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The Effects of Age, Control Beliefs, and Feedback on Self-Regulation of Reading and Problem Solving

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Abstract

We examined the effects of adult age and control beliefs on self-regulatory responses to feedback using a false feedback paradigm. Young and older adults read and attempted to solve a series of problems and periodically received either high- or low- performance feedback. Self-regulatory processes were assessed in terms of task specific beliefs consisting of self-efficacy and performance expectations as well as degree of attention allocated to reading the mysteries. Results showed that high-performance feedback increased self-efficacy and performance expectations relative to low-performance feedback and that these effects were comparable across levels of pre-existing control beliefs and across age groups. However, the effects of feedback on attention were moderated by age and pre-existing control beliefs. Older adults in the high-performance feedback condition who had high levels of control beliefs allocated more attention to the text than did their low-control peers. These findings suggest that positive feedback may encourage older adults to engage more fully in a reading task, however, only when they possess a strong sense of control.

Keywords

Self-regulation; feedback; attention; reading; beliefs

Self-regulation refers to efforts by the self to modify inner states or responses –including thoughts, emotions, impulses, and attention (Vohs & Baumeister, 2004) that occur within a wide range of human behaviors (e.g., Carver & Scheier, 1990; Pravettoni & Miglioretti, 2006; Zimmerman & Schunk, 2001), including reading (Stine-Morrow, Miller, & Hertzog, 2006), remembering (West, Bagwell, & Dark-Freudeman, 2005), and problem solving (Artistic, Cervone, & Pezzuti, 2003). Self-regulation is affected by factors that are present at the time the task is being performed (such as task-specific factors that influence attention), as well as by person factors (such as pre-existing beliefs about one's abilities). The present study explored the interplay of task-specific and person-specific influences on the self-regulation of reading and problem solving.

Self-Regulation of Reading

The Self-Regulation of Language Processing model (SRLP; Stine-Morrow et al., 2006) suggests that as individuals strive to comprehend a text, they regulate their attention based on their goals (e.g., reading to get the gist, reading to remember as much as possible, reading to

solve a problem) and perceptions of how well they believe they are meeting these goals (e.g., “I’m on track,” “I’m missing important parts of the problem”). This model, as well as others (e.g., Carver & Scheier, 1990), argue that these perceptions serve as important information that can modify, through internal feedback loops, subsequent behaviors and perceptions. Within the context of reading, individuals compare their actual comprehension levels to their desired comprehension levels and use this information to adjust their attention to meet these goals (e.g., “I wanted to solve this mystery but I’m not sure that I’m succeeding, so I will pay more attention to each of the suspects in order to better track their movements”).

This type of internal feedback loop relies on information that arises from sources that are intrinsic (e.g., “I feel as though I have solved the problem”) and extrinsic (e.g., a teacher or software program informs the individual that he/she has solved the problem) (Butler & Winne, 1995). Feedback that individuals are not meeting their goals can lead to negative affect; whereas progress toward goals may produce positive affect (Carver & Scheier, 1990), greater self-efficacy (Bandura, 1997), and greater task engagement (Butler & Winne, 1995) and attention.

Self-Regulation of Reading and Aging

Self-regulation of reading in later life is affected by age-related changes in person factors such as fluid abilities (e.g., speed of processing and working memory), knowledge, and beliefs (Stine-Morrow et al., 2006). These changes can affect self-regulation in several ways including the performance criterion selected (“good enough” versus “perfect”), understanding of - and willingness to - adhere to a stated goal (answering all problems correctly versus answering most correctly), perception of degree of discrepancy between actual and desired goals, and interpretation and use of feedback (incorporate new information right away and respond quickly; put off responding, wait and see if the current method works with more time). Although the model proposes that allocation policy in later life depends on many factors, in the present study, we focus on the role of control beliefs in the self-regulation of reading to problem solve.

In the present study, we examined whether the effects of external feedback on self-regulation would depend on younger and older readers’ pre-existing control beliefs. Self-regulation was operationalized in terms of task-specific beliefs (self-efficacy and performance expectations), and attention allocated to processing the text. Past research suggests that these processes are particularly relevant to self-regulation in response to feedback (Bouffard-Bouchard, 1990; Artistic, Cervone, & Pezzuti, 2003; Klein, Loftus, & Fricker, 1994; Libera & Chelazzi, 2006; Wood & Bandura, 1989). Because feedback is typically based on actual performance and performance is related to ability, feedback type (i.e., high- or low- performance feedback) and ability are often confounded. In the present study, we disentangled the effects of ability and feedback type on responses to feedback through the use of a false-feedback paradigm in which individuals were randomly assigned to groups that were told that their performance was either high or low relative to their age group. With random assignment, feedback groups were comparable, within each age group, in level of cognitive ability and pre-existing control beliefs. Below, we discuss three areas of research that provide the conceptual framework for the study: self-regulation of reading, the role of beliefs (pre-existing control beliefs and task-specific self-efficacy beliefs and expectations) in self-regulation, and feedback effects on self-regulation.

