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It has been claimed that the power PC theory reconciles regularity and power theories of causal judgment by showing how contingency information is used for inferences about unobservable causal powers. Under the causal powers theory causal relations are understood as generative relations in which a causal power of one thing acts on a liability of another thing under some releasing condition. These 3 causal roles are implicit or explicit in all causal interpretations. The power PC theory therefore fails to reconcile power theories and regularity theories because it has a fundamentally different definition of power and does not accommodate the tripartite causal role distinction. Implications of this distinction are drawn out.

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The power PC theory is a recent and sophisticated development in the long tradition of regularity-based theories and models of causal induction. It addresses causal judgment from contingency information. Contingency information concerns the mere dependence of one thing on another: that is, the extent to which one thing is present or absent when another is present or absent. In relation to causality, contingency information usually concerns candidate causes that may be present or absent and effects that may or may not occur. An objective measure of contingency is provided by the ΔP rule (Jenkins & Ward, 1965; McKenzie, 1994; Ward & Jenkins, 1965), shown in Equation 1:

\[ \Delta P = p(e|c) - p(e|\neg c). \] (1)

In this equation, \( p(e|c) \) is the probability of the effect occurring when the cause is present, and \( p(e|\neg c) \) is the probability of the effect occurring when the cause is absent. Although this is a good measure of contingency, it is not necessarily a valid indicator of causal relations because it fails to distinguish covariations that mark causal relations from those that do not. For example, if there are other possible causes of an effect, then it is uncertain to what extent occurrences of the effect in the presence of the candidate cause were caused by that candidate and to what extent they were caused by the other possible causes. In that case, it is uncertain whether ΔP is a valid indicator of the causal status of the candidate cause.

This problem is addressed in the power PC theory (Cheng, 1997; Novick & Cheng, 2004). In this theory it is assumed that people have the preconceived belief that things have causal powers to produce certain effects. Because powers themselves are unobservable, the task of causal induction is to arrive at an estimate of the strengths of causal powers. To do this, reasoners seek to distinguish the contribution to an effect of the candidate being judged from the contribution of the set of all other candidates. For a single causal candidate this is achieved by computing ΔP for the candidate and then adjusting ΔP in the light of information about the base rate of occurrence of the effect when the candidate is absent. When ΔP is positive Equation 2 applies:

\[ p = \Delta P/1 - p(e|\neg c). \] (2)

In this equation \( p \) stands for the causal power of the candidate being judged. This equation is valid when the causal candidate and the set of other causes of the effect are independent of each other. Novick and Cheng (2004) have extended the theory to cover the case of interactions between two causes. The theory shows how judgments are made about the conjunctive power of two candidates, which is the power of the conjunction of the candidates over and above the power that each has on its own. The extension involves a set of equations, different ones for different circumstances of judgment, but the basic principles are the same.

The aim of this article is to draw some distinctions between the power PC theory and an alternative account of causal understanding, the causal powers theory (White, 1989, 1992, 1993, 1995). A stated aim of the power PC theory was to integrate regularity and power theories of causal judgment (Cheng, 1997). I argue, however, that the theory fails in this aim because (a) the definitions of power in the causal powers theory and the power PC theory are fundamentally different, (b) the power PC theory does not identify the distinct functional causal roles that are central to the causal powers theory, (c) the causal powers theory has implications for the use of contingency information in causal judgment that are supported by experimental evidence but not shared by the power PC theory, and (d) some of the causal roles as well as causal powers in some cases cannot be assessed in the way specified under the power PC theory.
What Is Causal Power?

Regularity Theories and Singularist Theories

The power PC theory and the causal powers theory originate in two different philosophical traditions, regularity theories and singularist theories. Regularity theories have in common the propositions that causality per se is not observable, that it can be inferred only from suitable information about multiple instances, and that causal laws are defined in terms of universal generalizations. This last proposition distinguishes regularity theories from theories in which causation is also analyzed in terms of multiple instances but causal laws are expressed in terms of nomological generalizations, that is, necessity (e.g., Kneale, 1974). In singularist theories causation is analyzed at the level of single events. Analysis at this level tends to focus on the nature of the causal connection. This is often analyzed as a generative or productive connection (e.g., Harré & Madden, 1975; Taylor, 1966), but in some theories a precise set of conditions pertaining to a single occasion is the defining feature (e.g., Ducasse, 1965).

