Counterfactual Thought

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Abstract

People spontaneously create counterfactual alternatives to reality when they think "if only" or "what if" and imagine how the past could have been different. The mind computes counterfactuals for many reasons. Counterfactuals explain the past and prepare for the future, they implicate various relations including causal ones, and they affect intentions and decisions. They modulate emotions such as regret and relief, and they support moral judgments such as blame. The loss of the ability to imagine alternatives as a result of injuries to the prefrontal cortex is devastating. The basic cognitive processes that compute counterfactuals mutate aspects of the mental representation of reality to create an imagined alternative, and they compare alternative representations. The ability to create counterfactuals develops throughout childhood and contributes to reasoning about other people's beliefs, including their false beliefs. Knowledge affects the plausibility of a counterfactual through the semantic and pragmatic modulation of the mental representation of alternative possibilities.

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THE COUNTERFACTUAL IMAGINATION

There is an allure to imagining how things could have turned out differently. We spontaneously create counterfactual alternatives to reality when we think "if only . . . " or "what if . . . " and imagine how the past could have been different. In this article, I consider three key issues: what the mind computes to create counterfactuals, how the mind creates counterfactuals, and how knowledge modulates the plausibility of counterfactuals.

WHAT THE MIND COMPUTES TO CREATE COUNTERFACTUALS

The mind computes counterfactuals for diverse reasons. At one end of the counterfactual spectrum, imagined alternatives entertain and amuse us in fantasy and fiction, and they flourish in literature, film, and theater. At the other end, counterfactuals support logical, mathematical, and scientific reason, and they underpin complex deductions. In between these endpoints, counterfactuals serve several key purposes: They explain the past, prepare for the future, modulate emotional experience, and support moral judgments.

Explanations of the Past

Counterfactuals justify, defend, and excuse the past. For example, some politicians and media personalities responded to reports that American soldiers tortured and abused prisoners in the Abu Ghraib prison in Iraq by arguing that the treatment of prisoners would have been worse under former Iraqi president Saddam Hussein, a counterfactual defense that has been found to increase people's tolerance for human rights violations (e.g., Markman et al. 2008). Counterfactuals excuse poor performance, by denying effort or resources, for example, "If I had had more time . . . ", and they justify bad outcomes by denying control, for example, "If I had known . . . " (e.g., Markman & Tetlock 2000, McCrea 2008, Tyser et al. 2012). They manage impressions and derogate actions in various situations, from political rhetoric to accident safety reports (e.g., Catellani & Covelli 2013, Morris & Moore 2000).

Counterfactual: an imagined alternative to reality about the past, sometimes expressed as "if only . . . "

Counterfactual explanations also imbue the past with personal meaning—a sense of purpose and coherence—by influencing judgments that certain pivotal events were "meant to be" (e.g., Kray et al. 2010, Waytz et al. 2015). When people think about life events, such as their college or friendship choices, they judge their choices to have added meaning to their lives far more when they imagine how things could have turned out differently, compared to those who do not imagine how things could have turned out differently (e.g., Kray et al. 2010). Counterfactual explanations achieve their impact by identifying or implying relations of many different sorts, including causal, intentional, deontic, spatial, temporal, and inferential relations, but the link between counterfactuals and causes has received special attention (e.g., Spellman & Mandel 1999).

Counterfactuals and causes. On the one hand, counterfactual and causal thoughts are clearly entwined. For example, people judged that a painkiller caused a runner to experience a side effect of fatigue and lose a race when they knew about an alternative drug with no side effects. They imagined that if the runner had taken the other painkiller, she would not have experienced the side effects. But when the alternative drug also led to side effects, they judged that the painkiller had less causal impact on the outcome. They imagined that even if the runner had taken the other painkiller, she still would have experienced the side effects (e.g., McCloy & Byrne 2002). Philosophical analyses since the time of Hume and Mill have suggested that a causal relation, for example, "Heating the water to 100°C caused it to boil," appears to implicitly evoke a contrast between reality and a counterfactual alternative, for example, "If the water had not been heated to 100°C then it would not have boiled" (e.g., Nickerson 2015).

But on the other hand, the content of counterfactual and causal thoughts often differs. Suppose a drunk driver swerved across the road and crashed into Mr. Jones who was driving home by an unusual route. People identify the cause of the accident as the drunk driver swerving across the road, but they create counterfactuals such as, "If only Mr. Jones had driven home by his usual route, the accident wouldn't have happened" (e.g., Mandel & Lehman 1996). Causal explanations tend to refer to strong causes that covary with the outcome, such as the drunk driver, whereas counterfactuals consider how to prevent an outcome by removing enabling causes such as Mr. Jones's route (e.g., Byrne 2005, Frosch & Byrne 2012). Events often have several causes, and one cause can preempt or supersede another (e.g., Hilton & Schmeltzer 2015, Kominsky et al. 2015).

Counterfactual explanations require more cognitive effort than causal ones (e.g., Byrne 2005, 2007). When people reflect on a past event, they spontaneously offer about twice as many causal explanations that describe the facts as they happened, for example, "I didn't meet new people because I didn't go to the party," compared to counterfactual thoughts that refer to an imagined alternative, for example, "If I had gone to the party I would have met new people" (e.g., McEleney & Byrne 2006). But counterfactuals are particularly useful for identifying causes when experiments are not possible, such as in reflections on one's own past or in historical analyses, for example, "If all states in the twentieth century had been democracies, there would have been fewer wars" (e.g., Tetlock & Belkin 1996).

Not all counterfactuals are about causes, and counterfactuals that imply a causal relation differ in systematic ways from counterfactuals that identify other sorts of relations, such as intentions. For example, counterfactuals about a cause-effect sequence unpick the cause. Suppose Paul did not study and got poor marks. When people read about a cause, such as a shortage of library staff, that led to an effect, such as the library closed early, they imagine an alternative to the cause, for example, "If only there had not been a shortage of library staff . . . " (e.g., Walsh & Byrne 2007; see also Wells et al. 1987). In contrast, counterfactuals about a reason-action sequence unpick the action. When people read about a reason, such as Paul wanted to meet some old friends, that led

to an action, such as he went to a party, they imagine an alternative to the action, for example, "If only Paul had not gone to the party . . . " (e.g., Walsh & Byrne 2007; see also Juhos et al. 2015).

