Causal argument

Chapter · May 2017

CITATIONS
0

READS
124

3 authors, including:

Ulrike Hahn
Birkbeck, University of London
158 PUBLICATIONS **2,622** CITATIONS
SEE PROFILE

Frank Zenker
Lund University
48 PUBLICATIONS **160** CITATIONS
SEE PROFILE

Causal Argument

Preprint of: Hahn, U., Bluhm, R., and Zenker, F., (2017). Causal Argument. In: Waldmann, M. (ed.). Oxford Handbook of Causal Reasoning (chapter 25). Oxford, UK: Oxford University Press (DOI: 10.1093/oxfordhb/9780199399550.013.26; ISBN: 9780199399550).

Ulrike Hahn*

Dept. of Psychological Sciences

Birkbeck, University of London

u.hahn@bbk.ac.uk

Roland Bluhm

Berlin, Germany

academic@rolandbluhm.de

Frank Zenker

Department of Philosophy & Cognitive Science

LUX, Lund University, Box 192, 221 00 Lund, Sweden

Universität Konstanz, Philosophie

Postfach D9, 78457 Konstanz, Germany

frank.zenker@fil.lu.se

*corresponding author

Wordcount: 12,450

Abstract

In this chapter, we outline the range of argument forms involving causation that can be found in everyday discourse. We also survey empirical work concerned with the generation and evaluation of such arguments. This survey makes clear that there is presently no unified body of research concerned with causal argument. We highlight the benefits of a unified treatment both for those interested in causal cognition and those interested in argumentation, and identify the key challenges that must be met for a full understanding of causal argumentation.

1. Introduction

Although causality is fundamental to human cognition in many different ways, a review of theoretical work in argumentation studies and cognitive science suggests that 'causal argument' remains ill-understood. This holds for both senses of the term 'argument': argument as a situated process of actors engaged in an actual dispute, on the one hand, and, on the other, the essential component of such a dialectical exchange, namely arguments as individual claims and reasons for those claims. In particular, surprisingly little psychological research has been devoted to how people construct, process, and evaluate causal arguments in this latter sense of 'argument', that is, individual arguments in the sense of abstract inferential objects comprising premises and conclusions.

Nevertheless there are a number of independent strands of research involving causation and argument. The goal of this chapter is to bring these currently separate bodies of work together in order to provide a coherent basis for future empirical research on causal argument that elucidates the dialectical and inferential role of cause-effect relationships in reasoned discourse. Such a programme has immediate implications for what is a central aspect of everyday argumentation, and thus a central aspect of our everyday lives. Consequently, an improved understanding of causal argument should benefit directly a range of areas such as reasoning, argumentation, learning, science comprehension and communication, to name but a few.

However, insight into causal argument seems beneficial also for those projects within cognitive science aimed at understanding what 'cause' actually is, both normatively and in lay people's understanding. Causal argument, we will seek to show, thus not only constitutes an important topic for research in its own right, but can also provide new impetus to the many, more familiar, aspects of human behaviour and cognition concerned with causality, such as causal learning (see Chapters Rottman: this volume, Le Pelley, Griffiths & Beesley: this volume) or causal inference (see Chapter Griffiths: this volume).

2. 'Because': Reasons as Causes versus Causes as Reasons

The comparative scarcity of research on causal argument relative to work on causal learning or causal inference may surprise, since few topics seem to be more intimately related than argumentation and causation. This is nowhere more apparent, perhaps, than in the term 'because' itself. While it marks causal relations in the empirical world (e.g., 'Socrates died because the jury had him drink poison'), the same term is used more generally to identify justificatory and explanatory *reasons.* Imagine, for example, an argument about whether or not Jones killed Smith. Questions about Jones might be answered by stating something like 'we know it was Jones, not his wife, who killed Smith, *because* Miller saw him …'. The word 'because', here, signifies a relation of evidential support.[1] To the extent that such evidential uses of 'because' themselves imply a causal relation, that causal relation pertains to human beliefs and the relationships between them (i.e., knowledge of Miller's testimony should change our beliefs) as well as between beliefs and world (e.g., Miller's testimony 'I saw Jones kill Smith' is putatively caused by Miller witnessing that Jones killed Smith). In short, causes can provide reasons, and reasons can provide causes.

Both of these aspects are central to an understanding of 'causal argument'. The main function of argumentation as we use the term here is to effect changes in beliefs (e.g., Goodwin, 2010; Hahn, 2011; Hahn & Oaksford, 2012), specifically changes in beliefs that may be considered to be rational (as contrasted with 'mere persuasion'). Understanding causal argument therefore involves both asking to what extent causal arguments *should* change people's beliefs and how successful they actually are in changing people's beliefs.

