Arguing about potential causal relations

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Abstract: This short note aims at providing a general discussion about patterns of reasoning, and their argumentative counterparts, involved in the way human agents ascribe causality or reason from causal relations. This study is mainly motivated by the need for providing information systems users with appropriate explanations, according to the way these agents are likely to perceive and understand a reported situation.

Key words: Causality, explanation, argumentation.

1 Introduction

Causality is pervasive in the way humans try to understand and make sense of the world. This paper does not aim at discussing the philosophical underpinnings of the idea of causality, but more simply to lay bare different inference patterns that may be used for ascribing causal relations between reported events, or for reasoning about the expected consequences of known facts and given causal relations, be them hypothetical. Indeed, when a sequence of events takes place, a natural question is to understand what has caused what. Such a study is motivated by the need to be able in future information handling systems to predict how agents perceive and understand reported information and what kind of explanation it may be appropriate to give them.

Explanations have usually an argumentative structure, which may be often challenged by counter-arguments questioning the basis of the explanation. The arguments in favor or against a potential causal explanation clearly depend on the knowledge that the agent is supposed to have about the normal course of things. Moreover, argumentation in causal settings may refer to different issues, such as the apparent incompleteness or imprecision of the reported sequence of events, or the inconsistency of the agent's beliefs about the normal course of things with what is reported. Argumentation may also involve hypothetical reasoning, and even include the use of unreal conditionals, such as "interventions" (see Woodward, 2001; Pearl, 2000) aiming at distinguishing causality from correlation. However, interventions are not considered in the following and left for further research. Lastly, argumentation may also take an analogical form when situations are encountered that are similar to other situations that already took place where cause(s) was/were identified.

This discussion paper is organized as follows. The next section, Section 2, provides a background about different patterns of reasoning involving causality and their argumentative counterparts. In particular, the assessment of causality relations on the basis of beliefs on the normal course of things is considered. Section 3 examines different scenarios, where according to what is reported and what are the beliefs of the agent, the agent may have different perceptions of the information. Section 4 discusses the handling of causal arguments and their strength. The concluding remarks briefly consider more sophisticated patterns with hypothetical conditionals that pertain to the ascription of responsibility.

2 Background: Schema for reasoning about or assessing causality

When reasoning about causality, one should distinguish between different types of problems:

- i) generic causal relations are given, and we apply them to a particular situation in order to predict what is going to take place;
- ii) generic causal relations are given and we use them for diagnosing plausible causes that may have led to the observed acts;
- iii) given a reported ordered sequences of facts (including potential causes and effects), and given generic knowledge about the (normal) course of the world, the causal relation(s) that took place between the reported facts have to be identified;
- iv) from past experience, viewed as a set of reported ordered sequences of facts with identified causal relations, try to guess the causality relations that took place in a new reported sequence of facts, on the basis of similarity relations;
- v) from a sufficiently large set of reported sequences, try to learn generic causal relations.

Case (i) is just deductive causal reasoning, and is exemplified by the pattern

(generally) A causes B
A is true

B should be true (and might be expected to be reported as such)

As any deductive pattern, the set of the two premises constitute an argument in order to conclude that B is true. However, if the first premise has exceptions, one may face non-monotonic reasoning behaviors, namely "special situations where A is true may not cause B".

Case (ii) correspond to the pattern

(generally) A causes B
B is true

A might be true

This is an abductive pattern. Note that in case one knows several A_i's such that 'A_i causes B' (each A_i stands for a conjunction of elementary facts describing a situation), one would conclude that A_1 or… A_i or … might be true. Case (ii) can be turned into a deductive manner by changing the first premise into "B evokes A as a potential cause". Then, turning patterns (i) (or (ii) once modified) in an argumentative manner is straightforward, since the two premises of the pattern constitutes a minimal consistent subset that supports the conclusion.

Case (iv) and case (v) are respectively analogical and inductive reasoning. Case (v) is out of the scope of the paper. Case (iv) resembles case (iii) replacing generic knowledge by case-based knowledge.

Case (iii) should not be confused with case (ii). In case (iii), the causal relation(s), if any, is/are to be identified between reported facts. It is not so much a matter of finding out unreported facts (such as events that may have taken place and caused the observed – and reported – facts), as in (ii).