Beliefs

We distinguish between beliefs that are relatively constant across a similar array of cognitive situations, referred to as pre-existing beliefs, and beliefs that may be more sensitive to specific task requirements. Pre-existing beliefs about one’s cognitive performance are important because they could filter the individual’s general approach to how internal and external information is interpreted and how attention is allocated in response to this information

(Bandura, 1997; Butler & Winne, 1995; Miller & Lachman, 1999). Thus, individuals who believe they have control over their problem solving abilities may respond to feedback that they are underperforming by maintaining or increasing task engagement and attention to the text when trying to solve a problem. In contrast, those with low levels of control beliefs would be less likely to initiate processing changes in response to this information due to a belief that such a change would be unlikely to lead to gains. Self-efficacy is a similar construct in that it reflects confidence in one's abilities; however, these perceptions are task-specific (Bandura, 1997). Self-efficacy is typically measured by assessing confidence levels for varying levels of performance on a specific task, and then creating a summary score across all assessments for that task. In the present study, this type of self-efficacy measure, as well as a measure of performance expectations, were included to assess the impact of performance feedback on task-specific beliefs (cf. Bouffard-Bouchard, 1990). In contrast, the measure of control beliefs was included to assess a general orientation regarding perceptions of control over cognitive skills that individuals possessed prior to task engagement. To summarize, we examined the impact of pre-existing beliefs and age on task-specific beliefs (self-efficacy and performance expectations), and the degree of attention allocated to the task.

There is evidence to support the notion that reading self-regulation may depend on control beliefs and moreover, that there are age differences in these effects. For example, in a study assessing age differences in responsiveness to reading goals (emphasizing reading efficiency versus recall accuracy), memory beliefs accounted for age-related variance in responsiveness to these differential goals (Stine-Morrow et al., 2006). In another study, researchers assessed attention to easy versus difficult texts among younger and older adults with varying levels of control beliefs (Miller & Gagne, 2005). For older- but not younger- adults, shifts in attention depended on control beliefs. Older adults with a weaker sense of control allocated less time to difficult texts relative to those with a stronger sense of control. This finding suggests that older adults without a strong sense of control failed to persist when texts were challenging. However, feedback was not provided in those studies, making it unclear how feedback influences these types of self-regulatory processes.

Self-Regulation in Response to Feedback

Feedback is an important component of many models of self-regulation (e.g., Carver & Scheier, 1990). Information used to regulate future behaviors can be generated internally, based on various types of cues (Koriat, 1997) but it can also originate from external sources, for example, in the form of information regarding one's performance that is provided by another (e.g., instructor, coach). Positive feedback suggesting that one is performing better than others who are performing the same task has been shown to increase confidence and self-efficacy (Bandura & Jourden, 1991; Bouffard-Bouchard, 1990; Wells & Bradfield, 1998). These findings suggest that positive feedback may encourage greater task engagement and this in turn might be evident in higher performance expectations and greater attention to the text.

Age differences in the effects of feedback on self-regulation of reading are relatively unexplored. However, research examining age differences in the impact of feedback and goals on memory processing suggests that the effects of feedback on list memory tasks may differ for younger and older adults. For example, older adults showed lower levels of task engagement and performed worse when they received feedback relative to when they did not (West, Welch, & Thorn, 2001). Furthermore, goal-related memory gains for older adults were more likely to occur under supportive conditions in which positive feedback was given and task difficulty was set relative to one's own baseline performance (West et al., 2005). In general, research on the effects of goals and feedback on self-regulatory processes and performance outcomes showed consistently positive responses by younger adults, and weaker or inconsistent responses by older adults (cf. Stadlander & Coyne, 1990; West et al., 2003; West et al.,

2005; West et al., 2001). At the same time, there is little direct evidence concerning the extent to which age differences in the effects of feedback on self-regulation rely on pre-existing beliefs, although one examination of list memory showed that pre-existing control beliefs affected responsiveness to goals and feedback (West & Yassuda, 2004).

The Present Study

We investigated performance feedback effects on task-specific beliefs (self-efficacy, performance expectations) and attention while reading, as well as the extent to which age and pre-existing control beliefs moderated these relationships. Participants read, at their own pace, a series of problems in the form of “whodunit” mysteries on a computer monitor while their reading times were recorded. A false feedback paradigm was used such that half of the participants in each age group were randomly assigned to a group that received high-performance feedback and the other half was assigned to a low-performance feedback group. We assessed self-efficacy before and after the reading task, and we assessed performance expectations prior to each of 6 trials. Attention was examined using a resource allocation approach that estimated degree of attention from reading times. In particular, we examined attention to a specific reading process called conceptual integration, which refers to the extent to which readers spend time organizing and integrating ideas in the text (Just & Carpenter, 1980). Conceptual integration time is highly sensitive to text demands (idea unit density; Haberlandt & Graesser, 1989), comprehension (Miller, Stine-Morrow, Kirkorian, & Conroy, 2004), problem solving (Mayer, 1998; Miller & Gagne, 2008), and control beliefs (Miller & Gagne, 2005).

