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Research article

Selecting explanations from causal chains: Do statistical principles explain preferences for voluntary causes?

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Abstract

We investigate whether people prefer voluntary causes to physical causes in unfolding causal chains and whether statistical (covariation, sufficiency) principles can predict how people select explanations. Experiment 1 shows that while people tend to prefer a proximal (more recent) cause in chains of unfolding physical events, causality is traced through the proximal cause to an underlying distal (less recent) cause when that cause is a human action. Experiment 2 shows that causal preference is more strongly correlated with judgements of sufficiency and conditionalised sufficiency than with covariation or conditionalised covariation. In addition, sufficiency judgements are partial mediators of the effect of type of distal cause (voluntary or physical) on causal preference. The preference for voluntary causes to physical causes corroborates findings from social psychology, cognitive neuroscience and jurisprudence that emphasise the primacy of intentions in causal attribution processes. Copyright © 2009 John Wiley & Sons, Ltd.

Causal reasoning about goals and plans plays a central role in constructing representations in memory for narratives (Graesser, Robertson, & Anderson, 1981; Trabasso & Sperry, 1985; Trabasso & van den Broek, 1985). These mental representations often take the form of causal chains that describe how an outcome follows from a sequence of events (cf. Halpern & Pearl, 2005a; 2005b; Pearl, 2000; Sloman & Lagnado, 2005; Wilensky, 1981). Attribution research has been criticised for restricting its scope to simple causal structures (Kelley, 1983) and we seek below to build on studies of how explanations are selected from causal chains (e.g. Alicke, 1991; Brewer, 1977; Brickman, Ryan, & Wortman, 1975; Fincham & Jaspars, 1980; Fincham & Shultz, 1981; Johnson, Ogawa, Delforge, & Early, 1989; Lagnado & Channon, 2008; Mandel, 2003; McClure, Hilton, & Sutton, 2007; Spellman, 1997; Vinokur & Ajzen, 1982).

Causal chains typically involve complex sequences of events, all of which are necessary for the outcome, and can be said to be part of the larger causal story of how the outcome came about. Yet in ordinary conversation, we typically refer to one or at most two events as 'the' cause (Hesslow, 1988). How do we then select some events from the causal chain as 'causes', relegating others to the status of 'mere' conditions (Mackie, 1980)? Below, we investigate the claims of legal theorists Hart and Honoré (1985) concerning the selection of causes from conditions. They write that 'two contrasts are of prime importance... 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). While the utility of the notion of an abnormal condition for explaining patterns of causal attribution has been demonstrated in previous research (e.g. Hilton & Slugoski,

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1986), Hart and Honoré's claim that free and deliberate actions sometimes take priority over abnormal conditions in explanation of outcomes has yet to be systematically explained.

Hart and Honoré's (1985) suggestion implies that people are endowed with a 'means-end' schema that causes them to analyse event sequences with voluntary causes as means to an end and thus to trace causality back through intervening events to the goal that generated them. This idea is consistent with Heider's analysis of personal causality (Heider, 1958; Malle, 2004; Schank & Abelson, 1977), and it is also consistent with recent thinking in social cognitive neuroscience. For example, Keysers and Gazzola (2007) note that focusing on the causal power of intentional actions yields important adaptive advantages. If you notice the intentions of others, you are in a good position to predict their behaviour, responding quickly where appropriate to avoid harm. Consistent with this idea, intentional actions generate immediate and automatic intentional inferences; upon registering a human movement, both humans and monkeys automatically infer a goal corresponding to that movement (Allison, Puce, & McCarthy, 2000; Keysers & Gazzola, 2007). Research in social cognitive neuroscience has shown that inferences about intentional actions may involve different brain substrates than inferences about physical events (Decety & Grezes, 1999; van Overwalle, 2008). It also seems that perceptions of intentionality and causality are closely related and share common brain circuits (Hilton, 2007).

Research on attribution in causal chains suggests that people do indeed prefer voluntary actions as explanations, even when they occur in sequences that are otherwise identical to physical chains. McClure et al. (2007) studied opportunity chains (Hilton, McClure, & Slugoski, 2005), where the occurrence of a first event (e.g. a shrub catching fire) enables a second event (e.g. wind springing up) to produce an outcome (e.g. a forest fire). Participants rated intentional actions (e.g. a person setting fire to the shrub) more causal than natural events (e.g. sunlight focused by a piece of glass setting fire to the shrub) whether they appeared first or second in the causal chain (see also Lagnado & Channon, 2008). However, McClure et al. (2007) failed to find support for a statistical explanation of these causal preferences derived from Spellman's (1997) hypothesis that the more an event increases the probability of an outcome, the more it should be judged as causal. Thus McClure et al. (2007) found that even though the voluntary proximal cause (pouring petrol on the flames) and physical proximal cases were perceived to increase the probability of the outcome (fire) by the same amount, people still considered the voluntary action to be more causal.

ARE VOLUNTARY CAUSES PREFERRED IN UNFOLDING CAUSAL CHAINS?

In the present research, we test the generality of the results of McClure et al. (2007). First, we examine whether voluntary causes are preferred in unfolding causal chains and, second, whether this preference can be explained in terms of statistical models of the kind proposed by Spellman (1997). Unfolding causal chains differ from opportunity chains because they imply transitivity of causation, namely, that if X causes Y, and Y causes Z, then X should logically be judged to cause Z. For example, consider the chain of events that resulted in the crash of the Concorde airliner in July 2000. Investigations showed that the Concorde crashed after it hit a piece of débris on the runway during take-off, which pierced its fuel tanks, resulting in a petrol leak which led to fire in a wing and loss of engine power. Hilton et al. (2005) call these 'unfolding causal chains', in that once the Concorde hit the debris on the runway, its fate was sealed and the accident 'unfolded' from this initial cause. That is, collision with the debris caused the debris to fly up and puncture the fuel tank, which caused an engine fire, which in turn caused loss of control of the aircraft, which in turn caused a crash. They are therefore different from opportunity chains, where prior events do not cause subsequent events in a chain to happen, but rather enable those subsequent events to have a causal effect. For example, the smouldering fire in the shrub does not cause the wind to spring up, but does enable it to produce a forest fire.

In examples such as the Concorde crash, Hart and Honoré propose that causal ascription in the law first proceeds through a process of counterfactual reasoning which generates a chain of events with a sequence of conditions necessary for the accident to occur (see Halpern & Pearl, 2005, for a related analysis). Thus we reason counterfactually that if Concorde had not hit the debris, or if the debris had not hit the fuel tank, and so on, then the accident would not have happened. This then raises the problem of causal selection (Hesslow, 1988), and so a criterion for selecting causes from these conditions is required. Hart and Honoré (1985) argue that we trace the cause back to the proximal abnormal condition (cf. Hilton & Slugoski, 1986). Thus we would identify the debris on the runway as 'the' cause, as it appears abnormal, and we would ignore a distal abnormal cause such as faulty maintenance on the jet that dropped the debris.

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Changing perceptions of normality change perceptions of causality, and indeed when people learned that it was normal for debris to be on runways but abnormal for aircraft to be disabled by this debris, the design of the Concorde's fuel tank was identified as 'the' cause.

