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Getting a Grip: The PET Framework for Studying How Reader Emotions Influence Comprehension

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ABSTRACT

Comprehension models do not often account for the multifaceted and emotionally charged nature of reading in real-world settings. In addition, studies of how reader emotions influence comprehension often yield conflicting findings due to lack of specificity regarding the process, emotion, and task under investigation. The PET (Process, Emotion, Task) framework considers how reader emotions differentially influence comprehension as a function of the specific comprehension process, type of emotion, and task features. It offers testable hypotheses regarding the influence of reader emotion for levels in the tripartite theory, resonance, integration and validation, inferences, and coherence-based retrieval. It also considers how important interactions arise through text, reader, and activity variables. Therefore, the particular comprehension process, the specific emotion, and varying task features can lead to different predictions regarding the effects of emotion on comprehension processes. The PET framework provides organization to guide research and clarify understandings regarding how to support readers.

Introduction

Readers with varying skills, emotions, prior knowledge, and interests experience texts within many different contexts. Because comprehension is multifaceted, many studies rightfully attempt to isolate a small number of variables to ensure internal validity in studying how readers build mental representations of texts, how differing text properties can influence processing, how readers may vary, and even how contextual factors can modify comprehension processes. This work provides evidence for a cohesive set of theories regarding core aspects of comprehension processing and enables the field to begin embracing the complexity of comprehension without being overly reductive (Graesser, Gernsbacher, & Goldman, 2018; Kendeou & O'Brien, 2018). Although it is challenging to simultaneously examine multiple aspects of comprehension (Bohn-Gettler, 2018), it is necessary because the factors influencing comprehension do not operate in isolation (Bohn-Gettler & Kendeou, 2014; Rapp & van den Broek, 2005; Snow, 2002; van den Broek & Kremer, 1999). This article proposes the Process, Emotion, and Task (PET) framework for studying the complexity of how reader emotions influence comprehension.

Whether enjoying a story, doing homework, perusing the newspaper, or completing a project, we too often think of readers' minds and actions as separate from their contexts and emotions (Bohn-Gettler & Rapp, 2014). For example, learning about the death of a loved one before studying a textbook may result in distracted reading. Anger about a political event may bias a reader's interpretation of a newspaper editorial. Texts themselves can also evoke emotions, such as suspense or empathizing with a character's emotions (Elfenbein & Bohn-Gettler, 2016; Jacobs, 2015).

Therefore, emotions matter during comprehension: In all these settings, a variety of emotions could directly influence comprehension processes and products.

Even though comprehension theorists acknowledge that various settings and tasks can evoke emotions, reader emotions were necessarily omitted from reading comprehension frameworks in an effort to focus on complex computational models of cognitive processing (Kintsch & van Dijk, 1978; McNamara & Magliano, 2009). However, it is now time to face the challenge of understanding how reader emotion influences comprehension processing. Because this is a large task, this article focuses specifically on the emotions that readers experience as they enter into reading experiences but acknowledges the importance of studying how emotions can be reactive to text content to influence attention and processing (Elfenbein & Bohn-Gettler, 2016; Hsu, Jacobs, Citron, & Conrad, 2015; Jacobs, 2015; Kaakinen, Ballenghein, Tissier, & Baccino, 2018; Kneepkens & Zwaan, 1994; Oatley, 2004).

Although a growing body of work documents how reader emotions influence comprehension processing, research often yields somewhat inconsistent findings. For instance, some studies document how positive emotion improves, whereas negative emotion hinders, processing and comprehension (Bohn-Gettler & Rapp, 2011; Ellis, Moore, Varner, Ottaway, & Becker, 1997; Scrimin & Mason, 2015; von Hecker & Meiser, 2005). Other studies show how negative emotions facilitate while positive emotions hinder processing (Storbeck & Clore, 2005; Trevors, Bohn-Gettler, Szydlo, & Kendeou, 2018). Other studies show no differences between positive versus negative emotions on certain aspects of processing and/or memory (Bohn-Gettler & Rapp, 2011; von Hecker & Meiser, 2005), and others describe how positive and negative emotions lead to different processing modes (Beukeboom & Semin, 2006; Fiedler & Beier, 2014). Such discrepant findings pose a problem, because they may lead to the conclusion that emotions do not exert any consistent influence on comprehension, thus discouraging researchers from studying something so intertwined with learning and the human experience.

However, the existence of conflicting findings does not necessarily indicate a lack of influence of emotions on comprehension. Instead, I argue that contradictory findings are a function of imprecise conceptualization and measurement. For the field to move forward, there is a need for a coherent framework with which to categorize findings and interpret results. This will enable us to get a better “grip” on the field by having more systematic specifications regarding which components are under examination. Therefore, I propose a framework for studying how emotions influence comprehension processes—one that accounts for the complexities of both emotions and comprehension.