To the extent that high-performance feedback promotes greater task engagement, we expected that those in the high-performance feedback group would show higher self-efficacy, higher performance expectations, and greater attention relative to those in the low-performance feedback group. It is difficult to predict whether patterns would be similar across age groups because we are unaware of past research that has randomly assigned performance feedback to older adults when investigating self-regulation of reading or problem solving. In addition, we expected that those with higher levels of pre-existing control beliefs would show higher levels on the three self-regulatory variables relative to those with lower levels of pre-existing beliefs when collapsing across feedback groups. However, less clear was whether pre-existing control beliefs would interact with the effects of feedback. For example, it could be that the self-regulatory responses of those with high levels of pre-existing control beliefs are more influenced by high-performance feedback, resulting in greater efficacy and/or greater attention after feedback, relative to those with low control beliefs. It could be that adults with a low sense of control do not respond to either type of feedback if evaluative information leads to disruptive task-irrelevant thoughts. Given that past research has yielded inconsistent findings regarding older adults' responses to feedback on memory tasks, and there is no previous work with this paradigm, we do not make age predictions.

Method

Participants

Participants were 37 younger (18–32; $M = 22.4$, $SD = 3.6$) and 58 older (60–81; $M = 70.5$, $SD = 5.6$) adults. Younger adults were recruited from a university and the surrounding community; older adults were recruited from the university continuing education office, as well as advertisements in local newspapers. Participants were screened via a telephone interview in which we asked whether individuals were native speakers of English and were free of neurological impairments. Both younger and older participants were given a small honorarium for their participation. We administered a battery of individual difference measures to determine whether our sample showed the expected age-related declines in fluid ability but

preservation of verbal ability. The battery was also used to determine whether our two feedback groups (described in greater detail below) were comparable, within age group, on fluid and verbal measures as well as on a measure of pre-existing control beliefs. Means and standard deviations of these measures are presented in Table 1. To determine whether there were age or feedback group differences in these measures, we analyzed each within a 2 (Age: young, old) $\times$ 2 (Feedback: high, low) ANOVA. All of the analyses showed significant main effects of age, yet none of the analyses yielded significant main effects of feedback or Age $\times$ Feedback interactions, indicating that random assignment led to comparable groups on these basic assessments. For simplicity, we report only the main effects of age.

Verbal Ability—Verbal ability was assessed using two measures of print exposure, Author Recognition Task (ART) and the Magazine Recognition Task (MRT) (Stanovich, West, & Harrison, 1995) as well as the Advanced Kit-Factored Reference Vocabulary Test (KFRT). The ART requires individuals to place a check mark next to names of individuals who are authors and to leave blank names of individuals who are not authors (Cronbach's $\alpha = .77$). The same procedure is used in the MRT (Cronbach's $\alpha = .89$) in which magazine titles are selected from a list containing real and decoy titles. Scores are the number of correctly identified items. The KFRT vocabulary test consists of 36 multiple-choice items in two sections (Ekstrom, French, & Harmon, 1976). The two sections yielded a Cronbach's $\alpha = .92$. A composite verbal ability measure was calculated by averaging the z scores across the ART, MRT, and KFRT (Cronbach's α across the 3 items = .83). An ANOVA showed an age-related increase in verbal ability, $F(1,91) = 21.1, p < .001, \eta^2 = .19$.

Fluid Ability—Fluid ability was assessed using two measures of working memory and two measures of speed of processing. Working memory was assessed using the Computation Span (Salthouse & Babcock, 1991) and loaded sentence span tasks (Daneman & Carpenter, 1980; Stine & Hindman, 1994). In these tasks, participants read a series of equations or sentences, one at a time, and for each, responded to whether the statement is *True* or *False*. At the end of the series, individuals recalled the second digit (for the computation span) or the last word in each of the sentences (for the sentence span) in the correct order. Scores are the number of digits or words correctly recalled at the highest set size attained. The two tasks formed a reliable scale, Cronbach's $\alpha = .78$, and were averaged to form a measure of working memory span. Speed of processing was assessed with the letter and pattern comparison tasks (Salthouse & Babcock, 1991). These tasks require individuals to compare strings of letters or patterns as quickly as possible to determine if they are the same or different. The score is the total number of correct responses. The two tasks formed a reliable scale with Cronbach's α of .82; we averaged the two measures to form a composite index of speed of processing. We found significant age-related declines in working memory, $F(1,91) = 49.7, p < .001, \eta^2 = .35$, and speed of processing, $F(1,91) = 65.6, p < .001, \eta^2 = .42$.

