants with AD rated their emotional experiences similarly to control participants but differed in emotion expressivity, exhibiting more negative facial expressions while viewing sad vignettes. Smith (1995) attributed these findings to deficits in the ability to control negative facial expression.

Consistent with such a possibility, emotion regulation is an important factor in determining levels of experienced and expressed emotion. Gross (2001) argued that response-focused emotion regulation strategies occur after the emotion response has been triggered and require management of ongoing emotion expression. Typical examples include suppression (inhibition of emotion-expressive behavior) and amplification (behavioral augmentation of an already initiated emotion; see Bonanno, Papa, Lalande, Westphal, & Coifman, 2004; Gross, 2001). Bonanno et al. (2004) found that the ability to flexibly amplify or suppress emotion-expressive behavior predicts long-term adjustment and consequently has real world consequences.

In the context of AD, difficulties in applying both types of strategy may be anticipated because their use has been shown to be cognitively demanding (Bonanno et al., 2004; Gross, 2002), and AD is, by definition, associated with prominent neurocognitive impairment. Thus, difficulties with amplification may explain reduced expression to positively valenced stimuli (Burton & Kaszniak, 2006), while difficulties with suppression may result in increased responding to negatively valenced stimuli (Smith, 1995). However, because no study has tested the ability of participants with AD to apply different emotion regulation strategies, it re-
mains unclear whether the subtle abnormalities in behavioral expressivity identified in previous research do reflect difficulties in the control of expressive behavior. The aim of the present study was therefore to provide the first experimental manipulation of online emotion regulation strategies in AD.

It was predicted that AD would be associated with impairment in suppressing (down-regulating) and amplifying (up-regulating) emotion-expressive behavior and that any observed difficulties would be related to cognitive functioning. Further, because the ability to clearly show or hide one’s feelings presupposes an understanding of how one’s behavior will be perceived and interpreted by others, it was also predicted that effective use of these strategies would be related to theory of mind (ToM), broadly defined as the ability to understand others’ emotions, motivations, and thoughts. ToM deficits have been documented both in the context of normal adult aging (Bailey & Henry, 2008; German & Hehman, 2006; Phillips, MacLean, & Allen, 2002) and, to a greater extent, AD (Rankin et al., 2006).

Method

Participants

Forty adults in Melbourne participated, 20 of whom met Diagnostic and Statistical Manual of Mental Disorders (4th ed.; American Psychiatric Association, 1994) and National Institute of Neurological and Communicative Diseases and Stroke/Alzheimer’s Disease and Related Disorders Association criteria for AD and 20 of whom were nonclinical volunteers. The AD participants were recruited from a dementia day therapy center and an aged care hostel. The older controls were volunteers recruited from a dementia day therapy center and an aged care hostel. The older controls were volunteers recruited from the general community and did not differ from the AD participants in age, gender, or self-rated depression as indexed by the Geriatric Depression Scale (Yesavage et al., 1983), respectively.

Procedure and Measures

All procedures were approved by the Human Research Ethics Committee of the Australian Catholic University. For the experimental manipulation, three amusement film clips were selected from pilot work involving 11 clips. To minimize cognitive demands, we ensured that each of the clips was simple in content and of short duration (2.5 min on average). Eighty older adults (63–88 years old; M = 76.3)—most of whom were recruited from retirement villages (58%) or social clubs (42%)—completed the pilot testing. No cognitive screen was administered as the intention was to identify clips that elicited amusement in older adults of varying cognitive ability. The three clips that elicited the highest levels of positive affect and only minimal levels of unrelated emotion were selected. Neutral film clips were those used in previous emotion regulation research and depicted scenes from a wildlife documentary (Rottenberg, Ray, & Gross, 2007).

All data were collected in one testing session, which lasted approximately 2–3 hr (inclusive of frequent breaks). Prior to the experiment, participants were informed that they would be video recorded. After providing consent and completing the ACE–R, participants were tested in the following order:

The Mind in the Eyes Test (Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001) was used to index ToM. This measure requires participants to select which of four words best describes the thoughts or feelings expressed in 36 pictures of eyes. To ensure that a belief or intention was attributed to the person in the picture, the choices to be made comprised complex mental states such as “jealous” and not basic emotions such as “happy” or “angry.” Higher scores indicate greater ToM. There is considerable evidence for the sensitivity of this measure to ToM difficulties (see Baron-Cohen et al., 2001).