The causal powers theory is the psychological equivalent of a singularist theory, inasmuch as it proposes that the fundamentals of causal understanding constitute a conceptual framework for the interpretation of single occurrences (White, 1989, 1992, 1993, 1995). Under this theory the causal relation is understood as generative, which means simply that causes actually produce or generate effects. Around a generative relation are a set of causal roles that are involved in the production of effects. A simple example, which I have adapted from Cheng (1997), will serve to illustrate the main causal roles. A toddler drops a plate on the floor and the plate breaks. The effect is the plate breaking, and not less than three things are involved in producing it.

One of these three things is the hardness of the floor. This illustrates the concept of a causal power, which is a capacity of a material particular to produce a certain sort of effect: The floor has, we may say, the causal power to produce the effect of the plate breaking. Causal powers are grounded in the physical natures of the entities involved, in this case the composition of the floor.

However floors are hard all the time, whereas the breaking of the plate is a transient event. To explain how an enduring property of a thing can be a cause of a transient event, we must add a concept of a condition under which the causal power of the thing operates. This is called a releasing condition. The releasing condition for the power of the floor to break the plate is the act of dropping the plate. (More specifically, it is contact between plate and floor, with additional specification of the momentum of the plate at contact.) The third causal role is exemplified by the plate and can be called a passive power or liability. The plate has the liability to be broken by the floor. This passive causal power is similarly grounded in the physical nature of the plate and is also necessary for the effect to occur.

The breaking of the plate is therefore understood as a generative relation in which the causal power of the floor produces the effect of the plate breaking by operating on the liability of the plate under the releasing condition of forceful contact between them. At minimum, all three causal roles are assigned in every causal interpretation. Although the floor has the causal power to break a plate, this is not sufficient as an account of the breakage of a plate: The floor would not have this causal power (and would not produce the effect) if the plate did not have the liability to be broken by the floor, and if the plate was not dropped on the floor, the causal power of the floor would not operate to produce the effect. The involvement of all three is readily ascertained from a consideration of counterfactuals. The plate would not have broken if the floor had not been hard; it would not have broken if it had not been fragile; and it would not have broken if it had not been dropped.

Causal analyses can be more elaborate than this by specifying auxiliary causal roles. For example causal powers can be enabled or disabled by surrounding conditions (White, 2000). For example, the heating element of a kettle has the causal power to boil water, but it is only enabled to do so when the kettle is plugged in. Being plugged in is an enabling condition for the causal power of the heating element to operate, and it will actually do so when the kettle is switched on. Not being plugged in disables the heating element. The element has not lost its causal power, but because of surrounding conditions, the power cannot produce its effect.

The generative relation is necessary to this conceptualization in that generation or production is the mode of operation of a causal power. A causal power is defined as a capacity to produce a certain sort of effect, and without a notion of production, there is nothing that would serve to distinguish powers from other properties of things. It is possible to have a psychological theory of causal understanding that includes the generative relation and not the three causal roles, but it is not possible to have a theory that includes the three causal roles but not the generative relation. The meaning of the term power is too intimately tied to producing.

People may not use this terminology; their overt causal analyses may not specify all the roles; and any of the three causal roles may be identified as the cause, depending on factors such as the judge’s practical concerns (White, 1984). Nonetheless, these are the concepts that underpin interpretations of events according to the causal powers theory, and every causal interpretation implicitly or explicitly assigns at least the three main causal roles of causal power, liability, and releasing condition. That proposition is central to the critique of the power PC theory. Before proceeding to that, however, it is necessary to distinguish between causal roles and mechanisms.

Causal Roles and Mechanisms

Ahn, Kalish, Medin, and Gelman (1995) reported evidence that causal judgment cannot be accounted for by the use of covariation information alone because people seek information about causal mechanisms. According to Ahn et al. (1995), “a mechanism is some component of an event which is thought to have causal force or causal necessity” (p. 303). They also claimed that mechanism attributions are content specific and employ a vocabulary of theoretical entities. Ahn and Kalish (2000) stated that the basic assumption of mechanism is that “underlying two causally linked events, there is a system of connected parts that operate or interact to make or force an outcome to occur” (p. 201). This resembles the characterization of mechanism by Thagard (2000) as involving “a system of parts that change as the result of interactions among them that transmit force, motion, and energy” (p. 262). In the example of plate tectonics, the parts in the system are plates, and the interactions that occur include such things as sea-floor spread-
ing and collisions between plates, which transmit forces that lead to subduction, crustal deformation, and other changes to continental material. Although an explanation of the mechanisms can move reductionistically to the fundamental laws of physics, it more conventionally, and usefully, remains at the level described, which involves reference to domain-specific processes.