This chapter introduces relevant work on both of these questions. Understanding people's responses to causal arguments, both from a normative and a descriptive perspective, requires understanding what those arguments typically are. The natural starting point for investigation is thus the typical argument forms that involve aspects of causation found in eve-

[1] This duality—of reasons as causes for belief, and causes as reasons in argumentation—is not limited to English, and can also be discerned in other languages such as German 'weil'; Swedish 'darför', French 'parce que', Italian 'perque', Spanish 'porque', Polish 'ponieważ', Russian 'potomú čto', Chinese 'yīn', Japanese 'kara', … .

ryday life, and we describe present findings on this in the next section. The material of that section—'Arguments for causes and causes for arguments'—reflects the reasons/causes duality just described, as people argue in everyday life both *about* causes and use causes as arguments *for* particular claims. This initial consideration of types of causal arguments is then followed by examination of what literature there is on how people actually respond to causal arguments. The chapter concludes with a research agenda for future work on causal argumentation.

3. Arguments for Causes and Causes for Arguments

When asked to provide reasons why something has happened, might happen, or should happen, the term 'because' will soon arise. Similarly, we suspect, few disagreements (scholarly ones included) last longer than those about causes. In brief, causality is as ubiquitous in argumentation as it is difficult to understand fully the causal structure of the real world.

It seems reasonable to suppose that the language of causal arguments is intimately related to the cognition of causal relations in the world, and to the way people think about causal structure. As things stand, however, "[t]hough basic to human thought, causality is a notion shrouded in mystery, controversy, and caution, because scientists and philosophers have had difficulties defining when one event *truly causes* another" (Pearl, 2009, pg. 401). A paradigmatic example of these difficulties is J. L. Mackie's (1965) conceptual analysis of 'cause' as "an insufficient but necessary part of an unnecessary but sufficient condition (INUS)"—which, at least in initial reading, seems as difficult to understand as the notion it is trying to unpack.[2] Such conceptual difficulties in clarifying the basic concept are likely to be

[2] Mackie's statement reflects a widely shared understanding of causes as partial conditions of their contingent effects, and seeks to convey—in a great hurry—that (i) causes bring their effects about only under suitable background conditions, so that causes alone are not sufficient for their effects; (ii) that an effect cannot occur without its cause, so that causes are nevertheless necessary; (iii) that cause plus background conditions (and perhaps other things) together

reflected in actual discourse whenever ‘cause’ and related terms such as ‘effect’ are used argumentatively.

In order to examine causal argument, however, one need not start with a clear theoretical notion of ‘cause’. Instead, studying causal argument may itself be informative of laypeople’s underlying conception of ‘cause’, and thus provide raw material for both theoretically refined notions of ‘cause’ and for the psychology of causal cognition. Rather than first elucidate the notion of cause in an abstract manner, we thus start from a survey of causal argument types arising in everyday speech as they have been identified both through corpus analysis and in the argumentation literature. Only with a sense of the range of kinds of causal arguments is it possible to start addressing questions of their cogency and actual persuasiveness, and to examine possible implications of causal argument for an understanding of the notion of ‘cause’ itself.

3.1 Causal argument patterns from corpus analysis

Based on an analysis of corpora of natural language text, Oestermeier & Hesse (2000) provided an extensive typology for causal argument. Their categories rest on “the basic argumentative moves of defending, attacking, and qualifying claims” (2000, pg. 68). For each type, this typology

> “specifies three *types of premises* involved in causal arguments: Observational (i.e. spatial, temporal, or episodic), explanatory (i.e. intentional or causal), and abstract knowledge (i.e. conceptual knowledge about criteria for causation) […] [along with] the *inference patterns* which are needed to come up with a causal conclusion, namely, inferences from observations, generalizations, comparisons, mental simulations, and causal explanations” (2000, pg. 68).

---

constitute a condition, C, yielding the effect—thus making C a sufficient condition, since C cannot be a necessary condition (iv) as contingent effects can be alternatively conditioned.