Prefactual: an imagined alternative to reality about the future

Upward counterfactual: an imagined alternative about how things could have been better

Downward counterfactual: an imagined alternative about how things could have been worse

Preparations for the Future

Some counterfactuals explain the past, whereas others help people prepare for the future. For example, when people try to solve puzzles, they create counterfactual explanations that excuse their performance, such as, "Things would have been better for me if the allocated time were longer," but they create prefactuals to prepare for future attempts by considering how they could control the outcome, such as, "Things will be better for me next time if I concentrate more" (e.g., Ferrante et al. 2013). Counterfactuals help people to prepare for the future in several ways, such as in the formation of intentions and in supporting future decisions.

Counterfactuals affect the formation of intentions. Aviation pilots in a near-miss accident spontaneously imagine how things could have turned out differently, for example, "If I had understood the controller's words accurately, I wouldn't have initiated the inappropriate landing attempt," and they form specific plans and intentions to prevent a recurrence of the event (e.g., Morris & Moore 2000). People spontaneously create thoughts about how things could have turned out better after they play a blackjack game, for example, "If I'd gotten the 2, I would have beaten the dealer," and those who believe they will have the opportunity to play the game again create more counterfactuals than those who do not (e.g., Markman et al. 1993). People who create an upward counterfactual and imagine how things could have turned out better formulate intentions to carry out activities that will ensure a better outcome in the future, compared to those who create a downward counterfactual and imagine how things could have turned out worse, or who do not imagine how things could have turned out differently (e.g., Markman et al. 2008, Roese 1997). When people think about how their performance on an anagram task could have turned out better, for example, "I could have performed better than I did if I had tried more and different combinations of letters," they persist for longer in trying to solve subsequent anagrams compared to people who think about how their performance could have been worse. Their performance also improves, in part by changing thoughts about useful strategies (e.g., Markman et al. 2008).

Such preparatory counterfactuals help people to learn from mistakes and to prevent similar bad outcomes in the future by providing a roadmap to transition from the current situation to a different future situation (e.g., Epstude & Roese 2008). People who imagine a counterfactual alternative about the recent past are primed to read quickly an intention about the near future based on it (e.g., Smallman & McCulloch 2012). Results from functional magnetic resonance imaging (fMRI) studies show that episodic counterfactual thoughts not only recruit the same core network brain regions as the episodic recollection of specific past experiences, but also similar brain regions as the imagining of future good events or thinking about intentions and goals (e.g., Schacter et al. 2015, Van Hoeck et al. 2013; see also Barbey et al. 2011). When people imagine how things could turn out better, their intentions are affected in many important practical situations, such as stopping smoking (e.g., Page & Colby 2003). Counterfactuals that prepare for the future are useful in the formation of subgoals in artificial intelligence systems (e.g., Ginsberg 1986).

Counterfactuals support decision making. Counterfactuals also help to prepare for the future by influencing decisions. Thoughts about how things could have turned out differently if a different decision had been made often lead to regret for choices for which the person was personally responsible (e.g., Zeelenberg & Pieters 2007). Regret aversion leads to ameliorative action (e.g., Epstude & Roese 2008). For example, when people experience regret following a bad outcome

from their choice of provider for various sorts of services such as train or airplane travel, they switch to another provider (e.g., Zeelenberg & Pieters 2007; see also Ma & Roese 2014). Children as young as 7 years more often switch to a different choice when they experience regret about their choice after they discover that a nonchosen alternative would have led to a better outcome, compared to children who do not experience regret (e.g., O'Connor et al. 2014). The development of the influence of regret on decision making continues into late childhood and adolescence (e.g., Habib et al. 2012). Even some nonhuman primates appear to make choices influenced by counterfactual outcomes (e.g., Santos & Rosati 2015). Too much choice can lead people to be dissatisfied with their actual choice because of its many counterfactual alternatives, and it may be necessary to suppress or discount some of the counterfactuals (e.g., Hafner et al. 2012).

Emotional Experiences

The comparison of reality to a counterfactual alternative amplifies negative emotions such as regret, guilt, and shame, as well as positive emotions such as relief, satisfaction, and sympathy (e.g., Kahneman & Miller 1986). Counterfactuals modulate emotional experiences. For example, tourists who survived the 2004 tsunami in Southeast Asia spontaneously created thoughts about how things could have been worse far more than thoughts about how things could have been better, and they viewed themselves as lucky survivors rather than unlucky victims (e.g., Teigen & Jensen 2011). Counterfactual comparisons affect the experience of relief after near misses (e.g., Sweeny & Vohs 2012; see also Larsen et al. 2004).

People tend to imagine how things could have turned out differently after good events—near misses, lucky wins, and successes, as well as after bad events—tragic accidents, deaths, and failures, but they do so more often after bad events (e.g., Sanna & Turley 1996). Most people tend to imagine how things could have been better rather than worse, depending on various factors such as how long ago the events occurred (e.g., Rim & Summerville 2014). They tend to consider it more likely that bad events in their own past could have had a good outcome rather than that good events could have had a bad outcome (e.g., De Brigard et al. 2013). A counterfactual comparison can even make an objectively better outcome appear worse, for example, Olympic silver medalists were judged to look more unhappy at the moment when they discovered they had come in second compared to bronze medalists when they discovered they had come in third (e.g., Medvec et al. 1995; see also McGraw et al. 2005). Thoughts about how things could have been better may help prepare for the future by forming intentions to improve, but at an affective cost—they can lead people to experience negative emotions (e.g., Epstude & Roese 2008).

Differences in the specific content of counterfactual thoughts can accentuate different emotions. Guilt is amplified when people imagine how an outcome could have turned out differently as a result of a change to their actions, for example, "My friend wouldn't have argued with me if I hadn't given my telephone number to her boyfriend," whereas shame is amplified when they imagine instead a change to their personality, for example, "My friend wouldn't have argued with me if I weren't such a disloyal person" (e.g., Niedenthal et al. 1994). Guilt and self-blame are amplified in prisoners who engage in counterfactual thoughts about their capture, conviction, and sentencing (e.g., Mandel & Dhami 2005). Similarly, counterfactual thoughts amplify regret rather than disappointment when people imagine changes to their actions for choices for which they are responsible (e.g., Zeelenberg & Pieters 2007; see also Nicolle et al. 2011). Most people readily retrieve regrets from their autobiographical memories (e.g., Davison & Feeney 2008, Gilovich & Medvec 1995, Morrison & Roese 2011). Some regrets are for lost opportunities, and others persist when there are potential future opportunities for corrective action (e.g., Beike et al. 2009, Roese & Summerville 2005). Children begin to experience regret between approximately 5 and 7 years of

age; they subsequently develop an understanding of it and can predict when others will experience it (e.g., O'Connor et al. 2014, Weisberg & Beck 2010). Later still, they begin to anticipate future regret and develop strategies to avoid it, such as not seeking out information about the outcomes of nonchosen options (e.g., Guttentag & Ferrell 2008).