However, where causal chains include a voluntary action, Hart and Honoré (1985) proposed that a second principle of causal selection applies, where voluntary actions are privileged over other events. Thus they claim that in legal inquiries, causality is traced through a proximal abnormal condition if a prior voluntary act led to that condition. In the case of the Concorde crash, imagine that we learnt that someone knowing the vulnerability of Concorde to debris had deliberately placed debris on the runway in order to bring about the accident. Hart and Honoré argue that in such cases causality in the law is traced through the proximal cause (the debris) to the distal cause (planting the debris). If commonsense explanation follows these principles, it would be natural to say that 'The Concorde crashed because someone sabotaged it' but odd to say that 'The Concorde crashed because of debris on the runway'.

To summarise, work in social psychology, social cognitive neuroscience and jurisprudence suggests that people give priority to intentions in causal explanation. However, the preference for voluntary actions over physical abnormal conditions has not been tested in unfolding chains of the kind described above using the example of the Concorde crash. Below, we detail the structure of unfolding causal chains used in our experimental scenarios and then describe the predictions Hart and Honoré make regarding selection of abnormal conditions and voluntary actions. We then describe how models of intuitive statistical reasoning can account for people's preferences for intentional causes. In our first experiment, we test Hart and Honoré's (1985) predictions concerning causal selection in unfolding causal chains. In our second experiment, we present four statistical models of causal judgement and evaluate how well they explain the patterns of causal judgement observed in our experiments.

The Structure of Unfolding Causal Chains

One reason unfolding causal chains are of interest is that, as noted by Hart and Honoré (1985), they occur frequently in cases in the law, and the scenario we describe below is modelled closely on one of their examples. The others we use in our experiments have a similar structure that we detail below. Consider the example scenario taken from Hart and Honoré (1985):

> During the winter, a severe storm wet a road, thus bringing about icy patches on a country road while the temperature was below zero. Afterwards, a car came round a bend on this road, skidded on the icy patches and rolled over before colliding with a tree, resulting in considerable damage. The car driver had to be taken to hospital.

This narrative starts with a precondition (Event A), such as sub-zero temperature, which enables the operation of the subsequent causes. Hart and Honoré's distal cause forms the second link (Event B) in the chain—here, this cause is a natural event (the storm) and their proximal cause forms the third link (Event C, e.g. ice forming on the road). The fourth link (Event D) is the immediate cause (e.g. the driver's loss of control of the car). Finally is the outcome (e.g. the car crash). Whereas the first link (Event A, the precondition) stays unchanged through the narrative, the second, third and fourth links describe an unfolding chain of events ($B \rightarrow C \rightarrow D$) that result in the final outcome. There is thus transitivity of causation in from B through to the outcome.

A pilot study verified that in each of the three scenarios we used, mean ratings of less than 2 on a 7-point scale confirmed that the precondition (Event A) was not judged to be a good cause of the next event in the chain (Event B), consistent with its status as a precondition that enables but does not cause the next event to happen. However, consistent mean ratings of at least 4.5 on a 7-point scale confirmed that Event B was always perceived to cause Event C, Event C to cause Event D and Event D to cause the outcome. This established empirically that the ($B \rightarrow C \rightarrow D \rightarrow$ outcome) sequence constitutes an unfolding chain as B must be judged to cause C, C to cause D and D to cause the outcome.

Types of Voluntary Causes: Deliberate Versus Non-deliberate

If Event B causes Event C, Event C causes Event D and Event D causes the outcome, the following question must be asked: Which part of the unfolding causal chain is selected as 'the' cause of the final outcome (e.g. the crash)? In Experiment 1, we test Hart and Honoré's (1985) prediction that when the distal cause (Event B) is a free and deliberate human action, people trace causality backwards through the proximal abnormal condition (Event C) to that action. We tested this

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prediction by manipulating the nature of the distal cause. For example, in the voluntary deliberate action condition of the car scenario, we replaced the phrase 'a severe storm wet the road' with the phrase 'a man who wished to cause an accident sprayed a road with water'.

We also test Hart and Honoré's (1985) claim that actions are selected as causes because they are 'free and deliberate'. We did this by including actions that did not produce the outcomes in question as part of a deliberate plan. We thus included a third condition with 'voluntary and non-deliberate' actions such as 'a man flooded a road without thinking about the consequences' in the car scenario. Such an action is intentional in the sense that the man intended to wet the road, but non-deliberate in that he did not set out to bring about the rest of the causal chain.

We included voluntary and non-deliberate conditions in order to better specify whether it is human action *per se*, or deliberate human action that is privileged in the attribution process. Different theories make different predictions about the explanatory value of deliberate and non-deliberate actions. According to Hart and Honoré (1985), such voluntary and non-deliberate actions should be judged as less causal than voluntary and deliberate actions (cf. Fincham & Jaspars, 1979). However, from a social functionalist perspective, both negligent and deliberately malevolent actions are worthy of social sanction (Tetlock, 2002) and may be highlighted in the attribution process (McClure et al., 2007). For example, the man who flooded the road without thinking about the consequences could be held accountable for negligence and thus considered to be the cause.

Do Statistical Principles Govern Causal Selection?

It is possible that preferences for voluntary actions—or other kinds of event—as causes could reflect underlying statistical principles of causal attribution. For example, if free and deliberate human actions are preferred as explanations of an outcome over abnormal conditions, it could be because they are (a) stronger covariates of the effect in question (e.g. Cheng & Novick, 1992; Kelley, 1967, 1972), (b) more sufficient causes of that effect (Mandel & Lehman, 1998) or (c) increase the probability of the outcome more (Spellman, 1997)? We address the details of these statistical theories of causal attribution in the introduction to Experiment 2, by operationalising the principles of covariation (Cheng and Novick, 1992; Kelley, 1967), conditionalised covariation (Hilton, 1988), sufficiency alone (Mackie, 1980; Mandel & Lehman, 1998) and conditionalised sufficiency (Salmon, 1984; Spellman, 1997), by deriving scores from questions about the probability of the outcome. This will enable us to assess which statistical judgement rule best fits the observed pattern of causal judgements.

Overview of Experiments

We created three scenarios (car crash, avalanche, train crash), which we used in both experiments. Each scenario had the structure described above (Precondition: Distal cause → Proximal cause → Immediate cause → Outcome). Experiment 1 examines whether selection of proximal and distal causes changes as a function of the type of candidate distal cause (voluntary and deliberate human action, non-deliberate human action and act of nature). In Experiment 2, we address the question of why people prefer deliberate actions to natural events as explanations and examine whether the statistical rules described above can account for the causal judgements observed in Experiment 1. Regression analyses examined whether explanation preferences are mediated by statistical rules such as covariation, sufficiency alone and sufficiency increase.

EXPERIMENT 1: WHEN DO PEOPLE TRACE CAUSALITY THROUGH PROXIMAL CAUSES TO DISTAL CAUSES?

Method

Participants

Participants were 63 introductory psychology students, who took part as a class exercise at the University of Toulouse-II. Each received a booklet with three scenarios describing a car crash, an avalanche and a train crash.

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Procedure

Three scenarios were created (car, avalanche, train) each with three different distal causes (deliberate human action, non-deliberate human action and act of nature), creating nine versions (see Appendix). Each participant read one combination of story with cause-type, counterbalanced in a Latin square design. Participants first wrote down their preferred explanation in their own words and then selected their preferred explanation from a list of four corresponding to each link in the chain. Only the choice data were used for the analyses reported below. On a facing page, participants were asked to make probability evaluations using the procedure detailed in Experiment 2. These gave similar patterns of results to those obtained in Experiment 2 and so they are not reported here.