The PET framework represents a first step in bringing the disciplines of emotion and discourse comprehension together to more deeply understand how and why reader emotions influence comprehension processing. A basic assumption of this framework is that we cannot understand comprehension without considering the multifaceted variables that interact with one another. Doing so will further the field of comprehension, offer new insights, and increase the importance and generalizability of studies. The PET framework is situated in established theories and models of comprehension and emotion and proposes that researchers must consider which aspect of the comprehension process is being investigated, the characteristics of the specific emotion being studied, and account for features of the task. The PET framework also provides hypotheses regarding which processes are influenced by emotion. Table 1 provides an overview of these hypotheses.

This article first describes the cognitive processes that underlie comprehension and are hypothesized to be relevant to the PET framework. Second, it outlines theories of emotion that can inform when and how emotions may influence processing. Third, it explains the hypotheses put forward by the PET framework, making connections between theory and empirical findings in comprehension and emotion. Finally, it discusses conclusions, implications, and future directions.

Relevant Processes involved in comprehension

The PET framework proposes that studies must consider the specific comprehension process under investigation, identify the processes likely to be influenced by emotion, and provide hypotheses for how these processes may be influenced by emotion. Hence, the framework is grounded in several

Table 1. Hypotheses in the PET Framework.

Aspect of Comprehension	Aligning Emotion Theory	Hypotheses
Levels in the tripartite theory	Affect infusion model	Hypothesis 1: The effects of emotion on processing are most likely to emerge at the situation model level, when engaging in tasks that require constructive processing.
Memory constraints	Resource allocation models and control-value theory	Hypothesis 2: Emotions will sometimes constrain comprehension by using cognitive resources.
Resonance in a connectionist network	Semantic network models Affect infusion and theories of assimilation/accommodation	Hypothesis 3a: Congruency effects may sometimes occur. Hypothesis 3b: Emotions may influence how many concepts are deemed relevant during the resonance process.
Integration and validation	Affect infusion and theories of assimilation/accommodation	Hypothesis 4a: Positive emotions facilitate performance if the task requires global and/or assimilative processing. Hypothesis 4b: Negative emotions facilitate performance if the task requires local and/or accommodative processing.
Inferences	Affect infusion and theories of assimilation/accommodation	Hypothesis 5: Positive emotions facilitate assimilative, integration-based inferences.
Coherence-based retrieval	Control-value theory	Hypothesis 6: The effects of experimentally induced emotions on coherence-based retrieval may be mediated or moderated by control-value appraisals.
Other factors		Hypothesis 7: Emotion interacts with important mediating and moderating variables such as text-, reader-, and activity-based factors.

All hypotheses are grounded in the need to account for the nature of the task. Specifically, (1) tasks that are constructive (as opposed to reproductive) should be most sensitive to the influence of emotion on processing. And, (2) tasks that require assimilative processing should be facilitated by positive emotions, whereas tasks that require accommodative processing should be facilitated by negative emotions.

prominent models and theories of comprehension (McNamara & Magliano, 2009), including the construction-integration framework (Kintsch & van Dijk, 1978), the landscape model (van den Broek, Young, Tzeng, & Linderholm, 1999), the RI-Val model (O'Brien & Cook, 2016), and constructionist theory (Graesser, Singer, & Trabasso, 1994).

Successful comprehension involves encoding information into memory and organizing this information into a mental representation (Johnson-Laird, 1983; Kintsch & van Dijk, 1978). The tripartite theory proposes that readers encode information from a text along three different levels: the surface structure, which contains the exact words and propositions from the text; the textbase, which involves encoding the gist meanings of the text itself; and the situation model, where inferences between the current sentence and prior knowledge or prior text are established (Kintsch, 1998). Information from a text is processed in working memory (which is limited), prior knowledge can be activated, and ultimately a mental representation can be stored in long-term memory (with the acknowledgment that a representation can continue to be edited; Atkinson & Shiffrin, 1968; Kintsch & van Dijk, 1978; Miller, 1956).

The PET framework assumes resonance in a connectionist architecture, in which activation levels continuously change as a function of new information being presented in the text, material currently being processed in working memory, and activated concepts in long-term memory. Resonance is considered passive and dumb, such that both relevant and irrelevant concepts will be activated (Kintsch, 1998; O'Brien & Cook, 2016; van den Broek, Risdén, Fletcher, & Thurlow, 1996). As information becomes activated via resonance, it may become integrated and mapped onto prior text information, and readers may validate whether the integrated linkages align with prior knowledge and their broader understanding of the text (Cook & O'Brien, 2014; Kendeou, 2014; Richter, 2015; Singer, 2013). In addition, readers can make inferences to fill in information not explicitly stated in the text (Graesser et al., 1994; Kintsch & van Dijk, 1978). For example, text-based bridging inferences connect the current sentence to information presented earlier in the text. In contrast, knowledge-based inferences connect textual information with prior knowledge (van den Broek, Risdén, & Husebye-Hartmann, 1995).