Arguments for causal claims (pro-types) (pro-types)	**Arguments against causal claims (con-types)**	**Arguments qualifying causal claims**
Circumstantial evidence Spatio-temporal contiguity Co-occurrences Similarity of cause and effect	*Circumstantial counter evidence* Wrong temporal order No contact Free decision	*Causal complexities* Partial cause Indirect cause Common cause
Contrastive evidence Covariation Statistical covariation Before-after-comparison Experimental comparison Counterfactual vs. factual (conditio sine qua non)	Insufficient cause Unnecessary cause	Interaction Mix-up of cause and effect
Causal explanations Causal mechanism No alternative Typical effect	*Alternative explanation* More plausible alternative *Insufficiency of evidence* Fallacy post hoc ergo propter hoc Low force of statistical data Low force of single cases Unknown mechanism	*Causation without responsibility* No intention

Fig. 1: Types of arguments for causal claims (pro, con, qualifier); italicized terms name types of pro-evidence (circumstantial, contrastive, causal explanatory), types of con-evidence ([cir-

cumstantial] counterevidence, alternative explanation, insufficient evidence) and types of qualifiers (causal complexities, causation without responsibility); adapted from Oestermeier & Hesse (2000, pp. 69).

Fig. 1 shows Oestermeier and Hesse's basic typology (stripped of the examples and historical references they provide). This typology features eleven *pro* types (arguments offered in defence of a causal claim), ten *con* types (arguments which attack a causal claim), and six *qualifying* types (which refine a causal claim). For example, 'wrong temporal order' is a type of argument advanced against a causal claim. The premises of such an argument consist of episodic knowledge about the observed temporal order of the events *A* and *B.* These premises support an inference to the effect that *A* has not caused *B* because *A* happened after *B*, as in the example: "The server problems have not caused your system crash, the server problems occurred afterwards" (for examples of all types listed in Fig. 1, see Oestermeier & Hesse, 2000).

In the texts analysed by Oestermeier and Hesse, these types varied considerably in prevalence. The vast majority of instances of causal argument in the corpora analysed by Oestermeier and Hesse were of the causal mechanism type (78.2%). These are arguments that cite, and so seek to explain through, a causal mechanism. Structurally, these take the form '*A* caused *C* because *A* led to *C* via the process/mechanism *B*'. For example: "His anger caused the accident. It affected his concentration."

After causal explanations, the next most numerous type accounts for a mere 3.9% (!) of the total number of causal arguments in their corpus (Oestermeier & Hesse, 2000, pg. 76). Given the pervasiveness of the causal mechanism type, one might ask whether Oestermeier and Hesse's typology is fine-grained enough, or whether causal mechanism arguments should be further divided into sub-types. At the same time, however, Oestermeier and Hesse's notion of causal argument (and hence their typology) is limited to causal claims or conclusions (e.g. "smoking causes cancer") and the premises (reasons) offered to support those causal claims (e.g. "because smokers have a much higher risk of getting cancer"). However, research within

argumentation theory, described next, shows that everyday discourse features not only arguments *about* causes, and causal explanations, but also arguments *from* causes.

3.2 Scheme-based approaches

A long-standing tradition within argumentation theory has likewise sought to devise a typology of causal argument, though based on less systematic descriptive procedures than Oestermeier and Hesse's (2000) corpus analysis. Argument types, in this tradition, are referred to as schemes. The specific schemes identified by this tradition overlap only partially with those identified by Oestermeier and Hesse, so that a complete typology will need to consider both.

In contrast to basic corpus analysis, the so-called *scheme-based approach* to argumentation not only seeks to describe different types of informal argument schemes; it also pursues normative questions concerning their use. In other words, it seeks to provide guidance on which arguments *should* convince (on normative foundations for argumentation theory see Corner & Hahn, 2013). Hence, much of the extant work on causal argument in argumentation theory has remained tightly connected to classical fallacies such as *post hoc propter* hoc (inferring cause from correlation) and slippery slope argument (more on these below). To provide normative guidance, authors typically associate 'critical questions' with schemes in order to allow evaluation of the quality of particular instances. This tradition thus feeds directly into the burgeoning, applied literature on critical thinking (e.g., Inch & Warnick, 2009; but see also Hamby, 2013, and Willingham, 2007, for a critical perspective on this literature).

The central status of causal argument in everyday argument is reflected in the typologies of the scheme-based tradition. For instance, Garssen (2001) views causal arguments as one of three top-level argumentation schemes ('symptomatic argumentation', 'argumentation by analogy', and 'causal argumentation'), and maintains that *all* other schemes found in everyday informal argument are reducible to these three.[3] However, the scheme-based tradition

[3] These three types, and with them the critical questions associated with each, may partially overlap. For instance, as Hitchcock and Wagemans (2011, pg. 193) point out, a fever can both be viewed as an effect and as a symptom of the infection that causes it. Hence, an argument

itself is fairly heterogeneous and has produced a number of competing classification schemes which vary considerably in the number of basic schemes (argument types) assumed, ranging from 3 (as in Garssen, 2001) to 60 in Walton, Reed and Macagno (2008).

