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Depending on My Mood: Mood-Driven Influences on Text Comprehension

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Abstract

Reading comprehension is a critical component of success in educational settings. To date, research on text processing in educational and cognitive psychological domains has focused predominantly on cognitive influences on comprehension, and in particular, those influences that might be derived from particular tasks or strategies. However, there is growing interest in documenting the influences of emotional factors on the processes and products of text comprehension, because these factors are less likely to be associated with explicit reading strategies. The present study examines this issue by evaluating the degree to which mood can influence readers' processing of text. Participants in control, happy-induced, or sad-induced groups thought aloud while reading expository texts. Happy, sad, and neutral moods influenced the degree to which readers engaged in particular types of coherence-building processes in the service of comprehension. Although reading strategies clearly influence processing, understudied factors that are less explicitly goal-driven, such as mood, can similarly impact comprehension activity. These findings have important implications for the role of mood on reading instruction and evaluation.

Keywords

comprehension; mood; think aloud; induction; inferences; reading

One of the most common ways we derive information about the world is through reading. Whether it involves perusing a television guide, studying tax forms, or examining a news website, learning about the world requires us to comprehend written materials. Just as importantly (and perhaps even more so), reading is a crucial element of successful learning in more formal educational settings (e.g., textbook assignments; Hagaman & Reid, 2008).

To date, the processes that underlie and the products that result from reading comprehension have been examined with specific attention to cognitive contributors. For example, research has examined how readers encode information from the text into mental representations (Gernsbacher, 1990, 1997; Kintsch & van Dijk, 1978), make connections between different parts of the text using inferential processes (Graesser, Singer, & Trabasso, 1994; Zwaan,

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1999; Zwaan & Radvansky, 1998), and recruit background knowledge to evaluate and elaborate text propositions in the service of constructing meaning (e.g., Best, Floyd, & McNamara, 2008; Rapp, 2008; van den Broek & Kendeou, 2008). Understanding the ways in which information is extracted from text and stored in memory is important for both describing everyday comprehension activities and informing interventions that attempt to remediate reading difficulties.

A growing body of work has examined how readers' knowledge, expectations, and goals help guide the processes that underlie comprehension. These various influences affect the elements of texts that individuals will strategically focus on in the service of comprehension (Lorch, Lorch, & Klusewitz, 1993; Narvaez, van den Broek, & Ruiz, 1999; Tapiero, 2007; van den Broek, Lorch, Linderholm, & Gustafson, 2001). This focus is often referred to as *standards of coherence*, and it, in a general way, identifies readers' expectations for what they might attend to or disregard with the intention of understanding a text.

Standards of coherence have been studied by providing college-age readers with explicit instructions intended to influence both the strategies used during reading as well as the memory representations that remain after reading is completed. For example, participants might be asked to read with the goal of studying versus being entertained (Linderholm & van den Broek, 2002; van den Broek, et al., 2001). In general, individuals tasked with the goal of reading for study engage in processes intended to improve comprehension and memory for the text, such as reading at a relatively slow pace, paraphrasing, making predictions, making connections with background knowledge, and making intertextual connections. After reading, these participants also demonstrate increased retention of the text. In contrast, individuals tasked with reading for entertainment engage in processes that do not necessarily improve comprehension and memory for the text, such as reading at a quicker pace, making associations (e.g., building elaborations of the current sentence that may not be relevant toward establishing coherence), providing opinions, and generating affective responses to the text (Linderholm, Virtue, Tzeng, & van den Broek, 2004). They also remember fewer textual units than readers holding a study goal. These findings indicate that college students can successfully alter their reading strategies depending on their reasons for reading, with consequences for text retention.

Similarly, other projects have shown that certain strategies can be explicitly, and perhaps spontaneously, invoked by readers in the service of comprehension. As examples, readers engage in perspective-taking (Anderson & Pichert, 1978; Kaakinen & Hyona, 2005; Kaakinen, Hyona, & Keenan, 2002; Pichert & Anderson, 1977), develop and rely on reading goals (Linderholm & van den Broek, 2002; van den Broek, et al., 2001), have expectations about which text elements might be more or less relevant to their reading goal (McCrudden & Schraw, 2007), and have different motivations that can affect the pursuit of those goals (Guthrie et al., 2004). All in all, many studies have shown that readers will selectively pay attention to and remember information that aligns with their perspectives and goals, i.e., their standards for coherence.

In the studies referenced above, participants have generally been made explicitly aware of the goals and standards that they should develop. They may also be aware of, or at least have general expectations about, the different types of reading strategies they might apply during reading as a function of their goals or standards. There is little doubt that explicit strategies are employed during reading and that readers often alter these strategies as a function of an explicit reading goal (Kaakinen, et al., 2002; McCrudden & Schraw, 2007). However, the processes that have been documented as accompanying particular reading strategies may also be reflective of influences that readers are less aware of, and that potentially lie outside of explicit control. Mood1 presents one such influence, with a growing body of work

suggesting that mood-driven responses arise during comprehension and influence text memory (Dijkstra, Zwaan, Graesser, & Magliano, 1994; Egidi & Gerrig, 2009; Gerrig, 1993, 1996; Komeda & Kusumi, 2006; Miall & Kuiken, 1994, 1999; Rapp & Gerrig, 2002, 2006). The current study directly examines how mood might affect comprehension strategies and readers' resulting memory representations. We hypothesized that mood, in a manner analogous to standards of coherence, would guide the processes that readers engage in during comprehension.

Effects of Mood on Cognitive Processing

The notion that mood in general can affect cognition is, of course, not new. Generally, moods and emotions have been found to be related to memory encoding and retrieval (Bower, 1981), as well as to a variety of other cognitive processes, some of which include imagery (Mandler, 1984), appraisal (Scherer, Schorr, & Johnstone, 2001), and causal reasoning (Stein, Hernandez, & Trabasso, 2008). Mood has also been associated with achievement, such that positive emotions tend to increase learning (Pekrun, Frenzel, Goetz, & Perry, 2007).

Research and theory also demonstrate that mood can affect the content and the quality of mental representations. Semantic network theorists have posited that emotions can lead to a spread of activation to emotionally-related information in memory. For example, the concept "sadness" is related to the concept "funeral"; thus, thinking about or actually experiencing sadness might activate the "funeral" concept. Because of this spread of activation, individuals exhibit better retention for words and texts that are congruent with their current mood (Bower, 1981, 1987; Ferraro, King, Ronning, Pekarski, & Risan, 2003; Halberstadt, Niedenthal, & Kushner, 1995). Additionally, when learning word lists, individuals have better retention for words if their mood at retrieval is congruent with their mood during encoding (Bower, 1981; de l'Etoile, 2002; Thaut & de l'Etoile, 1993). When reading narratives, readers also identify with and have better memory for characters in similar moods. They also have better memory for texts that are written about in a tone congruent with the reader's mood (Bower, 1981; Bower, Gilligan, & Monteiro, 1981). Thus, memory is influenced by the mood of the reader and the mood invoked by or conveyed in a text description.

Besides exerting effects on memory, mood also appears to influence readers' online understanding of what they read. One way in which this emerges is through individuals' allocation of cognitive resources during processing. Both text and non-text studies have shown that negative (and sometimes positive) moods, as compared to neutral moods, can increase the likelihood that an individual will focus attention on task-irrelevant rather than task-relevant information, thus demonstrating that mood affects resource allocation (Ellis & Ashbrook, 1989; Ellis, Varner, Becker, & Ottaway, 1995; Kliegel, Horn, & Zimmer, 2003). As an example, this has been observed with perceptual grouping tasks in which participants must remember strings containing 6 letters each. The letters can be re-arranged to form two words or syllables, which can improve memory. Sad-induced, compared to neutral

[1]An extensive body of work has examined the role of mood, affect, emotion, and motivation. Although each of these constructs has been defined in a variety of ways, we adopt definitions based on Batson, Shaw, and Olseson (1992; see also Fiske & Taylor, 2008). Affect refers to overarching categories of experience, which includes experiencing and displaying emotions, moods, motivations, and making evaluations. Emotions are specific feelings that often have a clear cause. Moods tend to be more unfocused and without a clear cause. Motivation refers to desires and drives to act or cause behavior (Kleinginna Jr. & Kleinginna, 1981). Importantly, the mood induction procedures we utilized in the current project, and as employed in the extant literature, might be construed as emotion induction procedures. The ongoing debates about these terms (i.e., their overlap) and the induction nomenclatures are outside the scope of the current project. Our goal in these investigations was to directly examine whether non-strategic factors can influence text processing, rather than disentangling potential effects of mood, emotion, affect, and motivation. However, future work could usefully examine whether these constructs exert differential influences on the processes and products of comprehension.

participants, were less likely to re-group the letters, more likely to include irrelevant thoughts during the task, and overall demonstrated poorer memory for the strings (Seibert & Ellis, 1991).

It is worth noting that these types of attention-focusing effects appear to be specific to task-irrelevant information. While attention usually remains focused on task-relevant information regardless of mood, particular moods (especially sadness) can lead to focus on *both* task-relevant and task-irrelevant information (P. T. Hertel & Rude, 1991; Sedek & von Hecker, 2004; von Hecker & Meiser, 2005). Thus, sad mood manipulations can impact attention in ways that encourage a broader focus on text, largely through increased focus on the irrelevant aspects of the task. Given this broader focus, and likely because of it, participants in a sad mood, as compared to a neutral mood, are less accurate when identifying contradictions in texts, show poorer memory for texts when provided with memory cues, and are less accurate with regard to judgments about their own comprehension and the difficulty of texts (Ellis, Ottaway, Varner, Becker, & Moore, 1997; Ellis, et al., 1995). Participants in happy and neutral moods do not show the same processing decrements.

These findings indicate the need for differentiating positive, negative, and neutral mood states to adequately account for the effects of mood on comprehension. Recent findings have explicitly suggested that these differential mood effects might arise as a function of the strategies or processes that people rely on to complete tasks (Bless, Schwarz, & Wieland, 1996; Fiedler, 2000; Hanze & Hesse, 1993; Hanze & Meyer, 1998; Oatley & Johnson-Laird, 1987; Yost & Weary, 1996). As one example, in addition to a broader focus on both task-relevant and irrelevant information, negative moods are also associated with systematic and methodical problem-solving strategies (G. Hertel, Neuhof, Theuer, & Kerr, 2000).

Based on these accounts2, we hypothesized that during reading experiences, readers in a negative mood would engage in processing that broadly attends to both relevant and irrelevant information, and that utilizes systematic processing strategies. More specifically, readers in a negative mood should engage in text-based processes such as paraphrasing the important points of the text, while also engaging in processes that reflect a focus on irrelevant information. Examples of the latter might involve incorporating associations with irrelevant background knowledge, or providing opinions that are of little utility towards understanding the text.