Results

Table 1 shows the pattern of selections of each of the four types of explanation (precondition, distal cause, proximal cause and immediate cause) across the three types of distal factor (voluntary and deliberate human action, voluntary but not deliberate human action and natural event) and also broken down by scenario type. Our manipulations were successful in focusing participants' attention on the parts of the chain that most interest us, in that 85% of the attributions were to distal (Event B) or proximal (Event C) causes, none were to preconditions (Event O) and only 15% to immediate (Event D) causes. Indeed, the finding of so few attributions to immediate causes despite their close contiguity to and high covariation with the outcome is remarkable given the prominence of these cues in models of causal inference (e.g. Einhorn & Hogarth, 1986) and underscores the necessity of understanding why people prefer explanations from earlier parts of the causal chain.

We first tested Hart and Honoré's prediction that distal causes will be preferred over proximal and immediate causes (grouped together) as explanations when they were voluntary and deliberate human actions rather than natural events. These predictions were supported in an overall analysis ($\chi^2\,(1) = 25.73$, $p < .001$). Focused analyses showed the predicted effect in the car ($\chi^2\,(1) = 15.40$, $p < .001$) and avalanche ($\chi^2\,(1) = 20.79$, $p < .001$) scenarios, while the effect was in the predicted direction in the train scenario it did not reach significance ($\chi^2\,(1) = .52$, *n.s.*).

Our next prediction that deliberate human actions would be more likely than non-deliberate actions to be selected, as causes were not confirmed. Thus we found no tendency to prefer deliberate over non-deliberate actions as explanations for outcomes (overall χ^2 non-significant). However, results support the final prediction that the voluntary and non-deliberate actions would be preferred to the natural events as causes (overall $\chi^2 = 17.92$, $p < .001$). Focused analyses again showed a greater tendency to trace causality to a distal voluntary and non-deliberate action than to a distal natural event in the avalanche ($\chi^2\,(1) = 16.05$, $p < .001$) and train scenarios ($\chi^2\,(1) = 7.29$, $p < .01$). However, no significant difference was observed in the car scenario ($\chi^2 = .54$, *n.s.*)

Table 1. Experiment 1: Proportion of causal selections as a function of distal cause-type and scenario type of distal cause

	Type of distal cause		
Type of scenario and cause selected	Natural event	Voluntary non-deliberate action	Voluntary deliberate action
Car			
Second (distal)	0.12	0.21	0.67
Third (proximal)	0.64	0.72	0.33
Fourth (immediate)	0.24	0.07	0
Avalanche			
Second (distal)	0	0.68	0.76
Third (proximal)	0.35	0.08	0.08
Fourth (immediate)	0.65	0.24	0.16
Train			
Second (distal)	0.46	0.80	0.50
Third (proximal)	0.54	0.20	0.36
Fourth (immediate)	0	0	0.14

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Discussion

Experiment 1 confirms Hart and Honoré's prediction that causality is traced back through abnormal conditions to a distal cause in a causal chain when that distal cause is a voluntary and non-deliberate human action. This pattern was found in the car and avalanche scenarios, but not the train scenario.

The experiment did not support the prediction that voluntary and non-deliberate actions would be seen as less causal than voluntary and deliberate actions. While the deliberate nature of an action may affect judgements of causality in some cases (Fincham & Jaspars, 1979), it does not seem to do so in the present scenarios. However, voluntary and non-deliberate actions are judged as more causal than natural events in two of three scenarios tested. Hence, an important implication of these results is that a distal voluntary action does not have to be deliberate in order for causality to be traced back to it. Our results suggest that causality may be traced through the proximal cause to the distal cause where the non-deliberate action is seen as especially abnormal. For example, the non-deliberate action in the train scenario (cutting a wire leading to the generator belonging to a portion of the railway line without thinking about the consequences) may be seen as more abnormal as it involves breaking a prohibition not to damage others' property, especially if it is likely to endanger the safety of others. Further research will be necessary to examine these hypotheses.

For our purposes, it is sufficient to note that there are cases where people trace causality through proximal to distal causes. While this never happened when the distal cause was physical, in two of the three scenarios, this occurred when the distal cause was a voluntary and deliberate event. In addition, causality was traced through to the distal cause when the distal cause was a voluntary and non-deliberate action in two of the three scenarios studied.

While Hart and Honoré (1985) base their predictions on observations of English law cases, they do not advance any explanation of why voluntary and deliberate actions should be preferred as explanations. In Experiment 2, we test whether the pattern of causal attribution in unfolding chains observed in Experiment 1 can be explained in terms of a statistical principle such as covariation, sufficiency or sufficiency increase. For example, are voluntary actions preferred as explanations because they are stronger covariates of an effect because they are more sufficient conditions for the outcome or because they most increase the probability of an effect occurring given previous events in the chain (sufficiency increase)?

EXPERIMENT 2: DO STATISTICAL PRINCIPLES EXPLAIN SELECTION OF EXPLANATIONS?

Several theories of causal reasoning claim that people conduct some intuitive analogue of statistical reasoning in order to arrive at causal explanations for events. The statistical principle most often proposed is the covariation principle. According to this principle, a cause is: 'that condition which is present when the effect is present and which is absent when the effect is absent' (Kelley, 1967, p. 154). Cheng and Novick (1990, 1992) formalise this idea in terms of Delta-P (ΔP), which reflects the proportion of times effect occurs when a cause is present; less the proportion of times effect occurs when a cause is absent. In this view, causes are factors that increase the probability of occurrence of effects. The ΔP of a factor is calculated as the probability that the outcome occurs in the presence of a factor (its sufficiency) minus the outcome probability in the absence of that factor (necessity). A factor is judged as sufficient when the outcome is seen as probable in its presence and to be judged as necessary when the outcome is seen as improbable in its absence.

The covariation rule has typically been assessed through scenarios with simple causal structures that apply the logic of an analysis of variance to orthogonally crossed person, stimulus and occasion factors (e.g. Cheng & Novick, 1990; Försterling, 1989; Sutton & McClure, 2001). One suggestion for applying covariational analysis to causal chains came from Hilton (1988), who suggested that a naïve 'multiple regression analysis' could be used to filter out redundant predictors of an effect, once initial causes (or sets of causes) have been selected as explanations. As applied to causal chains, this suggestion could be interpreted as 'conditionalised ΔP', that is, the covariation between an event and the outcome less the covariation of the previous event in the chain and that outcome.

The covariation principle contrasts with the simpler and more heuristic principle of sufficiency. For example, Mackie (1980) argued against covariation as a criterion for causal attribution for particular events and proposed that lay causal attribution proceeds through applying a criterion of 'sufficiency in the circumstances' to a factor that is embedded in a 'causal field' of conditions that are jointly necessary to produce an event (see also McGill, 1989). The view that

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sufficiency, rather than covariation, is the key criterion for causal judgement is supported by Mandel and Lehman (1998), who report that sufficiency captured their participants' judgements of causality better than ΔP (sufficiency plus necessity). We therefore tested the degree of fit this judgement rule gave to our participants' judgements.