In case (iii), it is assumed that one is in a (reported) context C (C represents the partial available knowledge about the context). Moreover, it is supposed that a sequence such as Bt, At, ¬Bt' is reported, where t' denotes a time instant strictly after t (Bt means that B is reported true at time t). Besides, the agent that receives this sequential information has some knowledge on what is the normal course of the world in context C, and maybe also in context C ∧ A, regarding B. Namely, the agent may either believe that C $|\!\approx$ B (B is expected to be true), or that C $|\!\approx$ ¬B (B is expected to be false), or that C $\not|\!\approx$ B and C $\not|\!\approx$ ¬B (the truth or the falsity of B is contingent), where $|\!\approx$ is a non-monotonic consequence relation describing what is normal, and $\not|\!\approx$ stands for its negation. Similarly, in context C ∧ A, the agent may have the same form of belief. It is assumed, that C ∧ A is consistent (otherwise, one would have to take into account that the fact that A becomes true should modify C into a known way C'). Note also that 'A true' may as well recover an action that has been executed and whose execution is finished (e.g. the driver drank before taking his car), or something that has become true and that remains true (e.g., the driver is inebriated).

In such a situation, the two following definitions have been recently introduced in (Bonnefon et al., 2006).

Definitions 1 (Facilitation and Causation) Let us assume that an agent learns of the sequence Bt, At, ¬Bt'. Let us call C (the context) the conjunction of all other facts known by, or reported to, the agent at time t' > t. Given a nonmonotonic consequence relation $|\!\approx$, if the agent believes that C $|\!\approx$ B, and that C ∧ A $\not|\!\approx$ B (resp. C ∧ A $|\!\approx$ ¬B), the agent will perceive A as having facilitated the occurrence of (resp. as being the cause of) ¬B in context C, noted C : A ⇒fa ¬B (resp. C : A ⇒ca ¬B).

In (Bonnefon et al., 2006) experiments are reported, which tend to indicate the cognitive validity of the two above notions. Moreover, the properties of these definitions are studied in detail, and in particular, it is shown that

- If C: A $\Rightarrow$ca B or if C: A $\Rightarrow$fa B then C $|\approx \neg$A.
- a restricted transitivity property holds: If C: A $\Rightarrow$ca B, if C: B $\Rightarrow$ca D and if B $\wedge$ C $|\approx$ A then C: A $\Rightarrow$ca D. The two properties hold for $\Rightarrow$ca provided that $|\approx$ is a preferential entailment in the sense of (Lehmann and Magidor, 1992). The first property holds for facilitation ($\Rightarrow$fa) if $|\approx$ is a rational closure entailment.

Note that here transitivity requires B $\wedge$ C $|\approx$ A, i. e. A is not too specific with respect to B (it means that the normal way to have B (in context C), is to have A). For instance, for A = drinking, B = inebriated, D: staggering, we have 'drinking' $\Rightarrow$ca 'inebriated' and 'inebriated' $\Rightarrow$ca staggering' entail 'drinking' $\Rightarrow$ca 'staggering', since 'inebriated' $|\approx$ 'drinking'.

Note also that the causation definition can be presented in an argumentative manner (it would be the same for facilitation):
- at time t we were in context C and B was true,
- it is normal in context C that B be true and B should persist,
- at time t, C has been modified by the fact that A took place,
- normally in context C $\wedge$ A, B is false,
- indeed at time t' > t, B is reported to be false,

Then, an agent sharing the beliefs C $|\approx$ B and C $\wedge$ A $|\approx \neg$B, can argue that A has caused the fact that B has become false (in the absence of any other change reported in context C), or that B has become false, because A took place, otherwise if A had not taken place B would have persisted to be true (counterfactual).

Lastly, (Bonnefon et al., 2006) have also introduced the idea of justification, which corresponds for the agent to an epistemic state different from those in the above definitions. Namely, the idea of justification corresponds to the following patterns.