In contrast, positive moods encourage processing in which individuals should focus on relevant information, which is consistent with the view that positive moods result in attention to important features (P. T. Hertel & Rude, 1991; Sedek & von Hecker, 2004; von Hecker & Meiser, 2005). In addition, positive moods are associated with more creative, global, and flexible thinking and problem-solving (Gasper & Clore, 2002; Isen, Daubman, & Nowicki, 1987). Thus, we might expect readers in a positive mood to make connections between important elements of tasks and texts (Bless, et al., 1996; Corson, 2002; Fiedler,

[2]There is an emerging body of research that investigates how an instructor's affect can influence student learning. Educational research has documented that student learning improves when teachers are sensitive and responsive to students' emotions (Lepper & Woolverton, 2002). Recently, this work has documented that the affect conveyed by automated instructors can influence learning. Interestingly, it is more beneficial for student learning when automated instructors display negative rather than positive affect (Sullins, Craig, & Graesser, 2009). This may occur because moods are often used as cues to provide information about ambiguous situations (Schwarz & Clore, 2003). Therefore, positive emotions from the automated teacher may signal to a learner that they are performing well, even if they are not. In contrast, negative emotions from the automated teacher may signal to a learner that they should question their performance. This leads to cognitive disequilibrium, which can benefit learning (Graesser, Lu, Olde, Cooper-Pye, & Whitten, 2005; Sullins, et al., 2009). These results may appear to conflict with the work we reference, but importantly, the work we focus on examines the mood of the learner, rather than the mood presented by the instructor. Future work might usefully consider how these different moods complement or conflict among teachers and learners, and how the resulting interactions impact affect during learning experiences, as well as the consequences of those experiences.

2000; Hanze & Hesse, 1993; Hanze & Meyer, 1998; Isen, 1999; Isen, Niedenthal, & Cantor, 1992; Oatley & Johnson-Laird, 1987; Yost & Weary, 1996). Based on this view, we hypothesized that readers in a positive mood would engage in processing that involves making inferential connections between background knowledge and important parts of the text, and in general exhibit fewer processes that involve irrelevant information.

Many studies examining the effects of mood either do not include a control group (Brand, Reimer, & Opwis, 2007; Ferraro, et al., 2003), or opt to include a neutral mood condition to serve as a control (e.g., Seibert & Ellis, 1991). Neutral-induced participants generally engage in processes that focus attention on relevant information and enhance memory, but to a lesser degree than happy- and to a greater degree than sad-induced participants (Ellis, et al., 1997; Ellis, et al., 1995; Hanze & Hesse, 1993; Isen, et al., 1992; Thaut & de l'Etoile, 1993). Therefore, we hypothesized that neutral-induced participants would engage in processes such as paraphrasing the important points of the text and making inferential connections. However, we expected them to do this less often than happy- and more often than sad-induced participants. We also hypothesized that neutral-induced participants would engage in fewer non-coherence processes than sad- but more than happy-induced participants.

One wrinkle to the neutral predictions is that there is some debate concerning what constitutes appropriate neutral mood induction procedures (Rottenberg, Ray, & Gross, 2007). In studies utilizing film-based methodologies, neutral moods are sometimes induced by having participants view abstract visual displays that lack emotion (such as screen savers depicting moving lines, Gross & Levenson, 1995). However, this can result in participants feeling bored or annoyed. Another method is for participants to view moderately pleasant film clips (i.e., nature documentaries) that induce mild contentment and relaxation. We opted to use this latter method, which is often considered favorable because participants pay attention to the films, do not become annoyed with the activity, and exhibit less variability in terms of mood (Rottenberg, et al., 2007). However, because this method may induce relaxation, it is possible that it could actually increase the amount of non-coherence processing.

The Current Study

This project investigated the extent to which mood could potentially affect the cognitive processes that readers apply during their text experiences. To address this issue, we employed several methodologies. Mood was measured and assessed using methods from clinical studies of emotion (e.g., Watson, Clark, & Tellegen, 1988). Participant mood was linked to performance with a think aloud task, because this task specifically assesses comprehension and inference production (Ericsson & Simon, 1993; Trabasso & Magliano, 1996). Thinking aloud about a text requires readers to verbalize their thoughts and allows them to engage in deeper processing during which they may make intertextual inferences or connections with background knowledge. The think-aloud task was also selected because it invokes deeper, substantive processing, and this type of processing has been shown to motivate effects of mood on cognition (the Affect Infusion Model, Bower & Forgas, 2001; Fiedler, 2001; Forgas, 1995, 2000, 2002).

As further assurance that deeper processing would be invoked, allowing for mood-based effects, if any, to emerge, expository science texts were used in this study. Expository texts describe factual and informational topics, often through causal relationships, in terms of structure, function, or sequence (Brewer, 1980). Narrative texts, on the other hand, describe events, goals, and the actions of characters via unfolding plot. The focus of narratives is usually on understanding and organizing events in the story, and therefore readers tend to

make associations between events in the story, predictions about what will happen next, and, at times, connections to prior knowledge (Graesser, et al., 1994; Trabasso & Magliano, 1996). But despite the utility of establishing links to prior knowledge, the primary focus of narrative comprehension is often on understanding and organizing story events and plot. Expository processing, in contrast, tends to encourage understanding of the facts and causal relationships offered by the text content, which involves more necessarily integrating textual information with prior knowledge to build logical connections (Cote, Goldman, & Saul, 1998; Graesser, Leon, & Otero, 2002; McDaniel & Einstein, 1989; Wolfe, 2005; Wolfe & Mienko, 2007). Direct comparisons of genre have shown greater integration with prior knowledge for expository as compared to narrative materials (Wolfe & Mienko, 2007; Wolfe & Woodwyk, 2010). Attempts at integration with prior knowledge allow the reader to go beyond the information explicitly stated in the text, which can come at a processing cost, and reflects deeper processing (e.g., Campion, 2004; Graesser, et al., 1994; Weingartner, Guzman, Levine, & Klin, 2003; Zwaan & Rapp, 2006). Thus, expository materials offered a useful set of stimuli for examining how mood impacts readers' efforts towards comprehension, particularly with respect to their integration of text-specific details and prior knowledge.

With these materials and methods, we hypothesized that the experimentally induced moods would lead participants to engage in different processing activities with texts, in a manner similar to studies that have utilized explicit goal manipulations to investigate strategy-based standards of coherence (e.g., van den Broek, et al., 2001). Based on the resource allocation and affect infusion models, we expected that participants in an experimentally induced sad mood would rely on processing in which attention becomes defocused (e.g., Corson, 2002; Fiedler, 2000; Hanze & Hesse, 1993; Hanze & Meyer, 1998; Oatley & Johnson-Laird, 1987; Yost & Weary, 1996). This would be exemplified by think aloud processes that reflect relevant textual information, such as paraphrasing, as well as processes that do not enhance comprehension, such as providing opinions about the text or incorporating unrelated background knowledge. In contrast, we expected that participants in an experimentally induced happy mood would engage in processing focused on relevant information and making connections between concepts (Bless, et al., 1996; Fiedler, 2000; Hanze & Meyer, 1998; Isen, 1999; Isen, et al., 1992). This would be exemplified by think aloud processes that enhance comprehension, such as paraphrasing, generating inferences and connections between text elements, and incorporating relevant background knowledge to explain the text. Finally, we expected that participants in an induced neutral mood would rely on processing that enhances comprehension, but to a lesser degree than happy-induced participants, and to a greater degree than sad-induced participants.

To account for susceptibility to the effects of mood induction, we also assessed participants' working memory. Working memory is associated with the strategies that readers rely on during language comprehension tasks (Daneman & Carpenter, 1980; Daneman & Merikle, 1996), as well as what people remember from expository texts (Britton, Stimson, Stennett, & Gulgoz, 1998; Wolfe & Mienko, 2007). In addition, recall that readers' processing resources can be taxed when they experience different emotions, which could conceivably draw attention away from the important elements of a task (Ellis, et al., 1997; Seibert & Ellis, 1991). Thus, working memory might mediate the effects of mood on attention to relevant and irrelevant text information. And perhaps as importantly for this study, working memory is related to the degree to which readers strategically adjust their processing based on reading goals (Linderholm & van den Broek, 2002). Thus, working memory is an important potential contributor to processing that might influence or be influenced by mood. In support of this, adults with high working memory are better able to regulate their emotions, making them less susceptible to processing changes as a result of mood (Schmeichel, Volokhov, & Demaree, 2008). Alternatively, mood might override cognitive factors, such that working

memory does not influence any mood-driven effects (although, given previous work, this would be surprising).

Method

Participants

110 native English speaking undergraduates (36 males and 72 females) in psychology and education departments participated in this experiment. There were 84 Caucasian, 1 Native American, 9 African American, 7 Asian, and 7 Hispanic participants. The average age was 23.89 years (*SD* = 9.17). The data from nine participants were dropped from the analyses due to technical malfunctions or inattentive participation.

Materials

Mood Induction—Participants were randomly assigned to a neutral, happy, or sad mood group. To induce these moods, participants watched approximately 12 minutes of video clips utilizing the induction methodology described by Rottenberg, Ray, and Gross (2007). Participants in the sad condition watched film clips from "The Champ," "The Lion King," "Return to Me," and "Bambi" (Gross & Levenson, 1995; Rottenberg, et al., 2007). Participants in the neutral conditional watched a clip from "Alaska's Wild Denali" (Rottenberg, et al., 2007) and a National Geographic clip about the Greater Barrier Reef (Cryder, Lerner, Gross, & Dahl, 2008). Participants in the happy condition watched film clips from "Whose Line is It Anyway?" (Rottenberg, et al., 2007). The videos were played on a large computer screen, with participants sitting on a couch and wearing headphones during presentations of the film clips.3

PANAS-X—Immediately before and after watching the video clips, participants completed the PANAS-X, a questionnaire assessing participants' current moods. The questionnaire provides a checklist of emotional terms, and asks participants to rate the degree to which they are feeling those emotions on a 1 to 5 scale, with 1 labeled "very slightly or not at all" and 5 labeled "extremely." The instrument has high reliability and validity (Watson & Clark, 1994; Watson, et al., 1988). Items on the instrument can be grouped into subsets for assessing mood, and the subsets identified as most relevant for the current project included positive affect, joviality, negative affect, and sadness. Positive affect reflects the extent to which a person feels energetic, pleasurably engaged, and enthusiastic. Joviality falls within this basic positive emotion scale, but more specifically measures moods such as happiness and cheerfulness. Negative affect generally refers to the extent to which a person feels negative mood states, such as anger, fear, or sadness, and is unpleasantly engaged. Sadness falls within this basic negative emotion scale, and more specifically measures moods such as sadness and loneliness. The Positive and Negative Affect scales had coefficient alphas of .83 and .80 (pre-induction), and .91 and .86 (post-induction), respectively, in our samples.