Pre-Existing Control Beliefs—The Personality in Intellectual Aging Contexts (PIC; Lachman, Baltes, Nesselroade, & Willis, 1982; Lachman, 1986) assesses control beliefs pertaining to a wide variety of cognitive abilities attention, memory, problem solving. We identified a subset of items ($n = 8$) from the PIC that were specific to problem solving (e.g., "I'm good at solving puzzles," "I don't get concerned about my problem solving abilities") to obtain a measure of beliefs that was particularly relevant to this study, $\alpha = .90$. We found significant age-related declines in cognitive control beliefs (mean problem solving subset of PIC), $F(1,91) = 5.4, p < .05, \eta^2 = .05$.

To summarize, the analyses on the individual difference measures showed the expected age-related increases in verbal ability and decreases in fluid ability and cognitive control beliefs. However, the main effects of feedback and the Age $\times$ Feedback interactions were

nonsignificant, confirming that, within each age group, feedback groups were similar in terms of ability and control beliefs.

Task-Specific Measures

Self-Efficacy—To assess self-efficacy, participants rated their confidence, from 0 (“no confidence at all”) to 10 (“total confidence”), in their ability to achieve varying levels of problem solving accuracy on the mystery tasks. They were first given an anchor “80% correct is the average for a person in your age group” and then reported their confidence for achieving accuracy levels of 65%, 70%, 75% up to 100% accuracy. We assessed self-efficacy two times: prior to receiving feedback, but after completing the practice mystery (Time 1) and again at the end of the last mystery (Time 2). Self-efficacy strength was measured as the sum of the confidence ratings across all levels (possible range of 0 to 80), with a separate score for Time 1 and Time 2 assessments. Cronbach’s alpha was .97 at Time 1 and .98 at Time 2.

Performance Expectations—For each trial, participants rated, on a 7-point scale (1 = extremely unlikely, 7 = extremely likely), their expectations regarding performance. The first rating was made immediately prior to reading the mystery (extent to which they believed they would be able to solve the upcoming mystery). The second rating was made immediately after reading the mystery (but before answering the problem solving questions) and asked them to indicate the extent to which they felt they had solved the mystery. Immediately following that rating, participants predicted how well they would perform on the problem solving questions that followed (1- answer no questions correctly, 7- answer all questions correctly). Responses to the 3 ratings for each of the six mysteries ($n = 18$ items) formed a reliable scale, $\alpha = .93$; and were averaged to form a summary performance expectation measure.

Texts—Texts consisted of 6 whodunit mysteries which required individuals to solve a crime that had been committed (Conrad, 1998). Passages contained between 335 and 370 words ($M = 348.8$; $SD = 5.4$), with an average Flesch-Kincaid grade level of 6.6 ($SD = 1.2$) (indicating that the typical 7th grader will be able to understand the texts). For each mystery, we administered a series of questions so that we could provide feedback on task performance. Four questions for each mystery were designed to assess understanding of the key aspects of the solution (the perpetrator and key evidence). In addition, two questions were included that tapped memory for information that was not central to the solution. These were included to determine whether some readers attended to parts of the passage that were of no consequence to the solution. Although the central questions formed a scale with acceptable internal consistency ($\alpha = .65$), the noncentral questions did not ($\alpha = .05$), therefore we present data only on the performance for the 4 key questions tapping solution accuracy.

Final Evaluation of Performance Relative to Age Group—To determine whether the effects of the feedback manipulation were present at the end of the reading task, participants rated, on a 5-point scale, perceptions of their performance relative to their age group (1= My performance was far below average, for my age; 5 = My performance was far above average, for my age).

Procedure

The PIC was sent to participants’ homes for completion prior to the session, to assess pre-existing control beliefs. Upon arrival, participants completed the Print Exposure measures (Author Recognition Test, Magazine Recognition Test) followed by a 20-item mock problem solving test that was used solely to provide the basis for the first false feedback. While participants read the practice mystery, the experimenter “scored” the mock test. After completing the practice passage, participants completed the mystery self-efficacy beliefs measure (time 1). Administration of self-efficacy evaluations after a baseline or practice trial

is standard procedure (West & Yassuda, 2004), so that participants have a general idea of the characteristics of the task for which they are providing ratings. False feedback regarding performance on the mock test was provided next in writing on a form that was completed by the experimenter. Participants within each age group were randomly assigned to feedback conditions; in the high-performance feedback (High-PFB) condition participants were told they performed at the 84th percentile for their age group. Those in the low-performance feedback (Low-PFB) condition were told they performed at the 39th percentile for their age group. The forms included a brief explanation of how to interpret percentiles as well as a frequency distribution graph that illustrated their score in reference to others. The experimenter also explained the percentile information, asked participants whether they understood the information, and provided further instruction as needed. We included this short tutorial so that the feedback given in the subsequent reading task would be readily understood.