Finally, the landscape model distinguishes between cohort activation (an automatic process wherein concurrently activated concepts become associated to form a cohort) and coherence-based retrieval (an effortful process in which readers retrieve information and engage in processing as a function of goals for how well they seek to understand the text content, i.e., standards of coherence). For example, asking readers to approach texts with particular goals influences attentional focus, inference generation, text rehearsal, memory, and more (McCrudden & Schraw, 2007; van den Broek, Bohn-Gettler, Kendeou, Carlson, & White, 2011).

To further complicate matters, each of the processes described can be influenced by a variety of factors, such as text-, activity-, and reader-based variables (Snow, 2002; van den Broek & Kremer, 1999). As one example, text can constrain the degree to which readers engage in reader-initiated processes (van den Broek & Helder, 2017). This demonstrates that comprehension is far from simple: There can be main effects from each of these categories but also interactions between them.

When researchers study the interactions between various factors on comprehension processes and products, they often reveal particularly interesting effects. For example, Bohn-Gettler and Kendeou (2014) investigated interactions between working memory and reading goals (studying versus entertainment) as readers thought aloud about expository texts in which organization and cohesiveness were high (compare-contrast and problem-response) versus low (descriptive and chronological texts). They found a surprising three-way interaction: When readers with low working memory adopted a study goal, there were no differences in the proportion of text-based inferences as a function of text structure. However, when the same readers had an entertainment goal, text-based inferences increased for more structured texts relative to the less structured texts (in contrast to work documenting the benefits of study goals for text-based inferences; van den Broek, Lorch, Linderholm, & Gustafson, 2001). One post-hoc explanation for this unexpected finding could be that the scaffolding provided by more structured texts, combined with potential reductions in anxiety when reading for entertainment (compared with study), led to an increase in text-based inferences (Bohn-Gettler & Kendeou, 2014). This work documents the importance of considering how text-, activity-, and reader-based variables individually or interactively elicit or interact with reader emotions. It also supports the PET framework's contention that emotions may play differential roles depending on the aspect of comprehension under examination.

Emotions and processing

To make hypotheses regarding how emotion may influence comprehension processing, it is important to understand informative emotion theories. Beginning with definitions, affect is a broad term encapsulating moods, emotions, attitudes, and more. Moods represent long-term, general feelings that may be relatively low in intensity. Emotions are shorter-lasting, more specific, and are felt more intensely than moods (Batson, Shaw, & Oleson, 1992). The PET framework focuses on state-based reader emotions—that is, emotions experienced at a particular moment and in specific situations. (In contrast, trait-based emotions are longer-term, more stable tendencies of experiencing particular emotional reactions; Davitz, 1969).

Emotions arise based on cognitive appraisals of the self and of situations (Arnold, 1960; Lazarus, 1991). Pekrun's control-value theory highlights how appraisals vary along perceived value and perceived control over one's ability to be successful. If an individual feels efficacious and values a task, he or she is likely to experience positive emotions such as enjoyment, pride, or hope. However, if an individual does not anticipate success and/or does not value the task, he or she experiences negative emotions such as boredom, anger, or anxiety (Pekrun & Stephens, 2012).

Although many categories of emotion exist (for a review, see Pekrun & Stephens, 2012), emotions can be sorted using a valence by activation quadrant (for a visual taxonomy of this quadrant see Posner, Russell, & Peterson, 2005; Russell, 1980). Valence refers to whether an emotion is pleasant or unpleasant, whereas activation refers to the energy level associated with the emotion. For example, feeling angry is negatively valenced with high activation, whereas depression is negatively valenced

with low activation. Relaxation is positively valenced with low activation, whereas joy is positively valenced with high activation. Pekrun and Stephens (2012) describe how positive activating emotions are associated with increased motivation, whereas negative deactivating emotions are associated with lowered motivation. Negative activating emotions and positive deactivating emotions can have varying effects. For example, feeling angry can either motivate action or lead to withdrawal. At present, the PET framework focuses generally on positive activating and negative deactivating emotions because they yield the most consistent findings and hence enable specific hypotheses. Moving forward, I focus on the dimension of valence (and use the terminology “positive” and “negative”) to remain consistent with the literature but only cite studies in which positive activating or negative deactivating emotions are evoked.