Mechanism beliefs, then, are sophisticated domain-specific constructions, usually complex in the sense that they involve relations between individual causal relations. The search for mechanism is not a truly inductive activity but rather is the cue-guided application of preexisting content-rich beliefs. Findings that people seek mechanism information more than covariation information (Ahn et al., 1995) therefore do not disconfirm the hypothesis that regularity-based causal induction is the fundamental and primary means of acquiring causal beliefs: They show only that people treat most causal judgments as problems in the application of existing beliefs rather than as causal induction problems.

Domain specificity differentiates mechanism beliefs from causal role concepts. Causal role concepts such as powers and releasing conditions, and in particular the generative relations conceptualization of the causal connection, are domain general. In other words, they are the building blocks from which mechanism beliefs are constructed: Mechanism beliefs are complex causal role constructions relating objects and processes in the particular domain under consideration. Every causal judgment or interpretation involves implicit or explicit causal role assignment.

Furthermore, the assignment of causal roles is governed by domain-general principles. The thing in which the effect of interest occurs must be assigned the role of liability: That much is inherent in the definition of a liability. The phrase of interest indicates that judges are not necessarily interested in all aspects of an event (White, 1984, 1992). When a plate is dropped on the floor, the plate might break and the floor might be damaged. If the breakage of the plate is of interest, then the role of liability is by definition assigned to the plate. If the damage to the floor is of interest, then the role of liability is by definition assigned to the floor. Causal powers and releasing conditions are distinguished by the fact that the former role is assigned to a thing, an enduring material particular, and the latter role is assigned to a transient event. This distinction is also a matter of definition and therefore also domain general. In many cases it is the identity of the thing with the causal power that produced the effect that is uncertain: Assignment of causal power is in these cases a hypothesis that can then be tested by gathering relevant evidence.

The Concept of Power in the Causal Powers Theory and the Power PC Theory

Cheng (1997) claimed that the power PC theory reconciled the regularity and power analyses of causation by showing how observable features, suitably defined regularities, could be used to make inferences about unobservable theoretical entities, powers. The key equation in the power PC theory assesses the causal power of a causal candidate by integrating different kinds of empirical information. The claim is not correct, however, because the term power is defined in a way that is at odds with a singularist analysis. In the power PC theory, causal powers are defined as probabilities with which causes influence the occurrence of an effect (Novick & Cheng, 2004). This is fundamentally different from the definition of power in the causal powers theory.

In the causal powers theory the definition of causal power makes no reference to probabilities of effects occurring. It corresponds roughly to a notion of specific capability. Power refers to the specific kind of thing that a material particular can bring about, not to the likelihood with which it does so. The operation of a causal power is not a matter of probability or frequency, it is a matter of conditionality. In fact a power might never be exercised at all: A floor might never smash a plate (obviously, if a plate never comes into contact with it), but it still has the causal power to do so. This exemplifies a general understanding that powers are inherent in the natures of things. People can ascribe a causal power to a thing on the basis of knowledge of its nature even if they have no evidence for the operation of the power in question: We can, for example, judge that a particular floor has the power to smash plates even if we have never seen anything break on contact with it. In fact such ascriptions are essential because otherwise we would not know how to deal with unfamiliar objects.

A causal power operates to produce an effect when a suitable releasing condition obtains (and assuming whatever enabling conditions are required), and then it operates as a matter of necessity. The power PC theory does not address this kind of issue. Instead, the issue addressed is, roughly speaking, how many of a set of events can be attributed to one causal candidate rather than another. For example, how many among a set of birth defects can be attributed to alcohol consumed during pregnancy. Some term such as relative magnitude might be more appropriate than power. Here I shall use the term causal probability to denote what is computed by the key equation in the power PC theory, and I reserve the term causal power to denote the causally relevant property that is grounded in the physical nature of a thing in the causal powers theory.

Whether the power PC theory may be properly called a power theory is perhaps debatable. However it does not succeed in reconciling or integrating power and regularity accounts because it defines power in a way that does not fit with the definition of power in the causal powers theory.

1 People can ascertain causal powers, to some degree, not only by observing the effects that things produce but by acquiring knowledge of the properties that invest a thing with a causal power, often through perceptual experience. Thus, people may say that a floor has the causal power to break a plate because it is hard, not because they have seen it break a plate, and they know it to be hard because they have walked on it.