Walton et al.'s (2008) volume is certainly the most comprehensive treatment within the scheme-based approach, and has sought to amalgamate all individual schemes found in the prior literature, yet Oestermeier and Hesse (2000) include schemes not found in that treatment. There are thus continuing theoretical questions about what *should* constitute a separate argument scheme and how many distinct schemes there are, a question that is unlikely to be independent of the intended use of the typology (see also Hahn & Hornikx, in press, for discussion of principled scheme typology).

In the following, we provide a brief overview of the causal schemes identified within the scheme-based literature, following, by and large, Walton et al. (2008).

First, the seminal work in the scheme-based tradition, Hastings (1962), distinguishes two basic types of causal argument: argument from *cause to effect*, and its converse from *effect to cause*. Hastings sees both as involving further sub-schemes. For the first type, cause to effect, he distinguishes the sub-schemes 'prediction on the basis of existing conditions', referring to an argument whose conclusion states that certain events will occur, and 'causal argument based on a hypothetical', which concerns conclusions that would or will obtain (e.g., 'if we were to adopt the proposal, the budget would be overdrawn'). As Hastings notes, the hypothetical sub-scheme appears to be the more common version of the argument, and hypothetical causal arguments are particularly prevalent in policy debates.

For the second basic type of causal argument, effect to cause, a close relation obtains to two sub-schemes that Hasting's calls 'sign reasoning' (e.g., 'there are bear tracks, so there is a bear around'), and 'argument from evidence to a hypothesis', both of which typically involve causes. From this very general perspective, then, *most* arguments about facts are likely to be causal arguments.

---

from effect to cause—here: from fever to infection—may instantiate the symptomatic *or* the causal argumentation scheme, and possibly even both at the same time.

For the argument from cause to effect, Hastings (1963, pg. 74) states four critical questions that are assumed to be relevant regardless of the specific sub-type:

a) Does the cause have a valid causal relation with the effect? That is, is it the true cause?

b) How probable is the effect on the basis of the correlation?

c) Is the cause a sufficient cause to produce the effect?

d) Are any other factors operating to interfere with the production of the cause?

These questions reflect Hastings' view, formed on the basis of text analysis, that real world causal arguments are typically complex, involving many causal and correlational sub-components. It is also for this reason, or so Hastings speculates, that causal generalizations invoked in real-world causal arguments are rarely provided with explicit argumentative support. He consequently describes an assertion such as 'if the government nationalised industries, poor planning of the operation of those industries will ensue', for instance, as a claim with "many elements with varying probabilities" (1962, pg. 72), rather than a claim about a fully fleshed out causal model. It may be that in many, or even most, real-world contexts, people's causal models are rather sparse. This aspect seems important to any more detailed normative considerations about causal arguments in everyday life.

We next describe in more detail different types of causal argument schemes both for cause-to-effect and effect-to-cause.

3.3 From cause to effect

Since Hastings, many authors have included some form of argument from cause to effect within their basic classification of argumentation schemes (e.g., Perelman & Olbrechts-Tyteca, 1969; van Eemeren & Kruiger, 1987; Walton, 1996; Grennan, 1997; Kienpointner,

2002; Prakken & Renooij, 2001). What varies across these authors' work is their characterization of the nature of the scheme and how, if at all, it may be formalised.