Counterfactuals can also deflect negative feelings. For example, when opportunities for future action do not exist, people imagine how things could have been worse, as the tourists after the 2004 tsunami did, which can provide consolation (e.g., Epstude & Roese 2008, McMullen & Markman 2000, Teigen & Jensen 2011). People also inhibit counterfactuals about large losses more than small losses, and such self-censorship can provide the solace that the outcome appeared to be inevitable (e.g., Tykocinski & Steinberg 2005). The construction of counterfactuals about how things could have been worse, and the inhibition of counterfactuals, helps people to feel better, but at a cost—people do not benefit from the preparatory effects of counterfactual thoughts, such as learning from mistakes (e.g., Epstude & Roese 2008, McMullen & Markman 2000).

Counterfactual thoughts can become dysfunctional. Left unchecked, counterfactual thoughts can become dysfunctional. Regret is associated with depression, and people who report being severely depressed imagine alternatives to life events that appear unreasonable to others (e.g., Markman & Miller 2006, Roese et al. 2009). Regret and counterfactual thoughts are also associated with anxiety (e.g., Kocovski et al. 2005, Roese et al. 2009). Most people imagine how things might have turned out differently after traumatic life events, such as bereavements, illnesses, accidents, or assaults (e.g., Callander et al. 2007, Davis et al. 1995, Epstude & Jonas 2015). Their well-being is affected by these thoughts, for example, people who experience the death of a child or partner in a car accident and who continue to create counterfactuals in the months and years after the event experience most distress (e.g., Davis et al. 1995). The frequency of counterfactual thoughts and the symptoms of posttraumatic stress disorder are correlated (e.g., El Leithy et al. 2006).

Individuals differ in their tendency to imagine how things could have been different. People who are prone to daydreaming and fantasy show a greater propensity to engage in counterfactual thinking (e.g., Bacon et al. 2013), and so do people with a strong belief in free will (e.g., Alquist et al. 2015). Individuals also differ in their tendency to imagine that things could have been better rather than that they could have been worse (e.g., Rye et al. 2008). These differences occur as a result of enduring personality characteristics, such as self-esteem, as well as transient factors, such as mood (e.g., Sanna et al. 1999).

Moral Judgments

The comparison of reality to a counterfactual alternative can act as a powerful social glue that supports moral judgments such as blame ascriptions. On the one hand, counterfactuals and blame ascriptions are clearly entwined. Counterfactuals have long been used to determine legal culpability in "but for" arguments, such as that an injury would not have happened except for the defendant's conduct. When people listen to a lawyer suggesting a counterfactual about an attack in which changes to the victim's behavior change the outcome, they ascribe higher blame to the victim and lower blame to the attacker. Conversely, when changes to the victim's behavior do not change the outcome, they ascribe higher blame to the attacker and lower blame to the victim (e.g., Branscombe et al. 1996). Judgments of sympathy and compensation for victims, and punishment for perpetrators, are affected by how readily a counterfactual can be imagined (e.g., Macrae et al. 1993; see also Goldinger et al. 2003).

Conversely, people do not imagine an alternative to an action that leads to a bad outcome when the action conforms to a moral norm or obligation. Suppose Steven arrives home too late to

save his dying wife because he was delayed by several events, such as visiting his elderly parents, getting stuck in a traffic jam, and so on. People do not tend to imagine an alternative to the morally constrained action and wish, "If only Steven hadn't called in on his parents" (e.g., McCloy & Byrne 2000; see also Walsh & Byrne 2007). Violating a norm is associated with blame (e.g., Malle et al. 2014). Counterfactuals modulate blame by interrogating whether the event was preventable—the actor could have done something differently, and whether there was an obligation to prevent it—the actor should have done something differently (e.g., Malle et al. 2014). For example, when people hear about a doctor who prescribed a drug for a patient who had an allergic reaction to it and died, they blame the doctor and judge he should pay compensation. They do so when he could have done something differently—when there was another drug that he could have prescribed. And they do so when he should have done something differently—when he should have checked the patient's records to see whether she had allergies (e.g., Alicke et al. 2008).

But on the other hand, the content of counterfactuals and blame ascriptions sometimes differs, just as the content of counterfactuals and causal thoughts sometimes differs (e.g., Walsh & Byrne 2007). Consider Joe, who failed to pick up his son from school. Joe's neighbor brought his son home instead, and on the way the boy was injured when a drunk driver crashed into them. People imagine how things could have turned out differently by changing Joe's behavior. But they assign more fault—blame, responsibility, and causality—to the drunk driver than to Joe (e.g., N'gbala & Branscombe 1995). They ascribe blame to the strong cause, the drunk driver, whereas they imagine alternatives to the enabling cause, Joe's failure (e.g., Byrne 2005). Counterfactuals impact moral judgments by identifying or implying relations of many different sorts, not only causal relations but also deontic and intentional relations.

Counterfactuals and judgments about intentions. Counterfactuals influence judgments about other people's intentions (e.g., Knobe 2010, Pellizzoni et al. 2010). Imagine a chairman who starts a new program that will help increase profits but will also harm the environment. The chairman wants to make as much profit as he can and does not care about harming the environment. People judge that the chairman intentionally harmed the environment, even though it was a side effect of his goal. Imagine instead that the new program will help increase profits and will help the environment. The chairman wants to make as much profit as he can and does not care about helping the environment. People judge that the chairman did not intentionally help the environment (e.g., Knobe 2003). The effect also occurs for nonmoral side effects and for violations of nonmoral norms (e.g., Guglielmo & Malle 2010, Uttich & Lombrozo 2010). The difference between the harmful side effect and the helpful side effect is that for the harmful side effect, the chairman makes a choice between two options, pursuing his goals or meeting a moral norm of protecting the environment. In contrast, for the helpful side effect, the chairman does not choose between two options, he just learns that what he wants to do has a good side effect. Counterfactuals amplify judgments of intentionality: When people imagine how the outcome could have turned out differently, they judge that the chairman intended to harm the environment even more than when they do not imagine an alternative (e.g., Ndubuisi & Byrne 2013).