When considering how emotions influence cognitive processing in general, early work describes how, when evoked to feel a particular emotion prior to engaging in a task, other concepts related to that emotion are more likely to be activated in a semantic network (Bower, 1981; Schwarz & Skurnik, 2003). This results in memory facilitation for emotion congruent information (Bower, Gilligan, & Monteiro, 1981), selective attention to emotion-relevant stimuli (Mayer, 1986), and state-dependent learning (the facilitation of retrieval when an individual’s emotions at learning and retrieval align; Bower, Monteiro, & Gilligan, 1978; de l’Etoile, 2002). Congruency effects also appear in the interpretation of ambiguous homophones, such that hearing the word “die/dye” would be interpreted as “dying” when feeling a negative emotion, but “coloring” when experiencing a positive emotion (Ferraro, King, Ronning, Pekarski, & Risan, 2003; Halberstadt, Niedenthal, & Kushner, 1995). However, congruency effects have not always been consistently obtained (Kenealy, 1997; Ucros, 1989), perhaps because the type of task in which individuals engage may be a moderating variable (Fiedler & Beier, 2014).

Another earlier set of models considers emotional information as more memorable and salient than other types of information in memory (Payne & Corrigan, 2007). If the experience of emotions is part of a semantic network and emotions are more salient than other information in the semantic network, experiencing emotions may therefore place additional limitations on already limited cognitive resources (Meinhardt & Pekrun, 2003). This can sometimes lead to irrelevant thoughts and a lack of focus (Ellis & Ashbrook, 1989), poorer transfer and problem-solving strategies (Seibert & Ellis, 1991), and hindered performance (Ellis & Ashbrook, 1988). Like congruency effects, this work has not always obtained consistent results. For example, negative emotions have sometimes been found to enhance attention to details (Beukeboom & Semin, 2006; Fiedler & Beier, 2014; Sinclair & Mark, 1995). However, such work has informed models considering the additional load that emotion places on limited cognitive resources.

Forgas’s affect infusion model (1995) documents how positive versus negative emotions result in different processing patterns. Positive emotions are associated with open, global information searches and support creativity and flexible problem solving. Negative emotions are associated with local, analytic, and incremental processing methods (Fiedler, 2000; Forgas, 1995; Pekrun, 2017). Fiedler and Beier (2014) expanded this work to consider how positive emotions facilitate assimilative processing, in which individuals change external information to fit pre-existing internal representations. In contrast, negative emotions facilitate accommodative processing, in which individuals change their internal representations to fit new, external stimuli.

Based on this work, positive and negative emotions can each lead to both desired and undesired outcomes. For example, positive emotions are associated with processing that is more likely to incorporate prior knowledge (Storbeck & Clore, 2005), which could facilitate constructive inferences. It is more generative and creative (Bless & Fiedler, 1995; Gasper & Clore, 2002; Isen, 2001), which can enhance flexibility and problem solving. However, the relational processing and increased accessibility of activated knowledge associated with positive affect can leave individuals prone to false memory effects (Fiedler & Beier, 2014; Huntsinger, Clore, & Bar-Anan, 2010; Isen, Daubman, & Nowicki, 1987; Storbeck & Clore, 2005). Negative emotions are associated with processing that is more reproductive and focuses attention on details (von Hecker & Meiser, 2005). Although attention

to detail could burden already limited cognitive resources (Gunther, Ferraro, & Kirchner, 1996; Schwarz & Skurnik, 2003), it can also result in careful stimulus processing, the building of concrete and detailed representations, selective attention, and the avoidance of careless mistakes (Beukeboom & Semin, 2006; Fiedler & Beier, 2014; Sinclair & Mark, 1995). For example, when asked to describe an event in their past, individuals experiencing a negative emotion used more verbs and concrete descriptions of the objects and events, whereas participants experiencing a positive emotion used more abstract adjectives (Beukeboom & Semin, 2006).

Consideration of Task types

The models described can be used to generate hypotheses for comprehension processing. However, the hypotheses may not result in supporting data if the task is not subject to affective influences, and discrepancies in findings across studies may exist if the nature of the tasks employed are functionally different. Therefore, the PET framework advocates for clarifying two key features of the task: whether the task requires constructive versus reproductive processing and whether the task engages assimilative versus accommodative processing.

With regard to constructive versus reproductive processing, the affect infusion model (Forgas, 1995) documents how emotions are less likely to influence processing for reproductive tasks, meaning tasks that involve directly accessing information from memory, or doing a goal-directed search to remember a particular piece of information. Emotions are more likely to influence processing for tasks requiring constructive processing: processing that goes beyond merely recalling or reproducing but that requires transformation, filling in missing information, elaboration, problem solving, and so on. The PET framework proposes that any investigation of emotion's effects on comprehension must account for the type of task in which readers engage.