Finally, we tested the notion of conditionalised sufficiency, which is the sufficiency of the target event less the sufficiency of the previous event. Conditionalised sufficiency assesses the increase in predictive value obtained by 'entering' a factor into the equation and captures Spellman's (1997) intuition that a cause is the factor that increases the probability of an outcome. Spellman's (1997) crediting causality model proposes that an event is identified as causal if it increases the probability of occurrence of the outcome in question, beyond the effect's prior probability due to prior elements in the chain (for related proposals, see Brewer, 1977; Fincham & Jaspars, 1983). This could explain, for example, why engine fire is 'redundant' as an explanation of the Concorde disaster once you know the prior elements of the chain (e.g. debris on runway) as the engine fire is predictable in the circumstances. Once Concorde hit the piece of debris when it did, it was doomed, and no further explanation is necessary.[1]

Experiment 2 tests whether causal selection can be explained in terms of a statistical principle. Measures of the perceived necessity and sufficiency of each cause for the outcome allow us to test statistical models of causal explanation. We tested the covariation rule (ΔP) by combining sufficiency and necessity into a composite score and tested the sufficiency rule by taking its score alone. We also calculated a 'conditionalised ΔP' score for the proximal, distal and immediate causes by subtracting the ΔP of the precedent cause from that of the target cause, and a 'conditionalised sufficiency' measure of probability increase for these same causes, by subtracting the probability of the outcome in the presence of the preceding cause from its probability in the presence of the target cause.

In sum, Experiment 2 aimed to assess whether participants base their judgements of causality in our scenarios on either (i) covariation, (ii) conditionalised covariation, (iii) sufficiency, (iv) conditionalised sufficiency or (v) some combination of these. Having identified rules that give the best fit to the data, we then explore the question of whether they mediate preferences for voluntary actions as causes. Whereas we used a causal selection procedure in the previous experiment, in the present experiment we used 7-point causal rating scales in order to gain statistical sensitivity to explore mediating processes.

Method

Participants

Participants were 115 introductory psychology students who took part as part of a class exercise at the University of Toulouse-II.

Procedure

The same experimental design and procedure was used as in Experiment 1. Three experimental groups were created using a Greco-Latin square, and all participants read one of the car, avalanche and train scenarios paired with one of the three distal cause-types (deliberate, non-deliberate and natural). However, the dependent measure changed in that participants did not write free explanations and select causes, but evaluated the quality of the four candidate explanations on scales ranging from 1 (Not at all relevant) to 7 (Extremely relevant).[2] Following the procedure used by Brickman et al. (1975), participants were given a probability evaluation task where they judged the respective probabilities that the target event (e.g. car crash) would happen in the circumstances given the presence of each link and in its absence. For example, for the proximal cause in the car accident scenario, the questions were 'What were the chances that the accident would happen in any case because of the occurrence of the storm?' and 'What were the chances that the accident would happen in any case

[1]However, this presupposes that the presence of debris is entered first into the equation. If we did a 'stepwise regression' to explain the effect by considering all variables simultaneously, or simply considering the most recent ones first, we could end with 'engine fire' as an explanation and stop there.
[2]Although we have asked participants in previous experiments to judge how good an explanation is as a measure of perceived explanatory quality, in French the word 'pertinent' is preferred. 'Pertinent' can also be translated in English as 'relevant' and so we have used this English translation here. In any case, previous research shows that judgments of the goodness and relevance of explanations are highly correlated in English (McClure & Hilton, 1997, 1998) and German (Hilton & Erb, 1996).

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in the absence of the storm?' The first probability judgement corresponds to sufficiency and the second probability judgement corresponds to necessity. They indicated their judgement on an 11-point scale ranging from 0, 10, 20, through to 100%. Each of these two probability judgements was thus collected for each factor, making up eight judgements.

Results and Discussion

The ratings of the perceived goodness, sufficiency and necessity of each factor, along with the perceived covariation (ΔP) scores are given in Table 2.

Analysis of the Effect of Type of Distal Factor on Causal Ratings

There was no main effect of type of distal cause on the overall ratings of causes, $F(2, 232) = 2.29$, $p = .10$. There was a main effect of the temporal position of causes, $F(3, 348) = 37.67$, $p < .001$, $\eta^2 = .25$. The second (distal) cause ($M = 5.72$) and third (proximal) cause ($M = 5.66$) were rated equally highly, $t(117) = 0.48$, *n.s*. Both the distal cause, $t(117) = 3.92$ and the proximal cause, $t(117) = 5.33$, $p < .001$, were rated better explanations than the fourth (immediate) cause ($M = 5.02$; all planned comparisons here and below are two-tailed). In turn, the immediate cause was rated better than the first precondition ($M = 4.31$), $t(117) = 4.79$, $p < .001$. This replicates the pattern in Experiment 1 that the first factor (the precondition) was considered least causal and that the distal and proximal factors were considered most causal.

However, as predicted, the effects of temporal position on explanatory quality were qualified by an interaction with the type of distal cause, $F(6, 696) = 7.30$, $p < .001$, $\eta = .06$. When the second (distal) cause was a voluntary and deliberate action, it was preferred to the first (precondition) cause, $t(119) = 6.59$, $p < .001$, the third (proximal) cause, $t(119) = 3.00$, $p < .005$ and the fourth (immediate) cause, $t(119) = 4.51$, $p < .001$. Similarly, when the distal cause was a voluntary but non-deliberate action, it was also preferred to the initial precondition, $t(118) = 6.57$, $p < .001$, the third (proximal) cause,

Table 2. Experiment 2: Ratings of explanatory quality, sufficiency, necessity (reverse scored) and ΔP (sufficiency less necessity) as a function of distal cause-type

	Type of distal cause		
Temporal position of cause	Natural event	Voluntary non-deliberate action	Voluntary deliberate action
Explanatory Quality			
First (precondition)	4.07	4.43	4.47
Second (distal)	5.04	5.91	6.20
Third (proximal)	6.06	5.38	5.50
Fourth (immediate)	5.03	5.06	5.01
Sufficiency			
First (precondition)	45.6	45.7	54.6
Second (distal)	47.2	69.1	73.2
Third (proximal)	74.3	68.9	62.9
Fourth (immediate)	62.7	63.9	68.0
Necessity			
First (precondition)	82.3	86.1	80.6
Second (distal)	79.5	72.7	73.2
Third (proximal)	80.5	79.5	81.9
Fourth (immediate)	78.1	76.4	75.6
Covariation (ΔP)			
First (precondition)	26.9	31.8	35.2
Second (distal)	26.5	41.8	46.4
Third (proximal)	54.8	49.4	44.7
Fourth (immediate)	40.8	40.3	43.6

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$t(119) = 2.72$, $p < .005$ and the fourth (immediate) cause, $t(119) = 3.71$, $p < .001$. In contrast, when the second (distal) cause was a natural event, it was preferred to the initial precondition, $t(118) = 4.05$, $p < .001$, but as predicted, it was rated as an inferior explanation relative to the third (proximal) cause, $t(118) = 5.28$, $p < .001$. Also the second (distal) cause was rated only as good as the fourth (immediate) cause, $t(118) = 0.17$, *n.s.*, and the third (proximal) cause was preferred to the first cause (precondition), $t(119) = 10.0$, $p < .001$, and the immediate cause $t(119) = 4.53$, $p < .001$.

Which Statistical Rules Best Predict Explanatory Quality?

Participants' estimates of the probability that the event would occur given the presence of each factor and in the absence of each factor allowed us to calculate sufficiency and necessity scores for each of the four links in each causal chain and to calculate a ΔP score for each link by adding sufficiency and necessity (i.e. subtracting the probability that the outcome would occur in the absence of the target factor, from the probability that it would occur in its presence). In addition, we computed conditionalised statistical rules for Event B (distal), Event C (proximal) and Event D (immediate) by estimating the 'added value' that score contributed at that point in the chain by subtracting the relevant score of the previous link from it. For example, to calculate the conditionalised ΔP score for link 2 (distal) we subtracted the unconditionalised ΔP score for Event A (precondition) from the unconditionalised ΔP score for Event B, and so on. We show the correlation coefficients with explanatory quality for the respective sets of four unconditionalised (covariation and sufficiency) and three conditionalised (covariation and sufficiency) judgements in Table 3.