Participants then read and attempted to solve 6 mysteries and obtained feedback following performance on every other trial.ⁱ Feedback was presented in the following format: "Performance summary. 30th percentile: *30% of participants your age score at or below your score; *70% of participants your age score above your score." The performance levels given for feedback varied somewhat to increase the credibility of the feedback. Low-PFB consisted of performance levels of 30th, 28th, and 29th percentiles, whereas High-PFB consisted of performance levels of 90th, 92nd, and 95th percentiles, for feedback presented after solving passages 1, 3, and 5, respectively.

Participants read problems at their own pace, segment-by-segment, on a computer screen using DirectRt 2004 (Empirisoft, New York). Segments (containing 3–7 words) were advanced by pressing the space bar which removed the last segment and presented the next in its place. Millisecond reading times were recorded for each segment. After reading the mystery, participants completed performance-expectation ratings and answered problem solving questions.

After all 6 trials, participants completed the Mystery SE Time 2 measure and the manipulation check (rating of one's performance relative to age peers). Participants were then debriefed so that they understood the nature of the feedback they received as well as the purpose of the feedback. The experimenter showed interested participants their actual performance and the correct answers for each of the problem solving measures. Participants were asked whether they had any suspicions that their feedback may have been "rigged." Finally, the speed of processing, vocabulary, and working memory span tasks were completed. The session lasted less than 2 hours.

Results

We first present preliminary analyses consisting of evidence that our feedback manipulation was successful and a description of the analyses used to examine attention to conceptual integration while reading. We then present three models, using hierarchical linear regression, examining the effects of feedback, age, and pre-existing control beliefs on our three self-regulatory variables: self-efficacy, performance expectations, and attention. Means and standard deviations of these measures are presented in Table 2, broken down by age and performance feedback groups.

ⁱFeedback occurred repeatedly to insure that its effects would be felt throughout the session. Trial-by-trial analyses suggested that overall feedback effects dominated the findings, so separate trial analyses were not included here

Preliminary Analyses

Final Self-Evaluation of Performance—In order to determine whether our manipulation was successful in altering performance beliefs, we conducted an Age (young, old) $\times$ Feedback (high, low) ANOVA on responses asking participants to compare their performance to others within their age group. We found a main effect of feedback, $F(1,91) = 127.8, p < .001, \eta^2 = .58$, confirming that the High-PFB group rated their performance higher relative to their age peers than did those in the Low-PFB group. In addition, there was a main effect of age, $F(1,91) = 5.8, p < .05, \eta^2 = .06$, such that older adults rated their performance lower than did younger adults. The 2-way interaction was nonsignificant, $F < 1$, indicating that both older and younger adults accepted the veracity of the feedback they were given (see Table 2).

Debriefing—During debriefing, we asked individuals whether they had any suspicions regarding the veracity of the feedback they received. Three individuals (2 young, 1 older adult) in the Low-PFB group and 5 individuals (2 young and 3 older adults) in the High-PFB group reported some suspicion. In each case, however, individuals reported that these suspicions occurred when prompted by the experimenter (i.e., only in retrospect). Thus, suspicions were not expected to impact the participants during the problem-solving task. To verify this, analyses were conducted with and without these “suspecting” individuals and showed a comparable pattern of findings; thus these individuals were retained in all analyses.

Attention—The allocation of attention to conceptual integration when reading the mysteries was investigated using a resource allocation approach (e.g., Haberlandt, 1984; Just & Carpenter, 1980; Lorch & Meyers, 1990; Lorch & van den Broek, 1997; Stine-Morrow et al., 2006). With this approach, texts are coded in terms of characteristics (e.g., number of letters in the segment) and then regressions are conducted individually by participant to decompose his or her reading times into the reading processes associated with these characteristics. Regressions yield, for each individual, beta weights reflecting attentional allocation to the reading processes. The text characteristic of interest in the present study was conceptual integration which was indexed by coding 0/1 whether or not the segment fell at the end of a sentence (Just & Carpenter, 1980). Processes that occur at the end of a sentence, sometimes called “wrap-up,” include the organization and integration of concepts that have been introduced in the segment with information from past segments and from prior knowledge (Just & Carpenter, 1980). We also coded the text in terms of: 1) number of letters in each segment to control for orthographic coding; 2) criticality ratings to control for differences between problems; and 3) whether or not a new character was introduced in the segment (dummy coded 0/1) in order to control for processes that may add noise to an assessment of conceptual integration.

Mystery Problem Solving Accuracy—Proportion of multiple-choice questions correctly answered for each mystery was calculated and these scores were averaged across the 6 mysteries. Table 2 contains the means and standard deviations by age and feedback group. A 2 (Age: young, old) $\times$ 2 (Feedback: high, low) ANOVA on problem solving accuracy showed a significant effect of Age, $F(1,91) = 4.4, p < .05, \eta^2 = .05$, which, consistent with past research (Thornton & Dumke, 2005), indicated age-related declines in problem solving performance. We also found a nonsignificant main effect of Feedback, $F < 1$, and a marginally significant Age $\times$ Feedback interaction, $F(1,91) = 2.8, p = .10, \eta^2 = .03$. The marginal effect was due to significant age differences in accuracy within the high-PFB group, $t(46) = 2.7, p < .01$, but not in the low-PFB group, $t < 1$.