Second, positive emotions tend to facilitate assimilative processing, whereas negative emotions tend to facilitate accommodative processing (Fiedler & Beier, 2014). However, many studies do not account for the type of processing in which readers engage. For example, tasks involving conceptual change seek to encourage accommodative processing (Trevors & Kendeou, 2017), whereas reading with the goal of simple recall likely encourages assimilative processing (e.g., van den Broek et al., 2001). The PET framework proposes that any investigation of emotion's effects on comprehension processing should delineate between assimilative versus accommodative tasks and processing to understand the influences of positive versus negative emotions. More specific examples are provided in the relevant parts of the next section.

Hypotheses in the PET framework

Given the complexity of theory regarding the relations between comprehension and emotion, it is no surprise that seemingly inconsistent findings emerge. To ensure that emotions are not deemed unimportant to study, researchers must take care in specifying which aspect of comprehension is under examination, identifying the valence and activation levels of the emotion being considered, and documenting the type of task in which readers engage. By considering various aspects of comprehension in alignment with emotion theories, the PET framework offers hypotheses as a function of the comprehension process, emotion, and task. Table 1 provides a summary of each hypothesis in relation to specific aspects of comprehension and aligning theories of emotion.

Levels in the tripartite theory

The affect infusion model (Forgas, 1995) informs which levels in the tripartite theory of comprehension (Kintsch & van Dijk, 1978) are most likely to be influenced by emotion. Hypothesis 1 is that the situation model would be the most productive place for studying how reader emotion influences

comprehension processes, because the situation model should require some element of constructive processing when filling in missing information and connecting to prior knowledge. Although this hypothesis is based in theory and data (Forgas, 1995), more systematic testing of this hypothesis in the specific context of text comprehension would make an important contribution to the field.

Memory constraints

Resource allocation models posit that emotions (whether positive or negative) hold a privileged place in memory and introduce additional constraints on already limited cognitive resources. Research on the negativity bias (Egidi & Gerrig, 2009) and seductive details (Harp & Mayer, 1998; Sanchez & Wiley, 2006) supports this hypothesis to a certain extent, in that the inclusion of emotionally laden information in text makes it difficult to recall other more relevant information. Hence, Hypothesis 2 is that emotions sometimes constrain comprehension by using cognitive resources. In support of Hypothesis 2, some research documents how the experience of negative emotions leads to challenges in identifying contradictions in text and difficulty with providing task-relevant information. In contrast, positive emotions may enhance performance on controlled processing tasks, such as operation span tasks of working memory (Ellis, Ottaway, Varner, Becker, & Moore, 1997; Yang, Yang, & Isen, 2013).

However, some studies yield conflicting results, which could be a function of the type of task. For example, negative emotions decreased recall and increased the generation of irrelevant thoughts when thinking aloud while organizing unstructured letter sequences (Ellis et al., 1997). In contrast, after thinking aloud about text, Bohn-Gettler and Rapp (2011) found no differences as a function of positive versus negative emotion when recalling text. The tasks in Ellis et al. (1997) required participants to reorganize sequences to facilitate learning (a constructive task). In contrast, Bohn-Gettler and Rapp (2011) simply asked participants to restate the text without requiring constructive processing or reorganization (a reproductive task). This is a situation where the type of task may have interacted with the specific emotion, supporting the assertion that emotions are more likely to influence tasks requiring constructive, but not reproductive, processing. Taken together, empirical work supports the view that emotions can constrain cognitive resources, but additional work documenting the conditions under which this occurs would be beneficial.

Resonance in a connectionist architecture

Activation levels continuously change as a function of current text content, and the experience of an emotion activates other emotion-relevant concepts within a semantic network. Based on this work, Hypothesis 3a is that congruency effects may sometimes occur, such that information related to the reader's emotional state may be activated through a resonance process (Bower, 1981; de l'Etoile, 2002; Ferraro et al., 2003; Schwarz & Skurnik, 2003).

Moving beyond basic congruency effects, recall that resonance is a passive and dumb process (Cook & O'Brien, 2014; Kintsch, 1998; van den Broek et al., 1996), meaning that emotion-relevant information is likely to be activated regardless of the valence of the emotion. However, Hypothesis 3b is that emotions may influence the number of concepts deemed relevant for understanding the text and that would therefore reach an activation threshold to remain activated. In particular, the local focus associated with negative emotions may limit this number, whereas the more global focus associated with positive emotions may increase what is deemed relevant (Fiedler & Beier, 2014; Gasper & Clore, 2002; Serano, Scott, Yao, Thaden, & O'Donnell, 2015; Srinivasan & Hanif, 2010).

An increase in the number of activated concepts may be beneficial for creative problem solving but could enable irrelevant concepts to remain activated and possibly hinder comprehension (Baas, De Dreu, & Nijstad, 2008). In contrast, fewer activated concepts may be harmful for creativity but beneficial for tasks requiring attention to local details. There is some evidence in support of this

hypothesis, such as positive emotions resulting in improved performance on remote association tests and reducing anchoring (i.e., over-reliance on one piece of information; Isen, 2001). Positive emotions also broaden attention and increase the usage of global (as opposed to local) information when interpreting and solving problems (Beukeboom & Semin, 2006; Gasper & Clore, 2002; Srinivasan & Hanif, 2010).