Definition 2 ("Justification" or Explanation) Let us assume that an agent learns of the sequence B_t, A_t, $\neg B_{t'}$. Let us call C (the context) the conjunction of all other facts known by or reported to the agent at time t' > t. If the agent believes C $\not|\approx$ B, C $\not|\approx \neg$B and C $\wedge$ A $|\approx \neg$B, given a non-monotonic consequence relation $|\approx$, he will perceive A as justifying the fact that B is now false in context C.

3 Different possible scenarios

As already said, human agents when they are faced to reports try to make sense of them on the basis of their own beliefs. Depending on the cases, the agent may have the feeling to understand what took place, or to miss some important piece of information, or even to be puzzled. In the following, we examine different possible

types of scenarios, extending the setting underlying Definitions 1 and 2. First, these scenarios include one of the four possible (sub)-sequences of reported facts:

- C, Bt, ¬Bt', corresponding to a change without reported event
- C, Bt, Bt', corresponding to persistence without reported event
- C, Bt, At, ¬Bt', corresponding to a change with reported event
- C, Bt, At, Bt', corresponding to persistence with reported event

and are also characterized by the two following possible pieces of beliefs supposed to belong to the (supposedly consistent) epistemic state of the agent, in context :

- either $C \mid\!\approx B$, or $C \mid\!\approx \neg B$, or $C \not\mid\!\approx B$ and $C \not\mid\!\approx \neg B$;
- either $C \wedge A \mid\!\approx B$, or $C \wedge A \mid\!\approx \neg B$, or $C \wedge A \not\mid\!\approx B$ and $C \wedge A \not\mid\!\approx \neg B$.

Note that the case of believing both $C \mid\!\approx B$ and $C \mid\!\approx \neg B$ would be inconsistent with the hypothesis that $\mid\!\approx$ is a preferential entailment. Besides, if the agent has the default rule $C \wedge A \mid\!\approx B$ (or one of the other ones pertaining to A) in his epistemic state, and if At is *not* reported, it should be understood as the agent knows about some A such that $A \wedge C \mid\!\approx B$; obviously he may also know about some A' such that $A' \wedge C \mid\!\approx B$, or such that $A' \wedge C \mid\!\approx \neg B$, but this will be covered by another elementary scenario.

All together, we thus have 4×3×3 = 36 elementary scenarios, reviewed in Table 1. It is also assumed that B persists in context C.

Table 1. Epistemic states and perception of scenarios

1	C, Bt, At, ¬Bt'	$C \mid\!\approx B$	$C \wedge A \mid\!\approx B$	unexplained change, B should have persisted
2	C, Bt, At, ¬Bt'	$C \mid\!\approx B$	$C \wedge A \not\mid\!\approx B$ and $C \wedge A \not\mid\!\approx \neg B$	change *facilitated* by A
3	C, Bt, At, ¬Bt'	$C \mid\!\approx B$	$C \wedge A \mid\!\approx \neg B$	change *caused* by A
4	C, Bt, At, ¬Bt'	$C \not\mid\!\approx B$ and $C \not\mid\!\approx \neg B$	$C \wedge A \mid\!\approx B$	unjustified change after A
5	C, Bt, At, ¬Bt'	$C \not\mid\!\approx B$ and $C \not\mid\!\approx \neg B$	$C \wedge A \not\mid\!\approx B$ and $C \wedge A \not\mid\!\approx \neg B$	contingent change
6	C, Bt, At, ¬Bt'	$C \not\mid\!\approx B$ and $C \not\mid\!\approx \neg B$	$C \wedge A \mid\!\approx \neg B$	change *justified* by A
7	C, Bt, At, ¬Bt'	$C \mid\!\approx \neg B$	$C \wedge A \mid\!\approx B$	unexplained change, double defeated expectations!
8	C, Bt, At, ¬Bt'	$C \mid\!\approx \neg B$	$C \wedge A \not\mid\!\approx B$ and $C \wedge A \not\mid\!\approx \neg B$	from exceptionality to contingency
9	C, Bt, At, ¬Bt'	$C \mid\!\approx \neg B$	$C \wedge A \mid\!\approx \neg B$	back to normality thanks to A
10	C, Bt, ¬Bt'	$C \mid\!\approx B$	$C \wedge A \mid\!\approx B$	change for unknown reason
11	C, Bt, ¬Bt'	$C \mid\!\approx B$	$C \wedge A \not\mid\!\approx B$ and $C \wedge A \not\mid\!\approx \neg B$	change for unknown reason, A is a potential facilitating factor
12	C, Bt, ¬Bt'	$C \mid\!\approx B$	$C \wedge A \mid\!\approx \neg B$	A is a potential *cause* for the change