2 This is not to claim that people have a concept of necessity. I do think it probable that people understand that there is a difference between the mode of operation of human action in which it is, in some sense, up to the actor what they do and that of physical causality in which it is not in any sense up to a cause whether it operates. People may therefore operate with a kind of causal understanding that functions in a way equivalent to having a concept of necessity. It should also be noted that the fundamentals of causal understanding are probably implicit and cannot be articulated by laypeople: They exist in what Fletcher (1984) called common sense as a set of shared universal assumptions, as opposed to common sense as a set of cultural maxims and shared beliefs, which tend to be explicit and verbalizable.
Differences Between the Causal Powers Theory and the Power PC Theory and Implications for the Use of Contingency Information in Causal Judgment

The Generative Relation

In regularity theories, causality is defined in terms of conditions extrinsic to the causal relation. The causal relation itself is not analyzed at all. People make inferences about causality on the basis of available information concerning the extrinsic defining conditions. This position is grounded in the assertion that causal relations per se are unknowable or unperceivable (Cheng, 1997; Ross & Fletcher, 1985; Young, 1995). For example, Cheng (1997) asserted that “causal relations are neither directly observable nor deducible” (p. 397). In the causal powers theory, the causal relation is understood as a generative relation in which a cause actually produces or generates an effect. This idea of the generative relation gives meaning to all causal inferences, perceptions, and judgments: It is, more fundamentally than anything else, what distinguishes all causal relations from all other kinds of thing.

This yields an important means of differentiating these theoretical approaches. If the causal relation is understood as generative and information about a generative relation is available, then under the causal powers theory, causal inference should be guided by that information, even when it conflicts with regularity information. In a series of experiments Shultz (1982) and Shultz, Fisher, Pratt, and Rulf (1986) attempted to test this.

The participants were mostly young children, as young as 2 years in some experiments. The experimental strategy involved setting up a contest between generative transmission information and other cues to causality, including covariation. In one study, for example, participants had to judge which of two lamps caused a spot of light to appear on a wall. The procedure involved a series of stages separated by the introduction of a screen blocking the participant’s view of the lamps. In Stage 1 the participant saw a red-cased lamp pointing at a spot of light on the wall. In Stage 2 the participant saw a blue-cased lamp pointing at the wall but no spot of light. In Stage 3 both lamps were pointing at a spot of light on the wall. At this stage the participant was asked a series of questions about the cause of the spot of light. Most participants identified the red-cased lamp as the cause of the spot of light, in conformity with the cue of covariation. Then the experimenter turned the lamps around and the participants saw that the blue-cased lamp was on and the red-cased lamp was off. Then they were asked the same set of questions. This time most participants identified the blue-cased lamp as the source of the light, in conformity with generative transmission information. This result indicates that the generative transmission information, when it became available, overrode the covariation information that had previously been presented.

Cheng (1993) pointed out that, in fact, there is a covariation between a lamp being switched on or off and the appearance or disappearance of a spot of light. Thus, by assuming just a little domain-specific knowledge, the experiment can be construed as a contest, not between covariation and generative transmission but between two kinds of covariation. One of these, involving the mere presence of a lamp, is weaker than the other, involving the lamp being switched on or off; thus, the results show only that children understand which is the more reliable kind of covariation. This argument carries some force. Causes and effects do tend to covary, so covariation and generative transmission information can never be properly separated in an experimental test of this kind. Despite this, there remain three reasons for thinking that the generative transmission hypothesis provides the more compelling interpretation of Shultz’s (1982) findings.

One reason concerns verbal justifications. In each of his experiments, Shultz (1982) asked his participants to justify their choice (e.g., “Why do you think it was the red one?” p. 9). Participants consistently justified their choices by referring to generative transmission. Justifications in terms of covariation were rare.

Cheng’s (1993) argument against the generative transmission interpretation of the lamp experiment (Shultz, 1982, Experiment 2) depends on the previous acquisition of domain-specific knowledge about lamps and light. The argument therefore fails if it can be shown that people who lack the relevant domain-specific knowledge also make inferences on the basis of generative transmission cues and verbally justify their inferences by reference to generative transmission. Shultz (1982, Experiment 4) provided this kind of evidence by repeating the experiment with a sample of children from a rural area of Mali who had had no prior contact with the kinds of artifacts used in the study and obtaining similar results.

The third reason is that if generative transmission cues are available, then an appropriate causal inference can be made on the basis of a single instance with a novel kind of event. It could be argued that the results of Shultz (1982, Experiment 4) show this because the participants had no prior experience with the testing apparatus or with any kind of technology that might provide an appropriate basis for generalization. The claim is not that this is some kind of pure causal induction but merely that the availability of generative transmission information is sufficient for appropriate causal inference about a single instance in the absence of relevant prior experience. The importance of this is that causal inference from a single instance is usually assumed to be impossible under regularity theories because regularity can be assessed only across multiple instances.