Counterfactuals also influence how people judge the morality of their own intentions. People feel moral not only when they think about virtuous things that they did, but also when a counterfactual alternative is available about immoral things that they did not do (e.g., Effron et al. 2012). People who identified a white suspect of a crime believed that others would view them more positively when the counterfactual alternative was a black suspect rather than a white one. They subsequently judged ambiguous actions as not racist, such as a woman walking alone at night who sees a black man coming toward her and crosses the street. The foregone immoral counterfactual alternative to their earlier action seems to license subsequent dubious behavior (e.g., Effron et al. 2012).

Semifactual: an imagined alternative that results in the same outcome as reality, sometimes expressed as "even if . . . "

Counterfactuals and moral dilemmas. Counterfactuals affect decisions about whether it is appropriate to violate a moral principle (e.g., Bucciarelli et al. 2008). Suppose Mark is on a runaway train about to kill five men on the track. He can hit a switch to change tracks, which will save the five men, but his action will lead to the death of a man on the other track. Most people judge that it is morally appropriate for Mark to act. But suppose instead Mark is on a railway bridge above a runaway train that is about to kill five men on the track. He can push a nearby stranger off the bridge onto the tracks, which will save the five men, but his action will lead to the death of the stranger. Most people judge that it is not morally appropriate for Mark to act (e.g., Greene et al. 2004). Some moral dilemmas, such as the one about pushing a stranger, evoke emotional reactions more than others, such as the one about hitting a switch, but people can provide reasoned justifications for their decisions in both versions (e.g., Gubbins & Byrne 2014; see also Royzman et al. 2011). They readily create a counterfactual alternative to imagine what they could have done to avoid the worst outcome, in which five people died, for the version that requires hitting a switch. But they take longer to imagine what they could have done to avoid the worst outcome, in which five people died, in the version about pushing the stranger (e.g., Migliore et al. 2014).

The mind has evolved the ability to imagine alternatives to reality, which confers many advantages. The loss of counterfactual thinking following injury to the prefrontal cortex is devastating (see Impairments of Imagination sidebar). Counterfactual thoughts help people to explain the past, prepare for the future, modulate emotional experience, and make moral judgments. The process of computing counterfactuals is primarily an automatic, unconscious one, although people can sometimes intervene to deliberately create or suppress counterfactuals. What the mind computes and why people create counterfactuals constrains how the mind creates counterfactuals, to which we now turn.

HOW THE MIND CREATES COUNTERFACTUALS

An algorithm to specify the mental representations and cognitive processes that create counterfactuals takes as input the relevant facts of the actual event and produces as output a counterfactual alternative. The intervening processes change aspects of the mental representation of the facts to create a second mental representation, the counterfactual alternative.

Dual Possibilities

The computational mechanisms underlying counterfactual reasoning maintain and update two representations, the imagined alternative and the known or presupposed reality. When people read a counterfactual such as, "If there had been roses in the shop, there would have been lilies," they are primed to read quickly the conjunction "There were no roses and there were no lilies" as well as the conjunction "There were roses and there were lilies" (e.g., Santamaria et al. 2005). They consider that someone uttering the counterfactual means to imply "There were no roses" and "There were no lilies" (e.g., Thompson & Byrne 2002). People make inferences from counterfactuals that they otherwise find difficult from ordinary conditionals. For example, they make the modus tollens inference from "There were no lilies" to "Therefore there were no roses" (e.g., Byrne & Tasso 1999). They do so for various linguistic forms such as, "There would have been roses only if there had been lilies" (e.g., Egan et al. 2009). They make different inferences from "if only" counterfactuals compared to "even if" semifactuals, such as, "Even if there had been roses, there still would have been lilies" (e.g., Moreno-Rios et al. 2008). A counterfactual inducement such as, "If you had hit your sister, I would have grounded you" continues to have illocutionary force for the future as an ongoing threat (e.g., Egan & Byrne 2012).

IMPAIRMENTS OF IMAGINATION

The many problems that counterfactuals solve are perhaps most evident when the ability to create them is lost. Injury to the prefrontal cortex can result in an impairment of one or more of the computational processes that are required for counterfactual thinking. The loss of counterfactual thinking has devastating consequences. Some of the well-known deficits associated with prefrontal impairment, such as a failure to learn from mistakes and insensitivity to the consequences of decisions, as well as atypical regret and blame experiences, may result from an impairment in counterfactual thinking (e.g., Gomez Beldarrain et al. 2005, McNamara et al. 2003).

Individuals with injuries to the orbitofrontal or dorsolateral prefrontal cortex show an absence of spontaneous counterfactual expressions. For example, when healthy adults talk about a bad event from their past for a few minutes, they usually spontaneously mention a few ways in which it could have turned out differently, but individuals with injuries to the prefrontal cortex rarely mention alternatives (e.g., Gomez Beldarrain et al. 2005). Similar impairments occur in individuals with prefrontal cortex damage as a result of advanced Parkinson's disease (e.g., McNamara et al. 2003) or schizophrenia (e.g., Hooker et al. 2000, Roese et al. 2008). Such impairments have an impact on preparing for the future. For example, counterfactual impairments affect the formation of intentions. Individuals with schizophrenia who imagine a counterfactual alternative about the past are not primed to read a related intention about the future, unlike healthy individuals (e.g., Roese et al. 2008). Counterfactual impairments also affect decision making. fMRI results show activity in various brain regions including the medial orbitofrontal cortex when healthy adults experience regret on comparing the outcome of a gamble with a counterfactual nonobtained outcome (e.g., Coricelli et al. 2005). In contrast, individuals with lesions to the orbitofrontal cortex do not report experiencing regret and do not appear to anticipate regret to avoid bad outcomes on subsequent gambles (e.g., Camille et al. 2004). Analogous results are observed for individuals with obsessive-compulsive disorder (e.g., Gillan et al. 2014). The Counterfactual Inference Test contains items based on norms for the sorts of counterfactuals that most people tend to create (e.g., Hooker et al. 2000). It shows that people who have acquired injuries to the prefrontal cortex do not tend to create the same sorts of counterfactuals as healthy individuals do (e.g., Hooker et al. 2000, McNamara et al. 2003).