Texts—Participants were asked to read one of four expository texts, adapted from *Scientific American*4, with text assignment counterbalanced across the mood induction conditions. These texts were previously used by van den Broek et al. (2001). The texts ranged in length

[3]As an additional check on the appropriateness of the clips for each condition, at the end of the experiment we asked participants to provide ratings on the overall mood of the films that they watched, using a Likert scale with 1 labeled very sad, and 7 labeled very happy. A one-way ANOVA was conducted to compare the rated moods of the films in each condition. The overall effect was significant, $F(2, 98) = 297.13$, $p < .001$, $\eta^2 = .86$. Post-hoc Tukey tests revealed that the films presented in the happy condition ($M = 6.68$, $SD = .59$) were rated as happier than the films in the sad ($M = 1.50$, $SD = 1.05$, $p < .001$) and neutral ($M = 5.24$, $SD = 1.00$, $p < .001$) conditions. The films presented in the sad condition were rated as sadder than the films in the happy ($p < .001$) and neutral conditions ($p < .001$).

[4]The texts used in this study can be accessed at: http://webs.wichita.edu/depttools/depttoolsmemberfiles/COEdCESP/Sample%20Stimuli.pdf

from 656 to 771 words and had an average Flesch Kincaid Grade level of 11.2. The topics of the texts included the origins of the moon, sea turtle migration, therapies for meningitis, and changes in songbird populations. All of the texts described a problem found in nature, and then described several different hypotheses to potentially explain the problem. Each text ended with a description of and evidence for the most likely hypothesis. The texts were descriptive and did not contain emotional information.

Working Memory—Each participant completed the Reading Span Task of working memory (Singer & Ritchot, 1996), which is a modified version of the original task by Daneman and Carpenter (1980). In this task, the participant reads a set of unrelated sentences on a computer screen, one sentence at a time. While reading the sentences, they are asked to recall the final word presented in each sentence, as well as comprehend and remember sets of those sentences. Specifically, after reading each set of sentences, the participant is asked to recall the last word of each sentence in the set. Then, participants are presented one of the sentences from the set with two words missing. Their task is to fill in the missing words. Participants began with smaller sets of sentences (four sets of two sentences each), and proceeded sequentially to larger sets (three sets of three, then four, and then five sentences each).

Generally, span measures of this type have high reliability and validity (Miyake, 2001; Waters & Caplan, 2003). But for this task, a participant's score was calculated as the total number of final words recalled, but only for the sets in which both missing words were correctly recalled. Compared to a set size score, this continuous score is more normally distributed, has higher reliability, and higher criterion validity (i.e., Friedman & Miyake, 2005; Linderholm & van den Broek, 2002; Virtue, van den Broek, & Linderholm, 2006). Participants were randomly assigned to complete the Reading Span task at either the beginning or the end of the session to control for order effects. Cronbach's Alpha was adequate, $\alpha = .83$.

Distracter Task—In order to reduce any recency effects on memory performance, participants completed 3-minutes worth of paper-and-pencil addition and subtraction problems following the think aloud task. Their answers were not scored, because the sole purpose of the task was to prevent participants from rehearsing the text before providing their recalls.

Apparatus

The PANAS-X and the working memory tasks were presented on a Dell computer using E-Prime software. Participants were seated in front of a color monitor with their right hand resting on the mouse. The text was centered on the screen in standard upper- and lower-case type. The distracter task was completed on paper.

Pilot Study

Few projects have utilized mood induction procedures to evaluate participants' ongoing reading and resulting memory for extended texts. To test whether the mood induction would serve as a valid method for examining these issues, we conducted a pilot study with the procedure. The pilot study employed a music-based rather than a video-based mood induction procedure, based on their analogous effects in the extant literature (Eich, Ng, Macaulay, Percy, & Grebneva, 2007; Rottenberg, et al., 2007). One hundred and twenty-six native-English speaking undergraduate students were randomly assigned to a control (no mood induction), happy, or sad mood group. Happy and sad groups listened to 12 minutes of classical music using the methodology of Ferraro et al. (2003); participants in the neutral group did not listen to any music5. Participants first completed the PANAS-X, and then

engaged in a practice think aloud task. They next listened to 12 minutes of happy, sad, or no music. Following the induction, they again completed the PANAS-X. Next, participants engaged in a think aloud task with one of the four texts.

To test the effectiveness of the happy induction procedure, 2(happy vs. neutral) × 2(pre- vs. post-induction) repeated measures ANOVAs were conducted. Negative affect scores were higher at pre-induction than post-induction, $F(1, 83) = 29.27$, $p < .001$, $\eta^2 = .26$. None of the other effects were significant (F-values < 3.80). When the dependent variable was positive affect, none of the effects were significant (F-values < 3.38).

To test the effectiveness of the sad induction procedure, 2(sad vs. neutral) × 2(pre- vs. post-induction) repeated measures ANOVAs were conducted. Negative affect was higher at preinduction than at post-induction, $F(1, 82) = 19.06$, $p < .001$, $\eta^2 = .19$. None of the other effects were significant (F-values < 1.51). Positive affect scores were greater at pre-induction than post-induction, $F(1, 82) = 18.16$, $p < .001$, $\eta^2 = .18$. The condition main effect was not significant ($F = .74$). The interaction was significant, $F(1, 82) = 7.71$, $p = .007$, $\eta^2 = .086$. Participants in the sad condition had higher pre-induction positive affect scores than the post-induction scores for the sad and the neutral group (p-values < .03).

These results indicate that the mood induction was not entirely effective. Although the pre-post scores indicate reductions in opposite moods as a function of inductions, we did not see direct increases in matching mood as a function of those inductions. It may be that individual differences in music preference interfered with the efficacy of the musical induction procedure (Carter, Wilson, Lawson, & Bulik, 1995). We therefore considered whether pre-existing differences between participants' naturalistic moods might predict comprehension processes. Naturalistic moods might, to some degree, be resistant to the induction procedures, and in and of themselves prove informative with respect to mood-driven influences on text processing (Fernandez-Borrocal & Extremera, 2006; Gross, Sutton, & Ketelaar, 1998; Scherrer & Dobson, 2008). Thus, we used post-induction PANAS-X scores in a multiple regression to predict text-based coherence processes, knowledge-based coherence processes, and non-coherence processes. Each model controlled for the text the participant read and how often the participants listened to classical music. Then, the relevant mood measure from the PANAS-X (positive affect, negative affect) was added as a predictor to determine whether it explained unique variance.

Positive affect explained unique variance with regard to text-based coherence processes, $\Delta F(1, 118) = 6.23$, $p = .01$, $\Delta r^2 = .05$, and non-coherence processes, $\Delta F(1, 118) = 6.06$, $p = .01$, $\Delta r^2 = .05$. Positive affect did not explain unique variance with regard to knowledge-based coherence processes, $\Delta F(1, 118) = .66$, $p > .05$, $\Delta r^2 = .005$. Participants higher in positive affect engaged in more text-based coherence processes ($\widehat{\beta} = .10$, $SE = .04$, $t = 2.50$, $p = .01$) and fewer non-coherence processes ($\widehat{\beta} = -.10$, $SE = .04$, $t = 2.46$, $p = .01$), but positive affect did not predict knowledge-based coherence processes ($\widehat{\beta} = -.02$, $SE = .02$, $t = .81$, $p > .05$). Negative affect did not explain any unique variance in processing.

These results suggest that mood may be associated with the processes readers engage in during comprehension. Readers who were higher in positive affect engaged in more text-based coherence processes, and fewer non-coherence processes, than did readers lower in

[5]We opted to have participants not listen to any music as a neutral condition because the effects of music on an individual's mood can differ depending on the participants' experiences and beliefs about melody, pitch, rhythm, and so on. Therefore, individual preferences for music can affect the strength and direction of the effect of the music on the participant (Carter, et al., 1995; Vastfjall, 2001-2002). This could potentially obviate the impact of a song selected to induce a neutral mood. The happy and sad music employed in the pilot avoided this issue because it was suitably tested in previous work by Ferraro et al. (2003).

positive affect. Unfortunately, the mood manipulation was not directly responsible for the differences observed between readers. This is problematic because it does not allow for causal claims to be made regarding the relation between mood and cognitive processing during comprehension. Thus, while the effects of mood were obtained in the project, they were not derived from the induction. The pilot study revealed the need for considering an even stronger mood induction procedure than the music-based procedure. A video-based induction was selected, as described earlier in the Methods, because prior work has indicated it can have strong effects on mood (Rottenberg, et al., 2007; Westerman, Spies, Stahl, & Hesse, 1996). We now turn to the video-based procedure.

Procedure

To control for order effects, participants were randomly assigned to one of two different conditions in which the order of the tasks varied. In the first condition, following the consent process, participants engaged in a practice think aloud task. During this task, the experimenter demonstrated think aloud productions, with examples drawn from a rubric developed to exemplify all possible processes (e.g., elaborative inferences, paraphrases, predictions, etc.). After this demonstration, participants continued thinking aloud with the remainder of the practice text. Participants were asked to read the text one sentence at a time, with each sentence printed on a separate index card in a sorted stack. After reading each sentence, participants were asked to state their thoughts out loud before turning to the next index card. Participants received no help with decoding words or answering questions about the text, but received non-leading prompts if they forgot to think aloud, such as “What are you thinking now?” (Ericsson & Simon, 1993).

Following this practice task, participants were asked to complete the PANAS-X. After filling out the questionnaire, each participant watched the happy, sad, or neutral film clips. Participants were instructed to focus on the scenes, to try to let themselves feel the emotion that the films were trying to convey, and to allow themselves to become immersed in the films. After viewing the clips, the participants completed the PANAS-X a second time.

Following this, participants were randomly assigned to one of the four texts, and engaged in the think aloud task using the same procedures as described for the practice text (e.g., Trabasso & Magliano, 1996). Only one text was used for each participant because the texts were relatively long (656-771 words). The think aloud session lasted an average of 10 minutes and 46 seconds (*SD* = 2 minutes, 46 seconds). With regard to the verbosity of the think alouds, the average response to each card contained 16.50 words (*SD* = 6.82 words). As verified by ANOVAs in which the independent variable was condition, and text was a covariate, there were no differences across the mood induction conditions with regard to the length of the think aloud sessions or the verbosity of the productions (*F*-values < 1.02). The entire session was recorded using an mp3 recording device.

Following the think alouds, participants completed the distracter task. After the 3-minute task, they were asked to summarize the text and to make sure that they included what they thought were the most important points. Finally, participants completed the reading span task. Additionally, participants in the sad mood condition watched the happy film clips to ensure they would not leave the experiment in an experimentally induced sad mood.

The above description outlines one of the two sequences of tasks, intended to control for potential order effects. Participants who were randomly assigned to the other order condition engaged in the same procedure, with the only difference being that the reading span task was completed at the beginning of the session, immediately following the consent process.

Results

Mood Induction Verification

To begin, we assessed the effectiveness of the mood induction procedure, as measured with the PANAS-X. (See Table 1 for all descriptive statistics.) This proves crucial given the lack of induction effects obtained in the pilot music manipulation. Negative affect and sadness scores were highly correlated at both pre-induction (r = .63, p < .001) and post-induction (r = .82, p < .001). Positive affect and joviality scores were also highly correlated at both pre-induction (r = .88, p < .001) and post-induction (r = .90, p < .001). Because of these high correlations, we only report results for positive and negative affect.