Cheng (1993) argued against this on the grounds that covariation can in fact be assessed in a single instance. A single temporally extended instance can be divided into “time-slices.” It can be shown that the cause and the effect co-occur within a single time-slice, which means that they co-occur within the time scale of the instance. The problem with this argument is that it amounts to saying that temporal contingency of cause and effect is necessary and sufficient for causal inference in a single instance: A thing is deemed to be a cause if and only if it is temporally contiguous with the effect. In fact temporal contingency is not sufficient for causal inference in a single instance: Michotte (1963) reported several experiments in which observers did not infer causal relations between temporally contiguous events. Several studies have also shown that temporal contingency is not necessary for causal inference (Mendelson & Shultz, 1976; Siegler, 1975; Siegler & Liebert, 1974), although it is not clear whether this depends on the use of domain-specific knowledge.

In summary, therefore, the available evidence favors the hypothesis that people preferentially make causal inferences on the basis of generative transmission information when it is available. This is consistent with the claim made under the causal powers theory that the causal relation is understood as generative.
Power Alone Is Not Sufficient

In the power PC theory it is assumed that "the reasoner believes that there are such things in the world as causes that have the power to produce an effect and causes that have the power to prevent an effect and that only such things influence the occurrence of an effect" (Cheng, 1997, p. 372). If this is meant to refer to causal powers in the sense of the term in the causal powers theory, then it is incorrect. Referring to a causal power alone cannot be sufficient as an account of how an effect was made to happen. The problem, a familiar one in philosophy (Harré & Madden, 1975), is that a causal power is a stable property of a thing, and a stable property of a thing cannot be a sufficient cause of an effect that is discrete and bounded in time because the property is present on many occasions on which the effect fails to occur. This is precisely the reason for which the concept of a releasing condition is required in the causal powers theory. In the plate example, the floor has the causal power to break plates all the time, but it only breaks a plate at this particular moment. The releasing condition, the act of dropping the plate, extends the causal analysis by explaining why the floor breaks the plate at this moment and no other.

It is not likely that laypeople have much appreciation of the philosophical dimensions of this issue. Despite that, it is clear that people do appreciate the requirement of a releasing condition for a causal power to operate. Everybody knows that a floor cannot break a plate if the plate is not dropped on it, that one billiard ball cannot make another one move if the two do not come into contact, and that a drug cannot make a person ill if it is not administered to them. I am not, for present purposes, concerned with how such knowledge originates; I am concerned only with the fact that we have it; and the fact that we do have it is sufficient to demonstrate that an account of causal judgment in terms of powers alone is at best incomplete. The plate example illustrates the involvement of three definable causal roles in the production of an effect: powers, liabilities, and releasing conditions. Any causal analysis that identifies just one thing as the cause must therefore be incomplete. Of course, even if people understand the importance of all three roles and their different functions in causality, many causal analyses in everyday life are incomplete, so it could be that the power PC theory is an accurate description of how these incomplete causal analyses are done. It could also be argued that the power PC theory is in principle capable of identifying all three things—power, releasing condition, and liability—as causes. In fact identifying each one as an independent cause would not be correct because the occurrence of the effect is due to all three being together, and the absence of any one would be sufficient for the effect not to occur. But the extension of the power PC theory to the case of conjunctive causal power (Novick & Cheng, 2004) shows in principle how this problem could be surmounted. The extension deals only with interactions between two candidate causes, but there is no obvious barrier to extending the theory further to accommodate interactions between three factors.

However the most the power PC theory could provide would be an estimate of the conjunctive causal probability of the interaction between the three things—power, liability, and releasing condition—in other words an estimate of the probability with which the interaction between these three things produces the effect. The real problem with this is not so much that it is wrong, but that it misses the point. Under the power PC theory it may be possible to conclude that the plate broke because of an interaction between plate, floor, and the act of dropping the plate, but the theory fails to recognize the specific causal roles occupied by these things, that is, the role each of them plays in bringing about the effect. Roles are not specified by empirical regularities. They can be specified only by analysis of the instance in question. What it means to be a causal power is different from what it means to be a releasing condition, but such differences in meaning cannot be captured by a theory that identifies nothing other than empirical regularities.

