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

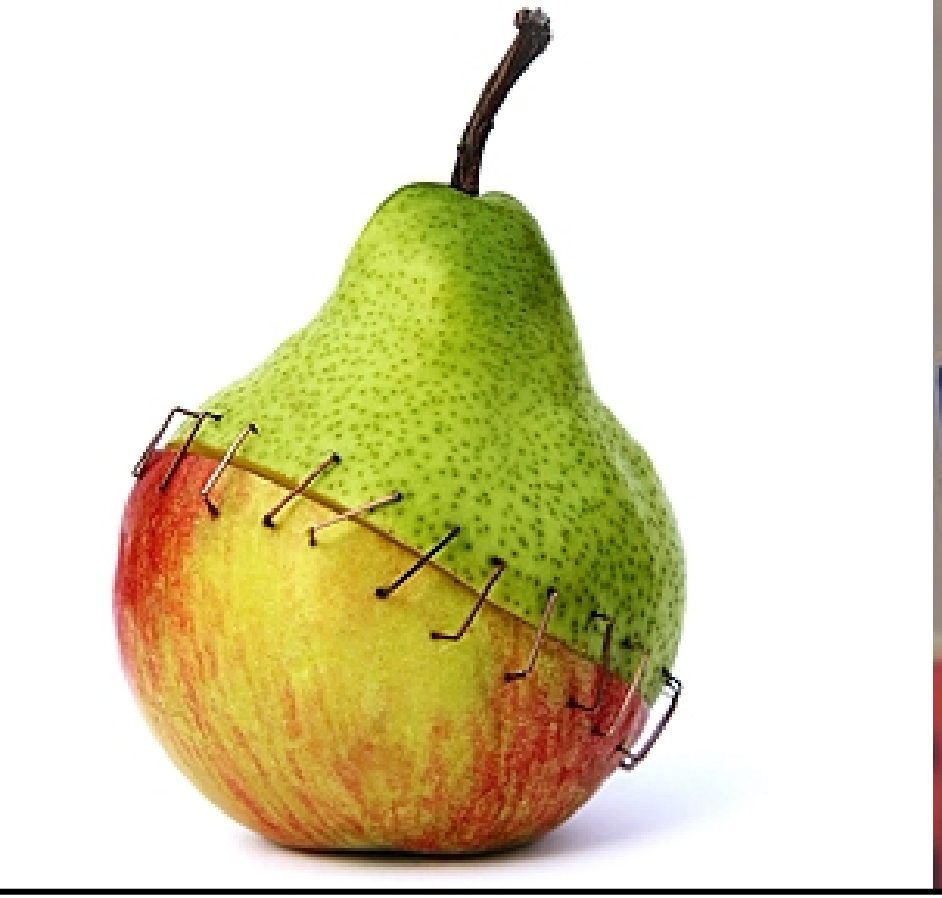
New technologies make knowledge widely accessible

+ 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:

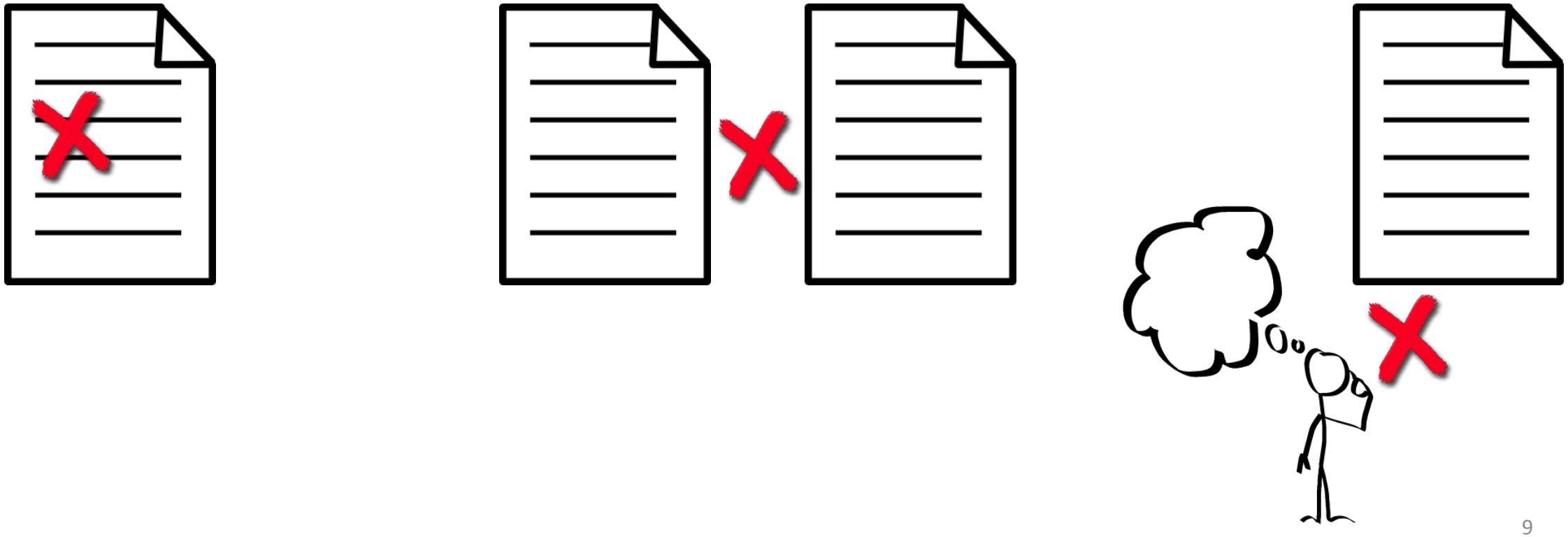
    Personal opinion ⟷ Rule of inquiry

(Bråten & Strømsø, 2009; Hofer & Pintrich, 1997)

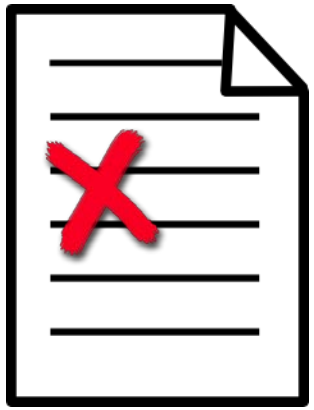
Unique Challenges for Learning Controversial Knowledge

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



Learning and Instruction, *Vol. 42*, pp. 31-46, 2016

Students Regulate Their Learning as a Function of Epistemic Beliefs and Discrepancies

Gregory Trevors[1] , Reza Feyzi-Behnagh[2], Roger Azevedo[3], and François Bouchet[4]

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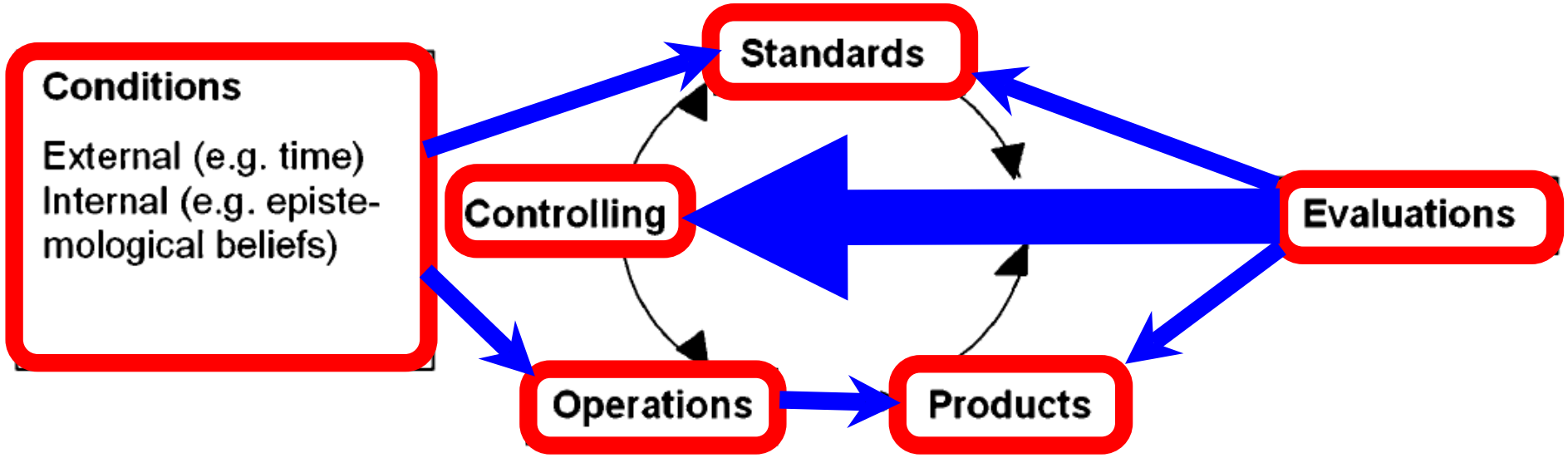
Purpose

