A Multi-Study Examination of the Relations Between Epistemic Cognition, Emotions, and Learning About Controversial Science Knowledge

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Outline

• Controversial Science Knowledge

• Epistemic Cognition

• Manuscript Foci
  1. Cognition and Metacognition
  2. Beliefs and Emotions
  3. Identity and Emotions
Communicating Science Knowledge in the 21st Century

New technologies make knowledge widely accessible

+ Self-authorship & cognitive biases

= Complex, evolving, conflicting, & confusing information
Science Communication Paradox

“Never have human societies known so much about mitigating the dangers they face but agreed so little about what they collectively know.” (Kahan, 2015)
With G.M.O. Policies, Europe Turns Against Science Over Evolution Concerns
Epistemic Beliefs

- How do we resolve conflicting information?
- Does science need to be “settled” before we believe it?
- Who’s a trustworthy source of information?
Epistemic Beliefs

- **Nature of Knowledge**
  - Structure:
    - Complexity ↔ Simplicity
  - Variability:
    - Uncertain ↔ Certain

- **Nature of Knowing**
  - Source:
    - Internal construction by oneself ↔ External reception from authorities
  - Justification:
    - Personal opinion ↔ Rule of inquiry

(Bråten & Strømsø, 2009; Hofer & Pintrich, 1997)
Unique Challenges for Learning Controversial Knowledge

Few studies have focused on uncovering the real-time *processes* of learning about controversial knowledge and the *factors* that predict them.
Controversial Knowledge:
Three types of conflicts
Disagreements within a source
Students Regulate Their Learning as a Function of Epistemic Beliefs and Discrepancies

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Purpose

To examine the relations between epistemic beliefs and cognitive and metacognitive learning processes when encountering discrepancies in science multimedia.
Self-Regulated Learning: Cognitive Architecture of COPES

Conditions
External (e.g. time)
Internal (e.g. epistemological beliefs)

Controlling

Products

Operations

Evaluations

Standards

Pieschl et al., 2008
Epistemic Beliefs

Nature of Science Knowledge
(Hofer & Pintrich, 1997; Stahl & Bromme, 2007)

Structured
Objective
Definite

Unstructured
Subjective
Ambiguous

Static
Irrefutable
Completed

Dynamic
Refutable
Uncompleted

Texture

Variability
Within-Text Discrepancy

“speed reactions”

“decrease reactions”
Between Text And Graph Discrepancy

increasing graph

“decreasing” in text
17

No Discrepancy Control
Tobii T-60 Eye-Tracker
Humidity

The amount of water vapor in the atmosphere is referred to generally as humidity. Damp, moist conditions are more likely to have condensation than evaporation, and this is said to be a high humidity. Dry conditions are more likely to have evaporation than condensation, on the other hand, and this is said to be low humidity.

A measurement of the amount of water vapor in the atmosphere at a particular time is called the absolute humidity. At room temperature, for example, humid air might contain 15 grams of water vapor in each cubic meter. At the same temperature, air of low humidity might have an absolute humidity of only 2 g/cm³. The absolute humidity can range from near zero at temperatures well below freezing, up to a maximum that is determined by the temperature at the time.

The relationship between the actual absolute humidity at a particular temperature and the maximum absolute humidity that can occur at that temperature is called the relative humidity. Relative humidity is a ratio between (1) the amount of water vapor and (2) the amount of water vapor needed to reach saturation at that temperature. The important thing to understand about relative humidity is that the maximum amount of water vapor in the air is limited by temperature.
Variables

**Predictor:**
- Beliefs about Texture / Structure of Science Knowledge
- Beliefs about Variability of Science Knowledge
- Prior Science Knowledge

**Dependent:**
- Metacognitive Judgments
- Eye Tracking
- Page Study Times
Canonical Correlations

- Predictors explained 22% of overall variance of dependent variables
- Only on Within-Text (WT) Discrepancy pages
Bivariate Correlations

Texture **negatively** related to metacognitive judgments
- Greater perception of science knowledge as **complex** related to **lower confidence** that pages with Within-Text discrepancies were understood.

Variability **negatively** related to study times & integration
- Greater perception of science knowledge as **dynamic and refutable** related to **less time** spent on pages with Within-Text discrepancies.
Conclusions I

The more individuals’ epistemic beliefs were aligned with the epistemology of science, the more sensitive they were at detecting and responding to discrepancies in science texts.
How and Why?

(2nd Study: Think-Alouds & Retrospective Interviews)

• ID16: “I know I’m not good in sciences, so I just followed what it said.”

• ID12: “There were sometimes when I thought the graph was wrong or had bad information, then I would get really confused and I would question my ability to think.”

• ID08: “I really didn't question it, because I don’t consider myself knowledgeable.”

• ID18: “When it comes to science I just don’t consider myself a better authority.”
Conclusions II

Learning processes relate to individuals’ level of **epistemic confidence**
  - confidence in one’s ability to question authoritative knowledge, and in oneself as a source of knowledge

Confidence to question content, sensitivity in detecting discrepancies, integrating multimedia representations to resolve them.
Disagreements between sources
Epistemic Beliefs and Emotions Predict the Source of Information in Summaries of Multiple Conflicting Documents

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Purpose

To examine the role of \textit{emotions as mediators} between \textit{epistemic beliefs} and \textit{learning} from multiple conflicting documents.
Hypothesized Model

Uncertainty

Complexity

Justification: Inquiry

Source: Active

Surprise

Curiosity

Enjoyment

Confusion

Anxiety

Frustration

Boredom

Summary
Materials and Procedure

1. **Beliefs**: 24-item Topic-Specific Epistemic Beliefs Questionnaire (Bråten & Strømsø, 2009)

2. **Texts**: 4 conflicting texts (human/natural causes; negative/positive effects) adapted from Strømsø, Bråten, and Britt (2009)

3. **Emotions**: 7-item scale, single adjective for each emotion (e.g., “Enjoying”) (Pekrun & Meier, 2011)

4. **Summaries**: “Type a short essay (minimum 2-3 paragraphs in length) summarizing the texts you read on climate change.”

