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Causes versus enabling conditions*

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Abstract

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People distinguish between a cause *(e.g., a malfunctioning component in an airplane causing it to crash) and a* condition *(e.g., gravity) that merely enables the cause to yield its effect. This distinction cannot be explained by accounts of reasoning formulated purely in terms of necessity and sufficiency, because causes and enabling conditions hold the same logical relationship to the effect in those terms. Proposals to account for this apparent deviation from accounts based on necessity and sufficiency may be classified into three types. One approach explains the distinction in terms of an inferential rule based on the normality of the potential causal factors. Another approach explains the distinction in terms of the conversational principle of being informative to the inquirer given assumptions about his or her state of knowledge. The present paper evaluates variants of these two approaches, and presents our* probabilistic contrast model, *which takes a third approach. This approach explains the distinction between causes and enabling conditions by the* covariation *between potential causes and the effect in question over a* focal set *– a set of events implied by the context. Covariation is defined probabilistically, with necessity and sufficiency as extreme cases of the components defining contrasts. We*

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report two experiments testing our model against variants of the normality and conversational views.

Introduction

In answer to the question, "What caused the airplane to crash?", aviation-accident investigators are unlikely to reply, "The gravitational pull of the earth." Rather, they are likely to reserve the title of "cause" for factors such as the malfunctioning of a critical component of the aircraft, pilot error, or wind-shear as the plane was landing. Gravity, they might say, was merely a condition that enabled the crash to occur. This distinction between a *cause* and an *enabling condition* is one that people-on-the-street make, and that lawyers and historians grapple with (see Einhorn & Hogarth, 1986; Hart & Honoré, 1959/1985; Hesslow, 1983, 1988; Hilton, 1990; Mackie, 1965, 1974; Taylor, 1983; White, 1965).[1]

This distinction cannot be explained by accounts of reasoning formulated purely in terms of necessity and sufficiency. Consider a particular plane crash for which the malfunctioning of a component and gravity were necessary factors. These two factors hold the same logical relationship to the effect in terms of necessity and sufficiency: the crash would not have occurred either if the component had not malfunctioned or if there had been no gravity; moreover, the malfunctioning of the component and gravity, along with other necessary factors such as the failure of a backup system, were jointly sufficient to have produced that crash. The problem that this distinction posed for a logic of causality formulated in terms of necessity and sufficiency was first noticed by the philosopher J.S. Mill (1843/1973), who noted that events are typically produced by a set of individually necessary and jointly sufficient factors, where the relation between a *condition* (a factor in such a set) and the effect is identical across all the conditions in the set.[2]

Proposals to account for this apparent deviation from accounts based on necessity and sufficiency may be classified into three types. One approach explains the distinction between causes and enabling conditions in terms of a criterion based on the *normality* of the possible causal factors within an appropriate context

[1]Except in our experimental materials, we use the term "enabling condition" because we think it is more descriptive than "mere condition", the more common term in the literature.

[2]For *types* of effects (e.g., forest fires in general) rather than particular instances of an effect (e.g., the fire in Yellowstone Park), the logical relationship between a factor and the effect is more complicated, because there are often alternative ways of producing a type of effect (e.g., there are multiple ways of producing forest fires). Developing Mill's ideas, the philosopher Mackie (1965, 1974) proposed that an individual "condition" (e.g., lightning) is an insufficient but necessary part of an unnecessary but sufficient *conjunctive set* of factors (e.g., lightning, the presence of combustible material, *and* the presence of oxygen) comprising a type of cause that produces a type of effect (e.g., forest fire). The relation between an individual condition and the effect, although more complicated in this case according to Mackie, is still identical across all conditions in the set.

(Einhorn & Hogarth, 1986; Hart & Honoré, 1959/1985; Hilton & Slugoski, 1986; Kahneman & Miller, 1986; Mackie, 1974; Turnbull & Slugoski, 1988). Another approach explains the distinction in terms of the *conversational* principle of being informative to the inquirer given assumptions about his or her current state of knowledge (e.g., Hilton, 1990; Mill, 1843/1973; Turnbull, 1986; Turnbull & Slugoski, 1988). A third approach may be characterized as explaining the distinction by the *covariation* between potential causes and the effect in question over a *focal set* – a set of events implied by the context. Covariation has been formulated in terms of differences between the target event and a contrasting causal background (Hesslow, 1983, 1988; Hilton, 1990; Mackie, 1974; McGill, 1989). We evaluate two variants of each of the first two approaches, then present our *probabilistic contrast model*, which takes the third approach. Covariation in our model is defined in terms of differences in the probabilities of the effect conditional on the presence versus the absence of potential causal factors (Cheng & Novick, 1990a, 1990b). We report two experiments testing our model against variants of the normality and conversational views. In addition, we assess our model against two other explanations of the distinction in the General discussion.

The normality criteria

Mill thought that everyday explanation diverged from scientific explanation in the "capricious manner in which we select from among the conditions that we choose to designate the cause" (1843/1973, vol. 7, p. 329). Rather than treating this everyday distinction as evidence for irrational biases, however, the legal philosophers Hart and Honoré (1959/1985) proposed that the distinction is in fact sensible and systematic, and that one of the features critical to the distinction is the normality of the conditions in the set: an abnormal condition (e.g., the malfunctioning of a component) will be designated as the cause, whereas normal conditions (e.g., the gravitational pull of the earth) are merely enabling conditions.

Noting that in everyday life causal questions are typically asked about events that are puzzling *because* they are a departure from the normal (e.g., a catastrophe), Hart and Honoré (1959/1985) proposed that two contrasts are important in distinguishing between causes and enabling conditions: "the contrast between what is abnormal and what is normal in relation to any given thing or subject-matter, and between a free deliberate human action and all other conditions" (p. 33). They maintained that central to the common-sensical concept of cause, and at least as essential as the notions of invariable or constant sequence stressed by Mill and Hume, is the notion of human intervention in a course of events that would normally take place. Postulating the generalization of this notion to cases in which there is no literal human intervention, they suggested that a cause is "*a* *difference* from the normal course which accounts for the difference in the outcome" (p. 29). They expounded on the normality contrast as follows: "normal conditions ... are those conditions which are present as part of the usual state or mode of operation of the thing under inquiry: some of such usual conditions will also be familiar, pervasive features of the environment: and many of them will ... be present alike in the case of disaster and of normal functioning" (p. 35). Notice that normal conditions include, but are not restricted to, constantly present ones. We will argue that constantly present conditions should be distinguished from other normal (i.e., highly prevalent) conditions.[3]

Hart and Honoré pointed out that the perception of what is a cause or an enabling condition may vary depending on context. The presence of oxygen, for example, would not typically be considered the cause of a fire; a cause might be an event such as the dropping of a lighted cigarette. However, "If a fire breaks out in a laboratory or in a factory, where special precautions are taken to exclude oxygen during part of an experiment or manufacturing process, ... there would be no absurdity at all in *such* a case in saying that the presence of oxygen was the cause of the fire" (Hart & Honoré, 1959/1985, p. 35). Rather than surrendering to the temptation to say that the distinction is arbitrary and capricious, Hart and Honoré explained the variation by the role of context in the interpretation of what is normal or abnormal. They noted that, in the example above, the exclusion of oxygen, and not its presence, is part of the normal functioning of the laboratory or factory. Normality is therefore defined with respect to the context of the causal event in question, and the condition that is *contextually abnormal* is predicted to be perceived as a cause. Contextually normal conditions are relegated to the status of enabling conditions.

In a similar vein, Mackie (1974) proposed that one would likely say that an event, rather than a standing condition, caused a certain effect (e.g., it was the spark rather than the presence of flammable material that caused the fire). Among events, one would likely prefer intrusive ones over steady ones (e.g., it was the severing of the artery rather than the pumping of the heart that caused the loss of blood). Notice that the above two criteria may be regarded as special cases of the normality criterion discussed by Hart and Honoré (1959/1985). Finally, Mackie wrote, "what is normal, right, and proper is not so readily called a cause as is something abnormal or wrong" (p. 34). This last criterion rests on the ethical or idealistic sense of normality as well as the statistical sense discussed previously. Hilton (1990) described a criterion of this type as involving a contrast between the target event and the background of an ideal case. According to this criterion, conditions that deviate from an ideal would be considered causes; those that do not would be considered enabling conditions.

[3]Because the present article is concerned with causality rather than responsibility, we will not discuss cases for which the second contrast, that between a free human action and other conditions, might play a role.

The above criteria were explained by Mackie in terms of a *causal field*, which was not defined, but rather illustrated by examples. Mackie explained that "A causal statement will be the answer to a causal question, and the question 'What caused this explosion?' can be expanded into 'What made the difference between those times, or those cases ... in which no such explosion occurred, and this case in which an explosion did occur? ... Anything that is part of the assumed (but commonly unstated) description of the field itself will ... be automatically ruled out as a candidate for the role of cause. Consequently if we take the field as being *this block of flats as normally used and lived in*, we must take Jones's striking a match to light his cigarette as part of the field, and therefore not as the cause of ... the explosion. What caused the explosion must be a difference in relation to the field, and the gas leak ... is the obvious candidate" (Mackie, 1974, p. 35). In another example, he explained why one ordinarily would not say that birth causes death, even though birth is both necessary and sufficient for death. The reason is that when we look for a cause of someone's death, the event of this person's death is a change in a field that includes the person having been alive for a while, and hence the person having been born. Birth, being part of the field, is therefore not perceived as a cause. Finally, to account for the effect of context on the distinction between causes and enabling conditions, Mackie proposed that different fields may be chosen under different contexts for causal accounts of the same event.

Mackie (1974, p. 119) related his account to Hart and Honoré's (1959/1985) as follows: "Features which are normal in [Hart and Honoré's] sense are the ones which in [my account] were relegated to the causal field, and therefore not allowed to count as causes." Although Mackie's discussion and illustrations of the causal field involved conditions that are constantly present in the given context, he did not explicitly distinguish between normality and constancy; instead, he accepted Hart and Honoré's statement that many – implying not all – normal conditions (i.e., those in the causal field) will be present in cases of both normal and abnormal functioning.