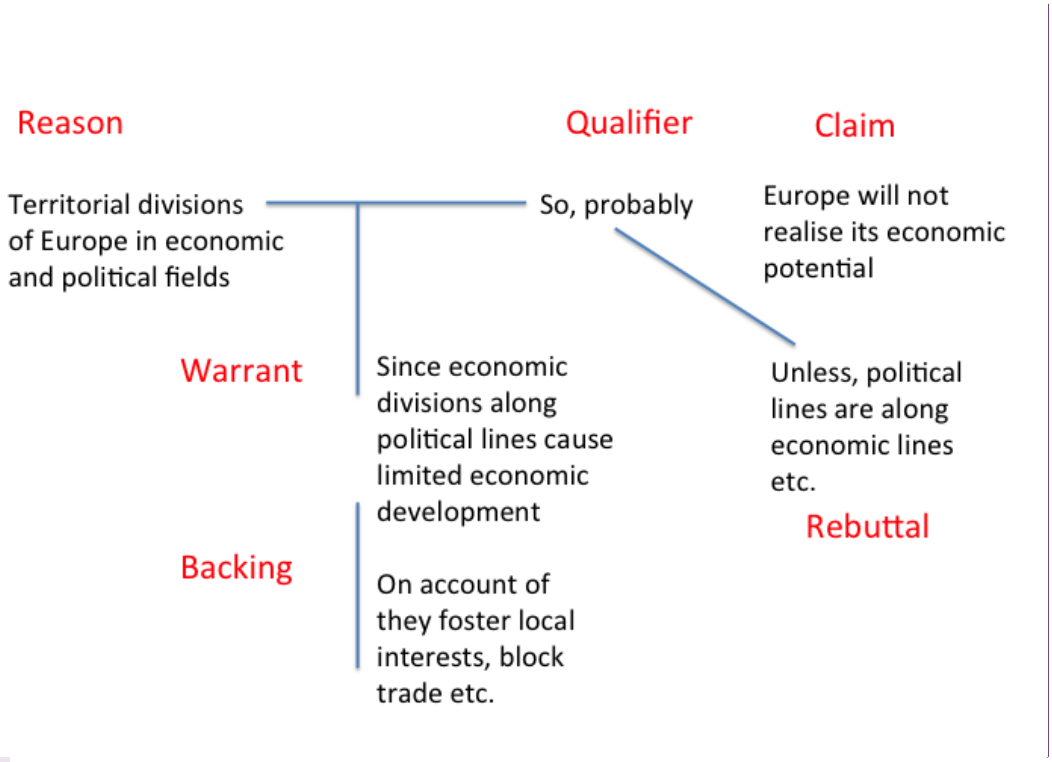
Hastings (1962), Walton (1996), or Grennan (1997), for instance, use Toulmin's (1958) framework to characterise informal argument, which has been popular also in the context of studying the development of argumentation skills (Kuhn, 1991). Toulmin's framework rests on the insight that classical logic has little to say about everyday informal argument, which must typically deal with uncertainty. As a more appropriate model Toulmin suggested the inherently dialectical argumentation between two opposing parties in a courtroom.[4] Following from this, Toulmin outlined a general format for representing arguments (Fig. 2). Arguments are broken down in to the basic components of 'claim' (the conclusion to be established), 'data' (the facts appealed to in order to support of the claim), 'warrants' (reasons that support the inferential link between data and claim), 'backing' (basic assumptions that justify particular warrants), 'rebuttals' (exceptions to the claim or the link between warrant and claim) and, finally, 'qualifiers' (indications of the degree of regularity with which claim may be stated, such as 'certain', 'highly probable', 'rare').

Fig. 2 shows an example argument from cause to effect analysed by Hastings (1962, pg. 67) in this way. This argument, taken from a speech by U.S. president Dwight D. Eisenhower, runs as follows:

> "Europe cannot attain the towering material stature possible to its people's skills and spirit so long as it is divided by patchwork territorial fences. They foster localized instead of common interest. They pyramid every cost with middlemen, tariffs, taxes, and overheads. Barred, absolutely, are the efficient division of labor and resources and the easy flow of trade. In the political field, these barriers promote distrust and suspicion. They served vested interests at the expense of peoples and prevent truly concerted action for Europe's own and obvious good." (quote taken by Hastings, 1962, from Harding (1952, 532).

[4] For a critical evaluation of the import of legal concepts into argumentation theory, in particular the central notion of 'burden of proof', see Hahn & Oaksford (2007b).

This framework provides a potentially useful way of identifying the various components of an overall argument, and has consequently been widely used in psychological research on the development and pedagogy of argument skills (see e.g., van Gelder, Bissett, & Cumming, 2004; von Aufschaiter, Erduran, Osborne, & Simon, 2008). On its own, however, it does little to provide an evaluative framework for everyday informal argument that might rival classical logic. Arguably, an argument might be better if a warrant is provided, than if it is not (see Kuhn, 1991, and below), but the Toulmin framework itself offers no grounds for a judgment on whether the warrant itself is more or less compelling.



[FZ1]

Fig. 2: Hastings' (1962) Toulmin diagram of an argument from cause to effect taken from a speech by Dwight Eisenhower. Full quote in text above.

It is clearly desirable to have a normative account of argument, that is, an account that tells us how we should argue, and what arguments we, as rational agents, *should* find compelling and which ones weak. Classical logic sought to provide such a normative standard for 'good argument'; Toulmin's diagnosis of its weakness in the context of everyday argument is right,

but his framework does not provide a more suitable replacement. Somehow, an evaluative, normative perspective must be able to engage with the actual content of claim, data, warrant and backing, not just their structural relationships *per se*. Indeed, in its structural orientation Toulmin's model ultimately shows the same limitations as the framework of classical logic that it seeks to replace.

