



Pretense, Counterfactuals, and Bayesian Causal Models: Why What Is Not Real Really Matters

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Abstract

Young children spend a large portion of their time pretending about non-real situations. Why? We answer this question by using the framework of Bayesian causal models to argue that pretending and counterfactual reasoning engage the same component cognitive abilities: disengaging with current reality, making inferences about an alternative representation of reality, and keeping this representation separate from reality. In turn, according to causal models accounts, counterfactual reasoning is a crucial tool that children need to plan for the future and learn about the world. Both planning with causal models and learning about them require the ability to create false premises and generate conclusions from these premises. We argue that pretending allows children to practice these important cognitive skills. We also consider the prevalence of unrealistic scenarios in children's play and explain how they can be useful in learning, despite appearances to the contrary.

Keywords: Cognitive development; Imaginative cognition; Counterfactual reasoning; Causal reasoning; Bayesian learning

1. Introduction

Children and adults understand the rules that govern reality, but they also know how to leave reality behind. This is one of the most important and fascinating aspects of human cognition: the ability to disengage from the real world and to move into the realm of imagination. It is also one of the most puzzling aspects of human cognition, especially in development. At a time when they need to absorb vast amounts of information about the way reality works, children spend a great deal of time engaged in pretend play, which often looks as though it has nothing to do with reality. Why?

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In this study, we answer this question by focusing on the similarities between the playful activity of pretending and the serious reasoning capabilities involved in counterfactual causal reasoning and learning. This argument owes a great debt to other researchers who have previously remarked on various aspects of these similarities (e.g., Amsel & Smalley, 2000; Bloom, 2010; Gopnik, 2009; Harris, 2000; Hoerl, McCormack, & Beck, 2011; Lillard, 2001; Nichols & Stich, 2003; Seligman, Railton, Baumeister, & Sripada, 2013). But none of these previous treatments have really tackled the central puzzle of pretense: Why is it useful? Moreover, although previous work has considered two-way links between pretending and counterfactual reasoning (e.g., Harris, 2000), or between pretending and learning (e.g., Sutherland & Friedman, *in press*), or between causal and counterfactual reasoning (e.g., Gopnik et al., 2004), none have presented a unified framework for describing the interconnections among all these cognitive processes. In this study, we provide such a framework, Bayesian causal models, and use it to address the question of why young children engage in pretend play.

2. Pretending in development

Children begin to spontaneously produce and comprehend symbolic play behaviors (substituting one object for another, e.g., pretending that a banana is a telephone) around age 2 (Fein, 1981; Friedman, Neary, Burnstein, & Leslie, 2010; Harris & Kavanaugh, 1993; Leslie, 1987; Nicolich, 1977; Singer & Singer, 1990). Children may be able to comprehend pretend sequences even earlier, as revealed by looking-time tasks (Onishi, Baillargeon, & Leslie, 2007; see also Bosco, Friedman, & Leslie, 2006). In addition, young children can use language, including words like “pretend” and “make-believe,” to accurately describe actions conducted in a pretend game (Woolley & Wellman, 1990).

Young children also understand that there is a difference between reality and fiction (e.g., DiLalla & Watson, 1988; Golomb & Galasso, 1995; Harris, Brown, Marriot, Whittal, & Harmer, 1991; Morison & Gardner, 1978; Samuels & Taylor, 1994; Skolnick & Bloom, 2006b; Woolley & Cox, 2007). And children do not confuse imagination with reality—a child who imagines that a pencil is in a box will not mistakenly direct someone asking in earnest for a pencil to the box (Woolley & Phelps, 1994; see also Bouchier & Davis, 2002; Golomb & Kuersten, 1996; Wellman & Estes, 1986). Even those children who create imaginary companions understand fully well that these companions are not real, except in the most rare circumstances (Taylor, 1999; Taylor, Shawber, & Mannerling, 2008). In sum, before turning 3, and before gaining a full grasp of the rules that govern reality, children demonstrate remarkable competence at understanding the rules that govern fictional representations (see Weisberg, 2013, for review).