The hypotheses regarding how emotions might influence resonance during comprehension need to be more directly tested. It remains unclear whether positive emotions should increase the number of concepts deemed relevant, whether negative emotions should decrease this number, or both. Many emotion studies examining how positive emotions enhance knowledge activation do not always include a control group, potentially masking how positive versus negative emotions change knowledge activation relative to a baseline. To address this gap, Bohn-Gettler, Marzolf, and Heisler (2016) induced readers to feel pride, guilt, or a neutral emotion (as a control). Participants read texts containing information about the ordering of real-world and made-up objects. After reading each text, participants answered true or false questions based on text-only information, text-based inferences, prior knowledge only (concepts related to objects presented in the text but not actually in the text), and questions requiring integrating prior knowledge with the text (an integration task; Singer, Andrusiak, Reisdorf, & Black, 1992). Bohn-Gettler et al. (2016) found that accuracy rates were equal for the positive emotion and control groups, but both groups had higher accuracy rates than the negative emotion group. Hence, negative emotions decreased activation of prior knowledge. However, positive emotions did not increase activation of prior knowledge relative to the control group, which contrasts with findings from the emotion literature. Because previous studies examining emotion did not necessarily use a control group and did not account for the nature of the task, changes in activation levels could not be compared with a baseline. This suggests a need to further explore the influence of emotion on resonance.

Integration and validation

The processing implications of positive and negative emotions should influence integration and validation. On a simplistic level, the global, broader activation and flexible processing associated with positive emotions should facilitate integration and validation, whereas the local focus of negative emotions should hinder it (at least for content presented much earlier in the text or for prior knowledge; Fiedler & Beier, 2014; Forgas, 2001; Pekrun & Stephens, 2012). In fact, Kiefer, Schuch, Schenck, and Fiedler (2007) found that positive-induced participants engaged in elaborative encoding strategies (which should facilitate integration), whereas negative-induced participants engaged in non-elaborative strategies.

However, it is critical to consider the types of tasks in which readers engage. Many studies address understanding text content in an assimilative manner, such that the text content aligns with the existing representation and hence facilitates integration and validation. In such cases positive emotions should facilitate performance (Hypothesis 4a). However, an interesting scenario arises when readers are confronted with information that challenges their existing representation and requires conceptual change. In such scenarios requiring accommodative processing, induced negative emotions could provide facilitation (Hypothesis 4b).

To examine this hypothesis, Trevors et al. (2018) induced positive, negative, and neutral emotions before asking participants to read texts addressing misconceptions. Each participant engaged with three texts: one contained a refutation with an explanation (which should provide additional scaffolding to help resolve the apparent conflict), one contained a refutation without an explanation (which should require more effort from the readers to modify their misconception), and one was a nonrefutation text. Near the end of each text, a target sentence contained the accurate information. Faster reading times for the target sentence containing the accurate information should reflect facilitation of learning. When refutations contained an explanation, there were no differences as a function of emotion because the explanation provided the necessary scaffolding to help resolve the

misconception. There were also no differences for the nonrefutation text. As hypothesized, for the refutation texts without an explanation, which presumably require more substantive processing, there was facilitation for the negative emotion group in comparison with the positive emotion group (Trevors et al., 2018). These data support the need to consider the process, emotion, and task to effectively interpret findings: Negative emotions facilitated integration, but only when the task required both substantive and accommodative processing. Although some data support this assertion, an important task for future research will be to further disentangle the effects of emotion on integration and validation, while accounting for whether the task requires assimilative or accommodative processing.

Inferences

Inferences represent a heuristic or a substantive process, making them constructive and subject to affective influences (Forgas, 1995). There is evidence that emotions influence the inference generation process during reading. Recall that positive emotions are associated with flexible and global processing, whereas negative emotions are associated with local, analytic processing (Fiedler & Beier, 2014; Forgas, 2001; Pekrun, Lichtenfeld, Marsh, Murayama, & Goetz, 2017). Thus, the processing associated with positive emotions should facilitate the generation of assimilative inferences during reading (Hypothesis 5).

To test this hypothesis, Bohn-Gettler and Rapp (2011) and Bohn-Gettler et al. (2017) induced participants to feel a positive, negative, or neutral emotion before thinking aloud about a scientific text. As hypothesized, positive (compared with negative) emotions increased the generation of text-based inferences. Unexpectedly, there were no differences between participants for knowledge-based inferences. Scrimin and Mason (2015) provided converging evidence using eye movement data: Readers induced to feel a positive emotion engaged in a higher degree of purposeful second-pass reading, which would support text-based inferencing.