To validate the effectiveness of the happy mood induction, 2 (Happy vs. Neutral) × 2 (pre- vs. post-induction) ANOVAs were run. When the dependent variable was negative affect, the main effect of pre- vs. post-induction was significant, such that the pre-induction scores were higher than the post-induction scores, $F(1, 70) = 50.63$, $p < .001$, $\eta^2 = .42$. There was a main effect of condition, $F(1, 70) = 5.50$, $p < .01$, $\eta^2 = .07$, such that neutral-induced participants had higher negative affect than happy-induced participants. The interaction was not significant.

When the dependent variable was positive affect, neither of the main effects were significant (F-statistics < 2.40), although the interaction was significant, $F(1, 70) = 11.10$, $p < .001$, $\eta^2 = .14$. Post-hoc tests revealed that positive affect increased from pre- to post-induction for the happy-induced group. In addition, at post-test, the happy-induced group had higher scores than the neutral-induced group (p-values < .05).

To validate the effectiveness of the sad mood induction, 2 (Sad vs. Neutral) × 2 (pre- vs. post-induction) ANOVAs were run. When the dependent variable was negative affect, the main effect of pre- vs. post-induction was not significant (F = 1.65). However, the main effect of condition was significant, such that sad-induced participants had higher negative affect scores than neutral-induced participants, $F(1, 69) = 4.51$, $p < .04$, $\eta^2 = .06$. Additionally, the interaction was significant, $F(1, 69) = 3.06$, $p < .01$, $\eta^2 = .33$. Post-hoc tests revealed that sad-induced participants had higher levels of negative affect at post-induction compared to neutral-induced participants, and negative affect increased pre- to post-induction for sad-induced participants. Negative affect decreased pre- to post-induction for neutral-induced participants. In addition, neutral-induced participants at post-induction had lower degrees of negative affect than sad-induced participants at pre-induction (p-values < .01).

When the dependent variable was positive affect, the main effect of pre- vs. post-induction was significant, $F(1, 69) = 56.48$, $p < .001$, $\eta^2 = .45$, such that positive affect was greater at pre-induction than at post-induction. The main effect of condition was also significant, such that neutral-induced participants were higher in positive affect than sad-induced participants, $F(1, 69) = 9.11$, $p = .004$, $\eta^2 = .12$. The interaction was also significant, $F(1, 69) = 14.06$, $p < .001$, $\eta^2 = .17$. Post-hoc tests indicated that positive affect decreased from pre- to post-induction in the sad-induced group. At post-induction, positive affect was lower in the sad-induced than in the neutral-induced group. In addition, the sad-induced group at post-induction had lower positive affect scores than the neutral group at pre-induction (p-values < .001).

Based on these results, the mood induction procedure was deemed to be effective6.

Scoring of the Think Aloud Protocols

Participants' responses during the think aloud task were recorded and transcribed. The predominant think aloud comment associated with each sentence in the text was scored for category of response by four judges blind to each participant's experimental condition, and each of the four judges scored an equal number of each of the four possible texts. A comment was considered predominant if the four judges independently deemed that it constituted the essence of the utterance, as a function of the sentence under consideration.

The response categories helped identify the type of processes engaged in by a reader at the point in the text during which a particular comment was provided. The categories of responses were adapted from van den Broek et al. (2001), and included the following: *associations* (comments providing information not related to text coherence); *elaborative inference/explanations* (comments employing background knowledge to explain the current text sentence); *connecting inference/explanations* (comments mentioning an immediately preceding sentence to explain the current text sentence); *reinstatement inferences* (comments mentioning information from earlier in the text, but not the immediately preceding sentence, to explain the current sentence); *predictive inferences* (comments that anticipate the upcoming text); *paraphrases* (comments that capture the gist meaning of a sentence); *evaluations* (opinions about the text); *monitoring comprehension* (reflections on one's understanding of the text); *affective responses* (emotional comments about the text, coded as either positive or negative); and *text repetitions* (verbatim repeating of all or a large proportion of the current sentence). Non-responses and responses that did not fall into any of these categories were scored as *other*. In addition, if a participant made a comment that reflected a misunderstanding of the text, it was also coded as *invalid*. Cohen's *kappa* was used to determine inter-rater agreement, which was acceptable (k = .88). Disagreements between judges were resolved by discussion. Table 2 contains examples of participant responses that correspond to each of the think aloud categories.

The frequencies with which participants engaged in each type of think aloud process were calculated and averaged into proportion data. (Because the texts were different lengths, transforming the data into proportions was necessary for comparison.) Because proportion data is often non-normal, an arcsine transformation was performed. The think aloud responses were then split into groupings that represented coherence-based and non-coherence-based processing.

Conceptually, paraphrases (P), connecting inferences (CI), reinstatement inferences (RI), elaborative inferences (EI), and predictive inferences (PI) were placed in the coherence-based category, whereas associations (A), evaluations (E), monitoring comprehension7 (MC), affective responses (positive: ARP, and negative: ARN), text repetitions (TR), and the "other" category (O) were placed in the non-coherence-based category. These groupings are all consistent with those described in van den Broek et al. (2001). The processes associated with the coherence-based category help to increase coherence by connecting the current sentence with the text or with background knowledge, to support understanding of

[6]To determine whether mood induction might also have affected post-induction attentiveness scores, a 3 (condition) × 4 (text) ANOVA was conducted. There was a main effect of condition, $F(2, 95) = 5.49$, $p = .006$, $\eta^2 = .10$. Post hoc Tukey tests revealed that participants in the happy condition had higher attentiveness scores than participants in the sad condition. There was no main effect of text, nor was there an interaction (F-values < .95). Because attentiveness varied based on condition, we checked whether attentiveness was related to think aloud processing. Multiple regressions were conducted such that the independent variables were post-induction attentiveness, condition, and text. In every model, attentiveness failed to predict think aloud processing (p-values > .22).

[7]Monitoring comprehension can conceptually function in the service of understanding a text (Lorch, et al., 1993). For the current coding, however, monitoring comprehension responses happened infrequently, and almost all specifically referred to comments that were not focused on text content. For example, most comments served to very generally confirm understanding (e.g., "I know that") or to acknowledge the receipt of new knowledge (e.g., "I didn't know that"), in line with van den Broek et al. (2001).

the text. Processes associated with the non-coherence category, although generally providing elaborative details, contribute less toward (and perhaps less directly toward) building a coherent representation of the text (Cote, et al., 1998; Trabasso & Magliano, 1996; van den Broek, et al., 2001; Zwaan & Brown, 1996).

Pearson correlations between the variables were computed to verify the coherence and non-coherence groupings (see Table 3). These correlations, however, revealed that the elaborative and predictive inferences exhibited few significant positive correlations with the other types of text-based coherence inferences. Elaborative and predictive inferences are associated with going beyond the information contained in the text (e.g., Graesser, et al., 1994). Doing so comes at a processing cost to the reader, and often involves the recruitment of background knowledge (Campion, 2004; Weingartner, et al., 2003; Zwaan & Rapp, 2006). For these reasons, elaborative and predictive inferences were considered as a grouping separate from the other coherence-building processes. This left three groupings; responses that were focused on the text itself, which we termed text-based coherence processes; responses that were focused on the recruitment of background knowledge, which we termed knowledge-based coherence processes; and responses that were not in the service of building coherence, which we termed non-coherence processes.

To evaluate these groupings, a confirmatory factor analysis was conducted using maximum likelihood estimation. Unfortunately, the model did not have a good fit: $\chi^2(51) = 88.08$, $p < .001$; Root mean square error of approximation (*RMSEA*) = .26; Comparative Fit Index (*CFI*) = .32. Therefore, an exploratory factor analysis[8] was conducted to determine more appropriate groups. The extraction method was Principal Components analysis, and varimax rotation was used. This analysis revealed three factors with an Eigenvalue of greater than 1 and that explained greater than 10% of the variance (see Table 4).

The first factor had high factor loadings for connecting and reinstatement inferences, so this factor was labeled text-based inferences. The second factor had high loadings for elaborative and predictive inferences, so this factor was labeled knowledge-based inferences. The third factor had high loadings for associations, evaluations, and monitoring comprehension comments, so it was labeled non-coherence processes. Paraphrases had a high factor loading with non-coherence processes, however this loading was negative (−.91). Therefore, paraphrases were considered to be a separate factor. Several processes did not load sufficiently (< .50) on any of the factors, and these included text repetitions, affective responses, and the “other” category. These variables also occurred the least frequently in comparison to all other processes. Therefore, these variables were removed from the analyses.

This left us with 4 categories: Paraphrases, Text-Based Inferences (connecting and reinstatement inferences), Knowledge-Based Inferences (elaborative and predictive inferences), and Non-Coherence Processes (associations, opinions, and monitoring comprehension). To confirm these groupings, another confirmatory factor analysis was used. Maximum likelihood estimation indicated that the model was indeed a good fit: $\chi^2(14) = 21.80$, $p > .05$; *RMSEA* = .075; *CFI* = .97. The non-transformed proportion data, separated by condition and working memory (high versus low, determined by a median split) are presented in Table 5.

[8]We thank an anonymous reviewer for suggesting this statistical procedure.

Processes During Reading

To begin, 3(condition: happy, sad, neutral) × 4(Text) × 2(high versus low working memory; determined by a median split) ANOVAs were run in which the dependent variables were the various categories of processing. On the working memory task, the mean score was 31.89 words correct (*SD* = 6.44). Based on condition, the means scores were 33.09 (*SD* = 5.88) for the happy condition, 30.15 (*SD* = 5.94) for the sad condition, and 32.21 (*SD* = 5.62) for the neutral condition.

For paraphrases, the main effect of condition was significant, $F(2, 72) = 4.23$, $p = .018$, $\eta^2 = .11$. Post-hoc Tukey tests revealed that happy-($p < .01$, $d = .81$) and sad-induced ($p < .05$, $d = .56$) participants generated more paraphrases than neutral-induced participants. The condition by working memory interaction was also significant, $F(2, 72) = 4.39$, $p = .016$, $\eta^2 = .11$. The neutral-induced participants with low working memory generated fewer paraphrases than all other groups except for sad-induced participants with high working memory (p-values < .03, .67 < d-values < .1.36). This indicates that the neutral mood induction procedure was more likely to affect the paraphrasing behavior of readers with low, as compared to high, working memory. None of the other effects were significant (F-values < 1.08).

For text-based inferences (connecting and reinstatement inferences), the main effect of condition was significant, $F(2, 71) = 3.33$, $p = .04$, $\eta^2 = .09$. Post-hoc Tukey tests revealed that happy-induced participants generated more text-based inferences than sad-induced participants ($p < .05$, $d = .46$). The text main effect was also significant, $F(3, 71) = 4.81$, $p = .004$, $\eta^2 = .17$. Post-hoc-Tukey tests revealed only one text difference: the *Sea Turtles* text elicited more text-based inferences than the *Songbirds* text ($p = .007$, $d = 1.23$). None of the other effects were significant (F-values < 2.14).