In addition, play behavior has been implicated in a variety of positive outcomes. Children who play more have been shown to have more advanced language skills, more productive interactions with their peers, more self-awareness and self-control, and more overall positive affect (Singer, Golinkoff, & Hirsh-Pasek, 2006; Singer & Singer, 1990). Children who engage in pretend play, in particular, are better able to infer and anticipate

how others are thinking and feeling (Lillard, 1993; Schwebel, Rosen, & Singer, 1999; but see Lillard et al., 2013).

But just how does pretend play influence development? Most researchers who consider this question tend to see pretending as an exercise of children's growing capacity to infer the mental states of others, or "theory of mind" (Goldman, 2006; Leslie, 1987, 1994; Lillard, 1993; Nichols & Stich, 2003). Understanding how pretense works is indeed an important theory of mind skill. However, our focus here is somewhat different. We believe that we can gain greater traction on the crucial question of why children engage in pretend play by thinking of pretend games as counterfactual causal scenarios.

3. Pretend play as counterfactual reasoning

Following the lead of other researchers (e.g., Amsel & Smalley, 2000; Dias & Harris, 1990; Gopnik, 2009; Harris, 2000; Lillard, 2001; Walton, 1990), we argue that pretend play shares the cognitive structure of counterfactual reasoning. Both of these activities involve considering events that have not occurred and thinking about what would be the case if they had. Three component abilities are central to both pretense and counterfactual thinking: disengaging with current reality, making inferences about the events and scenarios that would follow in an alternate reality, and keeping these alternative possibilities separate from reality.

The first of these, decoupling, is the ability to adopt a counterfactual premise. For example, one can consider what would be the case if the South had won the Civil War or if there were tea in an empty cup. These statements are true not in reality, but rather in a representation that does not necessarily match reality, often called a possible world (e.g., Currie, 1990; Lewis, 1978) or a fictional world (Skolnick & Bloom, 2006a). The second ability, creating an event sequence, is necessary to produce conclusions within the possible world. Having adopted a counterfactual premise, this ability allows reasoners to draw the appropriate inferences from this premise and to elaborate productively on the resulting scenarios: One can consider alternative governments following the Civil War or continue the tea party. Finally, the ability to make a reality/fantasy distinction is necessary to ensure that the conclusions drawn from the counterfactual premise do not contaminate what is known to be true in reality ("representational abuse"; Leslie, 1987).

Pretend play provides children with the opportunity to practice all these cognitive skills, just as physical play provides young animals with the opportunity to practice skills that they will need later in life. In the animal case, it is easy to see how play fighting can translate to the necessary adult skill of truly fighting. But counterfactual reasoning, like pretense itself, seems to be severed from reality. To make this analogy work, we must identify the role that counterfactual reasoning plays in adult human cognition, comparable to the role that fighting plays in adult animal life. Why would it be beneficial to have the ability to draw conclusions from false premises?

The answer to this question is that counterfactual reasoning is a crucial tool that we use to reason and learn about the world around us (e.g., Byrne, 2005; Gopnik, 2009;

Hoerl et al., 2011; Seligman et al., 2013; Weisberg, 2009). This argument has previously been explored in reference to children's ability to learn about the social-cognitive domain (Guajardo & Turley-Ames, 2004; Lillard, 2001; Peterson & Riggs, 1999), but our focus is on how pretending enhances children's cognitive abilities more generally. Specifically, we argue that the ability to generate counterfactuals is intimately tied to causal reasoning and learning. Although the link between counterfactual and causal reasoning has long been recognized in philosophy (e.g., Lewis, 1973), here we explore this connection from within a Bayesian causal model framework. Not only does this framework allow for a more precise formulation of this link (see Gopnik & Schulz, 2007; Gopnik et al., 2004; Pearl, 2000; Perfors, Tenenbaum, Griffiths, & Xu, 2011), it also enables us to clearly delineate the connections among pretending, counterfactual reasoning, causal reasoning, learning, and planning.

Consider the following example. We can predict that someone with yellow, nicotine-stained fingers will be likely to develop lung cancer because the two variables are correlated. To make this prediction, one only requires an associationist system that generates the second value (lung cancer) whenever the first value (yellow fingers) occurs. But making a true causal inference is different from drawing a simple association. We will make different counterfactual inferences if we believe that smoking causes cancer than if we believe that yellow fingers cause cancer. We will know that if we were to do something to change the value of yellow fingers, say by instituting a policy of hand washing, it would have no effect on cancer. Smoking prevention programs, on the other hand, would.