Inspection of Table 3 shows that overall, both unconditionalised and conditionalised ΔP predict less well, respectively, than unconditionalised and conditionalised sufficiency in almost all comparisons. These results therefore support the view that in these causal judgements, participants are using sufficiency rules more than covariation rules. Being a composite of sufficiency and necessity scores, ΔP was highly correlated with both, although necessity judgements were generally not correlated with sufficiency judgements. However, since sufficiency is included in the calculation of ΔP, this implies that including necessity in this calculation worsens the scores that are obtained from using sufficiency alone. It seems that adding necessity to sufficiency to create the ΔP score simply introduced noise, leading to less predictive power with ΔP than with sufficiency alone.

We then tested whether unconditionalised and conditionalised sufficiency rules contribute independently to the perception of explanatory quality. We calculated regression equations to predict the explanatory quality of distal (link 2), proximal (link 3) and immediate (link 4) causes from unconditionalised and conditionalised sufficiency scores in each of the deliberate, non-deliberate and natural causal chains (Table 4). The results show that unconditionalised sufficiency was a significant predictor of explanatory quality in all nine equations, but that conditionalised sufficiency added additional predictive power in four of these equations. Significantly, conditionalised sufficiency contributed significant predictive power to predicting causal judgement when the distal cause was a human action. This suggests that the 'surprise value' of human actions that makes a difference to the perceived probability of the outcome may contribute to their being perceived as a cause.

In sum, the regression analyses give support to the argument that causal selection in causal chains reflects an unconditionalised sufficiency rule. In addition, conditionalised sufficiency can also be important suggesting that the 'added explanatory value' that a human action contributes by increasing the probability of the outcome may also be taken into account in causal judgements.

Mediation: Does Perceived Sufficiency Explain Preferences for Deliberate Actions?

We now examine whether various statistical rules mediate the effect of distal cause-type on the perceived explanatory quality of the distal and proximal causes. As our previous analyses showed that unconditionalised sufficiency is the best predictor of explanatory quality, we focus on this variable as the most likely mediator (Baron & Kenny, 1986).

Our experimental design required that we analyse for mediating effects of distal cause-type within each of the car, avalanche and train scenarios.

We focus first on the contrast between deliberate human actions and natural events in the evaluation of distal causes. This allows us to test the hypothesis that people attribute causality to deliberate actions because these are perceived to be

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Table 3. Experiment 2: Correlations between statistical judgement rules and perceived quality of explanations for each link in causal chain

	Type of distal cause											
	Natural event				Non-deliberate actions				Deliberate actions			
Event	Precondition	Distal cause	Proximal cause	Immediate cause	Precondition	Distal cause	Proximal cause	Immediate cause	Precondition	Distal cause	Proximal cause	Immediate cause
Position	1	2	3	4	1	2	3	4	1	2	3	4
ΔP	0.33	0.41	0.23	0.47	0.22	0.46	0.50	0.51	0.28	0.30	0.25	0.35
+ΔP		0.28	0.07	0.44		0.32	0.45	0.41		0.30	0.30	0.19
Suff	0.30	0.48	0.28	0.58	0.31	0.46	0.55	0.56	0.42	0.31	0.40	0.44
+Suff		0.30	0.16	0.55		0.41	0.47	0.49		0.35	0.34	0.19

Judgement rule scores: ΔP, correlations between covariation (ΔP) scores and causal judgements; +ΔP, correlations between conditionalised covariation (ΔP) scores and causal judgements; Suff, correlations between sufficiency scores and causal judgements; +Suff, correlations between conditionalised sufficiency scores and causal judgements.

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Table 4. Experiment 2: Statistically significant beta-weights for regression equations predicting explanatory quality

Type of causal contrast	Suff	Suff+
Distal (deliberate)		0.35
Distal (non-deliberate)	0.19	0.34
Distal (natural)	0.48	
Proximal (deliberate)	0.39	
Proximal (non-deliberate)	0.41	0.23
Proximal (natural)	0.27	
Immediate (deliberate)	0.70	−0.34
Immediate (non-deliberate)	0.55	
Immediate (natural)	0.58	

Suff , raw sufficiency; Suff+, conditionalised sufficiency.

'sufficient in the circumstances'. The results in Table 5 show the beta-values for the cause-type before and after sufficiency has been entered into the equation. They show that sufficiency provided partial mediation in the car scenario and full mediation in the avalanche scenario (the train scenario was not tested as there was no difference in evaluations of deliberate and natural event distal causes).

Does Sufficiency Explain the Effect of Type of Distal Cause on Other Causal Preferences?

We observed eight further effects of contrasts between distal cause-type (deliberate vs. non-deliberate, deliberate vs. natural and non-deliberate vs. natural) on perceived explanatory quality of the four links in each scenario. This allowed further exploration of the hypothesis that perceived sufficiency mediates the effect of scenario type on causal judgements.

There was no effect of distal cause-type on sufficiency in three cases, thus eliminating sufficiency as a plausible mediator of the effect of distal cause-type in these cases, two involving a precondition and one involving an immediate cause. In the remaining five comparisons where there was an effect of cause-type on causal judgement, one involved a precondition, three a distal cause and one a proximal cause. The beta values for the regression equations are shown in Table 6. Sufficiency fully mediated the effect of cause-type on perceived explanatory causes in four of the five comparisons and partially mediated in the fifth.

Discussion

Our findings show covariation rules (covariation alone or conditionalised covariation) do worse than sufficiency rules (sufficiency alone or conditionalised sufficiency) in predicting causal judgement. While sufficiency alone emerges as the

Table 5. Experiment 2: Beta-weights for effect of cause-type (deliberate action vs. natural event) on explanatory quality of distal causes (with significance levels in brackets) with and without controlling for sufficiency

	Beta	
	Cause-type	Sufficiency
Car		
Deliberate vs. natural distal cause		
Cause-type alone	0.50 (0.001)	
Cause + sufficiency	0.25 (0.02)	0.36 (0.001)
Avalanche		
Deliberate vs. natural distal cause		
Cause-type alone	−0.49 (.001)	
Cause + sufficiency	−0.07 (0.57)	0.62 (0.001)

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Table 6. Experiment 2: Beta-weights for effect of cause-type on explanatory quality (with significance levels in brackets) with and without controlling for sufficiency