Next, we examined knowledge-based coherence processes (elaborative and predictive inferences). The main effect of condition was not significant, $F(2, 71) = .24$, $p > .05$, $\eta^2 = .01$. The main effect of text was not significant, $F(3, 71) = 1.16$, $p > .05$, $\eta^2 = .04$. The main effect of working memory was not significant, $F(1, 71) = .56$, $p > .05$, $\eta^2 = .01$. None of the two-way interactions were significant (F-values < .77). Finally, the three-way interaction was not significant, $F(6,71) = .89$, $p > .05$, $\eta^2 = .07$.

For non-coherence processes, the main effect of condition was significant $F(2, 69) = 8.68$, $p < .001$, $\eta^2 = .20$. Post-hoc Tukey tests revealed that neutral-induced participants generated more non-coherence processes than happy-induced ($p = .001$, $d = 1.02$) and sad-induced participants (although this was not significant, $p < .10$, $d = .53$). There was no difference between the happy- and sad-induced participants. The condition by working memory interaction was significant, $F(2, 69) = 4.05$, $p = .02$, $\eta^2 = .11$. Neutral-induced participants with low working memory generated more non-coherence processes than participants in all other groups, p-values < .02, .97 < d-values < 1.86. This indicates that the neutral mood induction procedure was more likely to affect the generation of non-coherence processes in readers with low, as compared to high, working memory. None of the other effects were significant (F-values < 1.29).

Post-Reading Memory

The post-reading summaries were coded such that each statement a participant made was matched to the corresponding idea units in the text. The texts were submitted to an analysis in which the most important ideas (mainly topic sentences) were identified. Two raters independently identified these components within each text, and disagreements were resolved via discussion. The percentage agreement was 92%. Participants' responses were

compared with these codings to evaluate what proportion of the highly important idea units were included in their summaries, and this proportion was arcsine transformed.

A 3(condition) × 4(text – random factor) × 2(high versus low working memory, determined by a median split) mixed model ANOVA indicated that there was a significant condition by text interaction, $F(6, 6) = 4.90$, $p < .04$, $\eta^2 = .83$. Post hoc tests indicated that for three of the four texts (the texts about *Sea Turtles*, *Meningitis*, and *Songbirds*), happy- and sad-induced participants remembered more main ideas than neutral-induced participants. For the text entitled *Origins of the Moon*, happy-induced participants remembered fewer main ideas than sad-and neutral-induced participants. None of the other effects were significant (F-values < 2.19).

Because the *Origins of the Moon* text produced a different pattern of results, we removed it and re-ran the same analysis. The main effect of condition was significant, $F(2, 4.06) = 8.78$, $p = .03$, $\eta^2 = .81$. Post-hoc Tukey tests revealed that neutral-induced participants recalled fewer important ideas than both happy- ($p = .003$) and sad-induced ($p < .05$) participants. None of the other effects were significant (F-values < 3.96).

Discussion

The goal of this study was to determine the extent to which mood exerts a role on readers' comprehension experiences during reading. We examined the processes readers applied as they read expository texts, as well as reader memory for the texts. The results indicated that happy- and sad-induced participants, in contrast with participants induced with a neutral mood, engaged in more paraphrasing. Neutral-induced participants, in contrast with participants induced with a happy mood, engaged in more non-coherence processes. In addition, happy-induced participants, in contrast with participants induced with a sad mood, engaged in more text-based inferences. Finally, happy- and sad-induced participants remembered more of the important details in texts than participants in the neutral mood condition. The results from this experiment demonstrate that mood may influence the processes readers rely on during comprehension, and can influence post-reading memory.

Alignment with Previous Work

Performance of participants in a positive mood was similar to the process and product results that have traditionally been reported in projects for which readers are provided with a study goal. Specifically for those projects, readers in a positive mood engaged in paraphrasing and text-based inferencing, but did not engage many non-coherence processes. In addition, performance of participants in the neutral condition for the current study was similar to that of readers provided with an entertainment goal; specifically, they engaged in non-coherence processes and less paraphrasing (Linderholm & van den Broek, 2002; van den Broek, et al., 2001). For the projects that have asked participants to read for study or entertainment, those goals were explicitly instantiated through experimental instructions that incurred particular reading strategies. In contrast, participants in the current project were not presented with an explicit goal manipulation; rather, their reading tendencies emerged following a mood induction. Despite little in the way of explicit encouragement to employ particular reading strategies, participants applied think aloud processes to their reading as a function of mood in a manner analogous to goal-based manipulations. This suggests that influences less task-driven than explicitly instructed goals can guide the standards readers might utilize during comprehension.

The findings from the current study also inform research that has examined mood and cognition in the context of resource allocation models. Previous studies have argued that negative affect can lead to the production of irrelevant, interfering thoughts (Ellis, et al.,

1997; Ellis, et al., 1995). These thoughts use up cognitive resources, which might decrease performance in general and comprehension in particular. In line with that work, participants in the sad-induced condition engaged in fewer text-based inferential processes than happy-induced participants. However, participants in the neutral mood condition, as compared to the sad-induced condition, actually produced more non-coherence processes.

More recent accounts of resource allocation have begun to argue that negative affect does not necessarily lead to any performance decrement. Instead, it can lead to rather diffuse attention such that both relevant and irrelevant information receive focus (Sedek & von Hecker, 2004; von Hecker & Meiser, 2005), along with a methodical, but not creative, approach to problem solving (G. Hertel, et al., 2000), as discussed in the Introduction. The performance of the sad-induced participants in the current experiment is consistent with this 'no decrement' view. Sad-induced participants remembered the same amount of important information as happy-induced participants, suggesting that their focus was not detracted from relevant textual information. Sad-induced participants also engaged in the same amount of paraphrasing as happy-induced participants, suggesting that they attended to relevant textual information during processing.

However, sad-induced participants engaged in the same amount of non-coherence processing as the happy-induced participants, suggesting little in the way of additional focus by on text-irrelevant information. This is inconsistent with resource allocation accounts. One important difference did seem to emerge between these groups: Sad-induced participants engaged in fewer text-based inferential processes than happy-induced participants. This is consistent with the affect infusion model, which argues that negative moods decrease the connections made between important elements in a text or task (Forgas, 1995).

Little difference was observed as a function of mood with regard to knowledge-based coherence processes, which are processes readers use to explain or make predictions about the text using background knowledge (Campion, 2004; Weingartner, et al., 2003). This is a somewhat counterintuitive finding: Recall that deeper, substantive processing should be specifically useful for explicating mood effects (Bower & Forgas, 2001; Fiedler, 2001; Forgas, 1995). Applying prior knowledge to generate predictions about text information requires a greater awareness and understanding of the text than making bridging connections between text components (Fletcher, 1989; Graesser, et al., 1994; Kendeou & van den Broek, 2007; Rapp, 2008; van den Broek, Risden, & Husebye-Hartmann, 1995). Therefore, this activity should reflect more substantive processing.

A potential explanation for the lack of knowledge-based effects might invoke their necessary dependence upon some level of familiarity with the content of a text. Recall the current study employed expository texts providing scientific accounts of natural phenomena. Expository texts, as compared to narratives, usually prompt readers to integrate textual information with prior knowledge (McDaniel & Einstein, 1989; Wolfe, 2005; Wolfe & Mienko, 2007). However, without sufficient prior knowledge these texts might not afford integrative behaviors. Thus, the deeper processing intended with the texts might be more likely to occur with some modest amount of familiarity with the topics. Future investigations of mood might examine how prior knowledge additionally influences comprehension processes. Although the current project did not specifically evaluate prior knowledge for the text topics, the findings here are still worthy of consideration, because many of our experiences with texts (e.g., class assignments, magazine articles about new discoveries) involve learning about information for which we possess relatively little prior knowledge.

Working Memory and Standards of Coherence

The current project also tested whether working memory might protect readers from the guiding effects of mood on reading activity (i.e., Schmeichel, et al., 2008). Participants in the neutral condition with low working memory engaged in fewer paraphrases and more non-coherence processes than almost all of the other groups, save for participants in the neutral condition with high working memory. This difference within the neutral group suggests that working memory might help readers overcome mood based effects. This is consistent with work showing that individuals with higher working memory are better able to regulate emotions and thus are less affected by mood (Schmeichel, et al., 2008). It is also consistent with work contending that individuals with higher working memory are better able to alter their cognitive processing strategies as a function of their reading goal (Linderholm & van den Broek, 2002).

The findings from the working memory analyses indicate that investigations of how reading strategies or approaches might be more or less malleable should also prove informative for understanding how readers develop and apply their decisions (explicit or otherwise) about how to understand a text. One intriguing hypothesis is that working memory might help readers avoid the types of processes that fail to support comprehension, even when those processes are potentially invoked by non-strategic influences such as mood.

A more general issue related to this point is whether readers are always aware of their reading strategies, or more generally, explicitly aware of their standards of coherence. If participants are tasked with approaching texts in particular ways (such as to read for study versus entertainment; edit a paper for grammar or theme; find inaccurate statements), they might work to establish strategies that enhance their successful completion of the assignment. In these cases, it seems likely that readers have at least some notion regarding the types of activities that might prove more or less useful for completing such tasks. Nevertheless, it could be the case that readers hold beliefs about how they differentially process material when they are feeling sad or happy, or the ways in which happy or sad experiences can change their thinking about or interactions with the world. Standards of coherence no doubt fall on a continuum with respect to whether individuals are aware of their standards, whether individuals actively rely on those standards, and the degree to which standards can change over time. Consideration of only those standards that are explicitly provided to participants limits the range of activities in which readers regularly engage during learning, and the generalizability of claims with respect to everyday comprehension.

The Role of Arousal

As discussed, participants in the neutral condition engaged in more non-coherence processes than participants in the happy condition, and less paraphrasing than participants in the happy and sad conditions. One possible reason for the observed pattern could be that the neutral film clips were not actually devoid of mood-instantiating effects. Viewing clips devoid of emotion, such as abstract visual displays, for long periods of time can lead to negative feelings (e.g., annoyance). In contrast, films that produce mild levels of contentment, such as the films in this study, can reduce negative affect and foster relaxation (Rottenberg, et al., 2007). It is possible that such relaxation led participants to engage in more non-coherence processes (which, we note, is similar to the processes observed for participants tasked with an entertainment goal). If so, future work might examine the role of arousal on comprehension processes (Bradley, Greenwald, Petry, & Lang, 1992; Revelle & Loftus, 1992; Russell, 1980). While individuals might experience differential mood states (e.g., happy or sad) as a function of traditional induction procedures, their arousal levels might fail to vary as a function of those inductions (or perhaps vary in ways that are not correlated with

mood). Arousal might therefore underlie some of the process and product effects observed in mood induction studies.9

Similarly, arousal might also underlie some of the effects that have been reported in projects on standards of coherence that have explicitly instructed participants to read with specific goals in mind. For example, if participants are asked to read for study or entertainment in rooms that are more brightly lit compared to settings in which the ambience is more subdued (as in previous work, e.g., van den Broek, et al., 2001), observed effects might not solely be a function of the task but also of the mood and arousal these environments and tasks engender. Because core aspects of the current findings resemble those obtained in projects comparing study versus entertainment conditions, the effects might similarly be a consequence of unintended arousal manipulations. If this is the case, the findings nonetheless suggest that reading processes can be guided by factors that are potentially orthogonal to strategic instructional effects.