13	C, Bt, ¬Bt'	C $\not\approx$ B and C $\not\approx$ ¬B	C∧A $\approx$ B	unexplainable change
14	C, Bt, ¬Bt'	C $\not\approx$ B and C $\not\approx$ ¬B	C∧A $\not\approx$ B and C∧A $\not\approx$ ¬B	fully contingent change
15	C, Bt, ¬Bt'	C $\not\approx$ B and C $\not\approx$ ¬B	C∧A $\approx$ ¬B	A would *justify* the change
16	C, Bt, ¬Bt'	C $\approx$ ¬B	C∧A $\approx$ B	back to normality (not due to A)
17	C, Bt, ¬Bt'	C $\approx$ ¬B	C∧A $\not\approx$ B and C∧A $\not\approx$ ¬B	back to normality, (could have been facilitated by A)
18	C, Bt, ¬Bt'	C $\approx$ ¬B	C∧A $\approx$ ¬B	back to normality (maybe due to A)
19	C, Bt, At, Bt'	C $\approx$ B	C∧A $\approx$ B	A agrees with persistence of B
20	C, Bt, At, Bt'	C $\approx$ B	C∧A $\not\approx$ B and C∧A $\not\approx$ ¬B	B has persisted in spite of A
21	C, Bt, At, Bt'	C $\approx$ B	C∧A $\approx$ ¬B	unexplained persistence of B
22	C, Bt, At, Bt'	C $\not\approx$ B and C $\not\approx$ ¬B	C∧A $\approx$ B	A explains persistence of B
23	C, Bt, At, Bt'	C $\not\approx$ B and C $\not\approx$ ¬B	C∧A $\not\approx$ B and C∧A $\not\approx$ ¬B	contingent persistence of B
24	C, Bt, At, Bt'	C $\not\approx$ B and C $\not\approx$ ¬B	C∧A $\approx$ ¬B	A disagrees with persistence of B
25	C, Bt, At, Bt'	C $\approx$ ¬B	C∧A $\approx$ B	back to normality
26	C, Bt, At, Bt'	C $\approx$ ¬B	C∧A $\not\approx$ B and C∧A $\not\approx$ ¬B	from exception to contingency
27	C, Bt, At, Bt'	C $\approx$ ¬B	C∧A $\approx$ ¬B	double defeated expectations, exceptional situation
28	C, Bt, Bt'	C $\approx$ B	C∧A $\approx$ B	expected persistence
29	C, Bt, Bt'	C $\approx$ B	C∧A $\not\approx$ B and C∧A $\not\approx$ ¬B	expected persistence
30	C, Bt, Bt'	C $\approx$ B	C∧A $\approx$ ¬B	expected persistence
31	C, Bt, Bt'	C $\not\approx$ B and C $\not\approx$ ¬B	C∧A $\approx$ B	contingent persistence
32	C, Bt, Bt'	C $\not\approx$ B and C $\not\approx$ ¬B	C∧A $\not\approx$ B and C∧A $\not\approx$ ¬B	contingent persistence
33	C, Bt, Bt'	C $\not\approx$ B and C $\not\approx$ ¬B	C∧A $\approx$ ¬B	contingent persistence
34	C, Bt, Bt'	C $\approx$ ¬B	C∧A $\approx$ B	from exception to normality in case A took place
35	C, Bt, Bt'	C $\approx$ ¬B	C∧A $\not\approx$ B and C∧A $\not\approx$ ¬B	persistence of exceptionality, might be facilitated to A
36	C, Bt, Bt'	C $\approx$ ¬B	C∧A $\approx$ ¬B	persistence of exceptionality

Table 1 briefly outlines the different perceptions that an agent may have about a reported scenario (possibly incompletely stated) depending on what he believes to be the normal course of things in different contexts, and thus what should be expected according to him. In case no particular event A is mentioned in the report, the agent may try to diagnose some A that would facilitate, cause, or justify that B is true or is false in t'.