	Beta	
	Cause-type	Sufficiency
Car		
Deliberate vs. natural: effect on precondition (Position 1)		
Cause-type alone	0.50 (0.001)	
Cause + sufficiency	0.12 (0.31)	0.27 (0.02)
Deliberate vs. non-deliberate: Effect on distal cause (Position 2)		
Cause-type alone	0.23 (0.045)	
Cause + sufficiency	0.10 (0.343)	0.44 (0.001)
Avalanche		
Non-deliberate vs. natural: effect on distal cause (Position 2)		
Cause-type alone	0.34 (0.002)	
Cause + sufficiency	0.05 (0.41)	0.46 (0.001)
Non-deliberate vs. natural: effect on proximal cause (Position 3)		
Cause-type alone	0.30 (0.008)	
Cause + sufficiency	−0.23 (0.03)	0.44 (0.001)
Train		
Non-deliberate vs. natural: effect on distal cause (Position 2)		
Cause-type alone	−0.38 (0.001)	
Cause + sufficiency	−0.12 (0.28)	0.23 (0.04)

best overall predictor of causal judgement, conditionalised sufficiency adds extra explanatory power when the distal cause is a human action. Being the strongest overall predictor of causal judgement, we focused on sufficiency alone in our mediation analyses and found that it was a plausible full or partial mediator of distal cause-type on judgements of the distal cause. However, in one of these cases, the deliberate versus natural comparison in the car scenario, residual variance in the effect of cause-type on explanatory quality of the distal cause was left unaccounted for by perceived sufficiency. This suggests that perceived sufficiency is not always enough to explain explanatory quality. In the five remaining cases where distal cause-type influenced the perceived explanatory quality of candidate causes, there was full mediation by sufficiency in four cases and partial mediation in one case. This suggests that changes in perceived sufficiency are often plausible mediators of the effect of distal cause-type on causal judgements at several points in the unfolding causal chains we studied, in sharp contrast to the results obtained with opportunity chains by McClure et al. (2007), who found no evidence that the cause-type (intentional vs. natural) on causal judgement was mediated by changes in perceived sufficiency. Other research using scenarios with different causal structures to those used here have similarly found that while people prefer voluntary actions as causes, probabilities do not predict causal evaluations (Lagnado & Channon, 2008). Our results therefore suggest that the intuition that a cause is that event which increases the probability of an outcome (Spellman, 1997) may be valid in some causal structures (e.g. unfolding causal chains) but not others (e.g. opportunity chains).

GENERAL DISCUSSION

We constructed three scenarios with unfolding causal chains wherein the first Event A was not judged as causing the second Event B (although necessary for it, see Experiment 2), but Event B was perceived as causing Event C, Event C as causing D and D as causing the outcome O. The pilot study showed that the B → C → D → O sequence was perceived as an unfolding causal chain in which there was transitivity of causation from B through to O. Both Experiments 1 and 2 confirm Hart and Honoré's (1985) prediction that people will see B (the distal cause) as the principal cause if it is a voluntary action, but will choose C (the proximal cause) if B is a natural event. Participants never designated Event A (precondition)

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and only rarely Event D (the immediate cause) as the cause, despite the fact that the immediate cause was spatially and temporally contiguous to the effect. Contiguity (both spatial and temporal) and covariation are classic cues to covariation in a Humean analysis (e.g. Einhorn & Hogarth, 1986), yet they fail to predict causal attribution in these scenarios.

These experiments clarify two issues concerning preferences for explanations in causal chains (e.g. Brewer, 1977; Brickman et al., 1975; McClure et al., 2007; Spellman, 1997). First, in line with the predictions of Hart and Honoré (1985), in an unfolding chain of physical events where there is transitivity of causation, causality is traced back to an antecedent abnormal condition (e.g. ice on the road), but may be traced through that cause if there is an underlying voluntary action as the distal cause (e.g. someone spraying the road with water, intending to produce the accident). Second and contrary to predictions derived from Hart and Honoré (1985), the present studies show that people may trace causality through a proximal abnormal condition to a distal voluntary action even if that action did not deliberately aim to produce the outcome in question (e.g. spraying a road without thinking about the consequences). Deliberate actions were sometimes judged as better explanations than non-deliberate actions, depending on the scenario. The question of when non-deliberate actions are judged as good explanations of outcomes requires further research. Non-deliberate actions may be good candidates as distal causes if they are particularly abnormal in some sense (negligent, antisocial, criminal etc.), such as skiing off-piste or disabling railway signals.

The Rule of Statistical Intuitions in Causal Preferences

The results in Experiment 2 show that subjective probabilities for each link in the causal chain predict when the distal or the proximal cause is preferred as an explanation. However, the data are more consistent with some probabilistic models than others. Sufficiency alone did better at predicting causal evaluations than did the ΔP coefficient that expresses the perceived covariation of a given cause with the effect (Cheng & Novick, 1992). Moreover, a measure of conditionalised sufficiency added explanatory power in Experiment 2 (e.g. in predicting the preference for voluntary causes). The data thus suggest that the participants primarily used a sufficiency rule, supplemented in key cases by the conditionalised sufficiency rule described by Spellman (1997). With these unfolding causal chains, proximal sufficient causes are disregarded as explanations if they fail to add predictive power to the causal chain. Mediation analyses in Experiment 2 show that sufficiency alone can partially explain why deliberate actions are preferred as distal causes over natural events.

Although Spellman (1997) motivates her crediting causality model by presenting it as a specification of Cheng and Novick's (1992) probabilistic contrast model, it seems that their index of causal strength (ΔP) does not apply well to the analysis of causal chains involving singular events. In unfolding causal chains, where all elements in the chain are in principle necessary for the outcome, the factor which most increases the probability of the outcome will also be the one that most increases the sufficiency of the causal chain. The finding that explanatory preferences are better predicted by sufficiency than by a contingency (ΔP) rule suggests that although people recognise each step in an unfolding causal chain as necessary for the outcome, their judgements of the quality of the explanation reflect the perceived sufficiency of each cause in producing the effect.

It may be that sufficiency becomes a salient and determining criterion for causal judgements when there are multiple necessary conditions for an effect, as in unfolding causal chains. In such cases, causes are selected on the basis of their 'sufficiency in the circumstances'. For example, Greene and Darley (1998) found that when the perceived necessity of an action for a death to happen is high, variations in its perceived sufficiency predict attribution to that action. Greene and Darley's results also suggest the inverse when the perceived sufficiency of an action for the outcome is high: in this case perceived necessity becomes more predictive. However, they do not relate the differential focus on necessity and sufficiency for causal attribution to underlying causal chain structure as we do. The participants' task in the present studies is to select the best explanation from the string of necessary conditions that constitute the unfolding causal chain, not to choose between causal scenarios (e.g. accident vs. sabotage). In such cases, perceived necessity influences perceptions of explanatory quality when there are competing causal scenarios to explain an event (Hilton & Erb, 1996).

Specifying the underlying causal structure thus helps explain why participants focus on sufficiency in causal judgement. Thus the sufficiency criterion may be used when the events constitute an unfolding causal chain where all of the candidate causes form a transitive causal chain resulting in the outcome. However, if the distal cause only enables the proximal cause to have an effect (thus breaking transitivity of causation in the causal chain connecting the distal cause to the final outcome), sufficiency may not mediate the preference for voluntary actions in causal judgement. This was indeed

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the case in the opportunity chains studied by McClure et al. (2007). Lagnado and Channon (2008) also studied scenarios that resemble opportunity chains in that a first action (administering poison) enabled a second but unforeseen event (a traffic jam) to bring about an outcome (the death of a victim while he was being transported to hospital) and likewise found no evidence for statistical mediation of the preference for voluntary actions as causes. Future research will need to clarify whether the sufficiency rule is a good criterion for selecting causes in certain causal structures (e.g. unfolding causal chains) but not others (e.g. opportunity chains).

A final methodological caveat needs to be issued. The immediate cause (the fourth and final link in the chain) was usually judged as less sufficient than the preceding proximal cause (the third link). It is hard to see how this can be the case from a logical point of view, as commonsense suggests that the immediate cause described in the scenarios should increase rather than decrease the likelihood of an accident. Yet, the fact that the immediate causes were rated as less sufficient suggests that participants may have first judged that they were poorer explanations than the proximal causes and then judged them as less sufficient in order to reflect their lesser causal status. Even if we accept this direction of causality (estimations of explanation quality influence subjective probabilities) we are still left with our fundamental conclusion that free and deliberate actions make better explanations than other kinds of causes in unfolding causal chains.