A number of psychologists who have considered the distinction have concurred with Mackie (1965, 1974) and Hart and Honoré's (1959/1985) normality explanation, in either or both its statistical and idealistic senses, sometimes with modification (Einhorn & Hogarth, 1986; Hilton & Slugoski, 1986; Kahneman & Miller, 1986; Turnbull & Slugoski, 1988). In the context of their "norm theory", Kahneman and Miller (1986, p. 148) noted that "The why question implies that a norm has been violated" and "requests the explanation of an *effect*, defined as a contrast between an observation and a more normal alternative." They specified a constraint on the choice of causal features in answer to a why question: a cause must be abnormal in the sense that it is not "a default value among the elements that the event [to be explained] has evoked" (p. 149). They further explained that "a property need not be statistically unusual to serve as an explanation; it is only precluded from being a default" (p. 149). To illustrate their point, they gave the following example: "Peculiar behaviors of cars observed on the road are frequently 'explained' by reference to the drivers being young, elderly, or female, although these are hardly unusual cases. The default value for an automobile driver appears to be a middle-aged male, and driving behavior is rarely explained by it" (p. 149). A default presumably involves a plurality but does not require a majority. Being non-default is therefore a less stringent requirement for a cause than being rare. We note that the default value in the above example is not one that is constantly present.

Einhorn and Hogarth (1986) interpreted the distinction between causes and enabling conditions in terms of causal "strengths", which are low for events that "generally occur". They illustrated their interpretation with the event of a watch face being hit by a hammer and the glass breaking, considering the event both without an explicit context and within the context of a test procedure in a watch factory: "[With no explicit context], a hammer that hits glass is an intrusive event that does not generally occur whereas a defect in the glass is a standing state. However, in a watch factory, the hitting of glass with hammers generally occurs during testing whereas a defect is something abnormal or wrong. Hence, in this context, the hitting of glass becomes more of a condition or standing state and the explanation loses much of its causal strength. Similarly, the defect explanation gains in causal strength due to its abnormality in these circumstances" (p. 5). Einhorn and Hogarth's explanations for both contexts are clearly congruent with statistical normality. For the factory context, their explanation also involves the notion of a deviation from an ideal case.

Hilton and Slugoski (1986) similarly adopted the normality view. According to them, among a set of individually necessary but jointly sufficient conditions, "The abnormal condition that distinguishes the target case from the contrast case ... becomes dignified as the cause. Those necessary conditions ... that are not abnormal ... are relegated to the status of mere conditions" (p. 77). Likewise, Turnbull and Slugoski (1988) concluded that "the covarying factor that is not taken for granted, which is unusual or abnormal in some way, is typically identified as the cause" (p. 69).

Conversational criteria: Assumptions about the inquirer's state of knowledge

There is an alternative explanation for every example of the distinction mentioned above: whereas a cause is always a condition assumed to be unknown to the hypothetical inquirer (otherwise there would be no reason for asking), an enabling condition is typically a condition assumed to be already known to the inquirer (Hilton, 1990; Mill, 1843/1973; Turnbull, 1986; Turnbull & Slugoski, 1988). Thus, for instance, a competent adult inquiring about an airplane crash presumably did not know about the malfunctioning of the critical component in the airplane, but did know that the gravity of the earth exerts a downward force; did not know about the dropping of a lighted cigarette, but did know that there must be oxygen in order for a fire to occur; did not know about the hammer accidentally hitting the watch face, but did know about the brittleness of glass; did not know about the particular disease that caused a patient's death, but did know that the patient had been born. A child, however, may not know about gravity, oxygen, or the brittleness of glass; these conditions may therefore be included, respectively, in answer to a child's question about the falling of objects, fire, and the breaking of glass.

The above explanation of the distinction between causes and enabling conditions has been regarded as an application of Grice's (1975) conversational maxim of quantity, which enjoins speakers to be as *informative* as, but not more so than, is required for the purpose of an exchange (Hilton, 1990; Turnbull, 1986; Turnbull & Slugoski, 1988). The informativeness account overlaps but does not coincide with another conversational explanation, a potential one applying Sperber and Wilson's (1986, 1987) notion of *relevance*. This notion is defined with respect to whether or not an item of information allows (a) the derivation of new assumptions, (b) the strengthening of old assumptions, and (c) the elimination of old assumptions in favor of stronger new assumptions that contradict them. Of the three defining features, only the first seems relevant to an explanation of the distinction between causes and enabling conditions. An item of information already known to the inquirer clearly will not allow the derivation of new assumptions, hence is not relevant in the above sense, and would be predicted to be an enabling condition, consistent with the prediction according to informativeness. The two variants of the conversational view differ, however, in that whereas all unknown conditions are informative, not all of them are conversationally relevant. A condition x that is constantly present and unknown to a particular inquirer would be informative to him or her, but irrelevant, because it would not allow the prediction of the effect. That is, a conclusion of the form, "if x then this particular instance of the target effect", presumably a new derivation, could not be made.

Predictions based on the informativeness or relevance of a factor given the inquirer's state of knowledge often overlap with those based on the (statistical or idealistic) normality explanation, because people (at least adults) often know about normal but not abnormal factors that jointly lead to an event. (Table 1 summarizes the predictions of the variants of the two explanations.) The variants of the conversational view and of the normality view concur in predicting that a known normal condition should be identified as an enabling condition, and an unknown abnormal condition that is not constantly present should be labelled a cause. Turnbull and Slugoski (1988, p. 69), in fact, treated the informativeness and normality views as equivalent: "The abnormal condition conception of cau-

Table 1. *Predictions regarding causal status according to various criteria depending on whether or not a condition is (a) assumed to be known to an inquirer, (b) constant, and (c) normal*

	Properties of a condition					
	assumed to be known to an inquirer[a]		assumed to be unknown to an inquirer			
			Constant		Not constant	
Criterion	Normal	Abnormal	Normal	Abnormal[b]	Normal	Abnormal
Informativeness	condition	condition	cause	cause	cause	cause
Relevance	condition	condition	condition	condition	cause	cause
Statistical normality	condition	cause	condition	–	condition	cause
Idealistic normality	condition	cause	condition	cause	condition	cause

[a]Variation in constancy is not listed for this column because none of the predictions depends on it.
[b]Abnormality in this column is to be interpreted only in the sense of deviation from an ideal, because a condition that is constant must be statistically normal. For all other columns, normality is to be interpreted in the sense of prevalence for the statistical-normality criterion, in the sense of deviations from an ideal for the idealistic-normality criterion, and in either of the two senses for the informativeness and relevance criteria.

sality fits well into a conversationally-based attribution theory. 'Mere conditions' correspond to assumptions that questioner and answerer mutually take for granted, while the abnormal condition corresponds to information the answerer believes the questioner does not know and which, when known, will resolve the questioner's puzzle."

Hilton (1990), however, proposed a "conversational model of causal explanation" that subsumes Hilton and Slugoski's (1986) normality criterion as a special case (the case above in which the inquirer is assumed to know about normal conditions but not about abnormal conditions). He assumed that "... in explaining an event to a competent adult, we would refer to individuating features of the case which cannot be presupposed from general world knowledge, such as abnormal conditions, and omit to mention ... [what] can be presupposed" (p. 67). He illustrated the principle with an example concerning a train crash, assuming that the explainer understands the crash to be due to a combination of several necessary factors that are jointly sufficient – a bent rail in the track, and the speed and weight of the train: "If one knows that the explainee knew about the speed and weight of the train but did not know that there was a bent rail in the track, the apt and informative answer to the *why* question would be to cite the bent rail as 'the' cause" (p. 66).

As summarized in Table 1, both variants of the conversational view differ from both variants of the normality view in predicting that (a) normal conditions that are not held constant would be identified as causes to an inquirer who does not know about them, and (b) abnormal conditions that are already known to the inquirer would be identified as enabling conditions. Moreover, the relevance view and the statistical normality view differ from the informativeness view in predicting that all constant conditions, even those unknown to the inquirer, would be merely enabling conditions.

Critique of the conversational and normality views

Conversational criteria

Hart and Honoré (1959/1985) contended that informativeness cannot explain the distinction between causes and enabling conditions. They maintained that in the case in which we are ignorant of a normal condition, we still classify it as an enabling condition after we learn of its causal status from science. To support their contention, Hart and Honoré gave the following example: "The dropping of a lighted cigarette remains the cause of a fire even when we learn from science, what we may not have initially known, that the presence of oxygen is among the conditions required for its occurrence" (pp. 34–35).

It seems to us that beliefs about the "true cause" and the "enabling conditions" of an event may be distinguished from the mentioning of a factor in reply to an inquirer's causal question. What the conversational criteria explain may be the *mentioning* of a factor, whereas Hart and Honoré's distinction concerns *beliefs* about the causal status of a factor. As a number of researchers have convincingly argued, replies to causal questions systematically differ depending on an answerer's assumptions about what the inquirer already knows (Hilton, 1990; Turnbull, 1986; Turnbull & Slugoski, 1988). A different issue, however, is whether mentioned and unmentioned causal factors correspond respectively to what are perceived as true causes and as enabling conditions. It seems that factors that are perceived as enabling conditions nonetheless sometimes may be included in reply to an inquirer who has no knowledge of them, along with definitions and other extra information. Consider a mother answering her 3-year-old's question about why plants in their garden are beautiful whereas plants in their neighbor's garden are brown and shrivelled. Assume that the child does not know that water, nutrients, and sunlight are necessary for healthy plant growth. The mother may explain, "Our plants grow better probably because we water and fertilize our plants more often. To 'fertilize' means to give food to plants. Plants need water and food to grow well. They also need sunlight, but our plants and our neighbor's plants get just as much sunlight." In this hypothetical reply, "sunlight" is informative, but does not have the status of a cause. Conversely, what are believed to be true causes may be omitted in an answer when they are not informative or not relevant (in Sperber & Wilson's, 1986, 1987 sense). Consider the mother in the above example answering the same question posed this time by a visiting friend. In this context, the reply may be, "I suppose I'm not as conscientious as my neighbors are about the drought in our region." It seems to us that in this context water is implicitly understood as a cause: lack of conscientiousness about the drought causes more watering, which in turn causes plants in the woman's garden to grow better. This later factor in the causal chain is omitted, not because it merely enables her plants to grow better, but because it would not be informative or conversationally relevant.

Normality criteria

We think that neither normality nor the conversational informativeness or relevance of an item of information can explain beliefs about its causal status. We evaluate here the statistical and idealistic versions of the normality view as explanations for the distinction between causes and enabling conditions.