Interactions Between the Reader, Text, and Task

The current study highlights the need to examine interactions that can occur between the reader, text-level factors, and tasks with respect to mood influences on cognition. As one example, this study demonstrated that working memory, a reader characteristic, protected readers from the varying effects of mood on processing. It is possible that other reader characteristics, such as reading skill or persistent emotional traits, could similarly play a role in an individual's susceptibility to mood induction procedures or to the effects of mood on processing. Because mood can be a challenging construct to measure and manipulate, an interesting avenue for future work may be to examine how such reader variables interact with the mood induction procedure itself (with the utilization of multiple manipulation checks), as well as the approaches readers utilize when comprehending a text.

The content of the text can also influence the processes utilized during comprehension. This emerged in the current project in an unintended but interesting way: The *Origins of the Moon* text, as compared to the other texts, obtained a different pattern of recall as a function of mood. It is possible that textual factors, such as content or syntactic complexity, could interact with mood. To investigate this possibility, we conducted a post-hoc analysis of the textual properties using Coh-Metrix (a tool that assesses the coherence and readability of texts, Graesser, McNamara, Louwerse, & Cai, 2004; McNamara, Louwerse, Cai, & Graesser, 2005, January 1). Compared to the other texts, the *Origins of the Moon* exhibited greater syntactic complexity, containing more negations and connections (such as *but, until*, or *although*). In addition, the content words were more abstract and occurred at a lower frequency than in the other texts. Although these variables were not systematically manipulated across texts, one possibility is that syntactic complexity and abstract content, among other textual variables, could interact with the effects of mood. If so, the investigation of the role of text-level factors and mood on comprehension experiences would further prove an interesting line of future work.

With regard to task-level factors, the current study utilized think alouds, which are useful for examining the types of processing that readers engage in over the course of reading. Think alouds capture instances of inferential processing, and provide insight into what is available

[9]With regard to the current findings, an interesting possibility could be that the role of mood on processing differs over the course of an experimental session. For example, it is possible that at the beginning of a task, participants might exhibit patterns associated with one mood, but as the task unfolds, another mood might emerge or the intensity of an existing mood might fade. To test this possibility, we separated the experimental session into sections, examining processing for the first third, the middle third, and the last third of the texts separately. We observed little variation in processing over the course of the experimental session: Results for each section were mostly consistent throughout the text.

from memory to the reader during comprehension (Ericsson & Simon, 1993; Trabasso & Magliano, 1996). But like any methodology, think alouds present certain challenges. For example, reading a text line-by-line, and speaking after each line, could interfere with processing (Magliano & Graesser, 1991; Nisbett & Wilson, 1977). Think alouds might also encourage processes that would not occur under traditional, silent reading conditions. Nevertheless, think alouds provide a starting point for the analysis of processing strategies during the course of reading (Ericsson & Simon, 1993; Trabasso & Magliano, 1996). The application of other methods (e.g., eye movements or reading times) in combination the above investigations would further determine whether mood can affect comprehension, as well as under what conditions mood specifically interacts with text processing.

Conclusions

The current findings serve to build additional links between research on mood and investigations of the processes that underlie successful comprehension. Our understandings of the world are often based on experiences that we have with texts. These experiences can occur in formal and informal educational settings (e.g., in schools, with textbooks, with museum exhibits, etc.). Much of the work on the design of interventions to make these experiences more effective has focused on the nature of the content and learning tasks. However, the findings of the current project indicate that a reader's mood might also exert an important influence on these experiences. If the activities that readers engage in to support their attempts at comprehending texts are influenced not just by task instructions but also by reader mood (even if that mood is neutral), it suggests a rather important need to address mood in intervention design. This is a claim that might not be all that striking to instructors in classrooms, but has certainly remained relatively understudied to date in research on reading comprehension.

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References

Anderson RC, Pichert JW. Recall of previously unrecallable information following a shift in perspective. Journal of Verbal Learning and Verbal Behavior. 1978; 17(1):1–12.

Batson, CD.; Shaw, LL.; Oleson, KC. Differentiating affect, mood, and emotion: Toward functionally-based conceptual distinctions. In: Clarke, MS., editor. Emotion. Sage; Newbury Park, CA: 1992. p. 294-326.

Best RM, Floyd RG, McNamara DS. Differential competencies contributing to children's comprehension of narrative and expository texts. Reading Psychology. 2008; 29:137–164.

Bless H, Schwarz N, Wieland R. Mood and the impact of category membership and individuating information. European Journal of Social Psychology. 1996; 26(6):935–959.

Bower GH. Mood and memory. American Psychologist. 1981; 36(2):129–148. [PubMed: 7224324]

Bower GH. Commentary on mood and memory. Behaviour Research and Therapy. 1987; 25:443–455. [PubMed: 3322254]

Bower, GH.; Forgas, JP. Mood and social memory. In: Forgas, JP., editor. The handbook of affect and social cognition. Vol. Vol. 95-120. Earlbaum; Mahwah, NJ: 2001.

Bower GH, Gilligan SG, Monteiro KP. Selectivity of learning caused by affective states. Journal of Experimental Psychology: General. 1981; 110(4):451–473.

Bradley MM, Greenwald MK, Petry MC, Lang PJ. Remembering pictures: Pleasure and arousal in memory. Journal of Experimental Psychology: Learning, Memory, and Cognition. 1992; 18(2):379–390. doi: 10.1037/0278-7393.18.2.379.

Brand S, Reimer T, Opwis K. How do we learn in a negative mood? Effects of a negative mood on transfer and learning. Learning and Instruction. 2007; 17:1–16.

Brewer, WF. Literary theory, rhetoric, and stylistics: Implications for psychology. In: Shapiro, RJ.; Bruce, BC.; Brewer, WF., editors. Theoretical issues in reading comprehension. Erlbaum; Hillsdale, NJ: 1980. p. 221-239.

Britton BK, Stimson M, Stennett B, Gulgoz S. Learning from instructional text: Test of an individual differences model. Journal of Educational Psychology. 1998; 90(3):476–491.

Campion N. Predictive inferences are represented as hypothetical facts. Journal of Memory and Language. 2004; 50:149–164.

Carter FA, Wilson JS, Lawson RH, Bulik CM. Mood induction procedure: importance of individualising music. Behaviour change. 1995; 12(3):159–161.

Corson Y. Effects of positive, negative, and neutral moods on associative and semantic priming. Current Psychology of Cognition. 2002; 21:33–62.

Cote N, Goldman SR, Saul EU. Students making sense of informational text: Relations between processing and representation. Discourse Processes. 1998; 25(1):1–53.

Cryder CE, Lerner JS, Gross JJ, Dahl RE. Misery is not miserly: Sad and self-focused individuals spend more. Psychological Science. 2008; 19(6):525–530. [PubMed: 18578840]

Daneman M, Carpenter PA. Individual differences in working memory and reading. Journal of Verbal Learning and Verbal Behavior. 1980; 19:450–466.

Daneman M, Merikle PM. Working memory and language comprehension: A meta-analysis. Psychonomic Bulletin & Review. 1996; 3(4):422–433.

de l'Etoile SK. The effect of a musical mood induction procedure on mood state-dependent word retrieval. Journal of Music Therapy. 2002; 39(2):145–160. [PubMed: 12213083]

Dijkstra K, Zwaan RA, Graesser AC, Magliano JP. Character and reader emotions in literary texts. Poetics. 1994; 23:139–157.

Egidi G, Gerrig RJ. How valence affects language processing: Negativity bias and mood congruence in narrative comprehension. Memory & Cognition. 2009; 37(5):547–555.

Eich, E.; Ng, JTW.; Macaulay, D.; Percy, AD.; Grebneva, I. Combining music with thought to change mood. In: Coan, JA.; Allen, JJB., editors. Handbook of emotion elicitation and assessment. Oxford University Press; New York, NY: 2007. p. 124-136.

Ellis HC, Ashbrook PW. The "state" of mood and memory research: A selective review. Journal of Social Behavior and Personality. 1989; 4:1–21.

Ellis HC, Ottaway SA, Varner LJ, Becker AS, Moore BA. Emotion, motivation, and text comprehension: The detection of contradictions in passages. Journal of Experimental Psychology. 1997; 126:131–146. [PubMed: 9163933]

Ellis HC, Varner LJ, Becker AS, Ottaway SA. Emotion and prior knowledge in memory and judged comprehension of ambiguous stories. Cognition and Emotion. 1995; 9(4):363–382.

Ericsson, KA.; Simon, HA. Protocol analysis: Verbal reports as data. The MIT Press; Cambridge, MA: 1993.

Fernandez-Borrocal P, Extremera N. Emotional intelligence and emotional reactivity and recovery in laboratory context. Psicothema. 2006; 18(72-78)

Ferraro FR, King B, Ronning B, Pekarski K, Risan J. Effects of induced emotional state on lexical processing in younger and older adults. The Journal of Psychology. 2003; 137:262–272. [PubMed: 12795548]

Fiedler, K. Toward an integrative account of affect and cognition phenomena using the BIAS computer algorithm. In: Forgas, JP., editor. Feeling and thinking: The role of affect in social cognition. Cambridge University Press; New York, NY: 2000. p. 223-252.

Fiedler, K. Affective influences on social information processing. In: Forgas, JP., editor. Handbook of affect and social cognition. Erlbaum; Mahwah, NJ: 2001. p. 163-185.

Fiske, ST.; Taylor, SE. Social Cognition: From brains to affect. McGraw-Hill; New York, NY: 2008. From social cognition to affect; p. 310-340.

Fletcher CR. A process model of causal reasoning in comprehension. Reading Psychology. 1989; 10:45–66.

Forgas JP. Mood and judgment: The affect infusion model (AIM). Psychological Bulletin. 1995; 117(1):39–66. [PubMed: 7870863]

Forgas, JP. Feeling and thinking: The role of affect in social cognition. Cambridge University Press; New York, NY: 2000.

Forgas JP. Feeling and doing: Affective influences on interpersonal behavior. Psychological Inquiry. 2002; 13:1–28.

Friedman NP, Miyake A. Comparison of four scoring methods for the reading span test. Behavior Research Methods. 2005; 37(4):581–590. [PubMed: 16629290]

Gasper K, Clore GL. Attending to the big picture: Mood and global versus local processing of visual information. Psychological Science. 2002; 13:33–39.