This kind of sophisticated planning procedure has two important features. First, it is based on causal knowledge; it requires a planner to have a representation of how the world works. Children do indeed possess the kind of coherent, complex, representations of the world, often called *intuitive theories* or *causal models*, that this kind of planning requires (e.g., Gopnik & Wellman, 1994; Wellman & Gelman, 1998).

Second, it requires the ability to reason counterfactually from those models. A planner must possess the ability to create a counterfactual scenario in which a target variable (smoking) is fixed to a particular value (yes or no). Then, based on the current causal model, an agent can infer the downstream consequences of this value for other variables. If these consequences are desirable (no smoking means no lung cancer), the agent can then act to change the current value of the variable to the alternative value. This ability to reason about causal dependencies allows the reasoner's causal models to generate both predictions about future interventions (what would happen if I were to do *x*), and past counterfactuals (what would have happened if I had done *x*). Although the term "counterfactual" has traditionally been applied to reasoning about past events, from the causal model perspective, both future interventions and past counterfactuals require exactly the same computations. Importantly, both go beyond simply predicting what will happen when *x* occurs.

In fact, this difference between how associative predictions and counterfactuals or interventions are calculated is a distinctive feature of the mathematical formalization of graphical causal models, often called "Bayes nets" (see Pearl, 2000; Spirtes, Glymour, & Scheines, 1993). Bayes nets distinguish between two types of inferences: *conditioning*, or

making simple predictions, and *intervening*, or making both counterfactual inferences and interventions. When conditioning, a reasoner considers the values of some variables in a causal model given the value of other variables, for example, the value of lung cancer conditional on yellow fingers. When intervening, the learner “fixes” the value of some variable and calculates the downstream effects of that change. The process of intervening results in what Pearl vividly calls “graph surgery:” The structure of the causal graph is changed to modify the causes of the intervened-on variable, and calculations are done on this altered graph.

We argue that this kind of intervention, that is, the variable fixing and graph surgery involved in computing counterfactuals and creating plans, relies on precisely the same kind of cognitive machinery that children use when they pretend: adopting a counterfactual premise, creating an event sequence, and quarantining the result of this process from reality. Using this method of planning, children can work through the possible options for what could happen using a representation or model that does not match the current reality, for example, inferring what would happen if they were to perform a specific action in the future. This ability allows them to explore the possible consequences of acting on the world without the time, effort, and danger that might accompany real-life exploration.

If this claim is correct, we would expect to see empirical relations between pretend play and intervention-based forward planning and counterfactual inference. In fact, the ability to engage in insightful planning, as opposed to simple trial and error, appears at just about the same time as object substitution pretense (Uzgiris & Hunt, 1975). While children can and do learn by observing correlations and forming associations, at least by the age of 2 they can also start to reason about future interventions and past counterfactuals.

A recent study (Buchsbaum, Bridgers, Weisberg, & Gopnik, 2012) demonstrates more precisely young children’s capacities to make counterfactual causal inferences and the relations between these capacities and pretense. Buchsbaum et al. first taught 3- and 4-year-olds a novel causal relationship: Placing a certain kind of block (“zando”) on top of a machine causes the machine to play “Happy Birthday.” Children were then asked a series of counterfactual questions: “What if this zando were not a zando; what would happen if we put it on the machine? And what if this [causally inert block] were a zando; what would happen if we put it on the machine?” Although children never saw either of these situations, about two thirds of them answered correctly and made the appropriate predictions based on their knowledge of the causal process.

Children were then asked to engage in a game of pretense, where colored blocks stood in for the zando and for the causally inert object and a box stood in for the machine. Again, about two thirds of the children spontaneously transferred the causal structure they had learned in the real world to the pretend scenario, correctly pretending that the pretend “zando” would make the pretend “machine” play music. They could even pretend appropriately after the experimenter assigned different pretend roles to the two blocks, making the one that had previously been the zando causally inert, and vice versa.

More strikingly, children’s performance with the counterfactual questions and on the pretense task was yoked: They either passed or failed both types of task. This correlation

remained even when general cognitive ability and executive function were controlled for. This result lends support to our argument for the existence of a strong connection between explicit counterfactual reasoning and the playful activity of pretense.