Effects of Feedback, Age, and Control Beliefs

Our main goal was to determine whether combinations of age and pre-existing beliefs influenced the extent to which feedback affected task-specific beliefs and attention. To explore

this question, we conducted a series of hierarchical linear regressions in which we predicted each self-regulatory variable from control beliefs, feedback type, and age. For models 1, 2, and 3, respectively, the dependent variables were self-efficacy (at Time 2), performance expectations, and attention. Main effects of age and pre-existing control beliefs were entered as continuous variables, and feedback type was entered as a dichotomous variable (0 = low PFB; 1 = high PFB). For each regression model, the main effects of feedback type, age, and control beliefs were entered in the first step; the two-way interaction terms were entered in the second step (Feedback $\times$ Control Beliefs, Age $\times$ Control Beliefs, and Age $\times$ Feedback); and the 3-way interaction term, Feedback $\times$ Age $\times$ Control Beliefs, was entered in the last step.

Model 1: Predicting Self-Efficacy at Time 2—A significant main effect of feedback, $\beta = .62, p < .00$, indicated that high-PFB was associated with higher self-efficacy. Consistent with past research, there was a main effect of age, $\beta = -.32, p < .001$, showing that increased age was associated with lower self-efficacy. The main effect of control beliefs approached but did not reach significance, $\beta = .14, p < .06$, indicating only a weak impact of pre-existing beliefs on self-efficacy across both feedback manipulations. Nonsignificant Feedback $\times$ Control Beliefs and Feedback $\times$ Age $\times$ Control Beliefs interactions, $p > .10$ for all, failed to support the notion that pre-existing control beliefs acted as a filter that alters the impact of feedback information on levels of self-efficacy. Figure 1 shows the main effect of the feedback manipulation on self-efficacy.

Model 2: Predicting Performance Expectations—When the dependent variable was performance expectations, the findings were very similar. We found main effects of feedback, $\beta = .38, p < .001$, showing that those in the high-PFB group had higher expectations than those in the low-PFB group. We also found a significant effect of age, $\beta = -.22, p < .01$, indicating that older adults had lower expectations than did younger adults. There was also a significant main effect of pre-existing control beliefs, $\beta = .25, p < .01$, such that higher levels of control beliefs were associated with higher performance expectations. However, none of the interaction terms was significant, $p > .10$ for all. These findings fail to support the notion that pre-existing beliefs act as a filter of feedback information in terms of performance expectations.

Model 3: Predicting Attention to Conceptual Integration—In contrast to the above findings, there were no significant main effects of age or control beliefs on attention, and there was only a trend for high-PFB to be associated with greater attention, $\beta = .19, p = .06$. However, there was a significant Feedback $\times$ Age $\times$ Control Beliefs interaction, $\beta = .21, p < .05$. This interaction was due to a significant Feedback $\times$ Age effect among those with higher levels of control beliefs, $\beta = .38, p = .05$, but not among those who had lower levels, $\beta = -.17, p > .10$. Figure 2 shows mean attention to conceptual integration for young and old as a function of feedback group and control beliefs groups (shown as a median split on control beliefs). Independent samples t-tests suggest that the significant 3-way interaction was due to larger feedback effects among older adults with high levels of control beliefs than among the other groups. Older adults with high control beliefs who received high-PFB allocated significantly more time to conceptual integration than did older adults with high control beliefs who received low-PFB, $t(16) = 3.8, p < .001$. Feedback differences within the three other groups were nonsignificant (older adults with low control beliefs, $t < 1$; young adults with high control beliefs; $t < 1$; young adults with low control beliefs, $t(19) = 1.3, p > .10$). This finding is consistent with the notion that pre-existing control beliefs may serve to facilitate or enhance the impact of positive feedback, but only among older adults.

Discussion

An important question in the literature is the extent to which person factors interact with task variables to impact self-regulation. The goal of the present study was to examine the effects

of control beliefs and age on task-specific beliefs and attention in response to feedback on a problem solving task. The SRLP model (Stine-Morrow et al., 2006) suggests that self-regulation of reading involves the allocation of attention to text processes in such a way that leads to an acceptable balance of actual states versus desired states. According to this model, readers compare their actual comprehension with their desired comprehension, based on both internal feedback loops and external sources of performance information. In order to examine the interplay of person and task factors, we randomly assigned younger and older adults with varying levels of control beliefs to performance feedback conditions and observed self-regulation in response to this feedback. Findings from the present study confirm the notion that external sources of information can be important and, further, that the impact of this information on self-regulation may be filtered by the individual's age and level of pre-existing beliefs.