Gernsbacher, MA. Language comprehension as structure building. Lawrence Erlbaum Associates; Hillsdale, NJ: 1990.

Gernsbacher MA. Two decades of structure building. Discourse Processes. 1997; 23:265–304.

Gerrig, RJ. Experiencing narrative worlds: On the psychological activities of reading. Westview press; Boulder, CO: 1993.

Gerrig, RJ. Participatory aspects of narrative understanding. In: Kreuz, RJ.; MacNealy, MS., editors. Empirical approaches to literature and aesthetics. Ablex publishing corporation; Norwood, NJ: 1996. p. 127-142.

Graesser, AC.; Leon, JA.; Otero, J. Introduction to the psychology of science text comprehension. In: Otero, J.; Leon, JA.; Graesser, AC., editors. The psychology of science text comprehension. Erlbaum; Mahwah, NJ: 2002. p. 1-15.

Graesser AC, Lu S, Olde B, Cooper-Pye E, Whitten S. Question asking and eye tracking during cognitive disequilibrium: Comprehending illustrated texts on devices when the devices break down. Memory & Cognition. 2005; 33(7):1235–1247.

Graesser AC, McNamara DS, Louwerse MM, Cai Z. Coh-Metrix: Analysis of text on cohesion and language. Behavioral Research Methods, Instruments, and Computers. 2004; 36:193–202.

Graesser AC, Singer M, Trabasso T. Constructing inferences during narrative text comprehension. Psychological Review. 1994; 101:371–395. [PubMed: 7938337]

Gross JJ, Levenson RW. Emotion elicitation using films. Cognition and Emotion. 1995; 9(1):87–108.

Gross JJ, Sutton SK, Ketelaar T. Relations between affect and personality: Support for the affect-level and affective-reactivity views. Personality and Social Psychology Bulletin. 1998; 24:279–288.

Guthrie JT, Wigfield A, Barbosa P, Perencevich KC, Taboada A, Davis MH, Tonks SM. Increasing reading comprehension and engagement through concept-oriented reading instruction. Journal of Educational Psychology. 2004; 96(3):403–423.

Hagaman JL, Reid R. The effects of paraphrasing strategy on the reading comprehension of middle school students at risk for failure in reading. Remedial and Special Education. 2008; 29(4):222–234.

Halberstadt JB, Niedenthal PM, Kushner J. Resolution of lexical ambiguity by emotional state. Psychological Science. 1995; 6(5):278–282.

Hanze M, Hesse FW. Emotional influences on semantic priming. Cognition and Emotion. 1993; 7(2): 195–205.

Hanze M, Meyer HA. Mood influences on automatic and controlled semantic priming. American Journal of Psychology. 1998; 111(2):265–278. [PubMed: 9664650]

Hertel G, Neuhof J, Theuer T, Kerr NL. Mood effects on cooperation in small groups Does positive mood simply lead to more cooperation? Cognition and Emotion. 2000; 14(4):441–472.

Hertel PT, Rude SS. Depressive deficits in memory: Focusing attention improves subsequent recall. Journal of Experimental Psychology: General. 1991; 120(3):301–309. doi: 10.1037/0096-3445.120.3.301. [PubMed: 1836493]

Isen, AM. Positive affect. In: Dalgleish, T.; Power, MJ., editors. Handbook of cognition and emotion. John Wiley & Sons; New York, NY: 1999. p. 521-539.

Isen AM, Daubman KA, Nowicki GP. Positive affect facilitates creative problem solving. Journal of Personality and Social Psychology. 1987; 52:1122–1131. [PubMed: 3598858]

Isen AM, Niedenthal PM, Cantor N. An influence of positive affect on categorization. Motivation and Emotion. 1992; 16(1):65–78.

Kaakinen JK, Hyona J. Perspective effects on expository text comprehension: Evidence from think-aloud protocols, eyetracking, and recalls. Discourse Processes. 2005; 40:239–257.

Kaakinen JK, Hyona J, Keenan JM. Perspective effects on online text processing. Discourse Processes. 2002; 33(2):159–173. doi: 10.1207/s15326950dp4003_4.

Kendeou P, van den Broek P. The effects of prior knowledge and text structure on comprehension processes during reading of scientific texts. Memory & Cognition. 2007; 35(7):1567–1577.

Kintsch W, van Dijk TA. Toward a model of text comprehension and production. Psychological Review. 1978; 85(5):363–394.

Kleinginna P Jr. Kleinginna A. A categorized list of motivation definitions, with suggestions for a conceptual definition. Motivation and Emotion. 1981; 5:263–291.

Kliegel M, Horn AB, Zimmer H. Emotional after-effects on the P3 component of the event-related brain potential. International Journal of Psychology. 2003; 38:129–137.

Komeda H, Kusumi T. The effect of a protagonist's emotional shift on situation model construction. Memory & Cognition. 2006; 34(7):1548–1556.

Lepper, MR.; Woolverton, M. The wisdom of practice: Lessons learned from the study of highly effective tutors. In: Aronson, J., editor. Improving academic achievement: Impact of psychological factors on education. Academic Press; San Diego, CA: 2002. p. 135-158.

Linderholm T, van den Broek P. The effects of reading purpose and working memory capacity on the processing of expository text. Journal of Educational Psychology. 2002; 94(4):778–784. doi: 10.1037/0022-0663.94.4.778.

Linderholm T, Virtue S, Tzeng Y, van den Broek P. Fluctuations in the availability of information during reading: Capturing cognitive processes using the landscape model. Discourse Processes. 2004; 37(2):165–186.

Lorch RF, Lorch EP, Klusewitz MA. College students' conditional knowledge about reading. Journal of Educational Psychology. 1993; 85(2):239–252. doi: 10.1037/0022-0663.85.2.239.

Magliano JP, Graesser AC. A three-pronged approach for studying inference generation in literary text. Poetics. 1991; 20:193–232.

Mandler G. Consciousness, imagery, and emotion - with special reference to autonomic imagery. Journal of Mental Imagery. 1984; 8(4):87–94.

McCrudden MT, Schraw G. Relevance and goal-focusing in text processing. Educational Psychology Review. 2007; 19(2):113–139.

McDaniel MA, Einstein GO. Material-appropriate processing: A contextualist approach to reading and studying strategies. Educational Psychology Review. 1989; 1(2):113–145.

McNamara, DS.; Louwerse, MM.; Cai, Z.; Graesser, AC. [2005, January 1] Coh-Metrix. Version 1.4Retrieved from http//:cohmetrix.memphis.edu

Miall DS, Kuiken D. Beyond text theory: Understanding literary response. Discourse Processes. 1994; 17(3):337–352.

Miall DS, Kuiken D. What is literariness? Three components of literary reading. Discourse Processes. 1999; 28(2):121–138.

Miyake A. Individual differences in working memory: Introduction to the special section. Journal of Experimental Psychology: General. 2001; 130(2):163–168. [PubMed: 11409096]

Narvaez D, van den Broek P, Ruiz AB. The influence of reading purpose on inference generation and comprehension in reading. Journal of Educational Psychology. 1999; 91(3):488–496. doi: 10.1037/0022-0663.91.3.488.

Nisbett RE, Wilson TD. Telling more than we can know: Verbal reports on mental processes. Psychological Review. 1977; 8:231–259.

Oatley K, Johnson-Laird PN. Towards a cognitive theory of emotions. Cognition and Emotion. 1987; 1(1):29–50.

Pekrun, R.; Frenzel, AC.; Goetz, T.; Perry, RP. The control-value theory of achievement emotions: An integrative approach to emotions in education. In: Schutz, PA.; Pekrun, R., editors. Emotion in education. Educational psychology series. Elsevier; San Diego, CA: 2007. p. 13-36.

Pichert JW, Anderson RC. Taking different perspectives on a story. Journal of Educational Psychology. 1977; 69(4):309–315.

Rapp DN. How do readers handle incorrect information during reading? Memory & Cognition. 2008; 36:688–701.

Rapp DN, Gerrig RJ. Reader's reality-driven and plot-driven analyses in narrative comprehension. Memory & cognition. 2002; 30:779–788.

Rapp DN, Gerrig RJ. Predilections for narrative outcomes: The impact of story contexts and reader preferences. Journal of Memory and Language. 2006; 54:54–67.

Revelle, W.; Loftus, DA. The implications of arousal effects for the study of affect and memory. In: Christianson, S-A., editor. The handbook of emotion and memory: Research and theory. Lawrence Erlbaum; Hillsdale, NJ: 1992. p. 113-149.

Rottenberg, J.; Ray, RD.; Gross, JJ. Emotion elicitation using films. In: Coan, JA.; Allen, JJB., editors. Handbook of emotion elicitation and assessment. Oxford University Press; New York, NY: 2007. p. 9-28.

Russell JA. A circumplex model of affect. Journal of Personality and Social Psychology. 1980; 39(6): 1161–1178. doi: 10.1037/h0077714.

Scherer, KR.; Schorr, A.; Johnstone, T., editors. Appraisal processes in emotion: Theory, methods, research. Oxford University Press; New York, NY: 2001.

Scherrer MC, Dobson KS. Predicting responsiveness to a depressive mood induction procedure. Journal of Clinical Psychology. 2008; 65(1):20–35. [PubMed: 19051242]

Schmeichel BJ, Volokhov RN, Demaree HA. Working memory capacity and the self-regulation of emotional expression and experience. Journal of Personality and Social Psychology. 2008; 95(6): 1526–1540. [PubMed: 19025300]

Schwarz N, Clore GL. Mood as information: 20 years later. Psychological Inquiry. 2003; 14(3-4):296–303. doi: 10.1207/S15327965PLI1403&4_20.

Sedek G, von Hecker U. Effects of subclinical depression and aging on generative reasoning about linear orders: Same or different processing limitations? Journal of Experimental Psychology: General. 2004; 133(2):237–260. [PubMed: 15149252]

Seibert PS, Ellis HC. Irrelevant thoughts, emotional mood states, and cognitive task performance. Memory & Cognition. 1991; 19:507–513.

Singer M, Ritchot KFM. The role of working memory capacity and knowledge access in text inference processing. Memory & Cognition. 1996; 24(6):733–743.

Stein, NL.; Hernandez, MW.; Trabasso, T. Advances in modeling emotion and thought: The importance of developmental online, and multilevel analyses. In: Lewis, M.; Haviland-Johnes, JM.; Barrett, LF., editors. Handbook of emotions. 3rd ed. Guildford Press; New York, NY: 2008. p. 574-586.

Sullins, J.; Craig, S.; Graesser, AC. Tough love: The influence of an agent's negative affect on students' learning. In: Dimitrova, V.; Mizoguchi, R.; Du Boulay, B.; Graesser, AC., editors. Artificial intelligence in education: Building learning systems that care: From knowledge representation to affective modelling. IOS Press; Amsterdam: 2009. p. 677-679.