The emotion regulation manipulation was then conducted as follows:

1. Neutral Film Clip 1. To establish baseline emotional responding for the participants, we randomly assigned them to watch one of the three neutral film clips (counterbalanced). Prior to each neutral film clip, participants were told, “Please watch the following film clip carefully,” and after watching each clip, they were asked to complete the Emotion Rating Form (described later).

2. Amusement 1: Spontaneous expression condition. Participants were randomly assigned to watch one of the amusing film clips (counterbalanced). In the spontaneous expression condition, participants were told, “We will now be showing you another short film clip. As before, it is important to us that you watch the film clip carefully. Please respond naturally and spontaneously to what you see.”

3. Neutral Film Clip 2.

4. Amusement 2: Suppression or amplification condition (counterbalanced). Prior to participants’ viewing the remaining amusement film clips, two sets of instructions were provided that corresponded to the suppression and amplification conditions. Suppression instructions were presented as follows:

This time, if you have any feelings as you watch the film clip, please try your best not to let those feelings show. In other words, as you watch the film clip, try to behave in such a way that a person watching you would not know you were feeling anything. To summarize, as you watch the film clip, try to hide your feelings as much as you can.

Amplification instructions were presented as follows:

This time, if you have any feelings as you watch the film clip, please try your best to let your feelings show. In other words, as you watch the film clip, try to behave in such a way that a person watching you...
would clearly know what you’re feeling. To summarize, as you watch the film clip, show your feelings as much as you can.

5. Neutral Film Clip 3.

6. Amusement 3: Suppression or amplification condition (counterbalanced). Emotion Response Forms were modeled on those used in previous research (Phillips, Henry, Hosie, & Milne, 2008). Thus, after each clip, participants rated on a scale from 0 (not at all) to 8 (extremely) the extent to which they experienced 10 emotions. Participants were given verbal instructions relating to completion of these forms, which were administered via paper and pencil. The form was designed to be very simple in format, and all participants were able to provide these ratings. Positive affect was the dependent measure and represented a composite score based on the mean of six items—happiness, amusement, interest, pleasantness, positive affect, and the degree to which the film clip was rated as “funny” (the other emotions that were rated but which did not contribute to this score were disgust, anger, sadness, and confusion). Cronbach’s alpha for the total score was calculated to be .91 for the spontaneous expression, .90 for the suppression condition, and .92 for the amplification condition.

Two community volunteers who had received no formal training in any psychology- or psychiatry-related discipline were paid to act as independent raters of behavioral expression of emotion and were kept blind to the aims of the study, group status, and regulation condition to which the participants had been assigned. Raters therefore watched the participants’ responses with the volume turned off. In addition to receiving verbal instructions, raters were provided with standardized written protocols that outlined how the ratings should be completed and were encouraged to contact the researchers should they have any questions. Interrater reliability was calculated on the basis of all 120 video clips (for each of the 40 participants, all clips for the spontaneous expression, suppression, and amplification conditions were rated). Each of the rated clips was approximately 3 min long. The raters were trained to code expressions of amusement using a rating form based on the Expressive Emotion Behavior Coding System (Gross & Levenson, 1993), which involved attending to both facial and other nonverbal expressions of emotion. This procedure provided an overall rating of behavioral expression of amusement as well as other aspects of emotional responding. The dependent measure was a composite positive affect score (the average score from four items—happiness, amusement, interest, and pleasant affect displayed). Cronbach’s alpha for this score was high for both raters across all three conditions (≥.90), as was interrater reliability (≥.80). Mean scores collapsed across the two raters were therefore used for analyses.

Results

As noted, before being asked to engage in any of the regulation conditions, participants were first asked to watch a neutral video clip to establish baseline emotional responding. Independent samples t tests indicated that after watching this clip, the groups did not differ in terms of self-rated positive or negative affect (all ps > .05).

Self- and behaviorally rated positive affect data are presented in Figure 1 for each of the three regulation conditions. Separate 2 (group) × 3 (regulation condition) mixed analyses of variance (ANOVA) was calculated to analyze these ratings. For self-ratings, analyses revealed that there was no main effect of condition, \( F(2, 76) = 1.56, MSE = 3.21, p = .217, \eta^2 = .039 \), or group, \( F(1, 38) = 0.26, MSE = 8.82, p = .615, \eta^2 = .007 \), or any interaction between group and condition, \( F(2, 76) = 1.44, MSE = 2.95, p = .244, \eta^2 = .036 \).