The statistical normality criterion (including the default variant) seems to us to have three major limitations. First, the criterion only addresses the issue of how a cause is selected from a set of conditions, but not the issue of how the set of conditions are distinguished from causally irrelevant factors. The above two decisions are assumed by proponents of the normality view to require separate processes involving different principles, for the good reason that normality alone cannot distinguish between conditions and causally irrelevant factors. Consider the following example: suppose that Jones was wearing his wedding ring, as he normally did, when an explosion occurred in his apartment. The ring and oxygen were both normal, but only oxygen was causally relevant. To discriminate conditions from causally irrelevant factors, proponents of the normality view specify a separate preliminary process. Hilton and Slugoski (1986), for example, proposed a "counterfactual criterion" that selects individually necessary and jointly sufficient factors. We will propose a model that resolves both of the above issues by a single criterion.

A second problem is that the statistical normality criterion does not account for the conception of the causes of prevalent events (e.g., objects staying in place instead of floating weightlessly), which have prevalent factors (e.g., the mass of the object and the gravitational pull of the earth) that are individually necessary and jointly sufficient to produce the effect. According to this criterion, prevalent conditions are not causes. If so, then prevalent events, which by definition include most events, are either to be perceived as having only enabling conditions, or would require a different psychological mechanism for understanding their causal nature. A position that can be traced back to Mill (1843/1973), but is still espoused by contemporary philosophers (e.g., Hart & Honoré, 1959/1985), is that typically only scientists ask causal questions about prevalent events, and that they (at least prescriptively) make no distinctions between causes and enabling conditions, but instead perceive all conditions according to their logical relationship of necessity and sufficiency with respect to the effect.

We concur with Hart and Honoré (1959/1985) and others (e.g., Kahneman & Miller, 1986; Lehnert, 1978; Weiner, 1985) that in everyday life people typically ask about the causes of only rare events and that it is typically scientists who ask questions about prevalent events and discover (or invent) concepts such as viruses and gravity. Ordinary people, however, clearly do perceive and understand such concepts when they are used in everyday contexts, and the causal status of such concepts does not seem to be influenced by their degree of normality. For example, a virus that causes a disease will be considered as much a cause of the disease regardless of how prevalent that virus is. Similarly, even though gravity is ubiquitous on the surface of the earth, the statement "the earth's gravity causes objects near its surface to fall" does not sound anomalous (even though a physicist might not put it that way). It clearly carries the usual causal implication that without the cause (e.g., in a special gravity-free chamber) the effect would not occur (i.e., objects would not fall). The statement might be made, say, in answer to a child's question, or to an adult who does not know about gravity. Children, like scientists, often ask about the causes of normal events (Berzonsky, 1971; Koslowski & Pierce, 1981; Shultz & Kestenbaum, 1984).

It seems to us, then, that a major weakness of the statistical normality position is that it cannot account for ordinary people's conception of causality regarding prevalent events, thereby implying that two distinct mechanisms underlie people's concepts of causality in everyday versus scientific situations.

A third problem is that causes of rare effects can be prevalent factors, when the causal relation is probabilistic. For example, among people who are exposed to similar amounts of sunlight and have similar amounts of protection from skin pigment, sunblock, and clothing, only a small percentage develop skin cancer. One might say that sunlight is a cause of their skin cancer, even though skin cancer is quite rare whereas sunlight may be common.

Modifying the requirement for a cause from being rare to being "not a default" does not solve the above problems. The events illustrated above have, or may have, causes that are defaults (e.g., gravity in the context of the surface of our planet). With respect to the example on driving given by Kahneman and Miller (1986), we note that although peculiar driving may be unlikely to be attributed to a driver being a middle-aged male (the default driver), poor design of automobiles can readily be attributed to the automobile being made by an American company, even in the context of Detroit, where American automobiles are no doubt the default.

The idealistic-normality view faces problems that parallel the first two problems above for the statistical variant: (a) it does not explain the distinction between conditions and causally irrelevant factors, and (b) it can only account for the causes of undesirable events (e.g., the malfunctioning of a critical component in an airplane causing it to crash), but not the causes of desirable events (e.g., the shape of its wings and the thrust of its engines causing an airplane to fly). A third problem springs from defining a condition as right, proper, or desirable if it is associated with a desirable outcome, but wrong, improper, or undesirable if it is associated with an undesirable outcome. (We assume that the criterion is defined with respect to the desirability of the outcome.) Given that the same condition may be associated with multiple effects, some of which are desirable and others not, the idealistic criterion would predict that the condition is a cause of the undesirable effects and merely an enabling condition for the desirable ones. For example, sunlight is necessary for the growth of desirable plants such as daffodils as well as of weeds such as dandelions. Suppose that some daffodils and dandelions grow side by side in the sunlit areas of a yard. According to this criterion, sunlight should be perceived as causing the growth of dandelions but merely enabling the growth of daffodils.

Computation of probabilistic contrasts over a set of events selected by the context

If neither conversational constraints nor normality is a criterion for selecting causes from a set of conditions, how are causes selected? We propose that a single mechanism can account for the conception of causality in both normal and abnormal situations: the computation of covariation between potential causes and the effect in question over a *focal set*, a set of events implied by the context. Covariation is hypothesized to be computed over the focal set as specified by our *probabilistic contrast model* (Cheng & Novick, 1990b), which applies to discrete variables.[4] Our model defines a *main-effect contrast* (specifying a cause involving a single factor), Δp_i, as follows:

$$\Delta p_i = p_i - p_{\bar{i}} \qquad (1)$$

where i is a factor that describes the target event, p_i is the proportion of cases for which the effect occurs when factor i is present, and $p_{\bar{i}}$ is the proportion of cases for which the effect occurs when factor i is absent. When Δp_i is greater

[4]The model applies to events that are learned indirectly (e.g., by academic instruction) as well as those that are experienced directly.

than some (empirically determined) criterion, then there should be a causal attribution to factor i. In other words, a cause is a factor the presence of which (relative to its absence) noticeably increases the likelihood of the effect. Only factors that are psychologically prior to the event-to-be-explained are evaluated.

As a contrast cannot be computed for a factor that is constantly present in a focal set (owing to division by zero in the computation of the proportion of the effect in the absence of the factor), the causal status of such a factor cannot be determined by events in the focal set; instead, its status is determined by events in other focal sets. In our model, such a factor is: (a) an enabling condition if it does covary with the effect in another focal set (i.e., a set of events selected under another context), but (b) causally irrelevant if it does not covary with the effect in any other focal sets.

We also defined an *interaction contrast*, which specifies a cause involving a conjunction of factors (e.g., the simultaneous presence of positively charged clouds and negatively charged clouds as the cause of thunder). By analogy to statistical contrasts, a two-way interaction contrast involving potential causal factors i and j, Δp_{ij}, is defined as follows:

$$\Delta p_{ij} = (p_{ij} - p_{\bar{i}j}) - (p_{i\bar{j}} - p_{\bar{i}\bar{j}}) \tag{2}$$

where p, as before, denotes the proportion of cases in which the effect occurs when a potential contributing factor is either present or absent, as denoted by its subscripts. To our knowledge, there has not been any explicit definition of conjunctive causes in terms of contrast in previous proposals on the distinction between causes and enabling conditions.

The definitions of contrasts in equations (1) and (2) apply to inhibitory factors (i.e., factors that decrease the likelihood of an effect) as well as facilitatory factors (i.e., factors that increase the likelihood of an effect). Positive contrasts specify facilitatory causes; negative contrasts specify inhibitory causes.

Not all factors that covary with an effect are perceived as its causes. Among a set of factors that covary with an effect, there may exist innate or acquired constraints governing which factors are likely to be considered causes. Covariation is clearly not a sufficient criterion for causal induction. On theoretical grounds, the problem of combinatorial explosion in covariation computation surely requires that there be some innate biases in the inductive process of individual organisms. On empirical grounds, it is clear that animals have innate biases in causal induction (Garcia, McGowan, Ervin, & Koelling, 1968; Garcia, McGowan, & Green, 1972). Other biases may be acquired through learning (e.g., Bullock, Gelman, & Baillargeon, 1982; Chapman & Chapman, 1969; Mendelson & Shultz, 1976). One possible extension of the covariation view to deal with this problem of differentiating between covariational relations that are causal or noncausal is to adopt a criterion of *conditional independence* (e.g., Reichenbach, 1956; Salmon, 1980, 1984; Suppes, 1970, 1984). In terms of our model, the adoption of such a criterion means computing contrasts separately for focal sets that are restricted to events in which a psychologically prior covariational factor is (a) present and (b) absent. A full discussion of this problem would go far beyond the scope of the present paper. We note that none of the alternative models proposed to explain the distinction between causes and enabling conditions can solve this problem.

We assume that a factor that does not have a noticeable probabilistic contrast will be considered causally irrelevant, independent of other constraints. That is, we assume that covariation is a necessary criterion. (The "wedding ring" example mentioned earlier, for instance, does not pose a problem for our model; ring-wearing does not covary with the occurrence of explosions, and therefore should be perceived as causally irrelevant for their occurrence.) But, of the factors that have noticeable probabilistic contrasts, we assume that only those that satisfy innate and acquired constraints (which in themselves are by no means sufficient to define causes) will be judged causal. In other words, such constraints circumscribe the set of *plausible* candidate factors. In the rest of this paper, we place no restrictions on factors with no noticeable probabilistic contrast, but confine the factors with noticeable probabilistic contrasts to those that are plausible candidates.

Focal sets

The idea of computation over a set of events implied by the context is adapted from Mackie's (1965, 1974) concept of a causal field and Hart and Honoré's (1959/1985) concept of contextually embedded causal questions. These ideas have been extended by a number of philosophers and psychologists (Einhorn & Hogarth, 1986; Hastie, 1983; Hesslow, 1983, 1988; Hilton, 1990; Kahneman & Miller, 1986; McGill, 1989). The central notion is that a causal question in a given context invariably implies comparisons among a selected set of events, which is often only a subset of all events related to an effect. Mackie (1974, p. 35), for example, pointed out that "What is said to be caused, then, is not just an event, but an event-in-a-certain-field." McGill (1989, p. 189) similarly hypothesized that "individuals structure the to-be-explained event as the difference or deviation between a target episode and a contrasting causal background." As the background changes, so would causal inferences.

