CS7370 : Causal Inference

Assignment 3

Author : Rishabh Samra

1 Introduction

One of the central question of cognitive development is how we learn so much from apparently limited evidence. The art of arriving at a generalized conclusion based on limited evidence is referred to as inductive generalization. Infants, who have not seen the complexity of this world said to derive much knowledge based on intuition and acts in some situation which no one teaches them. The question to ask is what explains the process of causal learning? How do children take the observed sparse data and construct abstract representation of causal knowledge?

2 Contribution

- Summarizes a set of theories from the adult literature on causal learning, including associative models, parameter estimation theories, and causal structure learning accounts.
- Gives a description of causal graphical models for children's causal knowledge.
- Examines the contributions of explanation and exploration to causal learning.

3 Summary

Children are remarkable causal learners. They are pre-causal and have sophisticated domain-specific causal reasoning abilities.They recognize various causal relations in psychological domain especially about other's intentions and desires. They understand that biological and psychological events can rely on hidden causal relations.They also display a variety of domain-general reasoning abilities and understand temporal priority (causes precedes effect), spatial priority etc. They might combine the prior causal information to predict effects of new action and to produce the action themselves.

3.1 Theories of Causal Learning and Applications to Cognitive Development

For describing how children engage in causal inference, we need to consider both existing domain specific knowledge they possess about how causal relations work and domain-general mechanisms by which they acquire new causal knowledge from information in the environment. Substantive knowledge allows children to make better causal inference when mechanism is known to them.

3.1.1 Theories Based on Associative strength and Parameter Estimation

One possible way children engage in causal inference is to associate causes and effects and assumes it has been identified. Causal learning takes place by translating associative information into a measure of causal structure.That measure of strength is combined with information to make causal inference or generate new interventions. Associative learning mechanisms are available to children at very early age in the form of their statistical learning capacities and is implicated in processing of causal data, social knowledge and linguistic information.
Statistical learning are related to infant's ability to generalize and Causal knowledge is learned from registering associative information among events.

3.1.2 Theories based on Learning Causal Structure

Children's ability to integrate existing knowledge have led many researchers to propose that children are learning an abstract Causal model.Interpreting the representation of Causal Graphical models involves making three assumptions:

- **Mechanisms**:
  Intuitions about causal mechanisms, and by extension, the 'calculus of intervention' have been examined in several psychological studies.Adults reason about causal relations by virtue of the 'do' operator.Also children understood causal relations in terms of 'generative transmission'.They register certain configuration of perceptual features as causal.They also infer presence of hidden causes when shown stochastic data,suggesting they interpret probabilistic events as indicating presence of hidden mechanisms.

- **Markov Assumption**:
  The Markov assumption translates conditional probability information into causal knowledge. It states that the value of an event (i.e., a node in the graph) is independent of all other events except its children (i.e., its direct effects)

conditional on its parents (i.e., its direct causes).For checking whether children assume markov assumptions and recognize conditional independence relations separately from there prior knowledge, one experiment of blicket detector was introduced which plays music when certain objects called blickets were placed and doesn't respond to others.After trying different combinations children were able to detect objects that activates blicket independently from those that not and thus assumed to follow markov assumptions.

- **Faithfulness**: It specifies that the data a learner observes is indicative of actual causal structure in the world. Sometimes faithfulness assumption is violated when there is effect modification due to some variable and true causal structure is not in consistent with data.

3.2 Integrating the two accounts

Children must have a mechanism for recognizing statistical regularities among events, but also parsing out conditional independence and dependence relations, and making causal inferences based on observed data.From birth,the way in which children learn causal knowledge and make causal inferences is guided by principles from the CGM framework.In the earliest stages of the sensorimotor stage, Piaget described the infant as only experiencing causality as a form of association of experiences: 'there is no causality for the child other than his own actions'. As infants learn to act on the world,they might move beyond such associations to recognize deeper relations among events.