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



Pieschl et al., 2008

Epistemic Beliefs

Nature of Science Knowledge

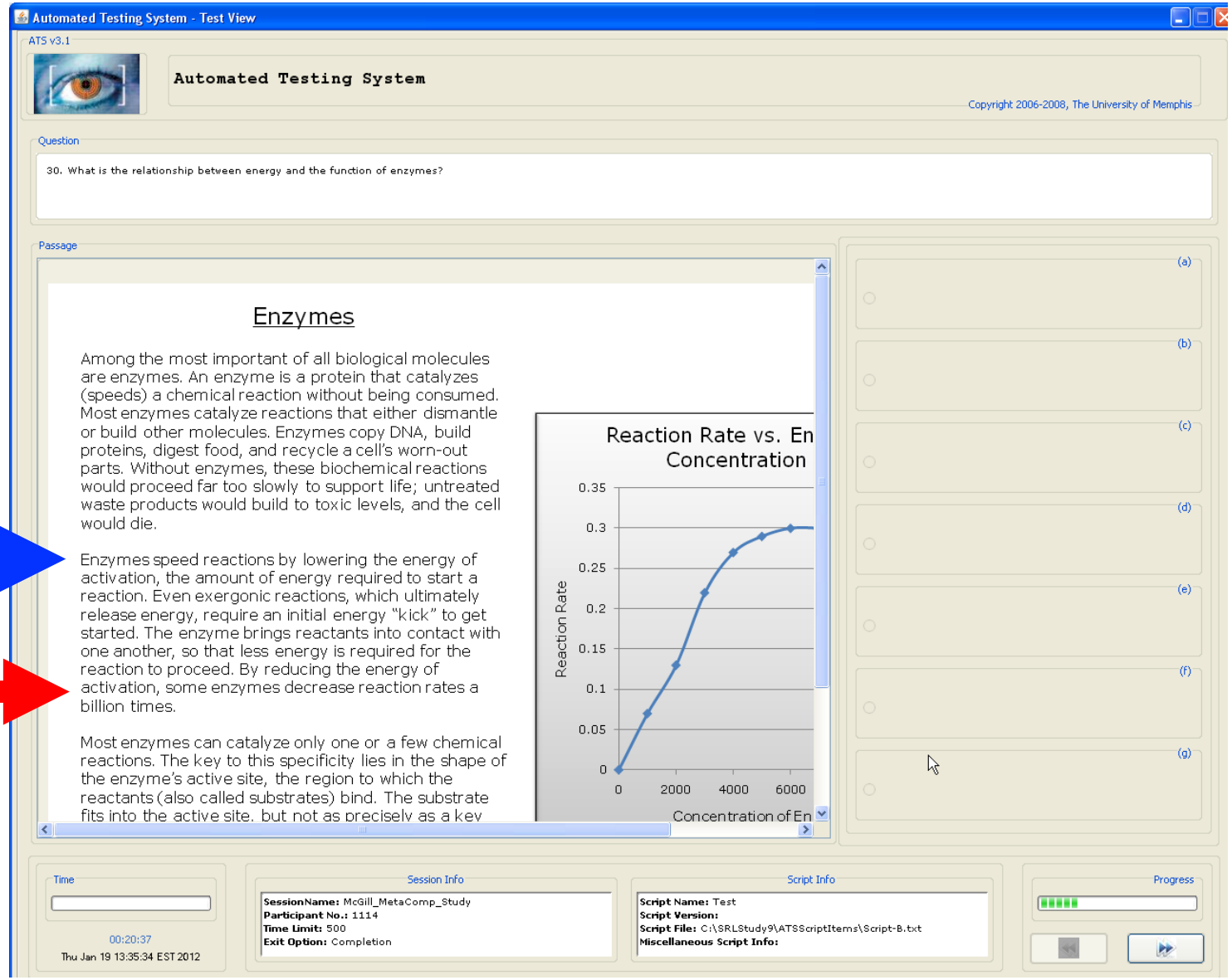
(Hofer & Pintrich, 1997; Stahl & Bromme, 2007)

Structured	Texture	Unstructured
Objective		Subjective
Definite		Ambiguous
Static	Variability	Dynamic
Irrefutable		Refutable
Completed		Uncompleted

Within-Text Discrepancy

"speed reactions"

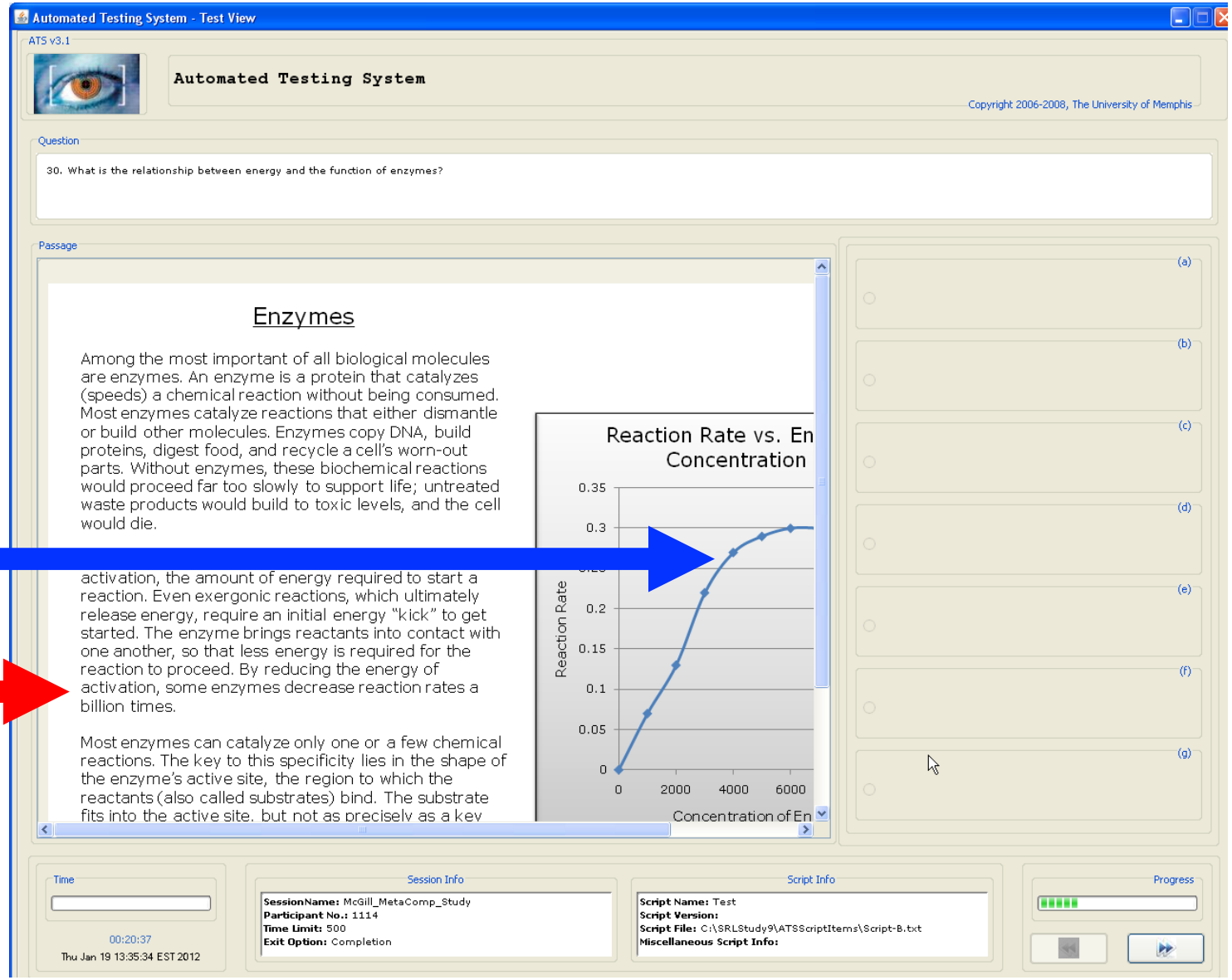
"decrease reactions"