Task-Specific Beliefs

As expected, a comparison between pre- and post-test self-efficacy levels showed that feedback valence affected self-efficacy beliefs such that high-performance feedback led to higher self-efficacy and low-performance feedback led to lower self-efficacy. The magnitude of this effect was comparable for younger and older adults. Regression analyses confirmed that age and feedback had additive effects on self-efficacy and also showed that control beliefs did little to affect post-test levels of self-efficacy. This finding suggests that performance feedback has similar effects on the self-efficacy of younger and older adults alike, irrespective of pre-existing levels of beliefs.

Also as expected, we found that performance feedback had a significant impact on performance expectations such that those who received positive feedback had higher expectations regarding performance than did those who received negative feedback. Similar to the findings on self-efficacy, we found that - even though younger adults had higher expectations than did older adults - age and feedback type did not interact. This finding is important because it suggests that the boost in expectations from positive feedback was not diminished among older adults. We also found that those with higher levels of control beliefs expected to perform better than their low control peers. This effect was also comparable across age and feedback groups. Thus, feedback valence, age, and control beliefs all had additive effects on expectations regarding performance.

In general, these findings are consistent with the notion that verbal persuasion by others, including feedback, is a key factor determining levels of self-efficacy and performance expectations (Bandura, 1997). The data add to the literature by showing that these effects of feedback were not attributable to differences in cognitive ability between those who received positive feedback and those who did not. The findings are also consistent with prior research showing that older adults have lower confidence in their abilities relative to younger adults (Berry, 1999; Miller & Lachman, 1999), and that these age differences are often maintained even as both groups respond similarly to manipulations designed to alter efficacy or performance (e.g., West et al., 2005). These findings add to the literature, however, by showing that performance feedback for problem solving has comparable effects on self-efficacy and expectations for younger and older adults, regardless of pre-existing age differences in control beliefs.

Attention

In addition to examining the effects of age, pre-existing beliefs, and performance feedback on task-specific beliefs, we investigated these effects on an objective assessment of self-regulation, namely, the degree of attention allocated to the effortful process of conceptual integration. The pattern of findings for attention differed somewhat from those for task-specific

beliefs. There was only weak evidence to suggest that positive feedback increased task engagement as reflected in attention. Similarly, pre-existing control beliefs did not have independent effects of attention. On the other hand, the effects of feedback on attention were moderated by age and pre-existing control beliefs. High-control older adults who received positive feedback allocated more time to the text relative to their high-control counterparts who received negative feedback. This finding suggests that aging may prompt a realignment of self-regulatory processes such that responses to feedback depend more heavily on pre-existing control beliefs with increasing age. Specifically, information that one's performance is in line with the intended goal of solving the problems appears to motivate older adults to allocate more time when they have a strong sense of control rather than when they have a weaker sense of control.

This finding is consistent with other research showing aging leads to a larger impact of beliefs on performance (e.g., Miller & Gagne, 2005; Lachman & Andreoletti, 2007; Riggs, Lachman, & Wingfield, 1997; Stine-Morrow et al., 2006). For example, the impact of control beliefs on attention to easy and difficult passages was assessed among younger and older readers (Miller & Gagne, 2005). Older adults with a high sense of control showed greater persistence when reading difficult texts relative to those who had low sense of control. In addition to greater persistence, older adults with strong control beliefs may be more sensitive to their own capabilities. Riggs and colleagues (Riggs et al., 1997) found that older high-control adults were better at selecting appropriately-sized units of text, which then lead to greater recall.

In the present study, we add to this literature by showing that control beliefs may moderate the effects of feedback in different ways that depend on age: older adults who received positive feedback, and who possessed a strong sense of control, allocated more time to integrating concepts in the text than did their peers who received negative feedback. This suggests that positive feedback promotes greater task engagement but only among older adults who possess a strong sense of control. In contrast, older adults who had lower levels of control beliefs did not respond to positive feedback by increasing their effort. It could be that these older adults were less willing to exert additional effort toward reading the problems, despite positive feedback, believing that this additional effort would be futile. Because older adults with low levels of control beliefs showed little response to positive feedback, an alternative explanation is that these individuals filter out external feedback information of any type, perhaps in an attempt to better focus on task demands. Clearly, more research is needed to better understand whether some individuals attempt to filter external information, and if so, whether attempts are successful in blocking out potentially distracting information that may interfere with internal feedback mechanisms. Past research suggests that an adaptive self-regulatory response among older readers may be an allocation policy that calls for increasing attention in response to task demands (Stine-Morrow et al., 2006). Here, that adaptive approach appears to have been taken by older adults with a strong sense of control. Using an intervention paradigm, it would be interesting to see if older adults, even those with low control beliefs, could be trained to take this more proactive approach on a range of cognitive tasks.