The subjunctive grammatical mood and words such as "would have," or "could have" as well as "if only" are important linguistic cues to counterfactuality. However, the subjunctive mood is not necessary or sufficient to indicate counterfactuality, and it can be communicated in languages such as Chinese that do not typically rely on such linguistic markers (e.g., Yeh & Gentner 2005). Some subjunctive conditionals are not interpreted as counterfactual. Obligations, such as "If the nurse had cleaned up the blood, then she would have had to wear rubber gloves," communicate the presupposition that the nurse did not clean up blood, but not that the nurse did not have to wear rubber gloves, nor that she did not wear them (e.g., Quelhas & Byrne 2003).

Real-world conflicts and "as if" simulation. For counterfactuals to help prepare for the future, they require not only a simulation of a possible alternative as if it were true but also an evaluative comparison of the alternative to the current reality to work out the difference between the two (e.g., Markman & McMullen 2003). Counterfactuals activate areas of the medial prefrontal cortex related to conflict detection (e.g., Van Hoeck et al. 2013; see also Barbey et al. 2011). People must resolve the conflict between the real world and the imagined counterfactual alternative, which can lead to an initial brief disruption in the immediate comprehension of a counterfactual

(e.g., Ferguson & Sanford 2008). For example, people read a counterfactual, such as "If cats were vegetarians, they would be cheaper for owners to look after," and then read information consistent with the counterfactual and inconsistent with real-world knowledge, such as "Families could feed their cat a bowl of carrots, and it would gobble it down happily." Eye-tracking measures show that they look at "carrots" for as long when they are primed by the counterfactual as when they are primed by an ordinary conditional about the real world. This result indicates that they envisage both the real world and the counterfactual alternative (e.g., Ferguson & Sanford 2008; see also Ferguson et al. 2008). The initial disruption by reality is rapidly resolved, and later measures indicate an immersion in the counterfactual alternative.

When the counterfactual context supports an immediate "as if" simulation, no disruption by real-world knowledge occurs (e.g., Nieuwland & Martin 2012). People read causal sentences, such as "Because NASA developed its Apollo Project, the first country to land on the moon was . . . ", that contained a false word (Russia) or a true one (America). The false word elicits a larger brain response than the true one in the N400, a peak recorded in event-related potentials around 400 milliseconds after the word, which indicates early semantic processing. The same effect occurs even for a counterfactual, such as "If NASA had not developed its Apollo Project, the first country to land on the moon would have been . . . ", when it ends with a word people consider to be false in the counterfactual context (America) or a word they consider to be true (Russia) (e.g., Nieuwland & Martin 2012).

For some counterfactuals, people dwell experientially on the imagined alternative; for example, they vividly envisage being hit by a truck after a near-miss experience and become transported into the alternative and simulate it as if it were true (e.g., Markman & McMullen 2003, Markman et al. 2008). In fact, counterfactual simulations can be mistaken for remembered events. When people select an action from a pair, such as clapping hands or snapping fingers, and then recall the action they performed or else imagine they had performed the other action, they falsely remember performing the action they had counterfactually imagined more than actions they had not imagined (e.g., Gerlach et al. 2014). Older adults do so more than younger ones (e.g., Gerlach et al. 2014). The simulation of a counterfactual activates sensory motor processes. People listened to counterfactuals that referred to movements toward or away from them, such as "If I had been far away from the basket, I would have passed the ball to another player," and they responded by pressing a key that required them to move their hand toward or away from them. The length of time to respond is affected by whether there is a match or a mismatch between the movement word and the movement response, just as it is for causal assertions (e.g., De Vega & Urritia 2011).

When people imagine how episodes from their past could have been better or worse, fMRI results show that the likely counterfactuals activate the same core brain network as episodic recollections, whereas unlikely counterfactuals require more imaginative work (e.g., De Brigard et al. 2013). Similarly, people visually read or aurally heard some real-world information such as, "The motor is switched off today," and they considered counterfactuals such as "If the motor had been switched on today, would it have burned fuel?" or ordinary conditionals such as "If the motor was switched on yesterday, did it burn fuel?" The fMRI results show greater activation for the counterfactuals in areas associated with increased mental imagery (e.g., Kulakova et al. 2013; see also Barbey et al. 2011). People may simulate an imagined alternative to reality by constructing mental models (e.g., Byrne & Johnson-Laird 2009, Johnson-Laird & Byrne 2002). They construct parsimonious mental representations because of the limitations of human working memory, and they tend to envisage possibilities that are true or are assumed temporarily to be true. They keep track of the epistemic status of their models as real or imagined (e.g., Byrne 2005, Johnson-Laird & Byrne 2002).

The Development of Counterfactual Thought

Children's appreciation of counterfactual alternatives to reality begins to make its first appearance as early as 2 years of age, when they begin to engage in pretend play, temporarily suspending their commitment to reality and adopting the perspective of a pretend situation (e.g., Harris et al. 1996). But counterfactual reasoning requires a further cognitive feat, to compare the known or supposed facts to the imagined alternative. Children aged 2 years can identify which toy horse "almost" fell off a table when one galloped right to the edge and the other stopped before reaching the edge. But when one horse galloped right off the table and fell, and the other stopped before reaching the edge, even 3- and 4-year-olds do not identify correctly which one almost fell (e.g., Beck & Guthrie 2011, Harris et al. 1996). Children aged 3 and 4 years have difficulties envisaging multiple possibilities. When they observe a mouse sliding down a slide that splits into two alternative tracks, they are correct in their answers to counterfactual questions such as "What if it had gone the other way—where would it be?" but experience more difficulty on open counterfactual questions such as "Could it have gone anywhere else?" (e.g., Beck et al. 2006). The accomplishment of counterfactual thinking continues to be refined throughout the childhood years. Children as young as 3 and 4 years make the correct counterfactual inference when they are told that a doll made a floor dirty with her shoes and are asked whether the floor would be dirty if she had taken her shoes off (e.g., Harris et al. 1996). But children aged 6 years and older make errors when they cannot rely on general assumptions and have to envisage alternative possibilities to take into account the specifics of what actually happened (e.g., Rafetseder et al. 2013).