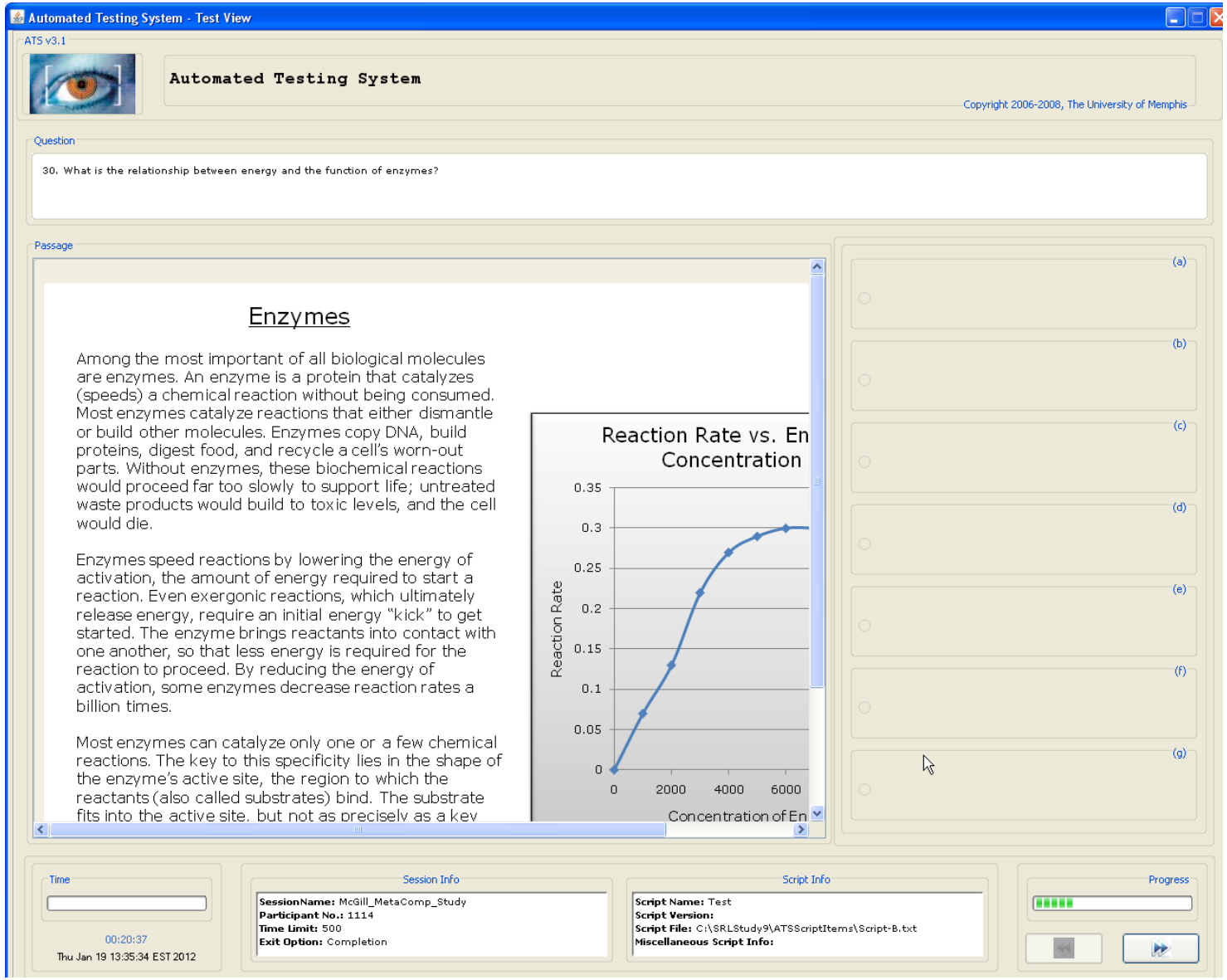
Between Text And Graph Discrepancy

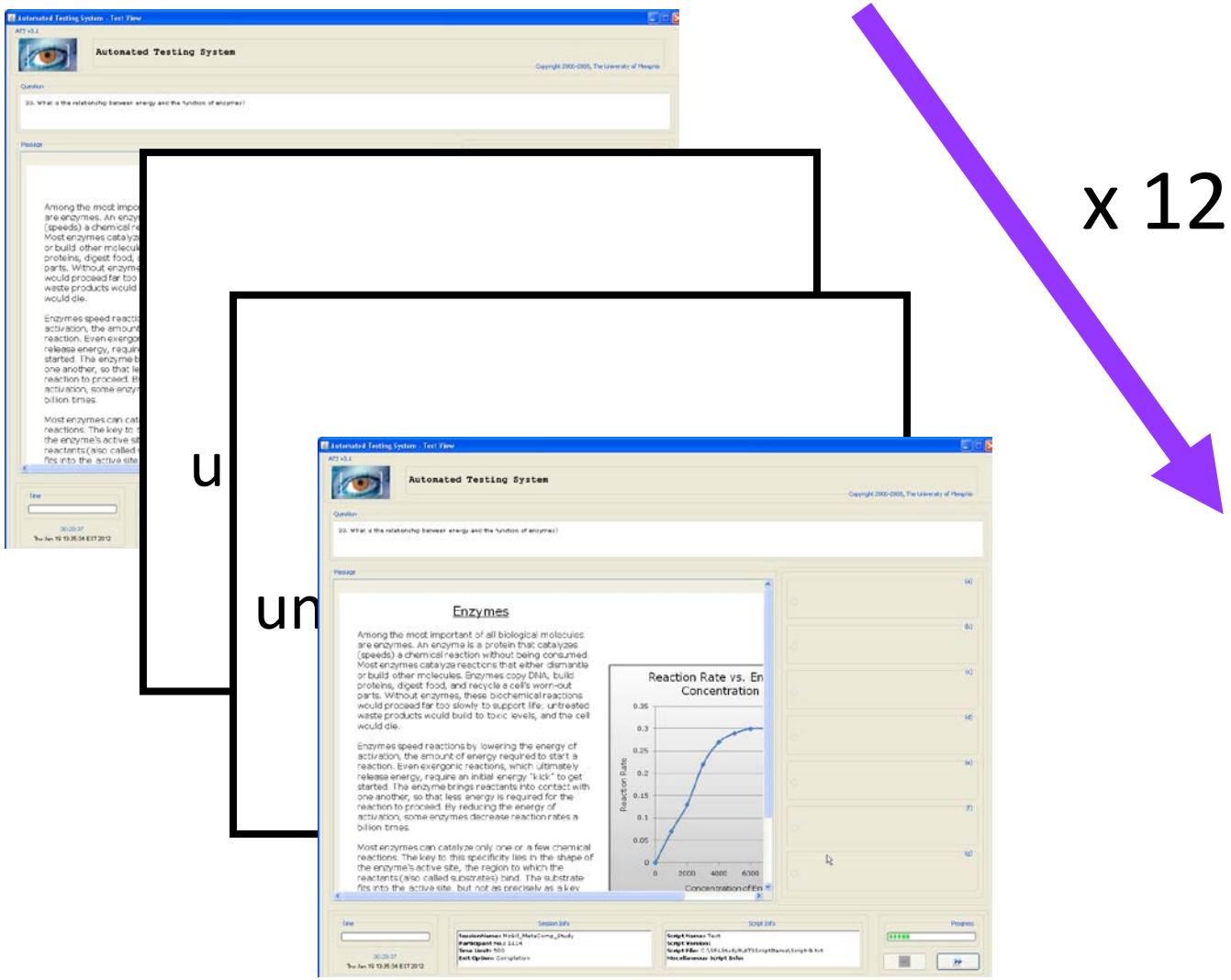
increasing graph

"decreasing" in text



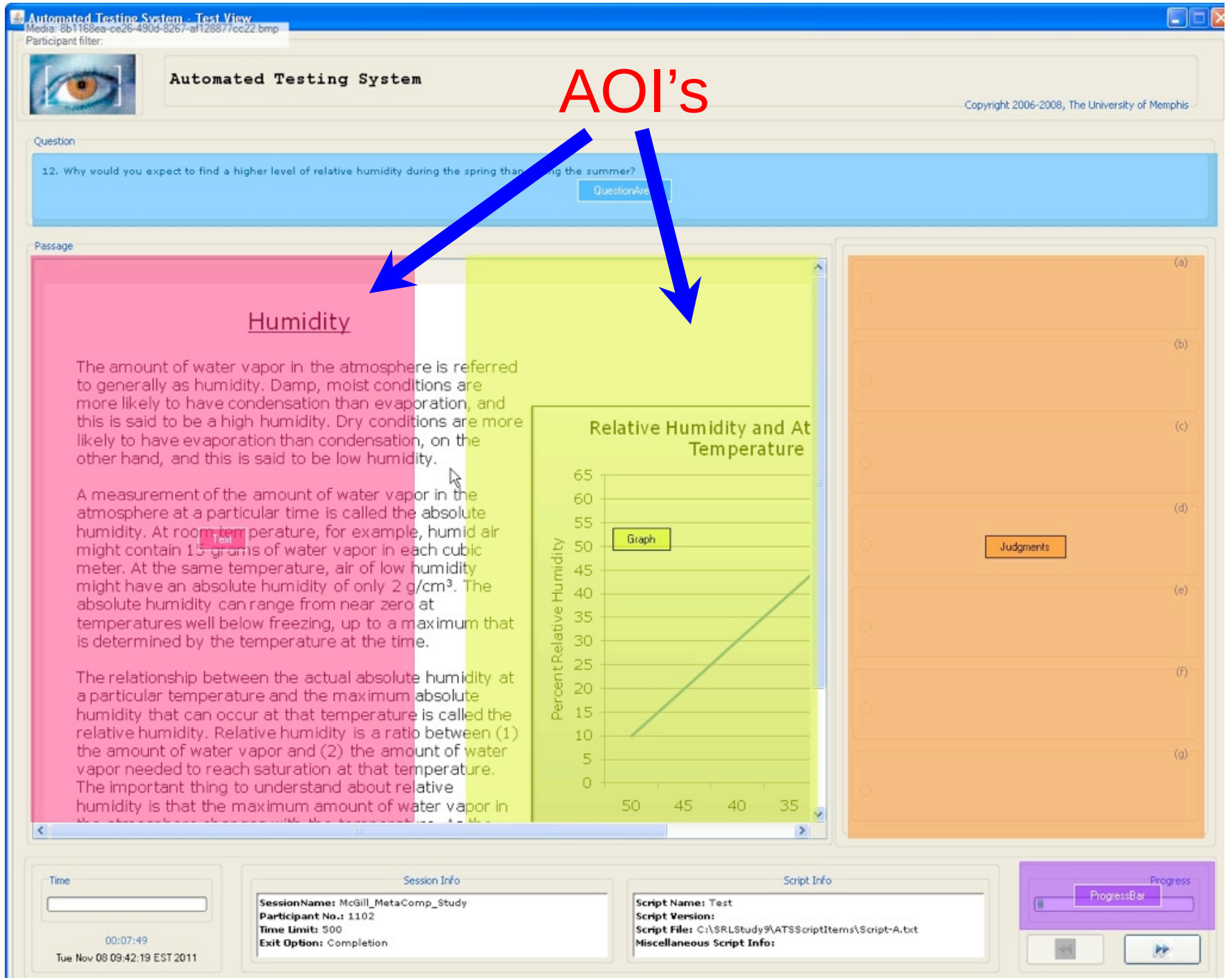
No Discrepancy Control




Automated Testing System
Enzymes
Reaction Rate vs. En
Concentration

x 12

Tobii T-60 Eye-Tracker

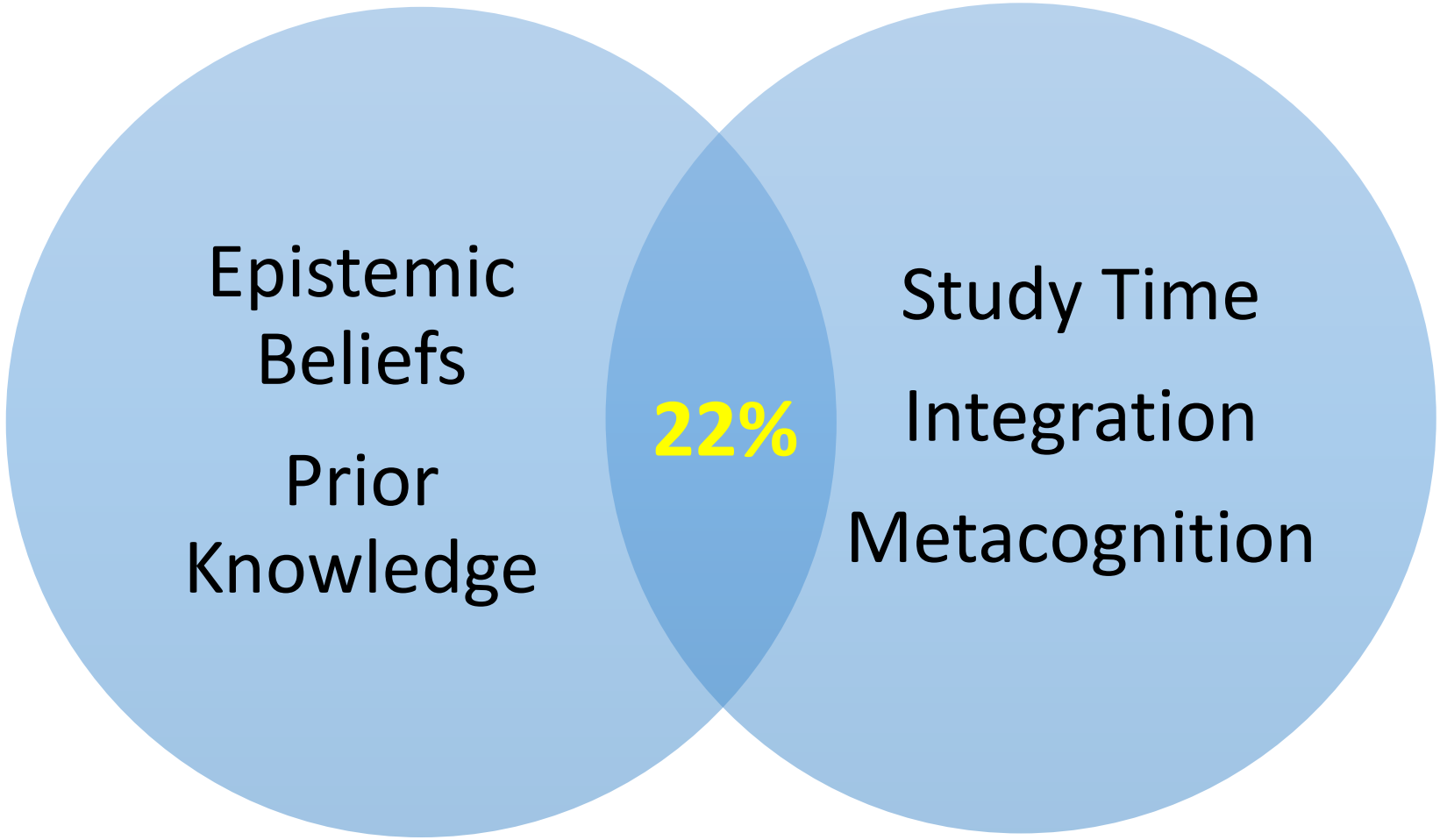

Automated Testing System - Test View
Media: 8b1168ea-ce26-490d-8267-af128877cc22.bmp
Participant filter:
Automated Testing System
AOI's
Copyright 2006-2008, The University of Memphis
Question
12. Why would you expect to find a higher level of relative humidity during the spring than during the summer?
QuestionAre
Passage
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
Text
Relative Humidity and At Temperature
Percent Relative Humidity
65
60
55
50
45
40
35
30
25
20
15
10
5
0
50
45
40
35
Graph
Judgments
(a)
(b)
(c)
(d)
(e)
(f)
(g)
Time
00:07:49
Tue Nov 08 09:42:19 EST 2011
Session Info
SessionName: McGill_MetaComp_Study
Participant No.: 1102
Time Limit: 500
Exit Option: Completion
Script Info
Script Name: Test
Script Version:
Script File: C:\SRLStudy9\ATSScriptItems\Script-A.txt
Miscellaneous Script Info:
Progress
ProgressBar

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.”