It is worth noting that age, control beliefs, and feedback type had differential effects on task-specific beliefs, attention, and mystery problem solving accuracy. These findings suggest that a wide range of measures is needed to fully capture the complexity of self-regulation. We suggest that subjective (e.g., beliefs and perceptions) and objective (e.g., strategy use, time spent performing various tasks, attention) measures of self-regulation are important, as are a combination of online (real-time) assessments and offline measures. It may also be helpful to include additional measures of person factors that reflect a wider range of motivational tendencies that could impact the effects of feedback information on self-regulation.

False Feedback as a Tool to Examine Self-Regulation

In the present study, we used random assignment to supply false feedback to individuals regarding their performance relative to their peers. External feedback can occur in many forms (regardless of veracity). For example, feedback can contain more specific information regarding processes (you're reading too quickly) or performance (items 3 and 5 were incorrect) or provide more general information regarding goals (you're exceeding your goal) or performance (you're performing as well as your peers). It can be more extensive by including advice for ways in which behavior can be changed to improve performance (e.g., following a series of comprehension errors, a teacher could suggest that a student read more slowly). Each of these forms of feedback presumably elicits self-regulatory responses that depend on task-specific factors as well as pre-existing beliefs and ability. The false feedback paradigm used in the present study allowed us to more systematically evaluate the role of feedback in self-regulation while holding constant (within age group) pre-existing beliefs and cognitive ability. A better understanding of the relationships among person and task factors is critical for increasing our knowledge of self-regulation in adulthood.

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Figure 1. Self-efficacy (SE) beliefs at time 1 and time 2 by age for low-performance feedback (Low-PFB) and high-performance feedback (High-PFB) groups.

Figure 2.

Attention to conceptual integration by age for low-performance feedback (Low-PFB) and high-performance feedback (High-PFB) groups and low- and high-control beliefs group.

Table 1
Individual Differences in Cognitive Abilities and Control Beliefs by Age and Performance Feedback (PFB) Group

	Young						Older						Total											
	Low PFB (n = 18)			High PFB (n = 19)			Total			Low PFB (n = 29)			High PFB (n = 29)			Total			Low PFB (n = 47)			High PFB (n = 48)		
	Mean	SD		Mean	SD		Mean	SD		Mean	SD		Mean	SD		Mean	SD		Mean	SD		Mean	SD	
Verbal Ability	-.42	(.67)		-.52	(.69)		-.47	(.68)		.32	(.90)		.28	(.79)		.30	(.84)		.03	(.89)		-.04	(.85)	
Working Memory Span	6.2	(1.0)		6.1	(0.9)		6.2	(0.9)		4.0	(1.5)		4.5	(1.4)		4.2	(1.5)		4.8	(1.7)		5.2	(1.5)	
Speed of Processing	31.8	(7.1)		33.9	(4.5)		32.9	(5.9)		24.4	(4.2)		24.6	(4.1)		24.5	(4.1)		27.3	(6.5)		28.3	(6.2)	
Control Beliefs	4.4	(1.0)		4.4	(1.0)		4.4	(1.0)		3.9	(1.2)		4.0	(1.1)		3.9	(1.2)		4.1	(1.1)		4.2	(1.1)	

Table 2

Means and Standard Deviations (SD) of Final Self-Evaluation, Self-Regulation Variables (Self-Efficacy, Performance Expectations, Attention), and Accuracy by Age and Performance Feedback (PFB) Group

	Young						Older						Total											
	Low PFB (n = 18)			High PFB (n = 19)			Total			Low PFB (n = 29)			High PFB (n = 29)			Total			Low PFB (n = 47)			High PFB (n = 48)		
	Mean	SD		Mean	SD		Mean	SD		Mean	SD		Mean	SD		Mean	SD		Mean	SD		Mean	SD	
Final Self-Evaluation of Performance	1.7	(0.8)		3.7	(1.0)		2.8	(1.3)		1.4	(0.6)		3.2	(0.9)		2.3	(1.1)		1.6	(0.7)		3.4	(0.9)	
Mystery Self-Efficacy Time 1	57.7	(16.5)		60.8	(14.7)		59.3	(15.5)		38.6	(17.9)		42.8	(16.4)		40.7	(17.0)		45.9	(19.6)		50.0	(17.8)	
Mystery Self-Efficacy Time 2	38.3	(18.8)		74.7	(16.5)		57.0	(25.4)		23.1	(15.4)		51.3	(17.4)		37.2	(21.8)		28.9	(18.2)		61.0	(20.5)	
Performance Expectations	3.3	(0.7)		4.2	(0.7)		3.7	(0.8)		3.0	(0.7)		3.5	(0.8)		3.3	(0.8)		3.1	(0.7)		3.8	(0.8)	
Attention to Conceptual Integration	.04	(.07)		.06	(.06)		.05	(.07)		.01	(.07)		.05	(.10)		.03	(.09)		.02	(.07)		.05	(.08)	
Mystery Problem Solving Accuracy	.56	(.12)		.62	(.13)		.59	(.13)		.55	(.14)		.52	(.13)		.54	(.13)		.56	(.13)		.56	(.14)	