4. Learning through pretending

The cognitive processes that are involved in pretend play are not only useful for planning; they are also crucial for learning. The causal models that are necessary for this kind of planning can themselves be learned using a counterfactual process (e.g., Griffiths & Tenenbaum, 2007; Griffiths, Chater, Kemp, Perfors, & Tenenbaum, 2010). This Bayesian learning strategy proceeds as follows: Take your current best model about how the world works. Modify that model to produce an alternative model. Assess the fit between the evidence generated by this alternative model and the actual evidence observed in the real world. This assessment is done by calculating the probability that the alternative model would generate the observed evidence: How probable is it that one would observe these events if the alternative model was a true representation of the causal structure of the world? Ask the same question about your current model. Use a Bayesian inference procedure to compare the two probability distributions. If the posterior probability of the alternative model is higher, discard your model and accept the alternative model as the true model of how the world works.

As in the planning case discussed above, to execute this learning algorithm, children need to perform exactly the operations used in pretense. They need to decouple from their currently accepted model, create an alternative (i.e., a counterfactual) model, and generate the observations that they would have seen if that alternative were true. They also need to quarantine these alternate models and data sets from the actual evidence to compare the outcomes of each model. Recent research has demonstrated that children are indeed able to do this, both generating counterfactuals and learning about novel causal models by 4 years of age.

For example, in Schulz, Gopnik, and Glymour (2007), 4-year-olds had to choose which of the three alternative causal models accurately described the workings of a simple machine, which had two gears and a switch. To do this, children had to predict the consequences of counterfactual interventions on the possible models. For example, if the switch made both the yellow gear go and the blue gear go, then removing the blue gear and turning the switch would still make the yellow gear turn. This would not be true if the switch made only the blue gear turn, which then made the yellow gear turn. When they were presented with a particular pattern of evidence about how the gears worked, children inferred the correct causal model (see also Gopnik et al., 2004). Other studies have shown that children can use this kind of reasoning to overturn their original hypotheses and adopt new ones (e.g., Kushnir & Gopnik, 2007; Schulz, Bonawitz, & Griffiths, 2007).

In these cases, children made inferences about physical causal systems. However, we know that preschool children are especially focused on developing causal models of the

minds of others—“theory of mind.” In fact, several studies show that children use the same causal inference methods to learn about psychological causation (Schulz & Gopnik, 2004; Seiver, Gopnik, & Goodman, 2012). Significantly, much of early pretend play is also focused on these kinds of psychological causal relationships, such as the creation of imaginary companions. These pretend scenarios allow children to explore and make predictions about specific interpersonal interactions, which may in turn give them insights into general psychological processes (see Lillard, 2001; Taylor, 1999).

This ability to learn about others from pretend and counterfactual scenarios is not limited to children. Recent work in cognitive literature studies has argued that adults derive pleasure from novels and movies because these fictional depictions can teach us true things about how other people work (Vermeule, 2009; Zunshine, 2006), and psychological studies of adults’ interactions with fiction indicate that they indeed import information from stories into their real-world causal models (see Green, Strange, & Brock, 2002). We argue that these links reflect the significance of psychological causal models for both adults and children. However, both pretense and fiction may also focus on alternative models of biological and physical causation, as in science fiction.

5. The unity of representation and reality

Thus far, we have argued that pretend play is best seen as a precocious application of children’s counterfactual reasoning abilities, providing children with precisely the opportunity they need to practice using these abilities. Once fully developed, these abilities will allow them not only to engage with pretend scenarios but also to solve real-world problems, to infer causal connections, to reason about the content of others’ minds, and to make strategic decisions.

This kind of reasoning is ubiquitous, and evidence presented in fictional contexts often changes both adults’ and children’s real-world beliefs. For example, adults who read a fact presented in a fictional story tend to incorporate this fact into their general background knowledge—even if the fact is false (Green & Brock, 2000; Marsh & Fazio, 2006; Marsh, Meade, & Roediger, 2003; Prentice, Gerrig, & Bailis, 1997). This is not simply a laboratory phenomenon. Intuitively, worries about excessive violence in television shows or approving depictions of smoking in movies are based on the idea that children who watch these movies will absorb these fictional depictions into their real-world action patterns (see Anderson et al., 2003; Heatherton & Sargent, 2009; Kirsh, 2006). On a somewhat smaller scale, children are able to learn new words presented in the context of a fictional story (Ganea, Pickard, & DeLoache, 2008; Simcock & Dooley, 2007).