For the behavioral ratings, there was no main effect of group, \( F(1, 38) = 1.19, MSE = 12.09, p = .282, \eta^2 = .030 \), but there was a main effect of condition, \( F(2, 76) = 30.0, MSE = 2.22, p < .001, \eta^2 = .441 \), and an interaction between condition and group, \( F(2, 76) = 7.67, MSE = 2.22, p = .001, \eta^2 = .168 \). This interaction was analyzed with tests of simple effects, which indicated that the AD group displayed lower positive affect than the control group in the amplification condition, \( F(1, 38) = 5.72, p = .022 \), but there was no group difference in behavioral display of emotion in the spontaneous expression, \( F(1, 38) = 1.61, p = .213 \), or suppression conditions, \( F(1, 38) = 1.04, p = .313 \).

We further analyzed the observed interaction using within-group comparisons of behavioral expression of amusement during each of the regulation conditions and behavioral expression of amusement during the baseline (spontaneous expression) condition. These indicated that for both groups, behavioral expression of emotion was significantly reduced during the suppression condition, \( t(19) = 3.13, p = .006 \), for the AD group and \( t(19) = 6.10, p < .001 \), for the control group. Neither group showed significant increases in behavioral display of emotion during the amplification condition compared with spontaneous expression, \( t(19) = 1.46, p = .160 \), for the control group and \( t(19) = 0.75, p = .462 \), for the AD group.

Finally, in order to assess the relationship of behavioral expressivity with cognitive function and theory of mind, we calculated partial correlations in which subjective ratings of positive affect were controlled. This was to ensure that any relationships between emotion expressivity and the other key measures were not due to differences in levels of experienced emotion. These data are reported in Table 1. It can be seen that the ACE–R was significantly correlated with control (but not AD) participants’ behavioral expression in the spontaneous condition. However, of particular interest is the finding that for both groups, performance on the Mind in the Eyes Test was correlated with behavioral expression in the amplification condition. No other relationships were significant.1

Discussion

No group effects were evident in self-reported positive affect, consistent with other AD studies that have found subjective emotional experience to be preserved (Burton & Kasznia, 2006; Smith, 1995). The present data also align well with previous research showing that AD is associated with subtle changes in emotion-expressive behavior that cannot be attributed to differences in the intensity of subjective experience and provides the

1 Following a reviewer’s suggestion, we also created an expressive flexibility score. As per Bonanno et al. (2004), this score was calculated by summing the difference between level of emotion expressed in (a) the amplification and expression condition and (b) the expression and suppression conditions. The AD group had reduced expressive flexibility relative to the control group, \( M = 1.00, SD = 1.26 \) and \( M = 3.60, SD = 2.59 \), respectively; \( t(38) = 3.29, p = .002 \), with reduced flexibility associated with worse performance on the ACE–R and Mind in the Eyes Test (\( r = .50 \) and .68, respectively; both \( p < .05 \).
first evidence that difficulties in regulating behavioral expression may be one mechanism contributing to these abnormalities.

Although there was no overall group difference in behavioral expression, the AD group displayed significantly lower positive affect compared with the control group when instructed to amplify their emotions. While neither group showed effective use of amplification relative to their baseline responding, only the control group displayed a trend in the right direction. This implies that behavioral augmentation of an already-initiated emotion may be a particularly difficult strategy to apply for those with AD. Expressive flexibility of emotion was also reduced in participants with AD, indicating less ability to regulate display in response to varying external demands.

The present study also provides evidence of important correlates of emotion regulation, with the finding that expressive flexibility and behavioral expression during amplification (but not expression or suppression) correlated with performance on the Mind in the Eyes Test. This result could indicate that effective behavioral suppression is relatively invariant in terms of outward display because it simply involves showing no outward display of emotion. This contrasts with amplification, in which appropriate behavioral responding is contingent on both situational factors and target emotion. Thus, effective use of amplification may require an intact understanding of how one’s behavior will be interpreted by others to a far greater extent than suppression. The only other significant relationship was the positive association between behavioral expressivity in the expression condition and ACE–R test performance for the control group. This relationship was not anticipated but might reflect greater levels of social ease in displaying emotions among able older adults.