3.3 Two Caveats About CGM's as a Description of Children's Causal Knowledge

One important caveat is that CGM's are a way of representing causal structure, not a specific commitment to how causal knowledge is learned. Second, CGMs have the potential to describe how children represent their causal knowledge at multiple levels.CGM can describe particular events as well as more general events. It is likely that learning about specific events using an algorithm from the CGM framework is guided not only by the data that children observe, but also the knowledge they possess regarding what kinds of specific causal models can be built.

3.4 Explanations And Exploration in Child's Causal Learning

3.4.1 Explanation

At very early ages, children generate appropriate domain-specific explanations and use questions effectively to elicit explanations from others as a means of acquiring new knowledge.It has been found that preschoolers generates more explanations when faced with outcomes that were inconsistent with their prior knowledge. Moreover, these explanations tend to refer to unobserved causal mechanisms and internal causal properties, and not external perceptual appearances.This provides promising evidence that explanation provides children the opportunity to articulate new hypotheses for events that, at first, disconfirm their current knowledge. It is said that explaining inconsistency triggers a process of hypothesis generation that encourages learners to formulate and entertain hypotheses they would not have spontaneously considered otherwise.Explanation-triggered hypothesis generation may promote the production of hypotheses that makes for informative explanations.There might be some connection between explanations and how children represent their causal knowledge.

3.4.2 Exploration

Children also seek out data when faced with ambiguity or uncertainty, and such exploration can inform the ways in which children learn new causal structure. That is, the weaker the representation of children's causal knowledge, the more likely they will explore their environment. Children's exploratory play is affected by the quality of the evidence that they observe. When multiple candidate causes are available for the same outcome and underlying causal structure is ambiguous, children preferentially explore confounded (as opposed to unconfounded) causal relations, show more variable play behavior when presented with probabilistic (as opposed to deterministic) information and can spontaneously disambiguate confounded variables.

Preschoolers do trade-off explanation and exploration in certain ways.When they lack explanatory information,they can learn causal structure from exploration and this learning is facilitated when they explore new knowledge as compared to information they already observed. Also there is interaction of explanation and exploration when learning. Children who had heard a particular set of instructions regarding novel object's function were less likely to explore the object than the children who had heard incomplete explanations. Children's exploration is affected by understanding of intent of individual who has generated explanations (who has more knowledge

about some subject).

WHY TO CONSIDER INTERACTION BETWEEN EXPLANATION AND EXPLORATION?
Given trade-off between explanations heard from others and exploration of environment, there is a need to examine interaction between explanation and exploration particularly when facing problem of inconsistency. Encouraging children to explain inconsistency confronts children with inconsistent evidence most likely to foster theory revision, guides hypothesis testing and promotes learning.

3.5 Causal Learning From Others

When children encounter novel data from which they learn,they integrate it with their existing knowledge to make novel inferences, generate novel explanations and engage in specific actions. This is correct but it assumes all the data children use to learn causal structure is directly observable but this is not the case as they learn from explanations provide evidence of them learning through testimony from others.They make inferences about unobservable biological events,psychological and supernatural events which are not directly observable and can't be learned from mere interacting with environment but must rely on information from others.Testimony doesn't leads them towards objective truth but towards culturally appropriate beliefs. Any belief he learns from interacting with society matches with them and its not about uncovering empirical evidence and drawing rational conclusions. They learn from testimony of others towards end goal of understanding and being part of cultural group.

4 Future Direction

It is required to study how humans think and it is made easier if we figure out the ways we depart from ideal. We need to investigate how thinking of a child differs from that of an adult. An ideal child, who has not watched the complexity of the world is more close to his true nature. His intuition seems to follow the cyclical rhythm of nature instead of straight and logical because on getting some feedback he continuously questions his purpose of life and tries to find the reason for his existence. So there should be introduction of something what we call as circular causality. For instance, consider a child who has done some mistakes which causes parents to scold him and after getting nervous he again committed some more mistakes and so on. Also investigation is required to determine the kind of information a child uses while

engaging between cycles of imitation (exploratory play) and innovation (generating explanations).