The power PC theory is therefore inadequate not so much because it models incomplete causal analyses but because it abjures any inquiry into the nature of the interactions that take place between things. Under the causal powers theory, causal analysis is primarily an inquiry into the different functions that different things have in relation to the production of effects. That is what is accomplished by assigning causal roles to the three components and by analyzing the causal relation as generative. The model of causality that results is not an assessment of the causal probability of the conjunction of two or three things: It is a construction of a causal interpretation for a single event in which each of the three components has a defined functional role. No regularity-based model, no matter how sophisticated, can provide that sort of construction. The truth about causality lies in causal role constructions, not in regularities.

It could be argued that such things merely lie outside the scope of the power PC theory: that the theory correctly describes the way to answer a certain kind of question about causality, to do with the extent to which one causal candidate (or the conjunction of two) is responsible for a set of effects as distinct from other possible causes of those effects, and that it should not be held to account for something that it does not purport to address. Moreover, it could be argued that the power PC theory is descriptive because people do not recognize causal roles and that their causal analyses are in fact analyses of the kind modeled in the power PC theory and not an inquiry into causal role assignments. However this would be to misjudge the import of the arguments about causal roles. Causal role assignments make a difference to the way contingency information is used to make causal judgments. White (2000) investigated the use of contingency information to make judgments about complex causal interpretations that specified both a cause and an enabling condition (called an enabler). A medical scenario was used in which the outcome was the occurrence or nonoccurrence of an allergic reaction in a patient and there were two possible causes, fictitious food additives. A series of judgment problems each concerned a different patient. Stimulus information was presented as a list of instances. In each instance each food additive might be present or absent and the allergic reaction might or might not occur. Participants scanned this information prior to making causal judgments.

One of the possible causes was a common factor, present in all the instances in any given problem. The other was a covariate, present in some instances, absent in others, and possessing some degree of covariation with the effect. The findings of an initial experiment supported the hypothesis that people prefer causal interpretations that fill more causal roles: A complex interpretation identifying the common factor as the cause and the covariate as an
enabler was consistently rated higher than a simple interpretation that just identified the covariate as the cause.

The key finding, however, came from a subsequent experiment. In this the complexity of interpretations was matched: Participants were asked to judge one interpretation in which the common factor was the cause and the covariate was an enabler and another in which the covariate was the cause and the common factor was the enabler. The critical problem was one in which the covariate was perfectly associated with the effect: Every time the covariate was present the effect occurred, and every time the covariate was absent the effect did not occur. There was a strong tendency to give higher ratings to the interpretation identifying the common factor as the cause. This result demonstrates that assigning causal roles to different factors transforms the way in which contingency information is used for causal inference.

The power PC theory fails to explain these results. \( \Delta P = 0 \) for the common factor, and \( \Delta P = +1 \) for the covariate. The two factors are independent, which is an assumption required by the equations of the power PC theory, because the probability of the common factor being present is the same when the covariate is present as when it is absent. The theory therefore predicts that the covariate and not the common factor should be identified as the cause. There could instead be an interaction between the two factors; in which case, the model proposed by Novick and Cheng (2004) would apply. This model also fails, however. It does not assign causal roles: It simply enables us to estimate the conjunctive causal power of the two factors. More specifically, the two interpretations offered for participants to judge in the second and third experiments were equal in complexity: Both specified a kind of interaction between the two factors, simply reversing the causal role assignments. For this reason the conjunctive causal power model is unable to predict that one of them will be preferred to the other or any difference between them. Thus, the power PC theory cannot explain how the use of contingency information varies depending on causal role assignments because it does not recognize the causal roles and because its procedure for generating a causal judgment is the same, regardless of which factor is identified as the cause.

The results of these experiments indicate not only that people do make and understand causal role assignments but also that they prefer interpretations that are more nearly complete in their explicit causal role assignments and that the way in which they use contingency information depends on the particular causal role assignments that are made. Furthermore the way in which they use contingency information is contrary to the predictions of any regularity-based model because, with complex causal role assignments, people assign the role of cause to the common factor, not to the covariate.

Using Contingency Information to Judge Powers, Releasing Conditions, and Liabilities

In principle the power PC theory could describe how causal powers, releasing conditions, or liabilities are judged from contingency information, if we ignore the problems that arise from its failure to recognize the differentiation of causal roles. However there is a problem in practice for this because conventional contingency information cannot be used to make judgments about either releasing conditions or liabilities. Contingency information concerns instances in which the cause being judged is either present or absent. This is the kind of information with which the power PC theory is concerned. This kind of information, however, is not appropriate to the judgment of releasing conditions and liabilities. Some examples will illustrate the point.