The Primacy and Immediacy of Intention

The finding that people are disposed to prefer actions as explanations is consistent with earlier research on explanation of goal-directed behaviour (e.g. Hilton & Knibbs, 1988; McClure & Hilton, 1997, 1998). It is also consistent with theories of equifinality, which propose that the generative intentions that produce events designed to result in a planned outcome take priority as explanations for goal-directed behaviour (e.g. Heider, 1958; Kruglanski, 1996). Our findings are also consistent with research in social cognitive neuroscience that has shown when people (and monkeys) register a human movement; they automatically infer a corresponding goal (Allison et al., 2000; Keysers & Gazzola, 2007). Although the voluntary causes used here involve verbal processing rather than visual perception of an animated movement, in both cases, inferring a goal in response to an intentional action may yield an evolutionary advantage (e.g. if you discern the intentions of others, you can respond to avoid potential harm) (Keysers & Gazzola, 2007).

Whether the preference for human action as explanations observed in our studies reflects an automatic process inherited through a social cognition module, or a reflective process of causal analysis, our results suggest that this preference can be seen to express a disinterested principle of 'information gain' (Jones & McGillis, 1976). Thus the clear preference for voluntary human actions over natural events as explanations in unfolding causal chains can be seen as consistent with a cool, calculating and 'scientific' principle of causal attribution—people attribute causality to that factor that is sufficient in the circumstances for the event to happen, especially if it they perceive that it alters the course of events by increasing the likelihood of the outcome. The rest is mere detail.

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REFERENCES

Alicke, M. D. (1991). Culpable causation. *Journal of Personality and Social Psychology*, *63*, 368–378.

Allison, T., Puce, A., & McCarthy, G. (2000). Social perception from visual cues: role of the STS region. *Trends in cognitive sciences*, *4*, 267–278.

DOI: 10.1002/ejsp

Baron, R. M., & Kenny, D. A. (1986). The moderator-mediator variable distinction in social psychological research: conceptual, strategic and statistical considerations. *Journal of Personality and Social Psychology*, *51*, 1173–1182.
Brewer, M. B. (1977). An information-processing approach to attribution of responsibility. *Journal of Experimental Social Psychology*, *13*, 58–69.
Brickman, P., Ryan, K., & Wortman, C. B. (1975). Causal chains: attribution of responsibility as a function of immediate and prior causes. *Journal of Personality and Social Psychology*, *32*, 1060–1067.
Cheng, P. W., & Novick, L. R. (1990). A probabilistic contrast model of causal induction. *Journal of Personality and Social Psychology*, *58*, 545–567.
Cheng, P. W., & Novick, L. R. (1992). Covariation in natural causal induction. *Psychological Review*, *99*, 65–82.
Decety, J., & Grezes, J. (1999). Neural mechanisms subserving the perception of human actions. *Trends in Cognitive Sciences*, *8*, 172–178.
Einhorn, H. J., & Hogarth, R. M. (1986). Judging probable cause. *Psychological Bulletin*, *99*, 1–19.
Fincham, F. D., & Jaspars, J. M. F. (1979). Attribution of responsibility to the self and others in children and adults. *Journal of Personality and Social Psychology*, *37*, 1589–1602.
Fincham, F. D., & Jaspars, J. M. F. (1980). Attribution of responsibility: From man the scientist to man as lawyer. In L. Berkowitz (Ed.), *Advances in experimental social psychology* (Vol. 13, pp. 82–139). New York: Academic Press.
Fincham, F. D., & Jaspars, J. M. F. (1983). A subjective probability approach to responsibility attribution. *British Journal of Social Psychology*, *22*, 145–162.
Fincham, F. D., & Shultz, T. R. (1981). Intervening causation and the mitigation of responsibility for harm. *British Journal of Social Psychology*, *20*, 113–120.
Försterling, F. (1989). Models of covariation and attribution: how do they relate to the analysis of variance? *Journal of Personality and Social Psychology*, *57*, 615–625.
Graesser, A. C., Robertson, S. P., & Anderson, P. A. (1981). Incorporating inferences in narrative representations: a study of how and why. *Cognitive Psychology*, *13*, 1–26.
Greene, E. K., & Darley, J. M. (1998). Effects of necessary, sufficient, and indirect causation on judgments of criminal liability. *Law and Human Behavior*, *22*, 429–451.
Halpern, J., & Pearl, J. (2005). Causes and explanations: a structural model approach. Part I: Causes. *British Journal for the Philosophy of Science*, *56*, 4, 843–887.
Hart, H. L. A., & Honoré, A. M. (1959/1985). *Causation in the law* (second edition). Oxford: Oxford University Press.
Heider, F. (1958). *The psychology of interpersonal relations*. New York: Wiley.
Hesslow, G. (1988). The problem of causal selection. In D. Hilton (Ed.), *Contemporary science and natural explanation: Commonsense conceptions of causality* (pp. 11–32). New York: New York University Press.
Hilton, D. J. (1988). Logic and causal attribution. In D. Hilton (Ed.), *Contemporary science and natural explanation: Commonsense conceptions of causality* (pp. 33–65). New York: New York University Press.
Hilton, D. J. (2007). Causal explanation: From social perception to knowledge-based attribution. In A. Kruglanski, & E. T. Higgins (Eds.), *Social psychology: Handbook of basic principles* (second edition, pp. 232–253). New York: Guilford Press.
Hilton, D. J., & Erb, H.-P. (1996). Mental models and causal explanation: judgments of probable cause and explanatory relevance. *Thinking and Reasoning*, *2*, 33–65.
Hilton, D. J., & Knibbs, C. S. (1988). The knowledge-structure and inductivist strategies in causal attribution. *European Journal of Social Psychology*, *18*, 79–82.
Hilton, D. J., McClure, J. L., & Slugoski, B. R. (2005). The course of events: Counterfactuals, causal sequences and explanation. In D. Mandel, D. J. Hilton, & P. Catellani (Eds.), *The Psychology of Counterfactual Thinking* (pp. 44–60). London: Routledge.
Hilton, D. J., & Slugoski, B. R. (1986). Knowledge-based causal attribution: the abnormal conditions focus model. *Psychological Review*, *93*, 75–88.
Johnson, J. T., Ogawa, K. H., Delforge, A., & Early, D. (1989). Causal primacy and comparative fault: the effect of position in a causal chain on judgments of legal responsibility. *Personality and Social Psychology Bulletin*, *15*, 161–174.
Jones, E. E., & McGillis, D. (1976). Correspondent inferences and the attribution cube: A comparative reappraisal. In J. H. Harvey, W. J. Ickes, & R. F. Kidd (Eds.), *New directions in attribution research* (Vol. 1, pp. 389–420). Hillsdale, NJ: Erlbaum.
Kelley, H. H. (1967). Attribution theory in social psychology. In D. Levine (Ed.), *Nebraska symposium on motivation*. Lincoln: University of Nebraska Press.
Kelley, H. H. (1972). The processes of causal attribution. *American Psychologist*, *28*, 107–128.
Kelley, H. H. (1983). Perceived causal structures. In J. M. F. Jaspars, F. D. Fincham, & M. R. C. Hewstone (Eds.), *Attribution theory and research* (pp. 192–238). London: Academic Press.
Keysers, C., & Gazzola, V. (2007). Integrating simulation and theory of mind: from self to social cognition. *Trends in Cognitive Sciences*, *11*, 194–196.
Kruglanski, A. W. (1996). Goals as knowledge structures. In J. A. Bargh, & P. Gollwitzer (Eds.), *Motivation and action* (pp. 599–618). New York: Guilford.
Lagnado, D. A., & Channon, S. (2008). Judgments of cause and blame: the effects of intentionality and foreseeability. *Cognition*, *108*, 754–770.
Mackie, J. L. (1980). *The cement of the universe: A study of causation*. Oxford: Clarendon Press.
Malle, B. F. (2004). *How the mind explains behavior: Folk explanations, meaning, and social interaction*. Cambridge, MA: MIT Press.