Further evidence is being obtained in a study (part of which is presented in Bohn-Gettler & Mueller, 2013) in which participants read stories requiring a bridging inference versus control stories and engaged in lexical decision tasks with words representing the inference that should have been generated (the stimuli were from Virtue, van den Broek, & Linderholm, 2006). The inference texts were manipulated to strongly or weakly constrain the inference to account for task features. As hypothesized, happy-induced participants were equally likely to have made the inference in both the strongly and weakly constrained texts. Sad-induced participants were not as likely to have generated the inference in the weakly constrained texts (Bohn-Gettler & Mueller, 2013). This provides further evidence that the process, emotion, and task type matter: The weakly constrained texts did not provide scaffolding for building bridging inferences and hence required constructive processing. It was only when this scaffolding was removed that positive emotions facilitated and negative emotions debilitated inference generation.

Although consistent effects have been found regarding the influence of emotion on text-based inferences, prior work did not find an effect for knowledge-based inferences. This finding raises the question of whether positive emotions facilitate inferences because of facilitation for knowledge activation, enhanced assimilative integration, or both. In fact, some emotion research questions whether positive emotions truly broaden the breadth of attention (Gable & Harmon-Jones, 2008). As described earlier, Bohn-Gettler et al. (2016) induced pride, guilt, or a neutral emotion in readers before engaging them in an integration task (Singer et al., 1992). Positive emotions did not enhance the activation of prior knowledge, whereas negative emotions hampered it. For inferences requiring integration of text-based content and for inferences requiring integrating text with prior knowledge, positive-induced participants outperformed neutral- and negative-induced participants. Importantly, the difference between positively and negatively induced participants was slightly larger for the questions requiring integration (text-based and text-with-knowledge inferences) in comparison

with questions requiring only prior knowledge activation or textual memory. This study suggested two different effects: Negative emotions impaired prior knowledge activation, and positive emotions facilitated integration (Bohn-Gettler et al., 2016). In alignment with the PET framework, this set of studies shows how particular emotions influence inference generation, but only under certain task conditions.

Coherence-based retrieval

As described, comprehension can be guided by coherence-based retrieval (McCrudden & Schraw, 2007; van den Broek et al., 2011). It seems intuitive to hypothesize that positive emotions should be associated with the ability to more flexibly adopt various reading goals, whereas negative emotions with more difficulty in adopting reading goals. However, Bohn-Gettler et al. (2017) asked participants to read with the goal of studying versus being entertained but found no interactions between reading goal and induced emotion. One interpretation is that standards of coherence are not influenced by emotion.

It is possible that the influence of experimentally induced emotions on coherence-based retrieval is mediated or moderated by control-value appraisals (Hypothesis 6). For example, particular reading goals may induce academic and epistemic emotions such as engagement, confusion, frustration, and boredom (Pekrun et al., 2017). If a reader is asked to study a chemistry text but appraises chemistry to be too difficult and of little value, reading for study could be frustrating regardless of whether a positive emotion is induced. To date, little work has examined the potential relationships between coherence-based retrieval and emotion, but such investigations could produce valuable theoretical and practical implications.

Other factors

Finally, within the PET framework, Hypothesis 7 is that emotions should interact with important mediating and moderating variables such as text-, reader-, and activity-based factors (Snow, 2002; van den Broek & Kremer, 1999). In Table 1, this final hypothesis is intentionally left underspecified, because the predictions from each category (text-, reader-, and activity-based factors) vary based on the particular factor interacting with emotion. Specific examples of interactions are described next.

Reader-based variables

Although the PET framework considers emotion as a reader-based variable, other reader variables could play an important role, such as personality (Elfenbein & Bohn-Gettler, 2016; Komeda, Kawasaki, Tsunemi, & Kusumi, 2009), prior knowledge (Ellis, Varner, Becker, & Ottaway, 1995), or reading skill (Cain, Oakhill, & Bryant, 2004). Working memory is particularly interesting to study, because individuals with higher working memory better regulate emotions, despite feeling emotions with the same degree of intensity (Schmeichel, Volokhov, & Demaree, 2008).

Schmeichel et al. (2008) did not study text comprehension and implications for processing, so Bohn-Gettler and Rapp (2011) tested whether working memory moderated the influence of emotion on text processing. For readers with low working memory (but not high working memory), happy-induced participants engaged in more text-based inferences than sad-induced participants. In alignment with Schmeichel et al. (2008), high working memory decreased emotion's influence on processing. Other reader variables may exist that moderate or mediate the influence of emotion on text processing, demonstrating the importance of considering potential interacting reader variables.