Abnormal events

On this view, a question such as "What caused the forest to be on fire?" can be understood as "What made the difference between this occasion in the forest on which there was a fire, and other occasions in the forest on which there was (mostly) no fire?" Note that the expanded question above does not include all the events in one's knowledge base that are related to fires: it does not include events in which oxygen is absent, for example, even though such events (at least in an abstract form) are in a typical educated adult's knowledge base. Now, assume that lightning struck the forest at the place where the fire started immediately before it started. Applying our model to the focal set of events, we see that the proportion of cases for which fire occurs in the presence of lightning is greater than the proportion of cases for which fire occurs in the absence of lightning (i.e., lightning covaries with fire). Lightning is therefore a cause. In contrast, the corresponding difference in proportions cannot be computed for oxygen, because oxygen is present in every event in that set. Oxygen does covary with fire in other focal sets, however; it is therefore an enabling condition. Finally, the presence of stones in the forest, which does not covary with forest fire in any focal set, would be considered causally irrelevant. Thus, covariation computed over a focal set of events can differentiate among causes, enabling conditions, and causally irrelevant factors for an abnormal event such as a forest fire. Notice that the probabilistic-contrast criterion does not require that fire always occurs in the presence of lightning in order for fire to covary with it, a feature that distinguishes our model from earlier explanations of the distinctions between causes and enabling conditions.

Cheng and Novick (1990a, 1990b) drew a distinction between the *data* on which the causal inference process operates and the *process* of inference computation itself. In the present context, one can entirely explain the paradoxical distinction between causes and enabling conditions by a shift in the set of data on which the distinction is based from the set of data on which the logical identity of causes and enabling conditions is based. Although causes and enabling conditions hold the same relationship to the target effect in terms of necessity and sufficiency with respect to the universal set of events in one's knowledge base, they do not do so with respect to the focal set. The distinction between causes and enabling conditions therefore does not contradict the status of these factors in terms of necessity and sufficiency within the focal set.

The computation of covariation over a focal set of events, rather than over the universal set of events that are causally relevant to fires (for example), maximizes the predictive value of the causes so identified for the focal set. If a primary goal of causal explanation is prediction, then the computation of covariation over a focal set is clearly adaptive. Consider some candidate answers to the question on the cause of the forest fire mentioned above in the context of the goal of predicting the next forest fire. The answer "the presence of oxygen" (which would covary with fire if all events in one's knowledge base that are causally relevant to fires are considered) is clearly not predictive of when the next fire will occur in the forest, for the obvious reason that oxygen is always present for all events in the forest (the focal set with which the questioner is concerned). In contrast, the answers "the lightning" or "the unusual dryness of the weather", which are based on the computation of covariation over a pragmatically restricted subset of events, are much more predictive of the next fire in the forest. The computation of covariation over a focal set therefore identifies causal factors that are more *useful* among those that are equally *true*. (The same consideration of the usefulness of deductive inferences led Cheng & Holyoak, 1985, and Cheng, Holyoak, Nisbett, & Oliver, 1986, to hypothesize "pragmatic reasoning schemas" in deductive reasoning.) Causes so identified better predict the effect in the focal set, independent of whether they are informative or relevant to an inquirer.

The relationship between covariation computed over a focal set and Sperber and Wilson's (1986, 1987) criterion of relevance should now be clear. We argued earlier that the relevance criterion applies to the spontaneous mentioning of a factor in reply to a causal question but not to the conception of a factor as a cause or an enabling condition. If we were to apply this criterion to the causal status of a factor, however, this criterion would concur with our model in predicting constantly present factors to be enabling conditions, even when they are unknown to an inquirer (assuming that their presence covaries with the effect in some other focal set). The concurrence follows from the fact that our interpretation of the relevance criterion is based on covariation (or the lack thereof) within the focal set. In contrast to that criterion, however, our model predicts that even when factors that covary with the effect in the focal set are known to the inquirer, and hence would not allow the derivation of new information (i.e., are conversationally irrelevant), they should still be perceived as causes.

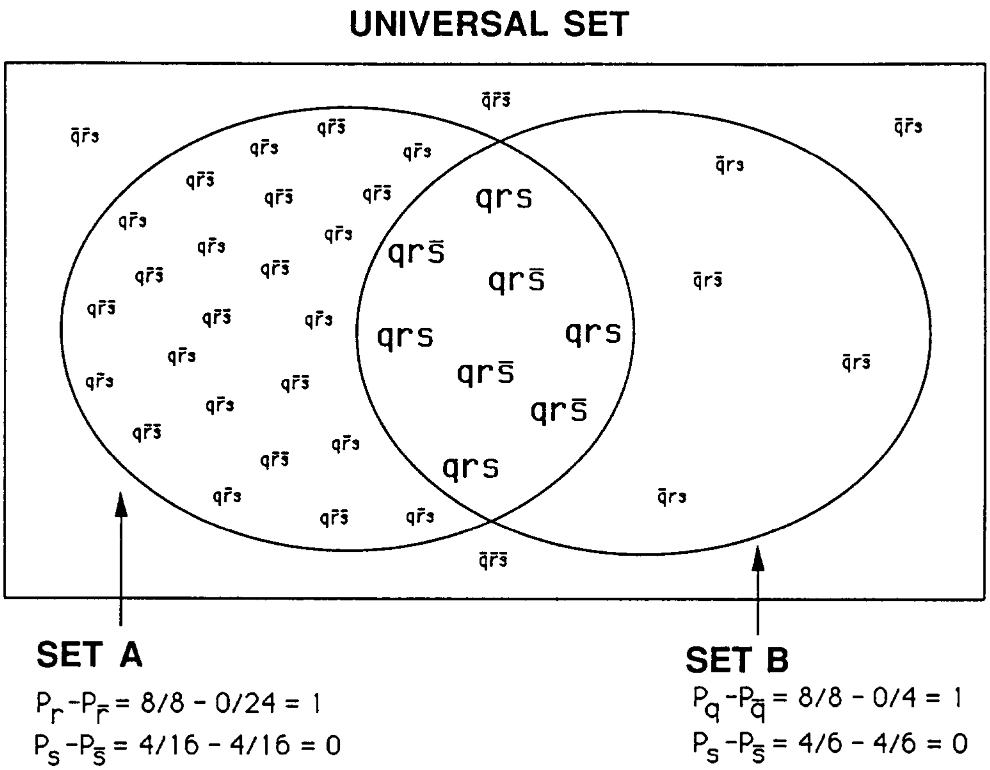
Normal events

Just as covariation computed over a focal set of events serves as a criterion for the distinction between causes and enabling conditions for abnormal events, so it does for normal events. Consider the question "What causes most (i.e., normal) children to grow in height?" In the context of North America, the question can be understood as "What makes the difference between normal North American children who grow in height and abnormal North American children who do not grow in height?" In the focal set of events implied by the question, the factors "having the pituitary hormone" and "having an adequate diet" covary with growth. These factors are therefore perceived as causes, even though they are highly prevalent (hence are defaults) and desirable (i.e., ideal) in the population in question. Being alive, however, is merely a condition that enables growth, because it is constant over the focal set.

An illustration of covariation computed over different focal sets

Our model explains the effect of context on the distinction between causes and enabling conditions by the selection of different focal sets over which covariation is computed, as illustrated in Figure 1. The figure is assumed to represent the entire set of events that are relevant to a particular effect in a hypothetical person's knowledge base. In the figure, each letter (e.g., *q*) represents a *potential*

Figure 1. *Computation of covariation within focal sets according to the probabilistic contrast model as an explanation of the distinction among causes, enabling conditions, and causally irrelevant factors. Each letter represents a* factor. *A bar above a letter denotes the* absence *of that factor. An* event *is represented by a sequence of letters denoting the conjunct of those factors in the event. The* presence of the effect *for an event is represented by placing the event in larger bold type. The* absence of the effect *for an event is represented by regular (non-bold) letters. Finally, loops enclosing events denote* focal sets.



causal factor. A bar above a letter (e.g., $\bar{q}$) denotes the *absence* of that factor. An *event* is represented by a sequence of letters (e.g., $\bar{q}rs$) denoting the conjunct of those factors in the event. The *presence of the effect* for an event is represented by placing the event in larger bold type. The *absence of the effect* for an event is represented by regular (small and non-bold) letters. Finally, loops enclosing events denote subsets of events selected under various contexts. That is, each enclosed subset represents a different focal set.

As can be seen in the figure, with respect to the universal set of events, factors q and r are individually necessary (i.e., $p_{\bar{q}} = p_{\bar{r}} = 0$) and jointly sufficient (i.e., $p_q < 1$, $p_r < 1$, but $p_{qr} = 1$) for the occurrence of the effect. Now consider subsets

A and B. For each of these subsets, one factor covaries with the effect, one factor is constantly present in the set, and one factor varies, but does not covary with the effect. For example, in set A, because $p_r = 1$, and $p_{\bar{r}} = 0$, r should be perceived as a cause of the effect for that subset. (Factor r is sufficient and necessary for the effect within set A. For simplicity of exposition, only deterministic covariations are illustrated in the figure, but the model applies in the same manner to probabilistic covariations.) Factor q, however, remains constantly present in that focal set. A contrast for q therefore cannot be computed (within that set, q is insufficient for the effect and its necessity is undetermined). Factor q therefore should not be selected as a cause. But it is an enabling condition because it does covary with the effect in another focal set, set B. (It would have been causally irrelevant if it did not covary with the effect in any focal set.) Conversely, in set B, q covaries with the effect, as mentioned, whereas r remains constant. Only q, therefore, should be perceived as the cause of the effect for that subset. Varying the relevant focal set thus alters which factor should be considered a cause and which an enabling condition.