Suppose we have a drug that might produce a certain side effect in patients and we want to ascertain whether this side effect is caused by the means of administration. There are various means of administration: The drug could be ingested as a pill, or it could be injected. These are releasing conditions. But how do we assess them using contingency information? We cannot plausibly compare ingesting a pill with not administering the drug at all: That would be a way of testing the causal power of the drug, not of testing whether ingestion is a releasing condition. If any comparison is to be made, it must be between different forms of administration. In other words, we assess a releasing condition not by comparing its presence with its absence but by comparing its presence with the known presence of some other releasing condition.

With liabilities an equivalent stricture pertains. It is not possible to assess the strength of a liability by comparing instances in which the thing with the liability is present to instances in which it is absent. In the plate and floor example, it makes no sense to assess the fragility of a certain kind of plate by comparing what happens when it is dropped on a floor with what happens when it is not dropped on a floor. Obviously it will not break when it is not dropped, so that tells us nothing.

In many cases the same structure applies to causal powers. In the plate and floor example it makes no sense to assess the hardness of a floor by comparing what happens when a plate is dropped on it with what happens when nothing is dropped on it. Equally, if I want to assess how good my new badminton racquet is, it is not sensible to compare what happens when I use it with what happens when I do not use it. It is not easy to assess how widespread this problem is without compiling a list of causal powers that can and cannot be judged from the conventional kind of contingency information. But it is not difficult to think of examples that have the same structure as the floor and badminton examples.

In summary, releasing conditions, liabilities, and some causal powers cannot be judged with the conventional form of contingency information, and it appears that such judgments must be made either by comparison with alternative occupants of the same causal role or by no comparison at all. Explaining causal judgment in such cases is an important task for research. However these cases appear to lie outside the scope of the power PC theory in its present form. Causal powers can (sometimes) be judged according to the prescriptions of the power PC theory, but releasing conditions and liabilities cannot.

Using Contingency Information to Judge the Strengths of Causal Powers

The power PC theory and the causal powers theory define causal power in different ways. These different definitions imply different accounts of what contingency information is used to judge. Under the power PC theory contingency information is used to assess the probability with which a cause produces its effect, and the theory specifies how contingency information is used for that purpose. In a sense, this is a notion of the strength of a statistical relationship.
Under the causal powers theory contingency information can be used to assess the strength of a causal power or a liability, but the strength of a power is not the same as the strength of a statistical relationship. This is shown most clearly by the fact that strength can be assessed with features of contingency information that are independent of contingency.

A series of studies by Johnson and colleagues (Johnson, 1989, 2001; Johnson, Boyd, & Magnani, 1994) used various scenarios in which an effect occurred only when both of two antecedent mental states were present. For example, in one scenario a series of verbal statements described a fictitious worker who tended to make mistakes at work only when she experienced both workload-related stress and feelings of annoyance with coworkers. One mental state was frequently experienced and the other only rarely. In this situation the contingency between cause and effect must be greater for the rare antecedent than for the common one because there are bound to be fewer nonoccurrences of the effect in the presence of the rare cause than in the presence of the common cause.

Johnson (1989) and Johnson et al. (1994) asked their participants to rate the extent to which the effect was caused by each of the two causes. They found that if the effect was described as frequent, the more prevalent cause, that is, the one that covaried less with the effect, received significantly higher causal judgments. This result appears to contradict the predictions of any regularity-based model, including the power PC theory, because no such model would predict that a weaker covariate would be given a higher causal judgment than a stronger covariate.

Johnson and colleagues (1994) interpreted their results as supporting the hypothesis that people judge strength as defined under the causal powers theory and that both contingency and prevalence information may be used for this purpose. Two further pieces of evidence supported this interpretation. Johnson et al. (1994) asked their participants to rate the strengths of the two causes and found that the more prevalent antecedent was rated as stronger than the less prevalent but more covarying antecedent. This supports the argument that the prevalence of a cause is interpreted as indicating its causal strength. Johnson, Long, and Robinson (2001) found evidence that the inference of strength mediates between the prevalence information and the causal judgment: That is, strength is inferred from prevalence information and causal judgments are then based on inferred strength.

The causal powers theory allows for more than one kind of strength to be assessed. Imagine a wind blowing leaves from a tree. A stronger wind will blow more leaves from the tree, and so the number (or proportion) of leaves blown is a measure of the strength of the wind’s causal power. Imagine now that somebody is shaking the trunk of the tree. This also dislodges some leaves. It is then possible to ask which of the two powers, of the wind and of the person, is the stronger. This could be assessed in a different way, by comparing the number of leaves dislodged when the wind is blowing and the person is absent with the number dislodged when the person is shaking the tree and the wind is not blowing.