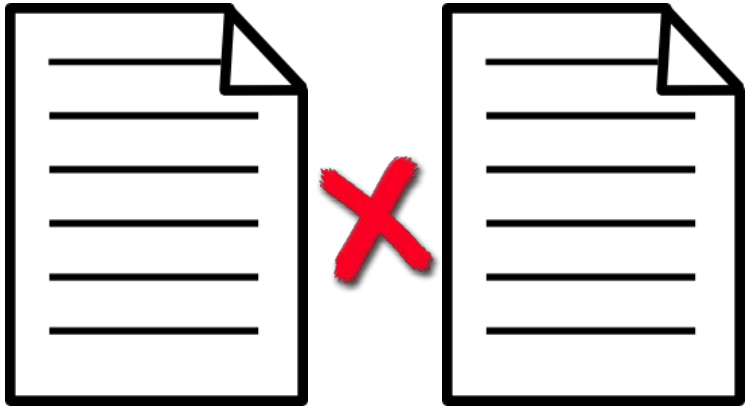
Conclusions II

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



Contemporary Educational Psychology, *Vol. 48*, pp. 116-132, 2017

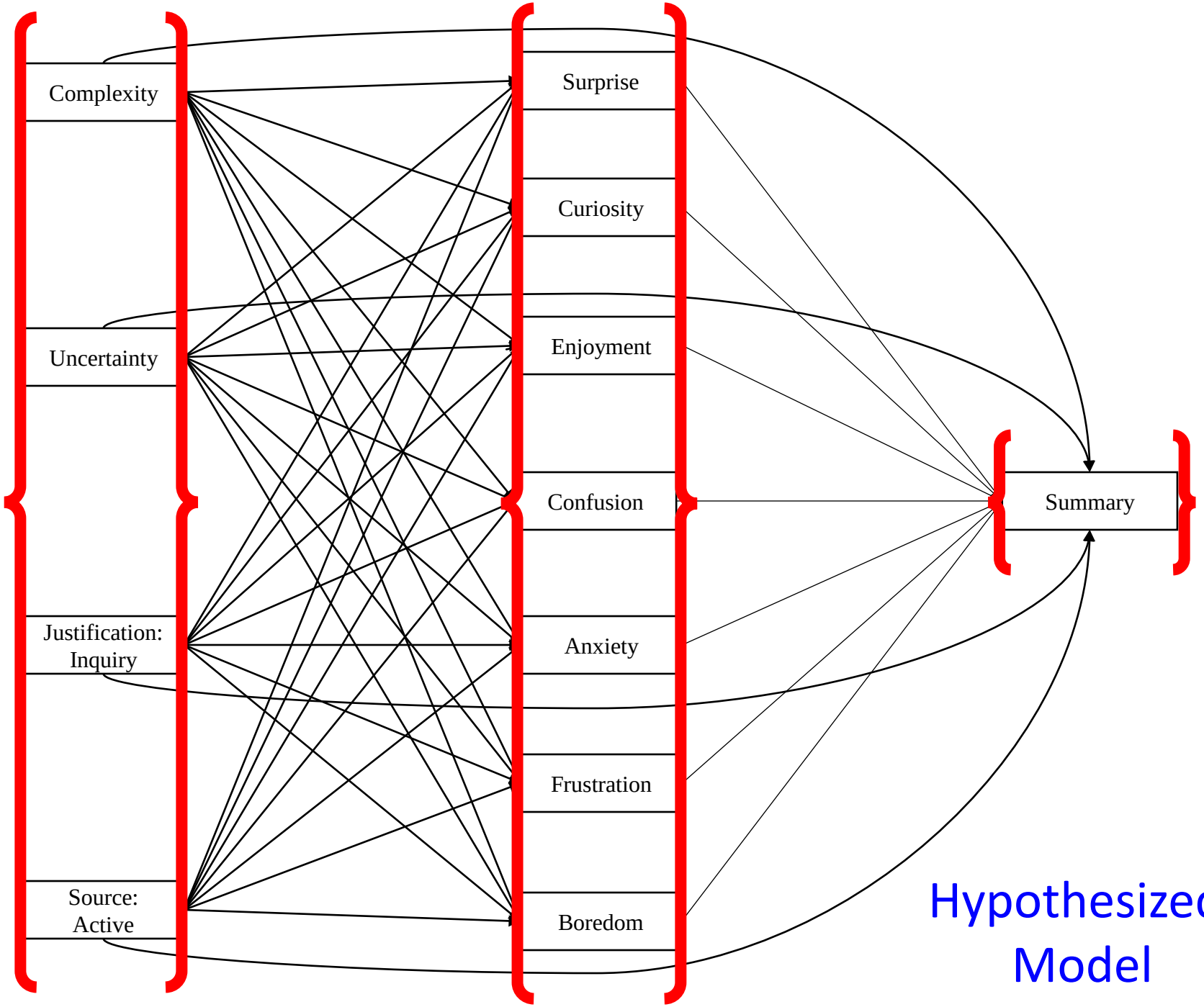
Epistemic Beliefs and Emotions Predict the Source of Information in Summaries of Multiple Conflicting Documents

Gregory Trevors[1], Krista R. Muis[2], Reinhard Pekrun[3], Gale M. Sinatra[4], and Marloes Muijselaar[5]

University of Minnesota, [2]McGill University, [3] University of Munich, [4]University of Southern California, [5]University of Amsterdam

Purpose

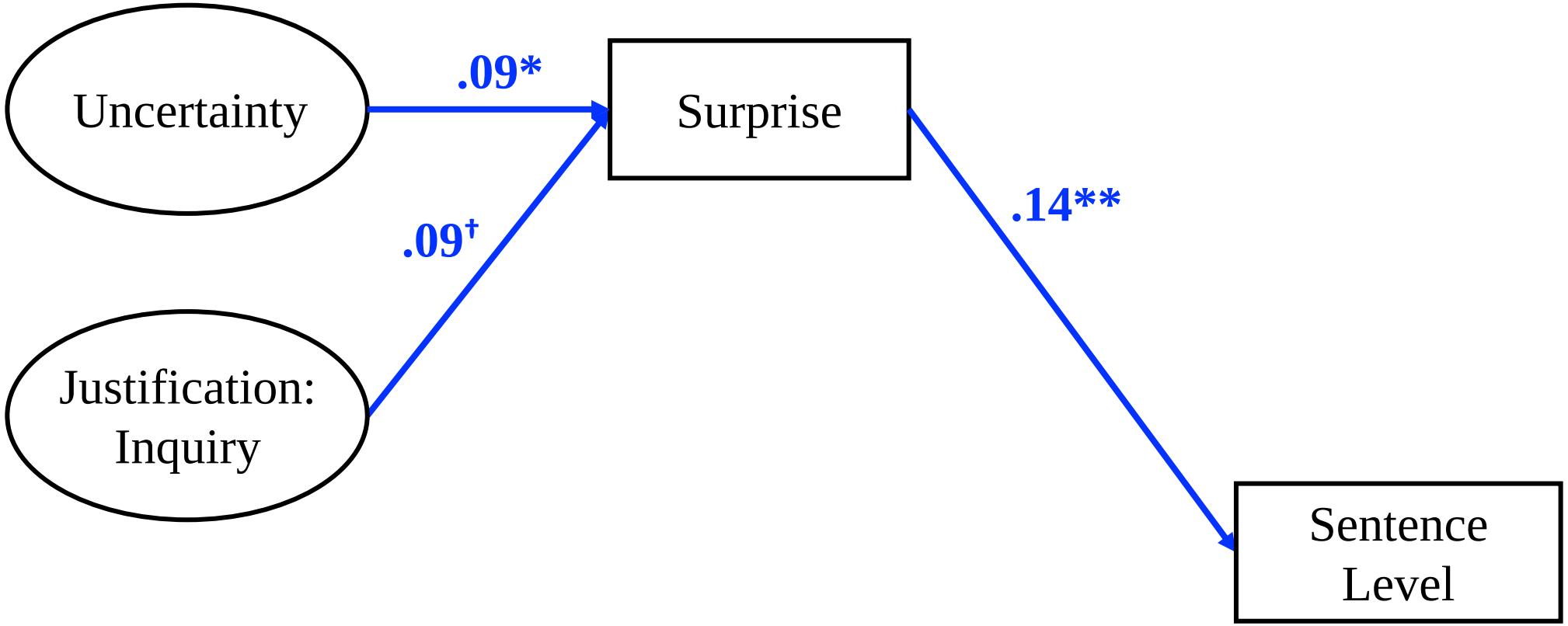
To examine the role of **emotions as mediators** between **epistemic beliefs** and **learning** from multiple conflicting documents.