Of particular interest in the present study was the finding that both groups were able to effectively inhibit ongoing emotion-expressive behavior. While a number of previous studies have shown intact use of suppression in older adulthood (Emery & Hess, 2008; Kunzmann, Kupperbusch, & Levenson, 2005; Magai, Consedine, Krivoshekova, Kudadjie-Gyamfi, & McPherson, 2006; Phillips et al., 2008), the present data are the first to show that even individuals in the moderate stages of AD are able to make effective use of this strategy. This finding seems particularly striking when contrasted with studies showing that deficits in cognitive inhibitory control are prominent features of AD and that these inhibitory deficits do not simply reflect change in more general cognitive function parameters (for a review, see Amieva, Phillips, Della Sala, & Henry, 2004).

However, Amieva et al. (2004) also concluded that inhibitory deficits in AD may not be the result of a general inhibitory breakdown, and thus some inhibitory mechanisms may be relatively preserved. Specifically, the studies reviewed showed that AD has a strong effect on tasks requiring controlled inhibition processes but relatively little effect on tasks requiring more automatic inhibition. It was argued that the distinction between automatic, reflexive inhibitory mechanisms and controlled inhibitory mechanisms may therefore be critical to predictions of the integrity of inhibitory mechanisms in AD.

Effective behavioral suppression may depend on well-practiced, automatic processes by the time one reaches older adulthood. Evidence consistent with this possibility is the apparent dissociation in older adults’ abilities to engage cognitive and emotional inhibitory processes. Thus, in contrast to well-documented difficulties in controlled cognitive inhibitory functions, there is evi-
emotion is disrupted in AD, the subjective experience of emotion 
Matovic, 2008). Although behavioral amplification of expressed 
stability but also by losses. This pattern has also been documented 
tional functioning in AD that is characterized by both relative 
ction depending on relatively reflexive processes.

ToM deficits in late adulthood (Bailey & Henry, 2008), which is 
tinction between reflexive and controlled inhibitory mechanisms. 
the latter also draws on controlled, strategic 
emotion regulation strategies, such as suppression, may have be-
ning for age-related stability or improvement in suppressing 
behavioral expression of emotion (Emery & Hess, 2008; Kun-
zmann et al., 2005; Phillips et al., 2008). It is of note that 
Kunzmann et al. (2005) found no age differences in the physiolo-
gical and subjective consequences of suppression, Scheibe and 
Blanchard-Fields (2008) found that use of this strategy incurred 
fewer cognitive costs for older relative to younger adults and 
tributed these findings to a lifetime’s accumulated experience of 
controller affect. Consequently, for older adults, use of some 
emotion regulation strategies, such as suppression, may have be-
come relatively automatic. The finding of intact suppression of 
emotion display in moderate AD would certainly be consistent 
with such a possibility, given Amieva et al.’s (2004) noted dis-
sion of the Mind in the Eyes Test revisied version: A study with 
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Evidence for a selective deficit in automatic activation of positive 

<table>
<thead>
<tr>
<th>Group/condition</th>
<th>ACE–R</th>
<th>Eyes</th>
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<tbody>
<tr>
<td>AD group (n = 20)</td>
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<tr>
<td>Expression</td>
<td>−.06</td>
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<tr>
<td>Suppression</td>
<td>.16</td>
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<tr>
<td>Amplification</td>
<td>.34</td>
<td>.56*</td>
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<tr>
<td>Control group (n = 20)</td>
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<tr>
<td>Expression</td>
<td>.49*</td>
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<tr>
<td>Suppression</td>
<td>.27</td>
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<tr>
<td>Amplification</td>
<td>.42</td>
<td>.79**</td>
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Note. Effects of self-rated positive affect were controlled. The AD group showed significant impairment on the Mind in the Eyes Test relative to the control group; M = 16.4 (SD = 4.56) and M = 24.1 (SD = 3.78), respectively; t(38) = 5.85, p < .001. However, the AD group performed substantially above chance. In the AD group, the Mind in the Eyes Test scores were not significantly correlated with ACE–R performance (r = .25). The specific language component of the ACE–R was unrelated to behavioral expression of emotion in the amplification condition (r = .13), which implies that for the AD group, the correlation between the Mind in the Eyes Test and behavioral expression during amplification did not reflect general linguistic difficulties. ACE–R = Addenbrooke’s Cognitive Examination—Revised; Eyes = Mind in the Eyes Test.

*p < .05.  **p < .01.

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