Notice that although s is sometimes present and sometimes absent in each subset, its presence or absence does not covary with the effect in either subset. Factor s is therefore causally irrelevant to the effect (at least for the person whose knowledge is represented in the figure). Covariation over specified subsets therefore accounts for the distinctions among causes, enabling conditions, and causally irrelevant factors. Recall that by comparison, the normality view requires a separate preliminary stage to discriminate conditions from causally irrelevant factors.[5]

We have proposed that covariation computed over a focal set serves as the criterion for distinguishing among causes, enabling conditions, and causally irrelevant factors, regardless of the normality of the event to be explained. Figure 1 illustrates this point. In set A, the presence of the effect is abnormal, whereas in set B it is normal. Contrasts regarding the presence of the effect for each set are illustrated in the figure. Contrasts can likewise be calculated regarding the absence of the effect, which of course have the *complementary* status with respect to normality in each set. Recall the growth example discussed earlier: we can just as easily ask what causes most children to grow as what causes a small minority of children not to grow.

Ideas similar to ours have recently been proposed by Hesslow (1983, 1988), McGill (1989) and Hilton (1990). McGill (1989, p. 189) hypothesized that "Distinctive features between the target episode and contrasting background are identified as potential explanations for the event." Similarly, Hilton (1990, p. 67)

[5]It may be argued that like the normality view, our model also requires two processes – the selection of the focal set and the application of the probabilistic contrast model to the focal set. But note that the selection of the focal set serves to account for the effects of context. For the normality view to accomplish the same, it would similarly require the selection of a focal set, in *addition* to the two processes discussed earlier.

specified that "The process of causal explanation proceeds by comparing the features in the target case to those in the background case. Those that are shared between the target case and the contrast case are *presupposed*, whereas the feature or combination of features that 'makes the difference' between the target case and the contrast case is *focussed* and selected as 'the' cause." He proposed that the difference between target and contrast cases is determined by Mill's method of difference.[6] The proposals presented by the above researchers are deterministic. If one is to recast their hypotheses probabilistically, however, it would seem most accurate to formulate them in terms of the probability of a potential causal factor conditional on the presence versus the absence of the *effect*. (The effect is present in the target episode and absent in the contrasting background.) We discuss the implications of the differences among such a formulation, our probabilistic contrast model, and related models of causal induction in philosophy and in cognitive and social psychology in Cheng and Novick (in press).

Empirical tests of five explanations of the cause-versus-enabling-condition distinction

Despite much theoretical discussion of the distinction between causes and enabling conditions, to our knowledge there has not been any empirical test of candidate explanations. We report two experiments testing five candidate explanations. The first experiment tests the two variants of the conversational view (informativeness and relevance) against our probabilistic contrast model. The second experiment tests the two interpretations of the normality view (statistical and idealistic) against our model.

Experiment 1: Conversational criteria versus covariation computed over a focal set

We manipulated the inquirer's state of knowledge for an event produced by a conjunction of multiple conditions. We did so by varying whether the causal question in a scenario was asked by the *mother* of the protagonist or by an intelligent *alien* from another planet who was visiting the protagonist. The protagonist and her mother presumably share a lot of general knowledge, whereas

[6]Hilton regarded this specification as part of his conversational model, emphasizing that contrast cases that are assumed to be novel to the inquirer are likely to be selected. McGill did not specify the relation between her hypothesis and conversational constraints.

the alien was asserted to have little knowledge about the event in question (plant growth).

We have argued for a distinction between the mentioning of a factor in reply to a causal question and its causal status. To separately measure (a) factors mentioned due to an inquirer's assumed lack of knowledge and (b) the conception of that factor as a cause or an enabling condition, we had subjects respond to a causal question in two ways. First, they were asked an open-ended question to which they could respond in whatever way they thought appropriate. Then they were asked to indicate the causal status (cause, mere condition, or neither) of several factors.

As we proposed earlier, the informativeness of a causal factor to an inquirer and its conversational relevance should constrain the mentioning of a factor in reply to a causal question. Both constraints predict that more causal factors will be mentioned in answer to the open-ended question in the alien than in the mother version, because more conditions were presumably unknown to the alien than to the mother. In addition, the conversational relevance view predicts that among conditions that are unknown to the inquirer, those identified as causes according to covariation within a focal set will have higher priority for mention than those identified as enabling conditions.

The predictions regarding causal status made by the conversational views correspond to their predictions regarding the spontaneous mentioning of a factor. These views maintain that spontaneously mentioned conditions (and only those conditions) will be considered causes. Hence, more conditions will be considered causes in the alien than in the mother version. In contrast, we predict that spontaneously mentioned conditions need not correspond to causes. Enabling conditions may be mentioned when they are informative. Conversely, what are believed to be true causes may be omitted in a spontaneous answer when they are not informative. Because causal status is determined by covariation within the focal set rather than by conversational principles, we predict that judgments on causes versus enabling conditions will not change across the alien and mother versions.

Method

Subjects and procedure

The subjects were 76 students at the University of California, Los Angeles (UCLA), who participated in partial fulfillment of requirements for their introductory psychology class. Each subject received a 4-page booklet as a distractor task in a memory experiment conducted on individual subjects. The subjects completed the task in 7–10 minutes.

Materials and design

We created two versions of a problem concerning the growth of plants in gardens. The two versions described the same events, differing only in the identity of the character – either an alien from another planet or the mother of the protagonist – who asked a causal question about a target event (plant growth). Subjects were randomly assigned to one of these two state-of-knowledge conditions by an experimenter who had no knowledge of the conditions.

The first page of the booklet described a brief scenario and asked an open-ended question. For both the "alien" and the "mother" version, the scenario started with the following paragraph:

> Joan moved away from the town where her parents live a few months ago to take a job in southern California. She noticed that in her neighborhood, some people don't seem to particularly care about gardening – they just let their yard go to pot. Actually, Joan has never had the least interest in gardening either, until she moved to southern California, where vegetation is highly varied and many exotic plants grow. She now takes very good care of her yard and is proud of it.

The "alien" version continued:

> A friendly intelligent alien from another planet arrived today for a visit. (He learned to speak English by watching intercepted TV transmissions before his spaceship landed.) Joan was delighted. After a brief introduction, she proceeded to show him around her house and her neighborhood. He was very curious about the many new things he saw. Knowing very little about plants, he asked, "Joan, what causes the plants in your garden to grow so well? I noticed that the plants in some of your neighbors' yards are brown and shrivelled." To show her good will, Joan has been answering his questions as accurately and completely as she can.

In place of the above paragraph, the "mother" version stated:

> Joan's mother arrived today for a visit. This is her first visit since Joan moved away. Joan was delighted. After letting her mother have a brief rest, Joan proceeded to show her around her house and her neighborhood. Surprised to see her beautiful yard, her mother asked, "Joan, what causes the plants in your garden to grow so well? I noticed that the plants in some of your neighbors' yards are brown and shrivelled." Joan has always had a habit of answering her mother's questions as accurately and completely as she can.

At the end of both versions, subjects were asked the open-ended question, "How would you answer this question if you were Joan?"

The second page provided an explanation of causes versus enabling conditions:

> In the next task we'd like to find out what you perceive as a "cause" and what you perceive as "merely a condition". The following example illustrates what we mean by the distinction. Suppose you saw a little girl playing on a lawn in her schoolyard when a little boy ran up from behind her and pushed her. She fell down

> and hurt her knees. If we were to ask you what caused her to fall down and hurt her knees, you're likely to say that the cause was the boy's push. In contrast, you're unlikely to say that the cause was the gravitational pull of the earth or the hardness of the ground, even though without the gravitational pull of the earth or the hardness of the ground the girl would not have fallen down and hurt her knees. In other words, you might say that the gravitational pull of the earth and the hardness of the ground are **conditions** that enabled the girl to fall down and hurt her knees, but the **cause** is the boy's push.

An explanation was necessary to introduce our terminology. We constructed our example to fit all explanations of the distinction between causes and enabling conditions discussed earlier. In the given context, the boy's push – the cause – is abnormal in both its statistical and idealistic senses, informative because it is unknown to the inquirer, and relevant because it allows the prediction of the effect (i.e., it covaries with the effect in the focal set). In contrast, the presence of gravity and the hardness of the ground – enabling conditions – are normal in both of the above senses, uninformative because they are presumably known to the inquirer, and irrelevant because they do not allow the prediction of the effect (i.e., they are constant in the focal set). Because our example is neutral with respect to all theories discussed, results that differentiate among them cannot be due to our instructions, but must be due to subjects' intuitive understanding of the distinction.

The third page probed subjects on the causal status of each of several factors in the scenario. Subjects were asked to recall the situation about Joan showing an alien (or her mother) around her house and her neighborhood, and the causal question was repeated. In the alien version, the question was preceded by the reminder that "the alien knows very little about plants." Then subjects were told, "Suppose Joan's answer includes the following list of factors. Indicate which of them *she would consider a cause, and which merely a condition*." For each factor listed, subjects had to indicate whether it was a cause, a mere condition, or neither. The factors were: (a) "she waters her plants appropriately," (b) "she fertilizes them appropriately," (c) "there is adequate sunlight," (d) "she used seeds from good breeds," and (e) "she has acquired a new interest in gardening." Finally, subjects were asked to write down any factors other than those listed above that they included in their answer to the open-ended question, and to similarly indicate the causal status of each.

On the final page, in order to measure subjects' prior covariational knowledge about plant growth, we administered a questionnaire in which we asked subjects to indicate which of a list of factors are necessary for plant growth: the grower has a "green thumb", appropriate amounts of water, adequate sunlight, appropriate amounts of fertilizer or nutrients in the soil, and seeds from good breeds. Subjects were asked to answer these questions on the basis of their best knowledge of science. They were also asked to list anything else that they thought was necessary.

Predictions. Consider predictions according to the two conversational principles. Notice that whereas none of the factors listed above should be presupposed by the alien to be causally relevant, some of them – water, nutrients, and sunlight, in particular – should be presupposed by the mother to be so. Good seeds may also be assumed to be causally relevant in her view, to the extent that it is considered a necessary factor by the subject. The only factor that is unknown to the mother is Joan's new interest in gardening. The informativeness criterion therefore predicts that, with the exception of a new interest in gardening, all factors should more likely be spontaneously mentioned, and identified as causes, for the alien version than for the mother version. Joan's new interest should be spontaneously mentioned, and considered a cause, in both versions. Relevance, in addition, predicts that among the conditions that are unknown to an inquirer, sunlight (a constantly present factor), should be less likely to be mentioned.