The development of counterfactual and false belief reasoning. The development of counterfactuals is important for the development of a theory of mind and the understanding that other people can have false beliefs (e.g., Riggs et al. 1998). From their first months through to adolescence, children exhibit an emerging and increasingly nuanced appreciation that other people's mental states—their beliefs, desires, and knowledge—may differ from their own. Consider a story about Sally and Anne, who are in the kitchen. Sally places some chocolate in the cupboard and she leaves. Anne takes the chocolate and moves it to the fridge. Sally returns. When 3-year-olds are asked where Sally will look for the chocolate, they tend to say she will look in the fridge; 4- and 5-year-olds tend to say she will look in the cupboard (e.g., Wimmer & Perner 1983). Counterfactuals such as "If Anne had not moved the chocolate, where would it be?" are a key ingredient in reasoning about false beliefs such as "Where does Sally think the chocolate is?" (e.g., Riggs et al. 1998). Children make correct counterfactual inferences earlier than correct false-belief inferences (e.g., Perner et al. 2004). Understanding false beliefs is correlated with counterfactual thinking even when age, verbal intelligence, and other linguistic factors are controlled (e.g., Guajardo et al. 2009). The two sorts of inferences activate similar brain areas (e.g., Van Hoeck et al. 2014). Children with autism spectrum disorders have difficulties with both sorts of inferences (e.g., Grant et al. 2004). Even children with high-functioning autism spectrum disorders create counterfactuals that differ from those of typically developing children (e.g., Begeer et al. 2009). Counterfactual and false-belief reasoning both require executive function skills, including working memory skills (e.g., to simulate two mental representations simultaneously), inhibitory control skills (e.g., to suppress attention to the mental representation of reality), and representational flexibility skills (e.g., to consider different perspectives on the same situation) (e.g., Beck et al. 2011, Drayton et al. 2011).

The mechanisms underlying counterfactual reasoning sustain alternative mental representations—the known or presupposed facts and the imagined counterfactual possibility. The sorts of changes people make to the representation of the facts to create the imagined alternative depend on the content and the contextual information that they have included in the mental representation of the facts, to which we now turn.

TRUTH AND LOGIC

Counterfactuals can be true or false, but how to establish their truth is a nontrivial matter (e.g., Nickerson 2015). A counterfactual such as "If kangaroos had no tails they would topple over" conveys that its "if" part is false—kangaroos do have tails, and that it's "then" part is false—kangaroos do not topple over (e.g., Lewis 1973). All counterfactuals have a false "if" part and a false "then" part, and thus the truth of a counterfactual cannot be a function of the truth of its components. A major advance in logical analyses of counterfactuals was the proposal that the meaning of a counterfactual depends on its truth in a possible world, one that is the same as this world except that the counterfactual is true in it (e.g., Stalnaker 1968). Counterfactuals require a consideration of the possible world that is most similar to the actual world (e.g., Lewis 1973).

But people do not have the cognitive capacity to consider all of the potentially infinite sets of possible worlds, and they cannot compare all of the counterfactual alternatives that can be constructed for any set of facts (e.g., Byrne 2005, Johnson-Laird & Byrne 2002). Moreover, ideas of a possible world that is as close as possible to actuality are slippery (e.g., Kratzer 2012, Williamson 2007). The attraction of counterfactuals such as "If Oswald had missed his target, Kennedy would not have been shot" is that they appeal to an imagined world that appears "only a muscle twitch away" from the actual one, where history has been minimally rewritten (e.g., Tetlock & Belkin 1996). But establishing what counts as a minimal change may be intractable—even a tiny change to one aspect of reality can have major consequences, and objectively small changes may be of significant psychological magnitude (e.g., Kahneman & Miller 1986). In fact, people judge counterfactual alternatives that they imagined to episodes from their past to be less plausible when they simulate them repeatedly. Even though the counterfactuals become more detailed and more easily constructed, the repeated simulations highlight further discrepancies between reality and the counterfactual (e.g., De Brigard et al. 2013).

HOW KNOWLEDGE MODULATES THE PLAUSIBILITY OF COUNTERFACTUALS

The mind constructs counterfactuals that are plausible—reasonable, believable, and acceptable. Their plausibility may be challenged, for example, by the discovery of further information or by others with different opinions, and the counterfactual may be augmented or abandoned (see Truth and Logic sidebar). An algorithm to simulate the processes that create counterfactuals will have the goal to produce plausible ones. Semantic and pragmatic knowledge modulates the representation of the facts upon which a counterfactual is based.

Additive counterfactual: an imagined alternative in which something extra is added to the representation of reality

Subtractive counterfactual: an imagined alternative in which something is deleted from the representation of reality

Fault lines: aspects of the representation of reality that people zoom in on when they imagine an alternative to it

Counterfactual "Fault Lines"

Some aspects of reality seem to be more mutable than others. People tend to change their mental representation of the facts of an event, such as a car accident, by creating an additive counterfactual that adds something extra to the event, such as "If only he had worn a seatbelt," rather than by creating a subtractive counterfactual that deletes something about the event, such as "If only he had not gone out" (e.g., Epstude & Roese 2008, Kahneman & Tversky 1982a). A striking discovery is that most people tend to imagine the very same sorts of counterfactuals. People zoom in on similar fault lines in their representation of reality (e.g., Kahneman & Tversky 1982a), as the following examples illustrate.

1. Exceptions: People create a counterfactual by changing an exceptional event to be normal. Suppose Mr. Jones left the office at his usual time but drove home by an unusual route and was killed by a truck that crashed into his car at an intersection. Most people imagine things could have turned out differently if he had gone home by his usual route. Suppose

instead that the accident happened when Mr. Jones left the office earlier than usual but was driving home by his usual route. Most people imagine that things could have turned out differently if he had left at his usual time (e.g., Kahneman & Tversky 1982a). One practical consequence of this exceptionality effect is that people feel more sympathy toward a victim who was mugged and judge that the perpetrator should be punished more harshly when the victim was on the way home by an unusual route rather than by the usual route (e.g., Macrae et al. 1993).