This kind of comparison is not predicted to occur under the power PC theory because it neglects leaves that are not dislodged, in other words nonoccurrences of the effect: It is a comparison between occurrences of the effect in the presence of either cause. But there is evidence that people do make this kind of comparative causal judgment. White (2004) found that judgments of one cause (A) are influenced by manipulating the prevalence of another cause (B) in the absence of A: The greater the prevalence of B in the absence of A, the lower causal judgments of A tended to be. This manipulation was independent of the contingency for B. White (2004) also showed that this effect was due specifically to manipulation of the number of occurrences of the effect in the presence of B alone: Manipulation of the number of nonoccurrences of the effect in the presence of B alone had no significant effect on judgments of A. This result supports the hypothesis that people judge this kind of comparative strength when there are two possible causes: Judgment of A dropped when the prevalence of B was greater because A then accounted for a smaller proportion of the occurrences of the effect.

In summary, then, there are two lines of evidence that people judge the strengths of causal powers and that this kind of judgment cannot be reduced to a mere judgment of the strength of a statistical relation: the prevalence effect found by Johnson and colleagues (Johnson, 1989, 2001; Johnson et al., 1994, 2001) and the comparative judgment effect found by White (2004).

Conclusion

The elegant mathematical formalizations of the power PC theory are an obviously attractive feature of a model of causal judgment, not least because, in principle, they specify precisely the conditions that would falsify the model. The causal powers theory lacks the precision of a mathematical formulation, and it is correspondingly more difficult to state what kind of evidence would falsify the theory. Although, it is not impossible. The theory would be falsified, for example, by compelling evidence that people do not understand the causal relation as generative. Without this, the concept of causal power loses its meaning, and any tripartite division of causal roles would have to be conceptualized in a different way. Moreover, although it appears straightforward to say what sort of evidence would falsify the power PC theory, in practice advocates of the theory can discount apparently disconfirming evidence in a variety of ways, such as by saying that the evidence lies outside the scope of the theory or that the dependent measure is inappropriately worded. There is more to falsification than mere precision in the theoretical propositions.

Even if the causal powers theory is wrong in its specifics, it is not easy to avoid a tripartite division among hypothesized distinctions among causal powers, liabilities, and releasing conditions. Under different circumstances people may be concerned to make a judgment about any of these in relation to some effect. Questions and judgments about causal powers are commonplace: We assess the power of a virus to cause an illness, the power of a fertilizer to produce more tomatoes, or the power of a substance in food to cause allergic reactions. Questions and judgments about liabilities are also commonly of interest: We assess whether someone is lactose intolerant—so that they suffer digestive problems when they eat or drink dairy products—whether one kind of tomato is more susceptible to a particular fungal infection than another, or whether a car is prone to skid when the brakes are applied. Questions and judgments about releasing conditions are also not unusual: We may want to know whether a medicine has to be taken orally or by injection, whether (as someone happened to ask me recently) rabies can be transmit-
ted by a cat scratch, or whether a fungicide should be sprayed on the leaves of a plant or watered into the ground.

It is hard if not impossible to think of any individual causal relation that cannot be analyzed in terms of this tripartite division. This is the nub of the problem for theories such as the power PC theory. We may often be interested in judging only one of the three roles, and it may seem on the basis of this that there is only one cause of an occurrence. But our causal interpretations implicitly or explicitly fill all three roles. There is no point in asking how the fungicide should be administered if we do not have an idea of its power (to kill fungal infections) or of the liability of the thing to which it is applied. We cannot fully understand lactose intolerance without understanding it as a liability evoked by a thing with a power (a dairy product) under a specific releasing condition (eating or drinking). Wherever our attention is focused in causal judgment, it is always in the context of a causal interpretation in which all three causal roles are assigned, at least as hypotheses for consideration. A comprehensive and valid model of causal judgment must take this into account.

The power PC theory, and its extension to conjunctive causal probability, could be the best way to answer a particular kind of question about causality, to do with the extent to which a given causal candidate or conjunction of candidates accounts for occurrences of an effect over and above what should be attributed to other causes. But the inadequacies of the theory are mainly in its failure to analyze the nature of individual causal connections. Causality is understood in terms of a model of the causal connection as a generative relation and the construction of causal role interpretations around generative relations, and analyzing an occurrence of an effect involves constructing complex causal role assignments, in a way that an assessment of causal probabilities of causal candidates does not accomplish.

References


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