Subsequent authors have therefore tried to introduce a stronger normative component via critical questions. They have also tried to formalise adequately the type of inference involved in order to bring out more clearly normative aspects of causal argument. Within the scheme-based tradition, the point of departure for such attempts has typically again been a *dialectical* perspective. Such a perspective tries to bring together the two different senses of 'argument' identified in the Introduction in order to evaluate arguments. It maintains that argument must be understood in the context of wider, dialectical exchange., that is, 'argument', in the narrow sense of an inferential object, can be evaluated properly only by reference to the wider argumentative discourse ('argument' in the wider sense) in which it occurs (e.g., van Eemeren & Grootendorst, 2004).

More specifically, the basic premise underlying much of the more recent work within the scheme-based tradition is that an argument such as that from cause to effect can be treated as containing a *defeasible generalization* (Walton, 1996; Walton et al., 2008), as indicated by the quasi-quantifier 'generally' (echoing Hastings' point that causal generalizations are typically not references to fully fleshed out causal models):

> Generally, if A occurs then B will (might) occur.
>
> In this case, A occurs (might occur).
>
> Therefore, in this case, B will (might occur)

From a formal perspective, however, this is not to be read as a probabilistic *modus ponens* (as in, e.g., Oaksford & Chater, 1994; Edgington, 1995; Evans & Over, 2004; a more detailed discussion of probabilistic modus ponens will follow below). Instead, authors within

the scheme-based tradition take this to be a *defeasible argument* (in the narrow sense) which is embedded in a (potential) series of dialectical moves (i.e., an argument in the wider sense). where, once a proponent has raised the argument, it is the respondent's task to reply either by challenging a premise, asking an appropriate critical question, or accepting the argument. Whether or not an argument ultimately "goes through," depends crucially on the allocation of the burden of proof (see, e.g., Walton, 1988; but also Hahn & Oaksford, 2007b). Raising critical questions may shift the burden of proof, so that the defeasible conclusion can no longer be maintained unless further evidence is provided.

While this provides a semi-formal rendition, at best, work in Artificial Intelligence (AI) over the last decade has sought to embed such an approach within more well-defined systems of non-classical logic (e.g. Prakken & Renooij, 2001; Gordon, Prakken & Walton, 2007). Much of this computational work on defeasible reasoning and argumentation has been driven by the belief that a probabilistic approach would be inadequate or impossible. Tthis work has generally ignored probabilistic treatments of conditional inferences such as m*odus ponens* (e.g., Oaksford & Chater, 1994). However, these burden of proof based approaches have recently been explicitly contrasted with Bayesian, probabilistic approaches to argumentation more generally (e.g., Hahn & Oaksford, 2006, 2007a; Hahn, Oaksford & Harris, 2013; Hahn & Hornikx, in press) and we will see positive examples of probabilistic treatments of such generalizations below.

Concerning the nature of the generalization from which a defeasible argument about causation is to unfold, Walton et al. (2008) provide several alternative bases for that generalization (where Si is the cause and Sj the effect):

1. *Regularity*: Sj regularly follows Si.
2. *Temporal Sequence*: Si occurs earlier than (or at the same time as) Sj.
3. *Malleability*: Si is changeable/could be changed.

4. *Causal Status*: Si is a necessary or sufficient or INUS condition of Sj.[5]
5. *Pragmatic Status*: Pragmatic criteria, like voluntariness or abnormality, may single out a cause.

The purpose of these clauses is to serve as operative criteria in reasoned discourse such that:

> "in any given case, the proponent of a causal argument can select one of these clauses as representing the kind of rule [s]he has in mind as representing the sort of claim [s]he is making […]. [I]t should be possible to make all or any of these claims, and so the analysis of causal argumentation schemes should permit all three possibilities." (Walton et al., 2008, 185)

Notice that clause 4 allows for causal over-determination, that is, cases where causes are *sufficient but non-necessary* for their alleged effects, that is, the effects may be brought about by one or more of several sufficient causes. Here, at the very latest, it becomes clear that the normative project concerning the evaluation of causal arguments must necessarily engage in the question of what a cause is.