2. Controllable events: People create a counterfactual in which they change an event within their own control. Suppose Steven arrives home too late to save his dying wife because he was delayed by several events, some within his control such as stopping for a beer at a bar, and some outside his control such as a traffic jam. People imagine things could have been different if Steven had not stopped at the bar—they mentally undo the controllable event more than the uncontrollable one (e.g., Girotto et al. 1991). A practical consequence of this controllability effect is that people who experience the death of a spouse or child in a traffic accident, in which it is established that their loved one was not to blame, tend to focus on their own behavior, for example, "If only I had not let him go to the store that night," rather than on the other driver's behavior (e.g., Davis et al. 1995).
3. Actions: People create a counterfactual in which they change an action. Consider Lisa, who has shares in company A, thinks about switching to Company B, and decides to do so. She loses $1,000. Consider also Jenny, who has shares in Company B, thinks about switching to Company A, but decides to stay where she is. She also loses $1,000. People judge that Lisa, who acted, feels worse (e.g., Kahneman & Tversky 1982b). A practical consequence of this action effect is that when people consider the risks from a vaccination and the risks from an illness, they sometimes decide not to vaccinate against the illness, even when the risks of a bad outcome from the vaccine are smaller than the risks from the illness. They prefer to do nothing, even when inertia also leads to change (e.g., Ritov & Baron 1990).
4. Recent events: People create a counterfactual in which they change the most recent event in a temporal sequence of independent events. Imagine a game in which two people toss a coin, and if they toss the same face coin they will both win $1,000. Alicia goes first and tosses heads, Laura goes second and tosses tails, and so they both lose. People imagine that the second player, Laura, will feel more guilt and be blamed more (e.g., Miller & Gunasegaram 1990). The temporal order effect occurs for sequences of more than two events (e.g., Segura et al. 2002). It has practical implications; for example, counterfactuals about sports events, or about historical events, tend to focus on the "last chance" juncture (e.g., Tetlock & Belkin 1996).

There are several alternative explanations for the extraordinary consensus in the creation of counterfactuals.

Exceptionality effect: the tendency to imagine an alternative by changing exceptional events to be normal

Controllability effect: the tendency to imagine an alternative by changing a controllable event rather than an uncontrollable one

Action effect: the tendency to imagine an alternative by changing an action rather than an inaction

Temporal order effect: the tendency to imagine an alternative by changing the most recent event rather than earlier events

Alternative Explanations

The plausibility of a counterfactual depends on the influence of content and context in the mental representation of the facts, from which the counterfactual is constructed.

Probability and causal models. One view is that people zoom in on fault lines in their representation of reality, such as exceptions or controllable events, because these fault lines correspond to events that are most likely to change the outcome (e.g., Petrocelli et al. 2011). For example, people were told about a game in which a contestant must choose to open one of three doors, and behind one there is a person. If the contestant chooses the door that the person is behind, they must answer correctly a trivia question asked by the person. Sam chose door 3 and did not

win—the person was behind door 2. People considered the counterfactual "If Sam had chosen door 2, then he would have won." The "if" part, "if Sam had chosen door 2," either had a high likelihood—Sam had wavered between door 2 and door 3, or a low likelihood—Sam's favorite number was 3. The "then" part, "then he would have won," either had a high likelihood—the trivia question was on a topic Sam knew about, or a low likelihood—the question was on a topic Sam knew nothing about. People attributed more responsibility and negative affect to Sam when the "if" part had a high likelihood and the "then" part had a high likelihood given the "if" part; that is, when Sam nearly chose door 2 and when he knew a lot about the trivia topic (e.g., Petrocelli et al. 2011). Judgments of the probability of a counterfactual can appear to be linked to judgments of its conditional probability (e.g., Over et al. 2007).

A related idea is that the causal facts determine a counterfactual's probability, and Bayes nets capture patterns of conditional probability information about how events within a causal system depend on their immediate causes (e.g., Sloman & Lagnado 2005). Counterfactuals are instructions to make a mini-surgery modification to a causal model (e.g., Pearl 2013). Consider a simple causal device that consists of four components, A, B, C, and D, in which A or B cause C—either alone is sufficient to cause C—and C causes D. On this view a counterfactual such as "If C hadn't operated, component A would still have operated' is plausible because an intervention on C, so that it is not operating, prunes the causal model to remove links into C, but the values of the other variables remain as they are. Yet when people were told about such a causal device, they judged that if C had not operated, A would not have operated, presumably because they reasoned that in the case in which C is not operating, neither A nor B could be operating (e.g., Rips 2010). They did not create minimal changes by assuming an intervention changed only the most recent event in the causal system before the counterfactual antecedent, leaving events leading to the counterfactual's antecedent to happen as they did (e.g., Rips 2010). Similarly, in causal sequences of life events, people do not intervene on the most recent event. Consider Mary, who is delayed on her way to a sale by a series of causally related events, for example, she had to wait while people crossed a pedestrian crossing, which then caused her to be held up in a subsequent traffic jam. People do not imagine how things could have been different by undoing the most recent event in such a causal sequence. Instead they imagine the very first cause in the causal sequence had not occurred (e.g., Wells et al. 1987; see also Segura et al. 2002).

The counterfactuals people create do not appear to be guided by likelihood. Consider the story about Mr. Jones, who left the office at his usual time but drove home by an unusual route and was killed by a truck that crashed into his car at an intersection. The most improbable event is two cars being in exactly the same place at the same time, and yet no one imagines an alternative to this unlikely event (e.g., Kahneman & Tversky 1982a). People also do not seem to interpret ordinary conditionals in terms of their probability (e.g., Goodwin 2014, Johnson-Laird et al. 2015). And the spontaneous counterfactuals of the tourists who survived the 2004 tsunami in Southeast Asia did not change the most improbable event, that they would happen to take their Christmas vacation in the one holiday resort in the world that suffered a major natural disaster at that time (e.g., Teigen & Jensen 2011).

Alternative possibilities. Another view is that people zoom in on the fault lines because they provide readily available alternative possibilities (e.g., Kahneman & Tversky 1982a). The availability of alternatives is determined by factors such as norms; for example, an exception recruits from memory its corresponding norm. Hence, people change exceptions to be normal, rather than changing normal events to be exceptional (e.g., Kahneman & Miller 1986).

A counterfactual is plausible when semantic and pragmatic knowledge ensures that the representation of the facts, upon which the counterfactual is based, includes alternative possibilities.

Consider Lisa, who switched shares from company A to Company B. The mental representation includes not only the current facts—Lisa has shares in Company B, but also the previous, now counterfactual, possibility—Lisa had shares in Company A. The mental representation provides a ready-made counterfactual alternative, if only Lisa had stayed with Company A. Now consider Jenny, who stayed with shares in Company B. The mental representation includes the current facts—Jenny has shares in Company B, but the past situation was the same as the current one, and so the mental representation does not include a second possibility. The mental representation does not provide a ready-made counterfactual alternative (e.g., Byrne & McEleney 2000). As a result, people judge that Lisa, who acted, feels worse (e.g., Kahneman & Tversky 1982b).

A test of this account is that each of the observed fault lines is eliminated when the mental representation of reality explicitly includes different alternative possibilities, as the following examples illustrate.