However, agents may start to argue in favor of causality on a basis slightly weaker than assumed in Definitions 1 and 2, namely only on the basis of a reported

modification of context (from C to C∧A), B becoming false, while the agent believes that C |≈ B, (but not necessarily that C∧A |≈ B, or that C∧A |≈ ¬B). Indeed, argumentation is a dynamical process where arguments and counter-arguments may interact with each other in order to assess a given claim (here, a possible cause). That's why in an argumentation approach a weak view of causality is used. As we shall see, the different cases appearing in Table 1 may give birth to different forms of counter-arguments.

4 Causal Argument

Causal arguments are a particular kind of arguments. They underlie two of the most common, challenging, and difficult questions we confront in our lives: "Why?" and "What if?" When historians debate the causes of a war, when environmentalists speculate on the effects of pollution, and when psychologists study the effects of racism, they are working in the realm of causal argument. That is, they are examining the complex process by which people, forces, events, and other phenomena interact to bring about other phenomena. Although some people may speak of *proving* a causal connection between two things, causal argument is by its very nature highly speculative and prone to mistakes. Part of the difficulty, as any scientist can attest, lies in isolating variables. In other words, when examining the many factors that may have caused an event to occur or the many effects that may be traced back to a cause, we must be careful to determine exactly which ones really are valid. Take, for example, the apparently simple case of the American Civil War. Anyone who has studied this conflict knows that slavery was an important issue that divided the northern and southern states. In the three decades preceding the Civil War, however, America also was experiencing a number of other important phenomena: social upheaval, migration and immigration, technological changes, and even an economic crisis. How can we prove that it was slavery and not one of these other factors that caused the war? The answer is that we can't. Indeed, as in other kinds of arguments, we rarely can prove our causal claims definitively.

Like inductive or analogical reasoning, these causal arguments are based on observed instances. They follow the form of an analogical argument up to one important point: whereas this type of argument carries as part of its premises the assumption that there is no significant difference between previously observed cases and what is known of the situation at hand, causal arguments rather heavily relies on the existence of a particular difference altering the current context and perceived as significant. More precisely, a causal argument is defined in the following way:

Definition 3 (Causal argument scheme)
A "argumentedly" *caused* ¬ B because:

a. Normally, in context C one has B that is true (i.e. C |≈ B)
b. The actual context is C' = C ∧ A (assuming consistency of C and A)
c. In the new context C', ¬B is reported as true.

A is said to be the *relevant or (significant) difference* between the two contexts C and C'. A *caused* ¬B is the *conclusion* of the argument, and points a, b and c constitute the *support* of the argument.

Definition 3 is exemplified by the following example.

Example 1. A bicyclist moves into the traffic lane in order to pass a truck illegally parked in the bike lane. The driver of a car approaching from the rear slams on her brakes in order to avoid hitting the bicycle. A following car fails to stop in time, and smashes into the back of the first.

The bicyclist's insurance company will probably claim that the illegally parked truck caused her client to swerve into the lane of traffic, using the following argument:

Let s = to swerve into the lane of traffic, i = illegally parked truck.

Argument A_1: i caused s because:

a. $C \mid\!\approx \neg s$
b. $C' = C \wedge i$
c. s is true.

As it is well-known in argumentation theory, an argument provides a reason for its conclusion. However, this does not necessarily mean that the conclusion is true. For that purpose, the argument needs to be defended against all its counter-arguments (called also defeaters). In our particular case of causal arguments, defeaters may be built by answering the following critical questions:

I. Does it hold that $C \mid\!\approx B$? Are there cases where $C \wedge \neg B$ holds?
II. Is it really the case that ¬B is true?
III. Is there another A' such that both $C \wedge A'$ and ¬B hold?
IV. Is the difference A pointed out between contexts C and C' relevant (w. r. t. a possible change from B to ¬B)?
V. Does the possible cause A invariably, or at least generally, produce the effect ¬B?