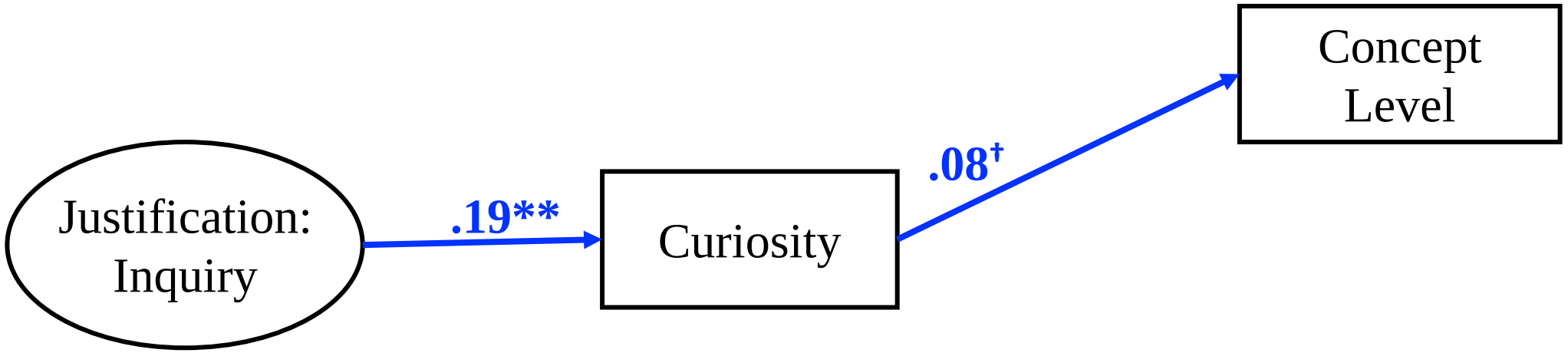


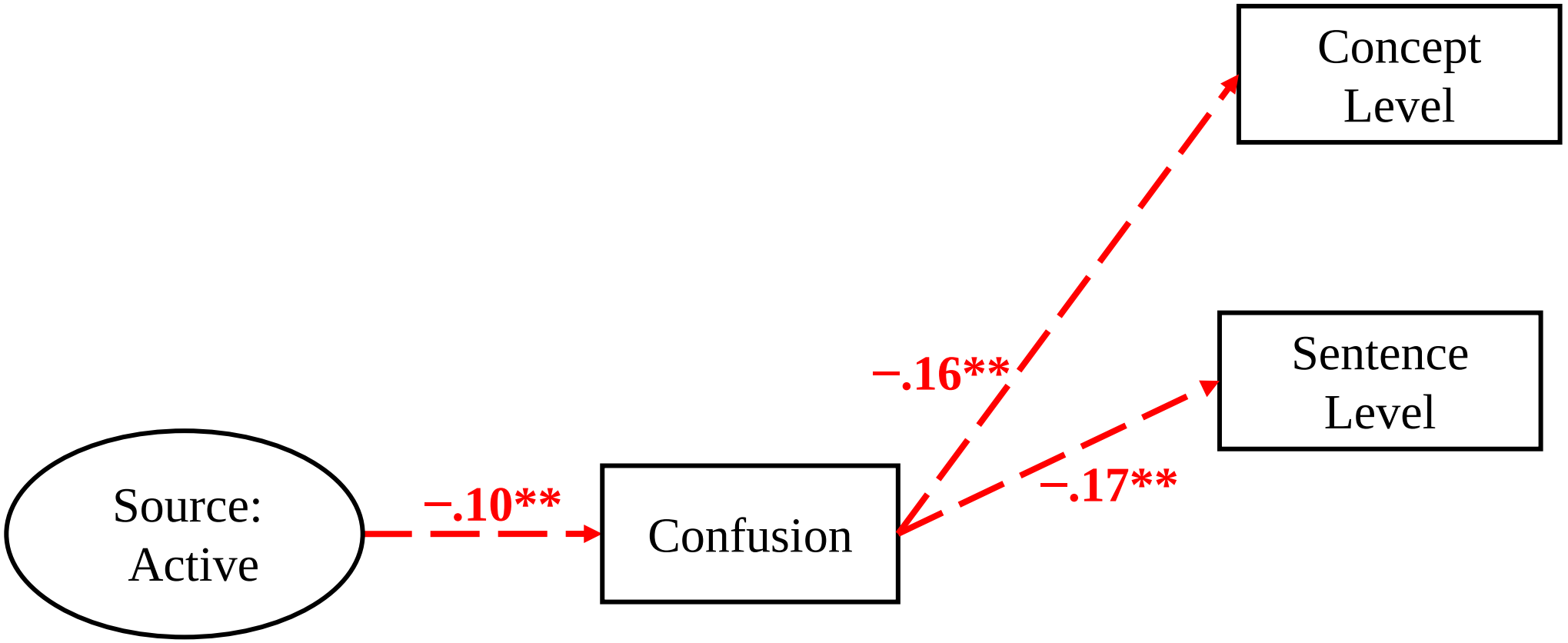
Hypothesized Model

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
.09*
Surprise
.09†
.14**
Justification: Inquiry
Sentence Level


Justification: Inquiry
.19**
Curiosity
.08†
Concept Level

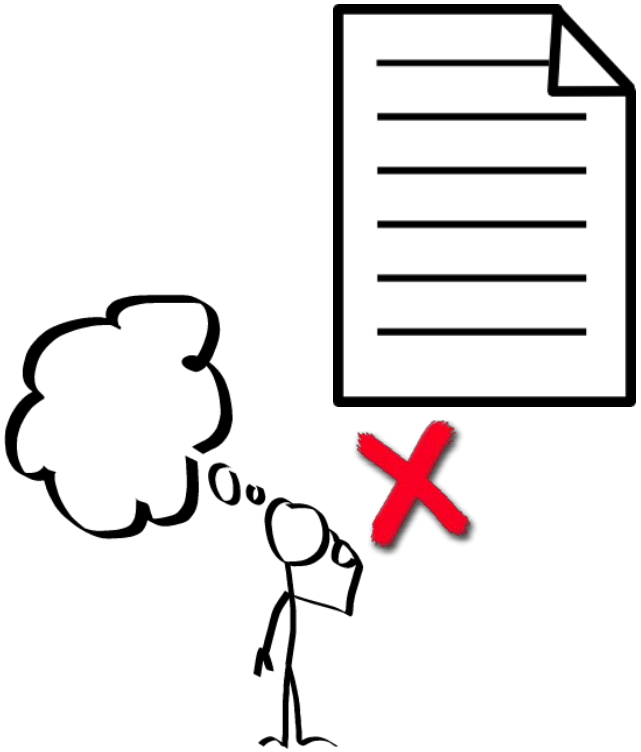

Concept Level
Sentence Level
−.16**
−.17**
Source: Active
−.10**
Confusion

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



Discourse Processes, *Vol. 53*, pp. 339-370, 2016

Identity and Epistemic Emotions during Knowledge Revision: A Potential Account for the Backfire Effect

Gregory Trevors[1], Krista R. Muis[2], Reinhard Pekrun[3], Gale M. Sinatra[4], and Phillip H. Winne[5]

[1]University of Minnesota, [2]McGill University, [3]University of Munich, [4]University of Southern California, [5]Simon Fraser University

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

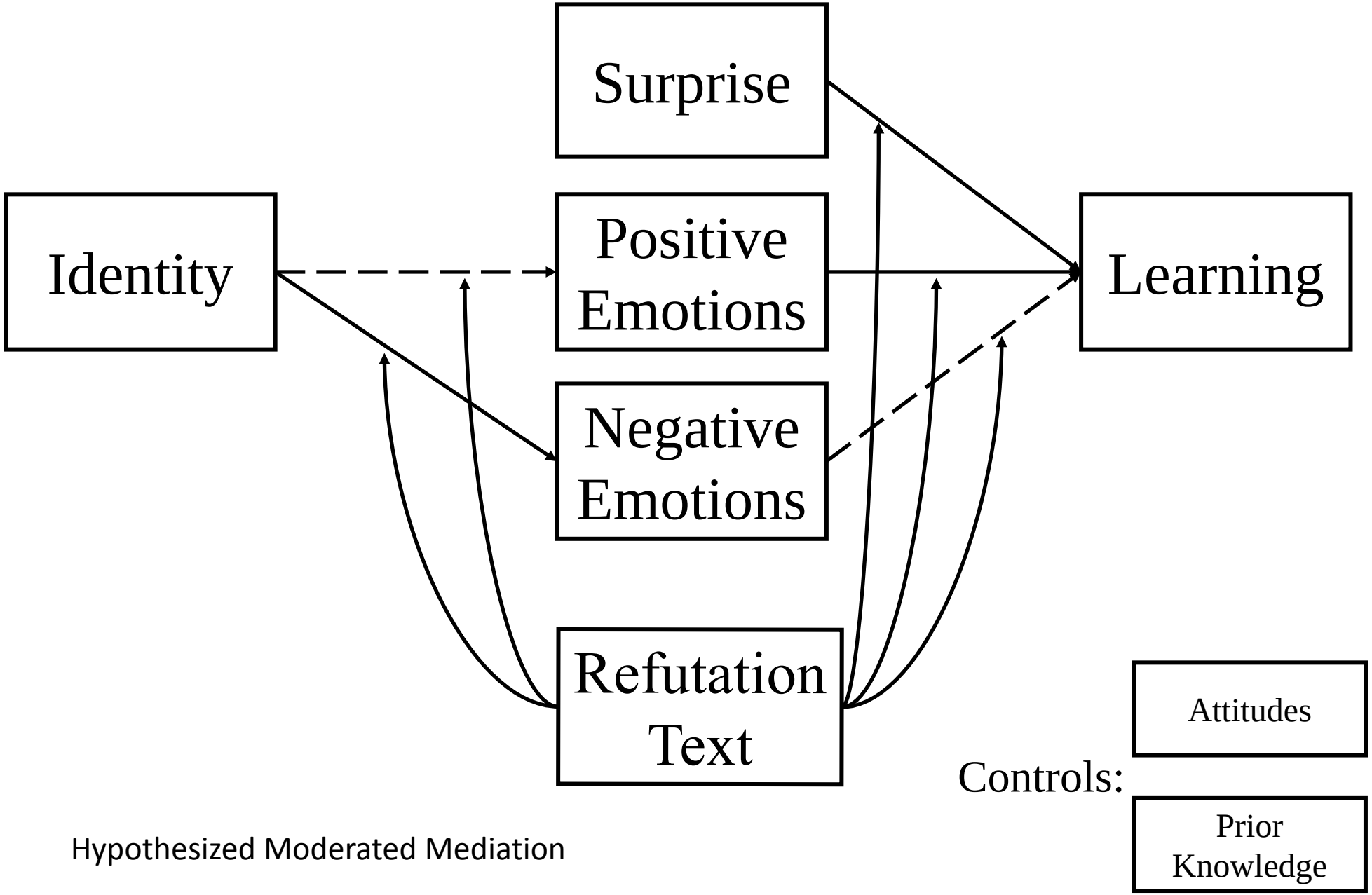
- **Misconceptions** about socio-scientific issues are often resistant to change (Sinatra, Kienhues, & Hofer, 2014)
  - E.g., Genetically modified foods are unnatural and toxic

- **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)