1. Exceptional and normal events: People do not change exceptions to be normal when they read a story about a gambler who usually chose a medium bet from the possible set of small, medium, or large bets, but this time chose a small bet. They imagine "If only he had chosen the large bet . . . " when the representation of the facts includes the information that the large bet led to a better outcome. They change the exceptional event to be exceptional in a different way, rather than to be normal (e.g., Dixon & Byrne 2011).
2. Controllable and uncontrollable events: People do not change controllable events when they experience the event rather than read about it. When people choose between envelopes that contain an easy or difficult sum, and fail to solve the sum within the given time, they imagine "If only I had been able to use pen and paper . . . " or "If only I had had more time . . . ." They mentally undo uncontrollable constraints of the situation rather than the envelope choice within their control, unlike people who read about the situation (e.g., Girotto et al. 2007). Observers behave like actors, not like readers—they too imagine alternatives outside the player's control (e.g., Pighin et al. 2011).
3. Actions and inactions: People do not change actions when they take a long-term perspective on events. When people read about college choices that turned out badly, they judged that the individual who acted would feel worse in the short term, but the individual who did not act would feel worse in the long term (e.g., Gilovich & Medvec 1995). They imagine alternatives to an inaction from a long-term perspective when it has unknown consequences; for example, the outcome from the foregone opportunity to switch colleges is unknown. But they imagine alternatives to an action even from a long-term perspective when the inaction has known consequences; for example, for investments, the outcome of a foregone opportunity is known (e.g., Byrne & McEleney 2000). They also regret inactions rather than actions when they imagine how episodes from their own past could have turned out differently; for example, they regret missed educational opportunities, not spending enough time with their family and friends, and not pursuing hobbies (e.g., Gilovich & Medvec 1995, Morrison & Roese 2011).
4. Recent events: People do not change the most recent event when the context provides an alternative to the first event. For example, people read that the first player in the coin toss game tossed heads, but there was a technical hitch and the game was restarted; this time the first player tossed tails and the second player tossed heads. People imagined a counterfactual in which the first player had tossed heads (e.g., Byrne et al. 2000). Likewise, people read a description of the coin toss game, which included an illustration such as that both players must toss the same face coin; for example, both players must toss heads. When they read that the first player tossed tails, the opposite of the illustration, and the second player tossed

heads, they changed the first event rather than the most recent event (e.g., Walsh & Byrne 2004).

Each of the observed fault lines can be eliminated when the representation of reality explicitly includes different alternative possibilities. The discovery provides some support for the idea that a counterfactual is plausible when semantic and pragmatic knowledge ensures that the representation of the facts, upon which the counterfactual is based, includes alternative possibilities.

Between the ages of 6 and 8 years, around the time when children are gaining some mastery at envisaging alternative possibilities, they begin to create counterfactuals that zoom in on the fault lines (e.g., Meehan & Byrne 2005). The tendency to do so is robust across cultures, even though the content of counterfactual thoughts reflects cultural priorities (e.g., Chen et al. 2006). Our everyday counterfactual thoughts tend to be firmly rooted in reality: We rarely imagine fantastical counterfactuals, such as that our neighbor would not have been killed when his car crashed if only people were immortal. The remarkable regularities in the counterfactuals that most people create reflect the role of semantic and pragmatic knowledge in modulating the representation of the facts upon which a counterfactual is based.

CONCLUSIONS

Beckett's assertion in *Malone Dies*—"I could die today, if I wished, merely by making a little effort, if I could wish, if I could make an effort"—pits the power of the imagination against pale reality. The mind has the competence to compute counterfactuals that serve many purposes, to explain the past and prepare for the future, and to modulate emotional experiences and moral judgments. The architecture of cognition imposes limitations on the nature of the counterfactuals that people create. Counterfactuals are limited by working memory restrictions on the nature and complexity of the alternative possibilities that can be envisaged. Their plausibility is susceptible to the vagaries of content and context. The extent to which specific counterfactuals serve well the many purposes for which they are designed depends on the quality of the knowledge that people access and include in their mental representation of reality. Episodic counterfactuals about how events could have been different in our own past are as vulnerable to distortion as the autobiographical memories on which they are based. Second-order counterfactuals, about how another person will imagine how events could have been different, exhibit many frailties of perspective taking. Notwithstanding these limitations on performance, counterfactuals free our minds from facts to allow a consideration of myriad other possibilities.

SUMMARY POINTS

1. The mind computes counterfactual alternatives to reality for many reasons. Counterfactuals explain the past by implying causal and other sorts of relations. They prepare for the future by affecting the formation of intentions and by influencing decision making.
2. Counterfactuals modulate emotional experiences, including negative emotions such as regret and guilt as well as positive emotions such as relief and sympathy. They can become dysfunctional, for example, in depression and anxiety and after traumatic events.
3. Counterfactuals support moral judgments about blame and responsibility. They affect judgments about other people's intentions, and they influence the resolution of moral dilemmas.

4. The mind computes counterfactuals by changing aspects of the mental representation of the facts to create a second mental representation corresponding to an imagined alternative. The mechanisms underlying counterfactual reasoning maintain and update two mental representations, of reality and its imagined alternative.
5. The ability to create counterfactuals develops throughout childhood. It relies on the development of working memory skills for simulating multiple possibilities as well as inhibitory control skills for suppressing attention to the mental representation of reality. Counterfactual thoughts support the development of reasoning about other people's beliefs, including their false beliefs.
6. People create counterfactuals that are plausible. They exhibit remarkable regularities in the alternatives to reality that they create. Most people zoom in on the same pivotal junctures or fault lines in their representation of reality to create a counterfactual alternative to it.
7. Semantic and pragmatic knowledge modulates the possibilities that people consider, based on their mental representation of reality, from which they create a plausible counterfactual alternative.

FUTURE ISSUES

1. Most research has examined "if only" thoughts, how people imagine the ways in which alternative antecedents could have led to a counterfactual outcome. Comparatively little research has examined "what if" thoughts, how people imagine alternative consequences that could have followed from a counterfactual starting point. Are "what if" thoughts like "if only" thoughts?
2. Most research has focused on counterfactual thoughts about the past—about what would have, could have, or should have happened. Do prefactual thoughts about the future—about what might, can, or should happen—share the same characteristics?
3. The computation of counterfactuals has been examined in various systems in artificial intelligence. But there are as yet few computational simulations of theories of the mental representations and cognitive processes that people rely on when they create counterfactuals.

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