On the surface, this is striking and surprising behavior. Why should adults or children believe information that has come to them from a source that explicitly professes to present false information? But part of what makes it possible to draw true conclusions from false situations is the fact that thinking about possibilities depends on the same causal models that we use to think about reality. Although pretending crucially involves thinking about something that is not true, such as the existence of tea in an empty cup, the vast

majority of what happens in a pretend scenario derives from our causal models and so matches what would happen in reality. The “tea” in the cup is meant to be drunk, not chewed, and when the cup is upended, the “tea” spills down to the table, not up to the ceiling (see Onishi et al., 2007; Weisberg & Goodstein, 2009). As this example shows, enacting a pretend scenario involves the use of inference mechanisms to combine a causal model with a set of counterfactual premises.

This is one of the most important aspects of our counterfactual reasoning system: Input from imagined sources into our various cognitive systems comes without any marking designating it as real or fictional. That is, our cognitive systems do not know where their input comes from (see Johnson & Raye, 2000). We feel emotions for and make inferences about both real and fictional events using precisely the same cognitive mechanisms, which means that navigating a fictional world proceeds in almost exactly the same way as navigating the real world (“single code theory”; see Bosco et al., 2006; Gendler & Kovakovich, 2005; Loftus, 1979; Nichols, 2004; Weinberg & Meskin, 2006). Our ability to learn facts from fiction is thus a straightforward application of our counterfactual reasoning abilities.

6. Multiple possibilities, multiple models

Planning and learning using the Bayesian processes we describe requires that children separate a possible model from the actual model of the world. As reviewed above, children can do this by the age of 3. However, children also need to be able to separate multiple possible models from each other, not just from reality. Making these separations allows them to compare models to each other and to weigh their various merits. Without this ability, children would only be able to consider one alternate possible model or one possible future at a time. This impoverished ability would exclude the kind of reasoning that children need to do to truly and efficiently learn and plan for the future. For example, planning often involves comparing the outcomes of performing two slightly different actions to decide which action to perform, a comparison that would be impossible without the ability to represent these two possible futures separately from each other.

Although this seems like a difficult cognitive task, previous research has demonstrated that children do possess the ability to separate possible worlds from each other. For example, a previous study asked 4-year-olds what Batman thinks about a fictional character from a different story, like SpongeBob SquarePants. Children reported that Batman thinks that SpongeBob is fictional—just as they themselves think that SpongeBob is fictional (Skolnick & Bloom, 2006b). Similar results are obtained when children were asked about pretend games that they were involved in; they judge that objects should not be transferred from one game to the other (Gopnik & Slaughter, 1991; Weisberg & Bloom, 2009; D. S. Weisberg, L. Wang, & A. M. Leslie, unpublished data; Wyman, Rakoczy, & Tomasello, 2009a, b).

The fact that children have the ability to separate multiple imagined worlds from each other does not necessarily imply that they are able to compare these worlds to each other,

or that they can do so effectively (but see D. S. Weisberg, J. Prabhakar, & A. M. Leslie, unpublished data, for evidence that they do). But this capacity for separating multiple worlds is a necessary prerequisite to both learning and planning in the way we have described, suggesting that world separation is not merely a quirk of the way in which imagined situations are represented.

7. Unrealistic pretend scenarios

We have argued that pretend play's utility in development is to allow children to practice their counterfactual reasoning skills. One interesting but rarely considered objection to this conclusion is that children's pretending often seems so unrealistic. Children do spend time pretending that they are mommy or daddy, but they also spend time pretending that they are Superman or interacting with imaginary companions who have a wide variety of unintuitive properties (Taylor, 1999). If the ability to pretend exists because it helps children's reasoning and learning about the real world, how can we account for wildly unrealistic pretend scenarios?