While clauses 1 to 4 more or less repeat standard criteria from work on causation within philosophy of science, clause 5 references pragmatic factors to also include the wider context of causal argument. Walton et al. motivate this by reference to causal argument in law

[5] Clause 4 gives three different kinds of conditionals, or rules of inference or warrant, each of which is hedged by a *ceteris paribus* clause. The necessary condition is: if Si would not occur, then Sj would not occur; the sufficient condition states: if Si would occur, then Sj would occur; and the INUS condition reads: if Si would occur within a set of conditions, each of which is necessary for the occurrence of Sj, then Sj would occur (see above Footnote 2 on Mackie's INUS condition).

(e.g., Hart & Honore, 1985) where particular types of causes are most relevant, most notably *voluntary* human actions which are singled out from the overall causal chain of events in order to assign various responsibilities to agents. This echoes Pearl's (2009, pg. 401) observation that, at least since Aristotelian scholarship, causality has served a dual role: causes are both "the target of credit and blame" on one hand, and "the carriers of physical flow and control on the other." Both aspects figure prominently in causal arguments. Indeed, it presently remains unclear whether there is a single, unitary notion of causality that suffices for both aspects, or whether seemingly competing accounts of causation such as counter-factual accounts (Lewis, 1973; see Bennett, 2003 for a review) and generative accounts (Dowe, 2000; Salmon, 1984) are in fact both involved in human causal judgments, albeit to different ends (see also Walsh, Hahn & DeGregorio, 2009; Illari & Russo, 2014). Similarly, it is unclear whether domains such as law posses notions of causality that differ from those of the physical or social sciences (see, e.g., Honore, 2010, for discussion and further literature; see also Lagnado & Gerstenberg, this volume). Closer textual analysis of real-world arguments, in law and elsewhere, should be informative here.

3.4 Argument from consequences

Finally, there is a type of argument from cause to effect that seems both practically important and prevalent enough to be discussed separately: namely the so-called argument from consequences. The argument from consequences is a type of what Hastings (1963, see above) calls 'hypothetical causal argument', Such an argument seeks to promote or deter from a particular course of action on the basis of that action's putative consequences. This type of argument forms the basis of much practical reasoning, that is, reasoning about what to do:

Argument from consequences

Premise: If A is brought about, good (bad) consequences will plausibly occur.

Conclusion: Therefore A should (should not) be brought about.

Within the scheme-based tradition, a number of closely related practical reasoning schemes are distinguished, such as a general scheme for 'practical inference' (I have goal X, Y realizes X, I should carry out Y; see Walton et al., 2008, pg 323; or similarly, the 'argument from goal', Walton et al., 2008, pg 325; Verheij, 2003) and a number of special cases of the argument from consequences feature prominently in the traditional catalogue of fallacies, such as the argumentum *ad misericordiam* (see e.g., Hahn & Oaksford, 2006), which uses an appeal to pity or sympathy to support a conclusion, or the argumentum *ad baculum*, an argument from threat (see also Walton, 2000), or slippery slope arguments (more on these below). For the argumentation theorist, these different subtypes may each hold interest in their own right (or at least it will be of interest whether or not these subtypes do, in fact, merit conceptual distinction because they actually raise normative and empirical issues of their own, see also Hahn & Hornikx, in press).

Common to consequentialist arguments is that valuations are central to their strength. Consequentialist arguments (see, e.g., Govier, 1982) about the desirability of a particular event, policy, or action rest not only on the probability with which a cause (a hypothetical action) will bring about a particular consequence (the action's effect), but also on the utilities of both the action and the desired/undesired future consequence. The strength of an argument from consequences, therefore, is properly determined by considerations of probability *and* utility. For example, when the relevant consequence of a given action under debate is (perceived to be) more or less neutral, this gives few grounds to in fact take that action, even if the consequence itself is almost certain to obtain. Likewise, if the consequence of an action is highly undesirable, that is, has a high negative utility, this will give few grounds to *not* avoid the action, even if the probability that this consequence will obtain is almost zero.

Given that consequentialist arguments are about action, it is unsurprising that they align well with Bayesian decision theory (Ramsey, 1931; Savage, 1954), which identifies optimal courses of action through the multiplicative combination of probability and utility. A number of authors have pursued a decision-theoretic approach to consequentialist argument (e.g., Hahn & Oaksford, 2006, 2007a; Evans, Neilens, Handley & Over, 2008; Elqayam et al.,

2015), including empirical examination of people's subjective valuations of argument strength for such arguments. This work will be described in more detail in our survey of experimental work below.

