Contextual Reasoning in Human Cognition and the Implications for Artificial Intelligence Systems

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Presentation Objective

- A review of literature that provides a foundation for contextual reasoning used in computer modeling based on the development of contextual reasoning in humans

Sternberg's Triarchic Theory of Intelligence

- *Steinberg's theory (Steinberg, et al, 1995) on intelligence included three main ideas:*
  - **Componential intelligence - verbal and math skills**(later known as ***analytical intelligence***)
  - **Experiential intelligence - dealing with novel situations** (later known as ***creative intelligence***)
  - **Contextual intelligence - ability to apply knowledge and shape the environment** (later known as ***practical intelligence***)

What is Contextual Knowledge?

- Considered to be one component in the puzzle to resolve difficulties in everyday life experiences (Butterworth, et al, 1993).
  - Familiarity with a problem may allow for a quicker solution as previous success may provide additional data
  - This additional data may help determine a new course of action for a newly presented problem

What is Contextual Knowledge?

- Accomplished through learned associations and the ideas in everyday routines that allow one to examine and adapt to challenges everyday (Butterworth, et al, 1993)
  - Adaptations that are made to solve a challenge become more routinized and the challenge is seen as less of a problem and more common which may allow other ideas to be examined

How is Contextual Knowledge Used?

- It is employed to analyze the content of a situation, event and/or idea
  - Ranking the different stimuli and their involvement in the challenge is absolutely essential to understand the complexity of the issue

How is Contextual Knowledge Used?

- According to Butterworth, Light, & Butterworth (1993), without contextual knowledge, it is more difficult to recall specific information that may be needed to solve a problem more appropriately
- Prior interaction with a situation allows us to have some immediate information about an event based on the previous experience

Context in Language Development

- Context familiarity is important to process information in natural language generation (NLG)
  - Represents knowledge in a graphical manner that connects correlated concepts in knowledge.
  - Can be used to assess conjoined types of relationships between concepts
- Neural processing continues until the problem is resolved (Parker, Hollister, Gonzalez, Brezillion, & Parker, 2013)

Context in Language Development

- According to Bowers, Mattys, Attenuation Model by Treisman (1960)
  - Selective filter
    - Activation Threshold
  - Dichotomous listening task

Why is Context in Language Development Important?

- According to Bowers, Mattys, & Gage (2009) distinguishing and filtering these familiar and learned sounds may play a part in the recognition and meaning of language
- Context allows us to complete this learned language task.

Context and Memory Systems

- If an intelligent system were taught to organize information by connecting relevant information based on context, then it would conceivably execute more rapidly. Furthermore, this could also assist in filling in any contextual blanks when a situation is unclear, based upon previously ordered knowledge. Long term memories can be reactivated and then modified and reestablished (Hubach, Gomez, & Nadel, 2011). This occurs because of the context stored and available in memory.

Reasoning with and About Context

- Hubach, Gomez, & Nadel (2011) assert that context can help reactivate long-term memories
  - These memories can then be modified and reestablished.
  - This occurs because of the context associated with these memories that is stored and available in memory.
- Pennycook and Thompson (2017): contextual weighting and real-life experience must be incorporated into reasoning for successful navigation in the real world.
  - Statistical modeling alone can move reasoning only so far.

The Goal of Artificial Intelligence

- According to Kokinov (1999) Artificial Intelligence systems should:
  - Provide correct, relevant solutions to problems faced by humans
  - Be able to communicate the solutions to the presented problem using natural language with appropriate descriptiveness
  - Act in an efficient manner by providing solutions in the appropriate time frame

Contextual Reasoning and Artificial Intelligence

- Many instances of implementation of context in the AI literature.
- Contextual processing is integral in the design of artificial intelligence systems
  - Helps process information with human-like capabilities.
- Our review focused on three well-known contextual paradigms that in different ways, reflect, cognitive context-based processes.

Context-Based Reasoning (CxBR)

- Assumes tactical reasoning is about recognizing one's context and knowing how to act when in it.
- Has been successfully used to represent tactical behavior in several applications (Gonzalez et al, 2008)
  - It decomposes the agents' behaviors into *major* and *minor contexts*
- These contexts contains behavioral information that is relevant to the current (*active*) context of the current situation
- They also contain knowledge for recognizing when the situation changes during a tactical event, and another context is more appropriate.

Context-Based Reasoning (CxBR)

- The CxBR model resembles the Treisman model (1960), and monitors each situation for key factors that help determine when to transition into a new context
- Tactical reasoning based on situational decomposition into contexts and subcontexts
- Relevant information to solve the problem is encoded while all extraneous information is suppressed

Contextual Graphs (CxG)

- Progressively refines the context through questions/answers to better identify the situation
  - Allows decisions to be made more accurately and efficiently (Brezillon et al, 2003).
- Streamlines decision making process through simple questions and actions.
  - Identifies the situations at the deepest level of detail and responds accordingly.

Contextual Graphs (CxG)

- Vygotsky (1978) and Piaget (1977) proposed that children learn decision making through modeling of different behaviors in their own cultures
  - based on the acceptable behaviors of the social agent
- The social agent helps guide the child to develop culture appropriate behaviors and mental schemata or contexts

Context-Mediated Behaviors (CMB)

- Every context is reviewed and analyzed for each situation
- All contexts are checked to find the appropriate context to which to transition for the particular situation that is encountered
- This system allows contexts to be merged when one context alone cannot be successfully used to address the situation

Context-Mediated Behaviors (CMB)

- Bandura's (2001) theory recognized that a variety of contexts must be considered when solving a new problem
- This problem solving behavior appears to develop utilizing context and environmental cues to shape internal preferences
- The child's agentic action is based on the context of situation and perceived solution of future events based on experiences

Conclusion

- Learning is an important part of development and context is an essential component of learning.
  - As a child gains more experience in the environment, he/she can often depend on the context of the situation to make appropriate decisions.
- Understanding how human contextual knowledge is obtained may help in the development of more in depth artificial intelligence learning of context
- The computational architectures that strive to utilize contextual understanding may be assisted by the using the process that is utilized by children.

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<Objective of presentation>

- Debra, I think we need a slide (or two) here on what message we are trying to convey to the audience in this presentation.
  - What is our assertion?
  - Hypothesis?
  - Insight?
- But we need to be careful we don't state the obvious, as we were accused of doing by one of the reviewers.
- How about something like "A detailed look at the literature that provides the foundation for contextual reasoning in computer modeling of human cognition"?
  - It is more of an insight rather than a hypothesis or assertion, but that is OK.

Context in Language Development

- context familiarity is important to process information in natural language generation (NLG), language activates representations within the mind that pertain to definitions and connotations of the words used and/or sounds, and processing continues (Parker, Hollister, Gonzalez, Brezillion, & Parker, 2013)
- Attenuation Model by Treisman (1960) indicates different attention channels going into a selective filter in the brain. According to Bowers, Mattys, & Gage (2009), being able to distinguish and filter these learned sounds may play a part in the recognition and meaning of language

Whoa, Debra! Much too many words. Need to condense this!