DOI: 10.1002/ejsp

Mandel, D. R., & Lehman, D. (1998). Integration of contingency information in judgments of cause, covariation and probability. *Journal of Experimental Psychology. General*, *127*, 269–285.
Mandel, D. R. (2003). Judgment dissociation theory: an analysis of differences in causal, counterfactual and covariational reasoning. *Journal of Experimental Psychology. General*, *132*, 419–434.
McClure, J., & Hilton, D. (1997). You can't always get what you want: when circumstances are better explanations than goals. *British Journal of Social Psychology*, *36*, 223–240.
McClure, J., & Hilton, D. (1998). Are goals or preconditions better explanations: it depends on the question. *European Journal of Social Psychology*, *28*, 897–911.
McClure, J. L., Hilton, D. J., & Sutton, R. M. (2007). Judgments of intentional and physical causes in causal chains. *European Journal of Social Psychology*, *37*, 879–901.
McGill, A. L. (1989). Context effects in judgments of causation. *Journal of Personality and Social Psychology*, *57*, 189–200.
Pearl, J. (2000). *Causality: Models, reasoning and inference*. Cambridge: Cambridge University Press.
Salmon, W. C. (1984). *Scientific explanation and the causal structure of the world*. Princeton: Princeton University Press.
Schank, R. C., & Abelson, R. P. (1977). *Scripts, plans, goals and understanding: An enquiry into human knowledge structures*. Hillsdale, NJ: Lawrence Erlbaum Associates.
Sloman, S., & Lagnado, D. (2005). Do we ''do''? *Cognitive Science*, *29*, 5–39.
Spellman, B. (1997). Crediting causality. *Journal of Experimental Psychology. General*, *126*, 323–348.
Sutton, R. M., & McClure, J. L. (2001). Covariational influences on goal-based attribution: an integrative model. *Journal of Personality and Social Psychology*, *80*, 222–236.
Tetlock, P. E. (2002). Social functionalist frameworks for judgment and choice: intuitive politicians, theologians and prosecutors. *Psychological Review*, *109*, 451–471.
Trabasso, T. R., & Sperry, L. L. (1985). The causal basis for deciding importance of story events. *Journal of Memory and Language*, *24*, 595–611.
Trabasso, T. R., & van den Broek, P. (1985). Causal thinking and story comprehension. *Journal of Memory and Language*, *24*, 612–630.
van Overwalle, F. (2008). Social cognition and the brain: A meta-analysis. *Human Brain Mapping*, 1–28.
Vinokur, A., & Ajzen, I. (1982). Relative importance of prior and immediate events: a causal primacy effect. *Journal of Personality and Social Psychology*, *42*, 820–829.
Wilensky, R. W. (1981). Meta-planning: representing and using knowledge about planning in problem-solving and natural language understanding. *Cognitive Science*, *5*, 192–234.

APPENDIX: STIMULUS STORIES WITH RESPONSE OPTIONS (EXPERIMENT 1)

Car Accident: Natural Event

During the winter, a severe storm wetted a road, thus bringing about the formation of icy patches on a country road while the temperature was below zero. Afterwards, a car came round a bend on this road, skidded on the icy patches and rolled over before colliding with a tree, resulting in considerable damage. The car driver had to be taken to hospital.

Car Accident: Voluntary and Deliberate Action

During the winter, a man who wished to cause an accident sprayed a road with water, thus bringing about the formation of icy patches on this country road while the temperature was below zero. Afterwards, a car came round a bend on this road, skidded on the icy patches and rolled over before colliding with a tree, resulting in considerable damage. The car driver had to be taken to hospital.

Car Accident: Voluntary but Non-Deliberate Action

During the winter, a man flooded a road without thinking about the consequences, thus bringing about the formation of icy patches on this country road while the temperature was below zero. Afterwards, a car came round a bend on this road, skidded on the icy patches and rolled over before colliding with a tree, resulting in considerable damage. The car driver had to be taken to hospital.

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From the Following Statements Please Select the Principal Cause of the Car Accident (Circle your Response)

The temperature
The spraying of the road (distal action option)/The storm (distal natural cause option)
The storm
The ice on the road
The loss of control of the car

Avalanche: Natural Event

This winter, snow accumulated creating many snow plaques in the mountains. Following unusually violent gusts of wind, one of these plaques at the top of the mountain got broken off, making it roll down the slope bringing about an avalanche that destroyed a part of the village, causing many people to be injured.

Avalanche: Voluntary and Deliberate Action

This winter, snow accumulated creating many snow plaques in the mountains. A man, wishing to destroy a village at the foot of a mountain, deliberately blew up one of these plaques at the top of the mountain making it roll down the slope bringing about an avalanche that destroyed a part of the village, causing many people to be injured.

Avalanche: Voluntary but Non-Deliberate Action

This winter, snow accumulated creating many snow plaques in the mountains. A skier, who was bored with the regular pistes, went off-piste (hors-piste) without thinking about the consequences. Following his presence on this part of the mountain, a large plaque of snow was got broken off, making it roll down the slope bringing about an avalanche that destroyed a part of the village, causing many people to be injured.

From the Following Statements Please Select the Principal Cause of the Train Accident (Circle your Response)

The accumulation of the snow
The man's action (distal action option)/The gusts of wind (natural cause option)
The snow plaque
The avalanche

Train Accident: Natural Event

Following a leak in a water pipe, a wire leading to the generator belonging to a portion of the railway line became corroded. This wire fed the signalling system of this section of the track and that it accordingly became damaged. As a consequence, the signalling system was unable to warn the driver of an oncoming goods train that he should stop because there was a goods train waiting on the line just round the bend. The first train thus continued normally without slowing down. Thus the oncoming train collided with the stationary train at high speed, resulting in a serious accident that seriously injured the driver.

Train Accident: Voluntary and Deliberate Action

Wishing to cause a train accident, a saboteur deliberately cut a wire leading to the generator belonging to a portion of the railway line. He knew that this wire fed the signalling system of this section of the track, and that it would accordingly be damaged. As a consequence, the signalling system was unable to warn the driver of an oncoming goods train that he should stop because there was a goods train waiting on the line just round the bend. The first train thus continued normally without slowing down. Thus the oncoming train collided with the stationary train at high speed, resulting in a serious accident that seriously injured the driver.

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Train Accident: Voluntary but Non-Deliberate Action

A man cut a wire leading to the generator belonging to a portion of the railway line without thinking about the consequences. He did not know that this wire fed the signalling system of this section of the track and that it would accordingly be damaged. As a consequence, the signalling system was unable to warn the driver of an oncoming goods train that he should stop because there was a goods train waiting on the line just round the bend. The first train thus continued normally without slowing down. Thus the oncoming train collided with the stationary train at high speed, resulting in a serious accident that seriously injured the driver.

From the Following Statements Please Select the Principal Cause of the Car Accident (Circle your Response)

The stationary train round the bend
The action of cutting the wire leading to the generator (distal action option)/The corrosion of the wire (distal natural cause option)
The signalling system failure
The speed of the train

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