Our adoption of a Bayesian framework allows for a novel response to this challenge. According to this framework, in intervention reasoning, the probability that the counterfactual premise is true is irrelevant. To return to our earlier example, before the discovery of the causal link between smoking and cancer, there were no smoking prevention programs because smoking was seen as an unlikely cause of cancer. But this initially unlikely model of how things work turned out to be the correct one. By exploring such unrealistic possibilities, we can discover useful ways of introducing weird events into the world, which can in turn change the world to bring about equally weird, although desirable, outcomes.

Moreover, the causal connectivity of the world is not immediately apparent on direct inspection. In fact, alternative causal models may yield the same results in many common cases. The differences between them may only become apparent when considering unlikely scenarios. Einstein's thought experiments are a good scientific example of how unrealistic counterfactuals can help to distinguish potential causal structures. Both relativistic and classical theories of physics make similar predictions in commonly observed cases. Considering very unlikely possibilities, such as a world where the speed of light is different, can help discriminate between these theories. Unlikely possibilities about imaginary companions or unreal tea parties may serve a similar function for children, allowing them to refine and appropriately constrain their causal models.

We can thus think of unrealistic pretense scenarios as playing a similar role for causal learning that motherese, or infant-directed speech (IDS), plays for language learning. IDS uses an exaggerated, unrealistic method of speaking, employing pitch contours that are much wider than those found in normal speech. Adults use IDS not because they are trying to teach their children to modulate their voices in this way, but because the features of IDS highlight those aspects of the speech stream that are important for learning syntactic structure (see Fernald, 2000). Unrealistic pretend scenarios are useful not because they

provide an accurate reflection of the causal structure of reality, just as IDS does not provide an accurate reflection of the prosodic structure of natural speech. Rather, unrealistic scenarios are useful because they highlight the boundaries of the causal space in a way that is easy to grasp.

8. Conclusion

Both young children and adults possess the extraordinary ability to imagine events and entities that they know full well are not real. We have argued that this ability exists because it bolsters children's counterfactual reasoning abilities. In turn, counterfactual reasoning plays an important role in how children learn about the world around them. Reasoning counterfactually is a key component in both planning and learning as children create and weigh possible causal models of the world. When learning, children consider alternative ways that the world could be; when planning, they consider alternative ways they could make the world be. In both cases, generating potential evidence patterns from counterfactual premises is crucial. Pretend play, because it engages the same set of cognitive abilities, provides valuable practice at doing precisely this sort of difficult mental task.

This proposal is intended to help unify earlier theoretical accounts and empirical results. However, it also makes new and falsifiable predictions. For instance, one strong implication of our view is that children who engage in more pretend play should exhibit superior counterfactual reasoning skills. The fact that children who struggled with answering counterfactual questions also struggled with making inferences in a pretend scenario provides preliminary evidence for this claim (Buchsbaum et al., 2012), but more focused work is needed on this topic. Training studies showing that increasing pretense could influence counterfactual inference, or vice versa, would be particularly valuable.

We also note that our argument is made at a computational level; we claim that pretending and counterfactual reasoning require the same cognitive abilities. However, it is possible that other aspects of the two activities are different and that this difference helps to make pretense a particularly effective scaffold for counterfactual reasoning. For example, pretending has a strikingly positive affective profile—put simply, pretending is fun—and this might serve as an incentive for performing relatively difficult counterfactual computations. Similarly, pretending might require less executive control than “serious” planning and learning. However, on our view, it would be surprising if we were to discover that the cognitive profiles of these two activities were radically different.

Finally, work on animal models can help to shed light on these connections. Several non-human animals, especially apes and corvids, clearly have the ability to make extensive predictions about the world and to use those predictions in planning (e.g., Mulcahy & Call, 2006; Raby, Alexis, Dickinson, & Clayton, 2007). However, the extent to which non-human animals have full capacities for counterfactual thinking and intervention is still unclear (e.g., Suddendorf & Corballis, 2007). Furthermore, pretend play, at least of the quality and quantity observed in humans, is rare in these species. More work is needed to determine the precise nature of both planning and pretending in non-humans.

Work on all these topics is ongoing, and we believe that these investigations will continue to reveal the many ways in which pretending, counterfactual reasoning, causal reasoning, learning, and planning are interwoven in development.

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