Tapiero, I. Situation models and levels of coherence: Toward a definition of comprehension. Lawrence Erlbaum; Mahwah, NJ: 2007.

Thaut MH, de l'Etoile SK. The effects of music on mood state-dependent recall. Journal of Music Therapy. 1993; 30:70–80.

Trabasso T, Magliano JP. Conscious understanding during comprehension. Discourse Processes. 1996; 21:255–288.

van den Broek P, Kendeou P. Cognitive processes in comprehension of science texts: The role of co-activation in confronting misconceptions. Applied Cognitive Psychology. 2008; 22:335–351.

van den Broek P, Lorch RFJ, Linderholm T, Gustafson M. The effects of readers' goals on inference generation and memory for texts. Memory & Cognition. 2001; 29:1081–1087.

van den Broek, P.; Risden, K.; Husebye-Hartmann, E. The role of readers' standards for coherence in the generation of inferences during reading. In: Lorch, RF.; O'Brien, EJ., editors. Sources of Coherence in Reading. Lawrence Erlbaum; Hillsdale, NJ: 1995. p. 353-373.

Vastfjall D. Emotion induction through music: A review of the musical mood induction procedure. Musicae Scientiae. 2001-2002; 6:173–211.

Virtue S, van den Broek P, Linderholm T. Hemispheric processing of inferences: The effects of textual constraint and working memory capacity. Memory & Cognition. 2006; 34(6):1341–1354.

von Hecker U, Meiser T. Defocused attention in depressed mood: Evidence from source monitoring. Emotion. 2005; 5(4):456–463. doi: 10.1037/1528-3542.5.4.456. [PubMed: 16366749]

Waters GS, Caplan D. The reliability and stability of verbal working memory measures. Behavior Research Methods, Instruments, & Computers. 2003; 35(4):550–564.

Watson, D.; Clark, LA. The PANAS-X: Manual for the positive and negative affect scale - expanded form. 1994.

Watson D, Clark LA, Tellegen A. Development and validation of brief measures of positive and negative affect: The PANAS scales. Journal of Personality and Social Psychology. 1988; 54:1063–1070. [PubMed: 3397865]

Weingartner KM, Guzman AE, Levine WH, Klin CM. When throwing a vase has multiple consequences: Minimal encoding of predictive inferences. Discourse Processes. 2003; 36:131–146.

Westerman R, Spies K, Stahl G, Hesse FW. Relative effectiveness and validity of mood induction procedures: A meta-analysis. European Journal of Social Psychology. 1996; 26:557–580.

Wolfe MBW. Memory for narrative and expository text: Independent influences of semantic associations and text organization. Journal of Experimental Psychology: Learning, Memory, and Cognition. 2005; 31:359–364.

Wolfe MBW, Mienko JA. Learning and memory of factual content from narrative and expository text. British Journal of Educational Psychology. 2007; 77:541–564. [PubMed: 17908374]

Wolfe MBW, Woodwyk JM. Processing and memory of information presented in narrative or expository texts. British Journal of Educational Psychology. 2010; 80:341–362. doi: 10.1348/000709910X485700. [PubMed: 20128958]

Yost JH, Weary G. Depression and the correspondent inference bias: Evidence for more effortful cognitive processing. Personality and Social Psychology Bulletin. 1996; 22(2):192–200. doi: 10.1177/0146167296222008.

Zwaan RA. Situation models: The mental leap into imagined worlds. Current Directions in Psychological Science. 1999; 8:15–18.

Zwaan RA, Brown CM. The influence of language proficiency and comprehension skill on situation model construction. Discourse processes. 1996; 21:289–327.

Zwaan RA, Radvansky GA. Situation models in language comprehension and memory. Psychological Bulletin. 1998; 123(2):162–185. [PubMed: 9522683]

Zwaan, RA.; Rapp, DN. Discourse comprehension. In: Traxler, M.; Gernsbacher, M., editors. Handbook of Psycholinguistics. Elsevier; San Diego, CA: 2006. p. 725-749.

Table 1

Means, Standard Deviations, and Within-Subjects t-test results for the pre-and post-PANAS-X Scores

Emotion	Pretest Mean (SD)	Posttest Mean (SD)	t	df	D
Happy Condition (n = 34)					
Negative Affect	1.39(.44)	1.06(.13)	4.68***	33	1.02
Positive Affect	2.93(.73)	3.25(.74)	2.35*	33	.44
Sad Condition (n = 34)					
Negative Affect	1.51(.53)	1.74(.63)	2.86**	33	.40
Positive Affect	2.70(.60)	1.98(.52)	8.28***	33	1.28
Neutral Condition (n = 33)					
Negative Affect	1.56(.50)	1.18(.28)	5.39***	32	.94
Positive Affect	2.97(.70)	2.80(.82)	1.85[a]	32	.22

*** $p < .001$.

** $p < .01$.

* $p < .05$.

[a] $p < .10$.

Table 2

Definitions and Examples of the Think Aloud Codes

Process	Definition	Text Excerpt	Example of Participant Response
Paraphrase	Comments that capture the gist meaning of a sentence.	What is not as obvious is why forest-dwelling migratory songbirds are also vanishing; especially the so-called Neotropical migrants that breed in northern latitudes but migrate to winter homes in the tropics.	Um, it's talking about um birds traveling to um migrate for the winter.
Connecting Inference	Retrieval of information from the sentence immediately preceding the current sentence to help explain the current sentence.	Most important, the impact hypothesis can explain the most difficult theoretical problem of why the earth rotates as fast as it does. A colliding body would probably not have struck the earth squarely; rather, it is highly likely that it would have struck the earth off-center.	Therefore causing it to spin the way that it does.
Reinstatement Inference	Retrieval of information from sentences prior to the immediately preceding one, to help explain the current sentence.	Until very recently, it killed up to one third of its victims. [6 intervening sentences] The mere suspicion of meningitis signals a medical emergency that leads the physician to immediately inject the patient with antibiotics.	Um, which makes sense, I guess, if a third of people who contract it die.
Elaborative Inference	Retrieval of background knowledge that helps explain the current sentence.	This would speed up a slowly rotating earth to its current value of rotation.	Um, cuz, its, there's gravity and there's no air resistance or anything in space so once its spinning there's nothing there to stop it.
Predictive Inference	Forward inferences that anticipate upcoming text or content.	Most important, the impact hypothesis can explain the most difficult theoretical problem of why the earth rotates as fast as it does.	I'm guessing they're going to say that the earth rotates as fast as it does because the impactor hit it, causing it to spin faster.
Affective Response – Negative	Negative emotional comment regarding the text.	In fact, anti-CD18 has produced a 100% survival rate in rabbits infected with meningitis.	Which makes me a little sad because I love rabbits.
Affect Response - Positive	Positive emotional comment regarding the text.	The spinning caused it to bulge so much at the equator that a small blob eventually spun off, becoming the moon.	That to me is funny [laughs].
Evaluation	Opinions	The spinning caused it to bulge so much at the equator that a small blob eventually spun off, becoming the moon.	Um I'm thinking that this is kind of a crazy theory.
Monitoring Comprehension	Reflecting on one's own understanding.	What possible explanations might be given for the forest fragmentation effect?	I don't know.
Text Repetition	Verbatim repetition of all or a large proportion of the text sentence.	There are good reasons why songbirds might want to nest away from the edge of a forest.	There are good reasons why they might want to nest away from the edge of a forest.
Association	Retrieval of information not related to text coherence.	Title: Origins of the Moon	…reminds me of cheese. I don't know why.
Other	Nonresponses and any other response that do not fall into any of the above categories.	When there were no waves in the tank, the turtles swam aimlessly.	Alright.

Table 3

Intercorrelations between the think aloud processes

	1	2	3	4	5	6	7	8	9	10	11	12
						Participants (n = 101)						
1. Paraphrase	-	0.08	−0.16	−0.44***	−0.24*	−0.34***	−0.25*	−0.77***	−0.70***	−0.03	−0.47***	−0.37***
2. Connecting Inference		-	0.35***	0.07	−0.15	−0.19	−0.03	−0.18	−0.27**	−0.11	−0.23*	−0.37***
3. Reinstatement Inference			-	0.28**	0.19	0.03	0.03	−0.02	−0.19	−0.06	−0.09	−0.13
4. Elaborative Inference				-	0.31**	−0.05	−0.04	0.13	−0.02	−0.24*	0.08	0.06
5. Predictive Inference					-	0.07	0.13	0.07	0.03	−0.08	0.04	−0.04
6. Affective Response – Negative						-	0.23*	0.29**	0.36***	0.19	0.27**	0.15
7. Affective Response – Positive							-	0.20*	0.24*	−0.02	0.10	0.11
8. Evaluation								-	0.56***	0.12	0.45***	0.31**
9. Monitoring Comprehension									-	−0.04	0.37***	0.29**
10. Text Repetition										-	0.10	−0.07
11. Association											-	0.22*
12. Other												-

*** $p < .001$ level (2-tailed).

** $p < .01$ level (2-tailed).

* $p < .05$ level (2-tailed).

Table 4

Factor Loadings for Think Aloud Processes

		Factor 1: Text-Based Inferences	Factor 2: Knowledge-Based Inferences	Factor 3: Non-Coherence Processes
	Eigenvalue:	1.84	1.24	3.37
	Variance Explained	15.29	10.30	28.06
Think Aloud Process				
Paraphrase		−.11	−.26	−.91
Connecting Inference		**.85**	−.24	−.14
Reinstatement Inference		**.71**	.38	.03
Elaborative Inference		.25	**.61**	.30
Predictive Inference		−.07	**.88**	−.03
Association		−.16	.03	**.65**
Evaluation		−.02	.01	**.85**
Monitoring Comprehension		−.22	−.11	**.73**
Text Repetition		−.01	−.09	.06
Affective Response – Positive		.03	.05	.13
Affective Response – Negative		−.07	.10	.37
Other		−.49	<.001	.45

Note. Numbers in **bold** represent the factors the think aloud processes that were considered to load highly onto that factor.

Table 5

Non-transformed proportions (and standard deviations) of the think aloud processes by condition and working memory

	Overall			High Working Memory			Low Working Memory		
	Happy	**Sad**	**Neutral**	**Happy**	**Sad**	**Neutral**	**Happy**	**Sad**	**Neutral**
Paraphrases	.51(.25)	.47(.26)	.31(.22)	.55(.24)	.40(.29)	.38(.22)	.45(.26)	.50(.24)	.24(.21)
Text-Based Inferences	.14(.09)	.11(.09)	.10(.06)	.13(.05)	.13(.09)	.10(.06)	.16(.12)	.09(.10)	.12(.07)
Knowledge-Based Inferences	.17(.10)	.15(.12)	.17(.11)	.16(.08)	.17(.13)	.19(.11)	.18(.13)	.14(.12)	.15(.10)
Non-Coherence	.11(.17)	.18(.19)	.29(.22)	.12(.18)	.21(.21)	.20(.21)	.10(.15)	.17(.18)	.38(.19)