Now consider predictions regarding causal status according to probabilistic contrasts. We proposed that the informativeness and relevance principles should jointly influence the spontaneous mentioning of a factor in reply to a causal question, but not influence its causal status, which should be solely determined by covariation within focal sets. The causal question asked by either the alien or Joan's mother may be interpreted by Joan as, "What makes the difference between the growth of plants in your yard and that in some of your neighbors' yards?" For this implied focal set, watering, fertilizing, good seeds, and gardening interest should be considered causes to the extent that subjects consider them to be necessary for plant growth, because they covary with plant growth. Sunlight, however, is constant across yards, therefore it should be identified as a mere condition. In other words, the probabilistic-contrast view predicts that the two versions should not lead to different conceptions of factors as causes or as mere conditions. For both the alien and the mother versions, sunlight should be a mere condition (despite being unknown to the alien and therefore informative to him), and the other factors – watering, fertilizing, using good seeds, and interest – should be considered causes to the extent that subjects consider them to be necessary factors (despite the first three being known to the mother and therefore neither informative nor relevant to her).

Results and discussion

Our results indicate that the informativeness and relevance principles jointly influenced the spontaneous mentioning of a factor in reply to a causal question, but did not influence causal status, which was determined by covariation within the implied focal set.

Prior knowledge

All subjects considered water, fertilizer/nutrients, and sunlight to be necessary.

Fifty-three per cent considered having seeds from good breeds, and 12% considered having a green thumb, to be necessary.

Spontaneously mentioned factors

For the open-ended question, we tallied all the responses given by subjects. Because many responses were given by only a few subjects, we only report the results for responses given by at least 25% of the subjects for at least one of the two versions of a problem. Six types of responses dominated: (a) watering the plants; (b) sunlight; (c) fertilizing the plants; (d) good care/effort/attention/time on the part of Joan; (e) less care/effort/attention/time on the part of Joan's neighbors; and (f) interest in or enjoyment of gardening.

Subjects who received the alien version of the problem (N = 38) were more likely to mention watering and sunlight than were subjects who received the mother version (N = 38): (a) 66% versus 32%, respectively, for water, $\chi^2(1, N = 76) = 8.90$, $p < .01$; and (b) 26% versus 5%, respectively, for sunlight, $\chi^2(1, N = 76) = 6.33$, $p < .02$. These factors, along with fertilizers or nutrients, are not known by the alien to be causal, but presumably are known by Joan's mother. Fertilizing the plants was mentioned more often by subjects who received the alien version (34% vs. 18%, respectively, for the alien and mother conditions), although the difference was not reliable, $\chi^2(1, N = 76) = 2.44$, $p > .05$. The two groups of subjects did not differ in how often they mentioned either the better care given by Joan compared to her neighbors (74% vs. 66%, respectively), $\chi^2(1, N = 76) = 0.56$, $p > .25$, or the worse care given by Joan's neighbors (29% vs. 42%, respectively), $\chi^2(1, N = 76) = 1.44$, $p > .20$. These factors should not be presupposed by either the alien or the mother. The above results indicate that conditions and supplementary information were mentioned or withheld depending on whether or not the inquirer is assumed to know about them, confirming that our manipulation of the inquirer's state of knowledge was effective and providing evidence for the use of the conversational principle of being informative.

Notice that contrary to the relevance view, sunlight (a constant condition) is still mentioned more to the alien than to the mother. However, even though the alien presumably did not know that sunlight is a causal factor, this factor was spontaneously mentioned by only a minority of subjects who received the alien version (26%), in contrast to other unknown causal factors in the focal set – ones that were not constantly present, such as water (66%) and better care given by Joan (74%), indicating the influence of conversational relevance.[7] This pattern

[7]A replication of this experiment using a scenario in which the protagonist was asked what caused a couch to catch fire by either her mother or an alien (who knew nothing about fire) provides further support for this conclusion. As in Experiment 1, subjects (N = 52) were clearly sensitive to the informativeness of an item of information given the inquirer's state-of-knowledge: half of the subjects who received the alien version spontaneously explained the properties of fire/smoking/cigarettes, whereas none of the subjects who received the mother version did so. Despite sensitivity to such,

of results suggests that informativeness and relevance jointly constrain the spontaneous mentioning of a factor. Interest or enjoyment was mentioned less often by subjects who received the alien version than the mother version (13% vs. 34%, respectively), $\chi^2(1, N = 76) = 4.66$, $p < .02$. Neither of the conversational views predicts this difference, although it provides additional evidence that subjects were sensitive to the state of knowledge of the inquirer. In sum, in response to an open-ended question in a conversational context, subjects were sensitive to the state of knowledge of the inquirer.

Causes versus mere conditions

We turn now to the question of which factors subjects (in their role as Joan) perceived as causes and which as mere conditions. Recall that subjects were asked about Joan's view of the causal status of water, fertilizer, sunlight, good seeds, and Joan's new interest in gardening for the better growth of plants in her garden. Consistent with the probabilistic-contrast view but contrary to both conversational views, water, fertilizer, and good seeds were highly likely to be considered causes by subjects receiving either the alien or the mother version of the problem. Watering the plants was considered a cause by 90% of the subjects who received *either* version, as was fertilizing the plants by 87% of the subjects who received *either* version; using good seeds was considered a cause by 61% of those who received the alien version and by 66% of those who received the mother version, $\chi^2(1, N = 76) = 0.23$, $p > .25$. (The relative magnitudes of the percentages reflected the extent to which each factor was considered necessary for plant growth.) These three factors, which covary with plant growth in the focal set, should be presupposed to be causal by the mother but not by the alien. Further supporting the probabilistic-contrast view, sunlight – despite being a factor for plant growth that was (a) unknown to the alien and (b) considered necessary by all subjects – was identified as a cause by only 18% of the subjects who received the alien version. This percentage did not differ statistically from the 21% for the mother version, $\chi^2(1, N = 76) = 0.08$, $p > .25$. Sunlight was present across all events in the implied focal sets for either version, and accordingly was identified as a mere condition by an average of 80% of the subjects. The probabilistic-contrast and conversational views do not differ on their prediction regarding the conception of Joan's new interest in gardening as a cause. The new interest is presumably unknown to either the alien or Joan's mother. It was designated a cause equally often for the alien and mother conditions (53% vs. 47%, respectively, $\chi^2(1, N = 76) = 0.21$, $p > .25$).

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very few subjects spontaneously mentioned either the combustibility of the couch or the presence of oxygen, even in answer to the alien (fewer than 10% for each factor). The lower frequency of mentioning these conditions (constants in the focal set) compared to that of mentioning a covarying factor – the dropping of the cigarette or contact between the cigarette and the couch (68%) – is consistent with an influence of covariation-based relevance.

The differing patterns of results regarding the spontaneous mentioning of factors in an explanation and the assessment of their causal status indicate that the spontaneous mentioning of a factor is clearly separable from the conception of that factor as a cause or an enabling condition. Moreover, a within-subject analysis across the open-ended question and the cause-versus-mere-condition question shows that of those who spontaneously mentioned sunlight in their explanation, only 33% considered it to be a cause. In contrast, 88% of those who did not spontaneously mention watering or fertilizing as a cause considered these factors to be causes.

It might be argued that the lack of difference in the cause-versus-mere-condition results between the mother and alien versions was a consequence of the "closed" format of the question, which might have encouraged subjects to answer as if they were in a science examination. They therefore might have reported all factors that they knew to be necessary as causes, ignoring their role as Joan (see Hilton, 1990). If so, their answers to the cause-versus-mere-condition question should reflect answers on the prior-knowledge questionnaire. This prediction was not borne out in our results. As mentioned earlier, sunlight, water, and nutrients were considered necessary for plant growth by all subjects. However, whereas water and nutrients (factors that covary with plant growth in the focal set) were identified as a cause by most subjects (90% and 87%, respectively), sunlight (a constant factor in the focal set) was identified as a cause by only a minority (20%) of the subjects. These percentages reflect subjects' sensitivity to covariation within the focal set, suggesting that they did adopt Joan's perspective, and contradict the hypothesis that they were simply stating their scientific knowledge regardless of context.

Summary

Our results show that the informativeness of a causal factor to an inquirer and its conversational relevance are contributing constraints influencing the mentioning of a factor in reply to an open-ended causal question. A factor already known to the inquirer is unlikely to be mentioned, even when it is a cause, because it is neither informative nor relevant. Factors that are unknown to the inquirer (both causes and enabling conditions) are more likely to be mentioned. However, among unknown factors, enabling conditions are less likely to be mentioned than causes, because enabling conditions are less relevant for prediction. Our results also show that although assumptions about the inquirer's state of knowledge affect the amount and kind of information that is mentioned in answer to an open-ended causal question, they do not affect the conception of a factor as a cause or an enabling condition. Factors that covary with the target effect within the focal set are identified as causes, whereas factors that are constant within the focal set (but are known to covary with the effect in some other context) are identified as merely enabling conditions, regardless of their informativeness or relevance to an inquirer.

Experiment 2: Normality versus covariation

According to the normality view, causes are abnormal conditions within a given context, whereas enabling conditions are normal conditions within the context. In contrast, according to the probabilistic contrast model, causes are factors that covary with the effect within a relevant set of events (regardless of the normality of the factors); and enabling conditions are factors that remain constant within the focal set (hence their covariation with the effect cannot be computed for that set), but are known to covary with the effect in some other subset of events (i.e., are causally relevant). Normality per se, according to this view, should have no effect on the perception of causes versus enabling conditions. We report an experiment that tested these two views.

We tested our probabilistic contrast model by manipulating the focal set on which subjects were expected to compute their causal inferences. The focal sets were presented in the form of two scenarios, which differed in the factor that covaried with the effect and the factors that remained constant. In addition to manipulating the focal set, we manipulated normality, in both its statistical and idealistic senses. For each scenario, the covarying factor is prevalent (hence a default) in one version but rare (hence not a default) in another. Furthermore, whereas one of the scenarios described a covarying factor that was desired (i.e., an ideal), the other scenario described a covarying factor that was not desired (i.e., a deviation from an ideal).

Both scenarios concerned plant growth. One was about the growth of a weed, dandelions, in a family yard (an undesired outcome) and the other was about the maturation of corn plants in corn fields (a desired outcome). In each scenario, one factor covaried with the effect. This factor differed across the scenarios (sunlight in the dandelion scenario vs. nutrients in the soil in the corn scenario). The remaining factors were held constant in each scenario: two of these factors were necessary for the effect according to subjects' prior knowledge (water in both scenarios in addition to one of the above two factors) and one of them was not (the presence of a house next to the plants). At the end of each scenario was a causal question about plant growth. Subjects were asked to indicate the causal status (cause, mere condition, causally irrelevant, and inhibitor) of each of the four factors.