5. **Data sources**: Memory and use of source information at two levels – concept (word) level and sentence level.
Uncertainty

Surprise

Justification: Inquiry

Sentence Level

Edge 1: Uncertainty → Surprise
   Coefficient: 0.09*

Edge 2: Justification: Inquiry → Surprise
   Coefficient: 0.09+

Edge 3: Surprise → Sentence Level
   Coefficient: 0.14**
Justification: Inquiry $\rightarrow$ Curiosity $\rightarrow$ Concept Level

$\text{Justification: Inquiry}$

$\text{Curiosity}$

$\text{Concept Level}$

$\text{Justification:}$

Inquiry

Curiosity

Concept Level

$.19^{**}$

$.08^{+}$
Conclusions

Emotions *mediate* the relations between epistemic beliefs and fundamental aspects of reading comprehension.

**Confusion** is especially detrimental for learning from multiple conflicting documents.
Disagreements between source and individual
Identity and Epistemic Emotions during Knowledge Revision: A Potential Account for the Backfire Effect

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Purpose

To determine if emotions mediate the relations between identity and learning from refutations and act as one possible explanation for the backfire effect that sometimes occurs when misinformation is retracted.
Theoretical Framework

• **Misconceptions** about socio-scientific issues are often resistant to change (Sinatra, Kienhues, & Hofer, 2014)
  - E.g., Genetically modified foods are unnatural and toxic

• **Backfire effect** — ironic strengthening of belief in misinformation after an attempted correction (Prasad et al., 2009; Nyhan & Reifler, 2010)
  - Identity (ego) protection (Kahan, 2015)
Theoretical Framework

• Misconceptions may be integrated with identity, such that efforts at knowledge revision may be appraised as threats and lead to experiencing anxiety (Gregoire, 2003)

• Negative emotions impact learning from texts and thus have implications for knowledge revision (Bohn-Gettler & Rapp, 2014; Zeidner, 2014)
Hypothesized Moderated Mediation

Identity

Surprise

Positive Emotions

Negative Emotions

Refutation Text

Learning

Controls:
- Attitudes
- Prior Knowledge
Method

Genetically Modified Foods

1. Dietary Self-Concept
   • “I often think about the lasting effects of the foods I eat.”

2. Two experimental conditions:
   • Expository (control) text vs. Refutation text
   • “You may think that the development of genetically modified foods occurs only in laboratories by scientists. This is also not correct! Genetic modifications may happen through natural processes.”

3. Epistemic emotions
   • “Confused”

4. Knowledge/Learning
   • Pre- and post-test
The graph shows the mean reported negative emotions across two conditions: Expository and Refutation. The solid line represents the high self-concept group, while the dashed line represents the low self-concept group. The y-axis represents the mean reported negative emotions, ranging from 1.00 to 2.00. The x-axis represents the text condition, with two categories: Expository and Refutation. The data indicates that the high self-concept group experiences a higher mean of negative emotions compared to the low self-concept group in both conditions.
Summary of Standardized Effects
Summary of Standardized Effects

<table>
<thead>
<tr>
<th>Self-Concept</th>
<th>Prior Knowledge</th>
<th>Profit Emotions</th>
<th>Negative Emotions</th>
<th>Learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive Attitude</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Correlation Coefficients:

- Prior Knowledge → Self-Concept: ~.40**
- Self-Concept → Positive Attitude: -.32**
- Positive Attitude → Text Condition: .26**
- Text Condition → Learning: .30**
- Negative Emotions → Learning: -.39**
- Learning → Self-Concept: .22*
- Learning → Positive Emotions: -.21*

* and ** indicate significance levels.
Significant moderated mediation in refutation condition, $\beta = -.09$

Moderator: Refutation Condition
Conclusions

Self-concept on learning negatively mediated via negative emotions, which was conditional on text condition (i.e., refutation text).

Possible evidence that refutations may be appraised as threats, which represents a new area of focus for knowledge revision research.
Final Conclusions
Conclusions Recap: Three Manuscripts

1. Confidence to question content, sensitivity in detecting discrepancies, coordinating sources to resolve them.

2. The relations between epistemic beliefs learning from multiple conflicting documents are mediated by emotions.

3. Identity can negatively impede the revision of misconceptions, mediated via personally-experienced negative emotions.
Contributions

Contemporary challenges to learning about controversial science.

**Theoretical:**
- Epistemic confidence
- Mediating emotion
- Identity in revision
- Boundary conditions for successful revision

**Methodological / Analytical:**
- Triangulation
- Eye tracking
- Think-alouds
- Metacognitive judgments
- Computer log data-mining
- Mediation and moderation analyses
Implications for Practice

1) “I’m not a science person” – designing STEM interventions to target epistemic confidence and identity

2) Scaffolding self-regulation of curiosity and ‘optimal confusion’
   (D’Mello & Graesser, 2014)

3) Re-framing revision interventions to account for identity
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