Text-based variables

Texts can contain emotional content, and narratives contain characters with emotions (Gernsbacher, Hallada, & Robertson, 1998; Gygas, Oakhill, & Garnham, 2003; Mouw, Van Leijenhorst, Saab, Danel, & van den Broek, 2017). For instance, Gygas et al. (2003) documented how readers infer

and integrate general, but not specific, protagonist emotions into the situation model. In addition, Elfenbein and Bohn-Gettler (2016) and Jacobs (2015) found that readers do not simply come to a text with a particular emotion, but rather their emotions may change in response to the text content. Trevors and Kendeou (2017) also found that emotional content influences readers' likelihood of revising misconceptions.

Text cohesion might also interact with reader emotion. Bohn-Gettler et al. (2017) found that participants induced to feel positive emotions performed better on comprehension questions following a text with low cohesion (which required assimilative inferences) compared with high cohesion (which required fewer assimilative inferences). In contrast, participants induced to feel a negative or neutral emotion performed better on questions following a text with high cohesion compared with low cohesion. This demonstrates that text properties can modify the influence of emotions on processing—in this case, similar to the reverse cohesion effect (McNamara, Kintsch, Songer, & Kintsch, 1996).

Activity-based factors

It is essential to again underscore the importance of considering the activities in which readers are asked to engage before interpreting the effects of emotion on reading. For example, D'Mello and Graesser (2012) described how feedback can induce epistemic emotions and how tasks that produce confusion can sometimes be productive for learning (D'Mello, Lehman, Pekrun, & Graesser, 2014). It is critical to account for specific task features. For example, does the task require readers to regurgitate what they read (assimilative, nonconstructive processing)? Does the task require conceptual change (accommodation)? Does the task require readers to integrate content from multiple sources to build a justified argument (constructive processing)? More carefully accounting for and testing for differences between whether the task is assimilative versus accommodative and constructive versus reproductive may provide greater clarity regarding the influences of emotion on comprehension.

Conclusions and future directions

In summary, it is vital for the field to become more systematic about considering the specific comprehension process, the particular emotion under investigation, and the features of the task. Without doing so, research will continue to yield seemingly inconsistent and perhaps uninterpretable findings regarding the influences of reader emotion on comprehension. This would also limit practitioners' abilities to support readers in multifaceted applied settings.

The PET framework provides several hypotheses that vary depending on the specific comprehension process, the type of emotion under investigation, and the type of task. In particular, emotion should play the greatest role at the situation model level. Negative emotions may exert some constraints on memory capacity and resonance; positive emotions should facilitate assimilative integration, validation, and inferences. Negative emotions should facilitate accommodative integration, validation, and inferences; control-value appraisals may mediate or moderate the influence of emotion on effortful processes. In addition, all these effects are subject to the constraints of text-, reader-, and activity-based variables. Even though several hypotheses occur through the PET framework, it again demonstrates the need for specificity.

Due to the complexity of integrating theories of comprehension with emotion to generate the hypotheses proposed in the PET framework, it was necessary to initially constrain the framework to focus on emotions evoked before reading as opposed to how readers' emotional reactions dynamically change during reading as a function of text content (Elfenbein & Bohn-Gettler, 2016; Kaakinen et al., 2018; Kneepkens & Zwaan, 1994; Oatley, 2004). There is excellent work on this topic, documenting how text can build emotion potential and direct attention and processing (Hsu et al., 2015; Jacobs, 2015). The PET framework and aligning comprehension theories acknowledge that processing will dynamically change in response to the text. Emotion potential in texts could

initiate various processes outlined in the PET framework, such as attention, resonance, integration, inferences, and more. This would be a rich area for future research.

A primary goal of the PET framework is to provide a foundation for future research in reader emotion and comprehension. Worthy avenues of future investigation are (1) further distinguishing between valence and activation; (2) testing hypotheses regarding constraints on resonance; (3) further determining distinctions between assimilative versus accommodative processes in reading; (4) exploring possible mediating or moderating relationships between control-value appraisals and reading goals; (5) developing more specific hypotheses related to text-, reader-, and activity-based factors; and (6) testing what this means in more applied settings. Furthermore, future research would benefit from using the three-pronged approach (Magliano & Graesser, 1991), that is, obtaining converging evidence through behavioral measures (e.g., reading times, probe latencies, eye-tracking, or observations), verbal protocols (e.g., think-alouds), and aligning theories of emotion and comprehension.

The PET framework provides guidance for how to be more systematic and careful in the study of emotion, particularly when considering its influences and interactions with text processing. Situating each finding within this framework could help the field become more coherent and cohesive, especially when attempting to develop testable hypotheses and explore seemingly disparate findings. Practically, emotions are integral in day-to-day life, and it is vital for researchers, practitioners, and instructional designers to have a coherent framework for considering how emotions influence comprehension when designing studies, supporting readers, and developing instructional materials.

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