Statistical normality was operationalized in the scenarios by specifying the positive value of the covarying factor as occurring in either most or few cases in the given context. For example, in the *prevalent* version of the *ideal* scenario, four out of the five corn fields tended by a farmer had virgin soil (the positive value of the covarying factor) whereas the fifth had its soil depleted of nutrients by previous farming. To ensure that virgin soil was perceived as a default in the given context, the farmer was described in the scenario as a pioneer settling in a valley where few people had reached and farmed. In contrast, in the *rare* version of this scenario, many corn plants matured in only one of the five corn fields. This field had virgin soil whereas the other four fields had depleted soil. To ensure that virgin soil was not perceived as a default, the farm was described in the scenario as inherited through many generations of farmers in a poor country. Because our operational definition of statistical normality satisfies the more stringent interpretation of being a majority, it also satisfies the less stringent one of being a default (Kahneman & Miller, 1986).

Before subjects read the scenarios, they were given the brief explanation of the distinction between causes and mere conditions described in Experiment 1. As mentioned earlier, because the example in the explanation fits the variants of the normality view as well as the probabilistic-contrast view, any results differentiating the two views must be due to subjects' intuitive understanding of the distinction.

To measure the perceived focal sets, subjects were asked to rate how accurately each of three expanded questions that specified different focal sets reflected their interpretation of the causal question in each scenario. To measure the perceived "default" values, subjects were asked to indicate the value of the covarying factor (e.g., rich soil vs. soil depleted of nutrients) that they expected in general in each scenario.

Some recent studies have demonstrated the effects of context on causal explanations (McGill, 1989; Turnbull & Slugoski, 1988; see also Hilton, 1990). We extend previous work by measuring subjects' focal sets and by testing covariation against statistical and idealistic normality.

The probabilistic-contrast view predicts that the two scenarios, which differ in the factor that yields a large probabilistic contrast (sunlight in the dandelion scenario vs. nutrients in the corn scenario) and the factors that are constantly present in the scenario (all variables besides the one with the large contrast), will produce different causes and enabling conditions. Moreover, it predicts that the normality of the covarying factor in the focal set (whether it is prevalent or rare and whether it fits the ideal or deviates from it) will not influence judgments on the causal status of any factor. In particular, it predicts that a factor that covaries with the effect in the focal set, even a statistically or idealistically normal one, will be considered a cause and be distinguished from conditions that are constantly present in the focal set.

In contrast, the statistical normality view predicts that within each scenario (dandelion or corn), only in the rare (non-default) versions should conditions be considered causes; in the prevalent (default) versions, they should be considered enabling conditions, despite large probabilistic contrasts for these factors within the focal set. The idealistic normality view, however, predicts that only conditions that deviate from an ideal (i.e., those in the dandelion scenario but not those in the corn scenario) should be considered causes.

Method

Subjects and procedure

The subjects were 78 UCLA students, who participated in partial fulfillment of requirements for their introductory psychology class. Each subject received a 6-page booklet as a distractor task in a memory experiment conducted on individual subjects. The subjects completed the task in 7–10 minutes.

Materials and design

The first page of the booklet was the explanation of causes versus enabling conditions quoted in Experiment 1. The last page of the booklet was the prior-knowledge questionnaire described in Experiment 1. The rest of the materials pertained to two brief scenarios, at the end of each of which was a question about an event in the scenario.

Subjects received the prevalent version of one scenario and the rare version of the other scenario, with the order of statistical normality and scenarios (i.e., idealistic normality) counterbalanced across subjects. Subjects were randomly assigned to one of the four combinations of the ordering of statistical normality and scenario by an experimenter who had no knowledge of the conditions. There were no order effects in the data; the order manipulation will therefore not be considered further.[8]

Following is the prevalent version of the ideal scenario, in which amount of nutrients covaried with plant growth and the amounts of sunlight and water were constant within the focal set:

> A young pioneer Greg built a cabin in a valley. He recently cleared an area next to his cabin, and planted corn in five fields. Although few other farmers had been in this valley, one of Greg's fields had had most of the nutrients in the soil depleted by several years of planting by a previous farmer. The other four fields were the ones that Greg had just cleared and had never been farmed before. At harvest time, Greg found that there were a lot of mature corn plants in the four new fields. But none of the corn plants in the old field matured. The plants in all five fields received the same amounts of water and sunlight since they were right next to each other. *What caused the corn plants to grow in the four recently cleared fields?*

The rare version of this scenario was identical to the above, with the exception that Greg, instead of being a pioneer settling in a valley with mostly virgin soil, "lives in a valley in a poor country, on a farm inherited through many generations in his family." Furthermore, the ratio of rich-to-depleted soil was reversed: four

[8]In a pilot study involving 72 subjects, for some subjects, information about the covarying factor was presented immediately before the causal question; for other subjects, this information was presented earlier in the scenarios. This manipulation had no effect on subjects' responses and was dropped in the present study.

of Greg's fields had had most of the nutrients in the soil depleted by many years of planting by his predecessors, and the fifth was one that he had just cleared.

Following is the rare version of the *non-ideal* scenario, in which sunlight covaried with plant growth and the amounts of fertilizer and water were constant within the implied focal set:

> A little boy Brad lives with his family in a wooded area. He noticed that there were dandelions covering the small open areas of his family's yard, but that there were no dandelions under the shade of the two large oak trees. He knows that sprinklers are distributed evenly over the yard. One day during a rainstorm he put jars out all over the yard and discovered that the amount of rain reaching the ground was roughly the same under the oak trees and in the open areas of the yard. He also found out that the soil was the same in all parts of the yard and that all parts of the yard had received the same amount of fertilizer. *What caused the dandelions to grow in the small open areas of the yard?*

The prevalent version of this scenario was identical to the above, with the exception that Brad, instead of living in a wooded area, lives in a barren area with few trees. In addition, the open areas of his yard were described as "large" and the oak trees were described as "small".

Questions and predictions. Subjects were asked four questions about the scenarios they received. The first question asked subjects to indicate whether each of four factors was a "cause (not a mere condition)", a "mere condition (not a cause)", or "irrelevant (neither a cause nor a mere condition)" for the growth of the respective plants (corn and dandelions). For the corn scenario, these factors were water, the farmer's house, sunlight, and nutrients in the soil. For the dandelion scenario, these factors were water, fertilizer, sunlight, and the boy's house.[9] The probabilistic contrast model predicts that subjects will be more likely to pick a particular factor as a cause in the scenario in which it covaries with the effect in the implied focal set than in the scenario in which it remains constant. Neither statistical nor idealistic normality should affect subjects' responses. Necessary factors that remain constant should be mere conditions, and unnecessary factors should be causally irrelevant.

The second question asked whether each of four factors "inhibited" the growth of the respective plants in the given context. For the corn scenario, these factors were lack of water, the farmer's house, sunlight, and lack of nutrients in the soil. For the dandelion scenarios, these factors were water, lack of fertilizer, lack of sunlight, and the boy's house. (Notice that two of the three necessary factors in each scenario were made negative by changing from the presence of the factor in the first question to the absence of the factor in the second question.) This

[9]The ordering of the factors in the two scenarios was varied so that the predicted answers for the first two questions according to our model would not be in a constant order across scenarios.

question was included as a further test of the idealistic normality view. Asking about inhibition rather than facilitation reverses the desirability of the conditions. Whereas the presence of nutrients in the corn scenario (leading to the maturation of the plants) was desired, the absence of nutrients in one or more of the fields (leading to the failure of the plants to mature) was not. The idealistic normality view therefore predicts that whereas the desired presence of each necessary factor (e.g., nutrients in the corn scenario) would be an enabling condition, the undesired absence of the same factor in the identical scenario would be an inhibitory cause. Conversely, this view predicts that whereas the undesired presence of each necessary factor (e.g., sunlight in the dandelion scenario) would be a cause, the desired absence of the same factor in that scenario would not be an inhibitory cause. In contrast, the probabilistic-contrast view predicts that the factor that covaries with the effect in the focal set would be judged to be a cause, and the absence of that factor would be judged to be inhibitory, regardless of whether the presence or absence of that factor is desirable within the context.

The third question measured subjects' focal sets. It asked subjects to rate on a 7-point scale three expanded versions of the causal question in terms of how accurately each reflected their interpretation of the causal question ("7" = very accurately, "1" = very inaccurately). Each expansion focussed the causal question on a comparison along a different one of the three relevant dimensions mentioned in the scenario. For example, one of the expansions for the causal question in the sunlight scenario was: "What caused the dandelions to grow where there was ample fertilizer, compared to other places where there was not ample fertilizer (assuming that all places had roughly the same amounts of water and sunlight)?"

The fourth and final question asked subjects to indicate the value of the covarying factor that they expected in general in each scenario. In the corn scenario, the question was, "Do most places in the valley where Greg lived (including his fields) have rich soil or soil depleted of nutrients?" In the dandelion scenario, the question was, "Do most places in the area where Brad lives (including his yard) receive direct sunlight, or are most places in the shade?" This question was to ensure that our manipulation of prevalence was effective and that the prevalent covarying factors did fit the definition of normality in terms of being a default.

Results and discussion

The results for the focal-set question confirm that we successfully manipulated the focal sets. For the expansion that focussed the contrast on the presence and absence of nutrients (or fertilizer), subjects were far more likely to give that expansion the highest rating in the corn than in the dandelion scenario (86% vs. 1%, respectively). For the expansion that focussed on the presence and absence of sunlight, subjects were far more likely to give that expansion the highest rating in the dandelion than in the corn scenario (89% vs. 4%, respectively).

The results for the question on the value of the covarying factor that subjects expected in general in each scenario confirm that our manipulation of prevalence was effective. Most subjects indicated that they expected most places in the valley where the corn farmer lives to have rich soil in the prevalent version (86%); few (7%) did so in the rare version. Similarly, most subjects indicated that they expected most places in the area where the little boy lives to receive direct sunlight in the prevalent version (83%); fewer (19%) did so in the rare version. The positive value of the covarying factor was therefore the expected value in the prevalent versions, not only in the particular area where the causal question was directed (i.e., the particular farm or the yard), but also in the whole area in the scenario in general. It seems that such a value would be considered a default under any reasonable definition of the term. As in the last experiment, all subjects indicated appropriate amounts of water, sunlight, and nutrients to be individually necessary for the growth of plants.