It is worth noticing that answering the above questions amounts to exhibit one or several of the prototypical situations listed in Table 1. For instance, arguments against the causal argument can be built by answering the question 'Does it hold that $C \mid\!\approx B$?' (see point I above). This is the case if we are for instance in situations 7, 8, 9, 16, 17, 18, 25, 26, 27, 34, 35, 36 of Table 1. The point III above is illustrated by an agent who believes $C \mid\!\approx B$ and $C \wedge A \mid\!\approx B$, and thus expresses that he does not understand why the reported sequence C, Bt, At, ¬Bt' took place (case 1 in Table 1). Then pointing out that in fact we are in context $C \wedge A \wedge D$ and that $C \wedge A \wedge D \mid\!\approx \neg B$ holds, would for instance solve the case (case 3 of Table 1).

Let us further illustrate the above ideas through a toy example.

Example 2. Suppose that several persons all get sick after eating a pizza during a party organized by their friend Mary. Moreover, each of them had a fancy hat also.

Let p: eating the pizza; h: wearing a hat, s: being sick, pa: attending a party.

Mary tries to understand what causes the sickness of her friends. She builds the two following causal arguments:

Argument A_2: p caused s because:
pa $|\approx \neg s$ (expressing that generally when we go to a party, we are not sick)
C' = pa $\wedge$ p
s is true.

Argument A_3: h caused s because:
pa $|\approx \neg s$
C' = pa $\wedge$ h
s is true.

Paul, who took part to the party, does not agree with the causal argument A_3 provided by Mary, and presents the following counter-argument that says that having a hat does not cause being sick. Indeed, this argument shows clearly that a part of the intended cause is not "relevant". This refers to the critical point IV.

Argument A_4: h $|\approx \neg s$

Note that the above argument (A_4) is not a causal argument. Indeed, causal arguments may be defeated by other causal arguments, or simply by classical explanatory arguments.
According to Dung (1995), the argument A_3 is defeated by A_4, which is undefeated. Thus, the causal argument A_3 of Mary will be rejected.

Suppose now that the friends learn that their fancy hats were treated by means of some toxic product (to). Then, one can build the following causal argument against A_4.

Argument A_5: to caused s because:
h $|\approx \neg s$
C' = h $\wedge$ to
s is true

It is clear that A_5 defeats the argument A_4, since A_5 shows a situation where one can wear a hat and get sick.

5 Concluding remarks

This paper is only intending to offer a preliminary discussion about two related issues that are both connected with the way agents may understand or not, maybe in a causal way or not, a reported sequence of events. The first issue was to figure out what may be the different types of reaction an agent may have in face of such a sequence, depending on his beliefs on the normal course of things, while the second issue was to discuss the form of causal arguments, where do they come from, and how they may be refuted. Moreover, other related issues such as the use of

argumentation by an agent involved in reported events for presenting these events in a way advantageous for him (as, e. g., in the ongoing work by Boutouhami (2007)) have not been considered. Another important issue is the fact that Dung's acceptability semantics are not sufficient in case of causal arguments, although they are required for a proper development of an argumentative approach to causality assessment.

When arguing about changes that took place in scenarios of the form Bt, At, ¬Bt' (t' > t), and trying to look for responsibility (either for rewarding, or for suggesting guilt), one often uses patterns of hypothetical reasoning of the form: "If A' had taken place, ¬B would not have happened". This covers both situation where A' is an uncontrolled event, as in "if no storm had taken place, there would be no flood", or where A' is an action that had be performed by some agent, as in "if the driver had abstained drinking, he would not have got a fee". In the above two examples ¬B is something undesirable, and A' may be regarded as a cause for it. But similar patterns exist where ¬B is desirable, as in "if Peter had not received a solid education, he would have not succeeded", or in "if embankments had not be built, the flood would have not been avoided". Note that the condition part of the conditional statement may appear either in a positive or in a negative form, both when ¬B is desirable or not: one may say "if the driver had abstained drinking, …" or "if the driver had not drunk, …", as well as "if Peter had not received a solid education, …", or "if Peter had received a poor education, …", depending on what the arguer decides to emphasize. Apart from assessing if such conditionals hold or not, a clearly important issue for further research, when looking for responsibility, is to take into the feasibility, the cost, the permission status of doing, or not doing, A'.

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