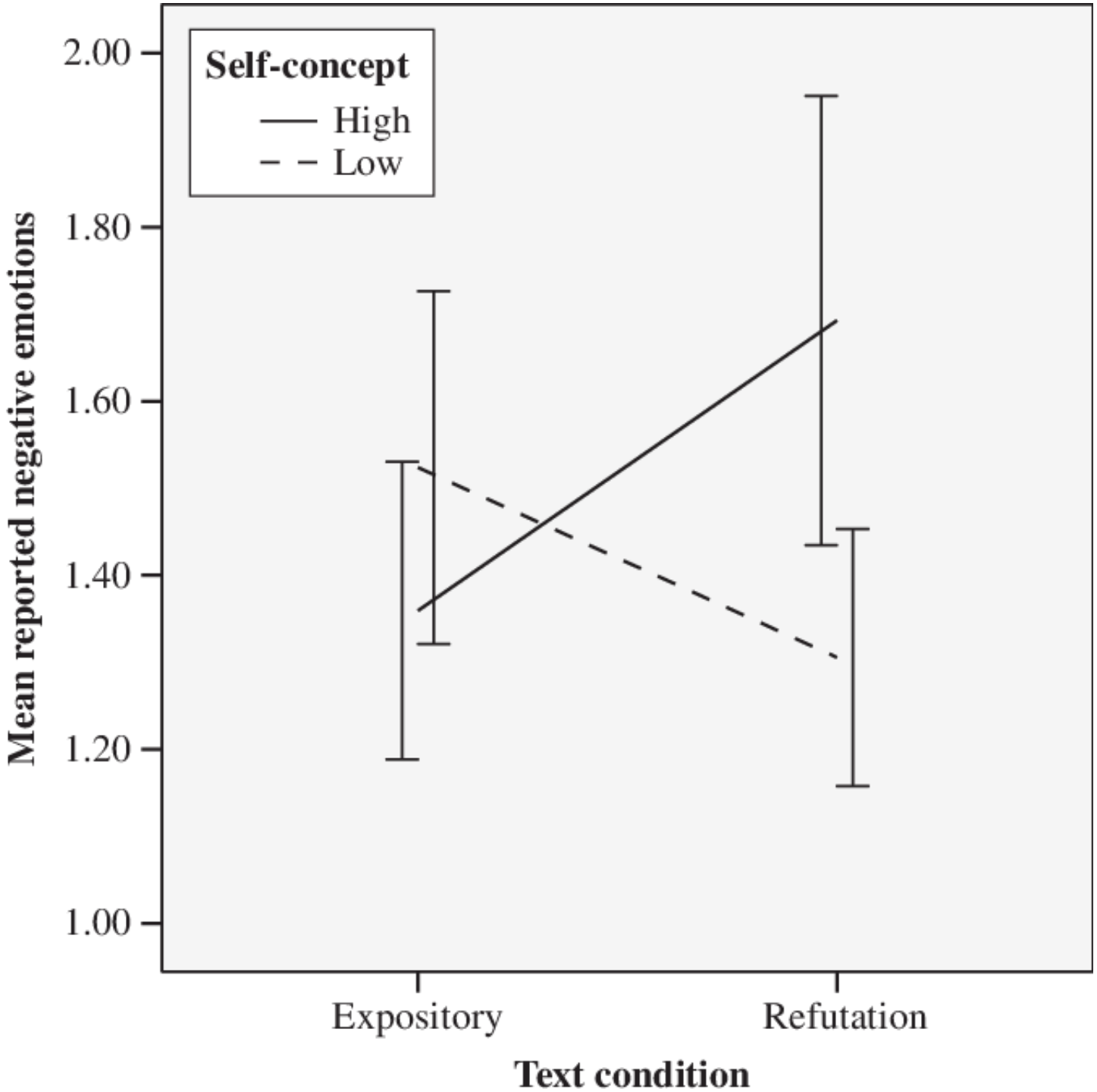


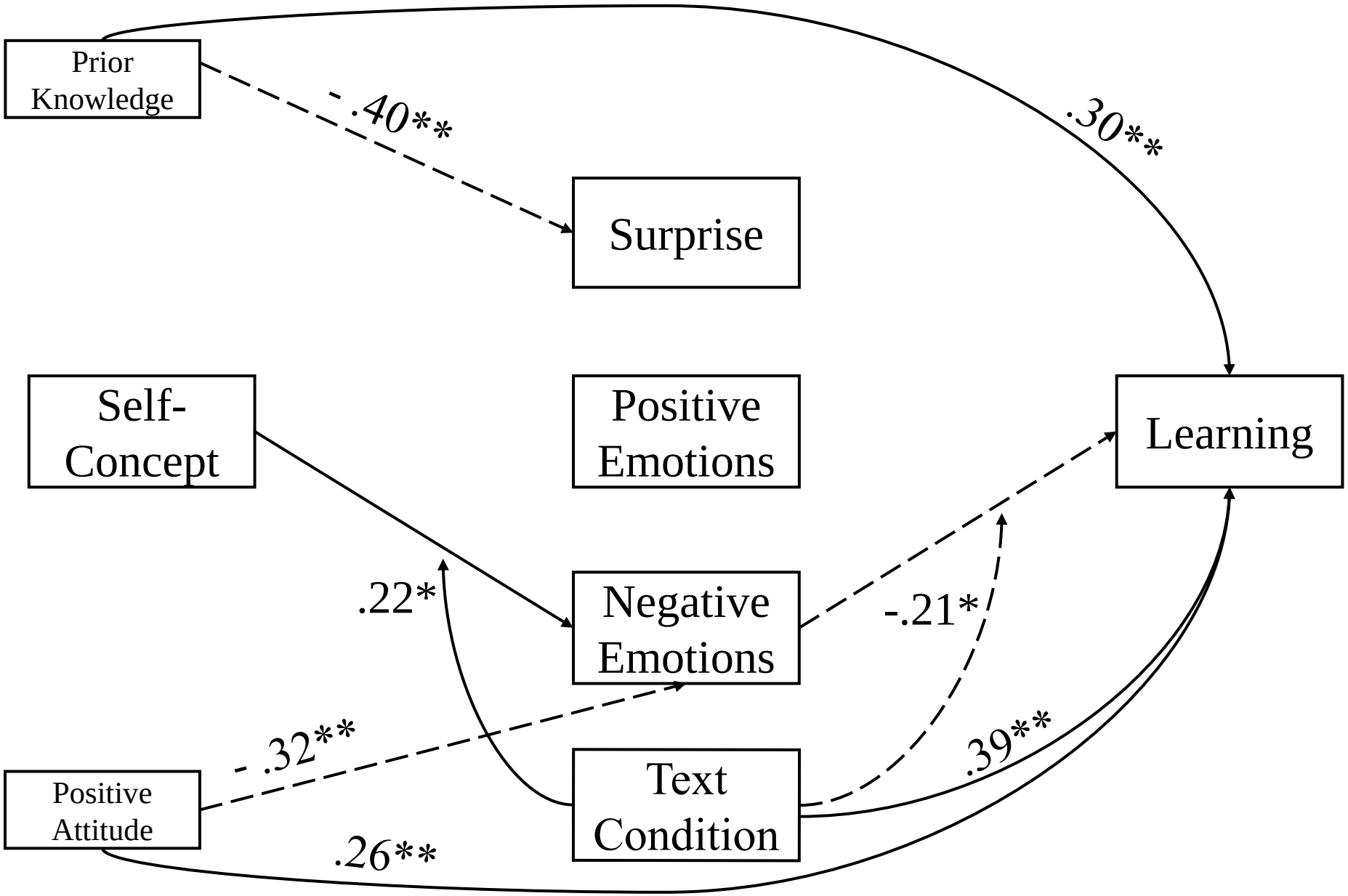
Hypothesized Moderated Mediation

Method

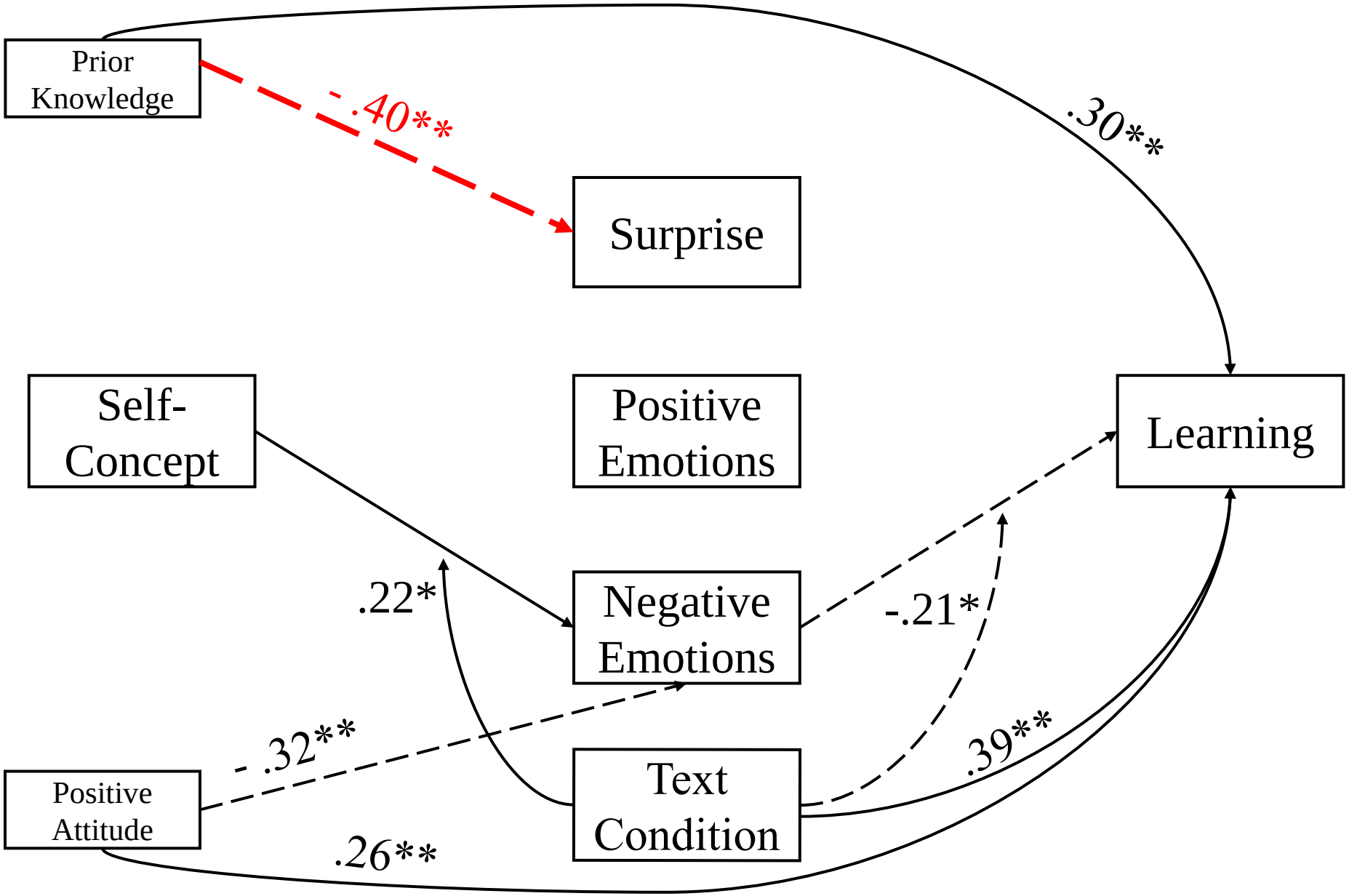
Genetically Modified Foods

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

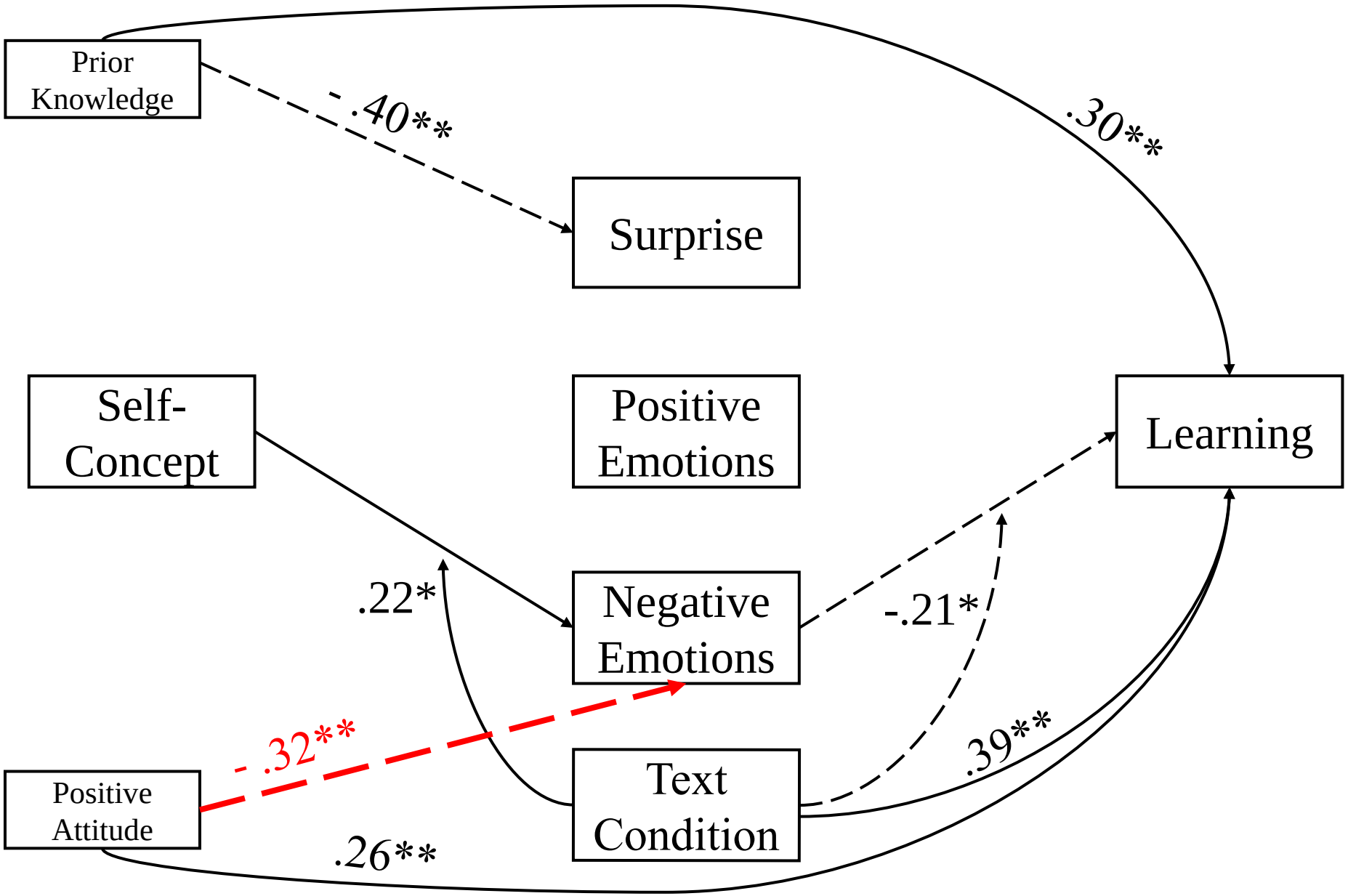

Self-concept
High
Low
2.00
1.80
1.60
1.40
1.20
1.00
Mean reported negative emotions
Expository
Refutation
Text condition



Summary of Standardized Effects

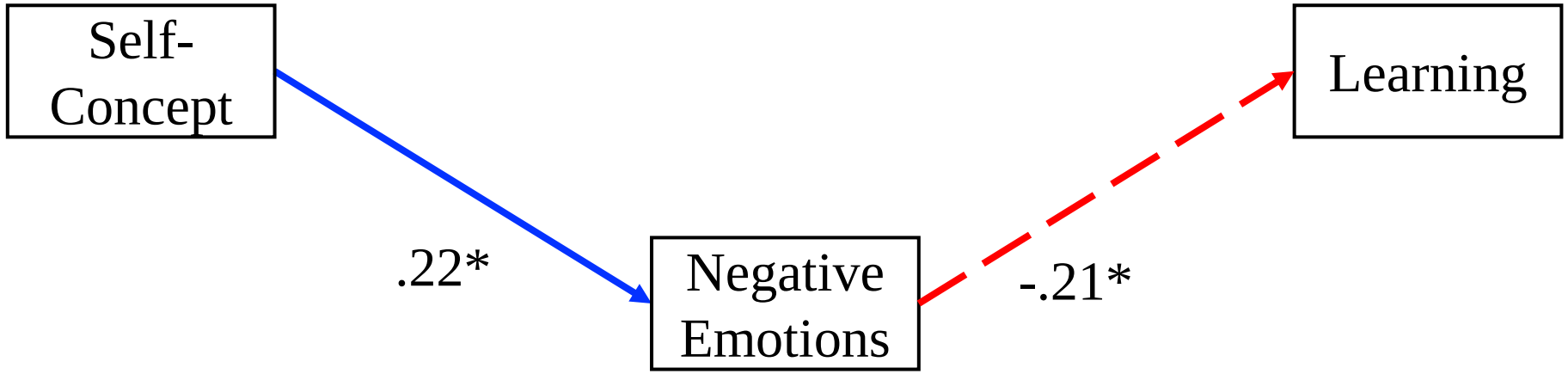


Summary of Standardized Effects



Summary of Standardized Effects

Significant moderated mediation in refutation condition, β = -.09



Moderator: Refutation Condition

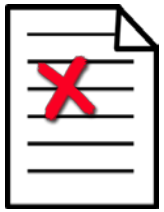
Conclusions

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

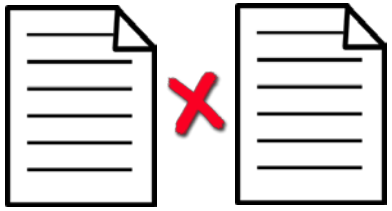
Possible evidence that refutations may be appraised as threats, which represents a new area of focus for knowledge revision research.

Final Conclusions

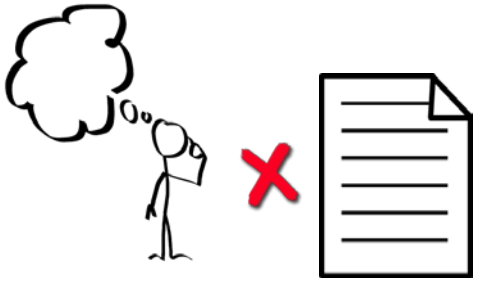
Conclusions Recap: Three Manuscripts



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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- **Co-Authors:** Dr. Reza Feyzi-Benagh; Dr. Eric Poitras; Dr. Roger Azevedo; Dr. François Bouchet; Dr. Reinhard Pekrun; Dr. Gale Sinatra; Dr. Marloes Muijselaar; Dr. Phil Winne
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