We turn now to the critical question on causes versus mere conditions. The probabilistic contrast model predicts that subjects should be more likely to choose a particular factor as a cause in the scenario in which it covaried with the effect in the implied focal set than in the scenario in which it was constant, regardless of the prevalence or the desirability of the factor. The results were as predicted by this model (see Table 2). Because the model specifies its predictions with respect to the focal set, our analyses below are restricted to subjects for whom our focal set manipulation was effective.[10] An average of 90% of the subjects indicated nutrients to be a cause for the corn scenario, compared to only 7% who did so for the dandelion scenario, $\chi^2(1, N = 69) = 43.8, p < .001$ for the prevalent version of each of the two scenarios, and $\chi^2(1, N = 67) = 48.9, p < .001$ for the rare versions. Conversely, an average of 93% of the subjects indicated sunlight to be a cause for the dandelion scenario, compared to only 12% who did so for the corn scenario, $\chi^2(1, N = 69) = 47.1, p < .001$ for the prevalent version of each of the two scenarios, and $\chi^2(1, N = 67) = 42.0, p < .001$ for the rare versions. The third necessary factor, the presence of water, was constant in both scenarios. As predicted, it was indicated as a mere condition by most subjects (84%) in both scenarios. The fourth factor, the presence of the protagonist's house, was rarely indicated as a cause or a mere condition. They were indicated

[10]Across the four problems, from 11% to 17% of the subjects were excluded because their focal set for a problem (as indicated by their answer to question 3) did not correspond to the one on which we base the predictions for our analyses. These subjects were too few to permit separate statistical analyses. (Among them, 76% rated the three alternative focal sets equally.) Because our manipulation was largely successful, the pattern of results remains unchanged when all subjects were included. As might be expected according to the probabilistic contrast view, when we included subjects who held focal sets different from the ones on which our predictions were based, a smaller percentage of subjects (76% to 89%, reduced from 77% to 95% in Table 2) chose the "cause" and "mere condition" responses predicted on the basis of the predominant focal sets.

as irrelevant by most subjects in both the corn and the dandelion scenarios (96% and 97%, respectively).

As should be evident from a comparison of the results across the prevalent and rare versions of each scenario in Table 2, the prevalence of a factor had no discernible effect on causal judgments for any of the four factors. The comparison was not statistically significant for any of the factors. Our results clearly show that subjects discriminated between prevalent factors that covary within the focal set (these were identified as causes) and prevalent conditions that were constant (these were identified as enabling conditions).

Recall that the idealistic normality view predicts that only conditions that deviate from the ideal should be selected as causes; that is, the presence of sunlight

Table 2. *Percentage of subjects indicating a factor to be a cause or a mere condition in Experiment 2 for prevalent and rare causes in an ideal and a non-ideal context*

(a) Context in which "nutrients" has a large contrast and other factors are constant (corn scenario–ideal)

Statistical normality	*N*	Sunlight		Nutrients		Water		House	
		Cause	Mere condition	Cause	Mere condition	Cause	Mere condition	Cause	Mere condition
Prevalent	32	12	**88**	**91**	9	12	**88**	0	3
Rare	35	11	**77**	**89**	11	11	**77**	0	6

(b) Context in which "sunlight" has a large contrast and other factors are constant (dandelion scenario–non-ideal)

Statistical normality	*N*	Sunlight		Nutrients		Water		House	
		Cause	Mere condition	Cause	Mere condition	Cause	Mere condition	Cause	Mere condition
Prevalent	37	**95**	5	11	**81**	8	**84**	0	5
Rare	32	**91**	9	3	**84**	3	**88**	0	0

Note: Subjects whose ratings in the focal-set question reveal that they did not adopt the focal sets assumed by this analysis are excluded from this table. Numbers in bold type indicate the percentages of subjects who chose the responses predicted by the probabilistic contrast model.

in the dandelion scenario should be the only cause, and the absence of nutrients in the corn scenario should be the only inhibitor. Contradicting these predictions but in support of the probabilistic-contrast view, the positive values of both contextually covarying factors – the presence of nutrients in the corn scenario (a desired state) and the presence of sunlight in the dandelion scenario (an undesired state) – were judged to be causes (90% and 93%, respectively). Similarly, the negative values of both covarying factors – the absence of nutrients in the corn scenario (an undesirable state) and the absence of sunlight in the dandelion scenario (a preferred state) – were judged to be inhibitors (94% and 96%, respectively). (Also as predicted by probabilistic contrasts, no other factor was considered an inhibitor in either scenario; less than 2% of the responses indicated other factors to be inhibitors.)

These results clearly show that factors that covaried with the effect in the set of events implied by the context, regardless of their prevalence or desirability, were perceived as causes (so identified by 92% of the subjects on average). In contrast, factors that remained constant in that focal set, but were nonetheless known to be necessary for the occurrence of the effect, were relegated to the status of mere conditions (so identified by 83% of the subjects on average).

General discussion

The results of our experiments support our probabilistic contrast model over a number of alternative explanations of the distinction between causes and enabling conditions. Let us briefly summarize the basis for this conclusion.

The locus of explanation for causes versus enabling conditions

The normality, conversational, and probabilistic-contrast views localize the explanation for the distinction between causes and enabling conditions at different stages. Both variants of the normality view explain the distinction at the inference stage. They hypothesize that people perceive a distinction between causes and enabling conditions despite their identity in terms of necessity and sufficiency because natural causal induction uses a rule that is not formulated in those terms. In comparison, both variants of the conversational view hypothesize that the distinction is made *after* the process of inference is completed. According to this view, causes and enabling conditions do not differ in the diagnosis that results from causal inference. Rather, they only differ in their informativeness or relevance to an inquirer and hence in their appropriateness in being given in explanation to him or her. Finally, the probabilistic-contrast view traces the distinction to a stage *before* the process of inference begins. It explains the distinction by differences in the patterns of data that correspond to causes and enabling conditions for a focal set. Although causes and enabling conditions hold the same relationship with the target effect in terms of necessity and sufficiency with respect to the universal set of events in one's knowledge base, they do not do so with respect to the focal set. The probabilistic-contrast view therefore resolves the puzzling deviation from characterization in terms of necessity and sufficiency by denying the existence of such a deviation.

Our results clearly support the probabilistic-contrast view. In Experiment 2, we demonstrated the effect of patterns of data in the focal set on the distinction between causes and enabling conditions. We manipulated the patterns of data in the focal set and confirmed the effectiveness of our manipulation by measuring subjects' identification of the contextually implied focal sets. Our results show that factors that covaried with the effect in the focal set were perceived as causes, and necessary factors that were kept constant in the focal set were perceived as enabling conditions.

We made a distinction between the spontaneous mentioning of a condition in answer to a causal question and its conception as a cause or an enabling condition (its causal status). Our results in Experiment 1 support that distinction. As we proposed, the informativeness of a causal factor to an inquirer and its relevance based on covariation with the effect in the focal set (i.e., its causal status) both influence the mentioning of a factor in reply to a causal question. A factor already known to the inquirer is not mentioned, even when it is a cause (i.e., a factor that covaries with the effect within the focal set); but among factors that are not known to an inquirer, an enabling condition (i.e., a condition that is constant within the focal set) is less likely to be mentioned than a cause. Furthermore, the results of this experiment show that although assumptions about the inquirer's state of knowledge influence the spontaneous mentioning of a condition, they do not affect its causal status. When a constant condition is mentioned (because it is not known to an inquirer), it is nonetheless considered an enabling condition. Moreover, factors that covary with the effect in the focal set – even when they are not mentioned (because they are already known to the inquirer) – are perceived as causes. In short, the informativeness and relevance of a causal factor to an inquirer determine the spontaneous mentioning of this factor in a conversation, but do not explain its causal status.

Our results also provide evidence against the variants of the normality view. Experiment 2 clearly shows that factors that covaried with the effect in the set of events implied by the context were perceived as causes, regardless of their prevalence or their status as a default or an ideal. By identifying the focal set, we have shown that the same inferential rules underlie the concept of causality in everyday life, where causes are typically statistically abnormal or deviate from an ideal, and in scientific situations, where causes are often statistically normal and do not deviate from an ideal.

Further alternative explanations

There are other potential explanations of the distinction between causes and enabling conditions besides variants of the three that we have considered. We will consider two other hypotheses here.

Is a cause a generative source?

One further alternative is that causes may be factors (e.g., lightning, a hammer's strike, a boy's push) that imply a generative source or mechanism (e.g., see Shultz, 1982), whereas enabling conditions (e.g., the presence of oxygen, a defect in a watch face, gravity) are not. It is not clear, however, how this explanation accounts for some examples of the distinction we have mentioned. Consider Mackie's example of an explosion in an apartment. The striking of a match does not seem to imply a generative source any less than a gas leak, yet a gas leak is more likely to be considered the cause. Similarly, being born seems to imply a generative source, and yet it is not considered the cause of death.

A major obstacle to finding either clear support or clear refutation for an explanation in terms of generativity is the vagueness of the definition of a generative source. Indeed, Hume's rejection of this classical conception of causality in favor of the covariation view may be regarded as a critique of the vagueness of such a definition. Is gravity, for example, such a source? In any case, it seems to us that however the concept of a generative source is defined, it would still fail to account for the shifts in the perception of causes versus enabling conditions as a function of context. In Experiment 2, for example, sunlight and nutrients imply generative sources in one scenario as much as in the other. Yet each was perceived either as a cause or as an enabling condition, depending on the pattern of covariation in the focal set.

Is a cause more observable?

A second alternative explanation is that causes may be more observable than enabling conditions. However, the effects of context pose the same difficulty for this explanation as they do for the generativity hypothesis. Causal factors (e.g., sunlight and nutrients, sparks and oxygen, hammering and defects) are often just as observable in one context as they are in another. Accordingly, we conclude that neither of these additional potential explanations of the distinction between causes and enabling conditions provides an adequate account of it.

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