3.5 From effect to cause

What then of arguments from effects to causes? As noted above, a number of schemes concerning inference from data to a hypothesis are pertinent here, whether the hypothesis be a causal generalisation or an individual event. Most authors in the scheme-based tradition have included some form of 'argument from sign' and/or from 'evidence to hypothesis' (see Walton et al., 2008, for further references). At the most general level (where the hypothesis may be of any kind, causal or otherwise) such arguments seem well-captured by Bayesian inference (see also Hahn & Hornikx, in press), though there are also theoretical and empirical questions here about the relation of such inference to abduction and inference to the best explanation (e.g., van Fraassen, 1989; Lombrozo, 2007; Weisberg, 2009; Schupbach & Sprenger, 2011; Lombrozo, this volume). The fact that these inferences concern putative causes, however, puts them in the remit of causal learning (see e.g., Chapter Rottmann, this volume). An important project would thus be to square psychological results on causal learning with the types of arguments people entertain when seeking to identify putative causes. Chief among the "specialist" arguments seeking to identify causation is the classic fallacy of 'inference from correlation to cause' which we discuss next.

3.6 Correlation and the Bayesian approach to argument strength

Putative fallacies, or 'arguments that seem correct but are not' (Hamblin, 1970), or that 'seem to be better arguments of their kind than they in fact are' (e.g., Hansen, 2002; Walton, 2010), pervade everyday informal argument. Catalogues of fallacies (originating with Aristotelian scholarship) have been the focus of longstanding theoretical debate, and a full understanding of the fallacies has remained a central concern to philosophers, communication scholars, logicians, rhetoricians and cognitive scientists interested in argument.

A staple of the traditional fallacies catalogue is the 'inference from correlation to cause', known by its Latin name as the '*post hoc* fallacy', as in *post hoc, ergo propter hoc* (which roughly translates as 'after this, hence because of this'), or relatedly '*cum hoc ergo propter hoc*' fallacy (Latin for 'with this, therefore because of this'). In more modern terms, this is normally stated as: 'there is a positive correlation between A and B (premise), so A causes B (conclusion)'. As a (fallacious) example, one may consider the— (now debunked—) claim that MMR vaccination causes autism– a spurious link that could arise due to the temporal of MMR vaccination and the emergence of overt signs of autism.

The relevant argument scheme has been associated with the following critical questions (see Walton et al., 2008):

CQ1: Is there really a correlation between A and B?

CQ2: Is there any reason to think that the correlation is more than a coincidence?

CQ3: Could there be some third factor, C, that is causing both A and B?

These critical questions reflect the general appreciation that, although they are not deductively valid (i.e., their conclusions are not logically entailed by the premises), such arguments nevertheless can be, and often are, reasonable inductive inferences. Such arguments, then, need not be 'fallacious' in any stronger sense than lack of logical validity (and logical validity itself is no guarantee that an argument is strong, as the case of circular arguments demonstrates, see, e.g., Hahn, 2011). Moreover, this lack of logical validity is a feature that they have in common with the overwhelming majority of everyday arguments, since informal argument typically involves uncertain inference. The argument scheme approach thus highlights a characteristic aspect of most fallacies within the catalogue: depending on their specific content, instances of these arguments often *seem* quite strong in the sense that their premises lend inductive support to their conclusions.

Exceptions and content-specific variation have generally plagued theoretical attempts to provide a comprehensive formal treatment that explains why fallacies make for "bad" ar-

guments of their kind on specific occasions of their use. The logical structure of these arguments cannot be the key, however, because versions of the same argument form, and hence the same logical structure, differ in relative strength. Variations in strength must be due to content specific variation, and so require a formal framework such as probability theory (as an intensional formal system, see Pearl, 1988), which makes reference to content. From a probabilistic perspective, then, the allegedly fallacious arguments that were historically tabulated as fallacies are typically not fallacious *per se*. Rather, specific instances are weak due to their specific content, and probabilistic Bayesian formalization brings this to the fore (see e.g., Oaksford & Hahn, 2004; Hahn & Oaksford, 2006, 2007a; and, specifically in the context of logical reasoning fallacies, Oaksford & Chater, 1994; Korb, 2004).

For the argument from correlation to cause, a probabilistic perspective can go beyond the three simple critical questions offered in the scheme-based tradition. Specifically, a wealth of statistical techniques for inferring causation from essentially correlational data have been developed: learning algorithms for causal Bayesian Belief Networks and structural equation modelling (see e.g., Pearl, 2000) provide salient examples (see also, Rottman, this volume). These techniques seek to learn causal models from data and, as part of this, provide evaluation of how good a given causal model is as a description of available data, thus providing measures of how convincing a particular inference from correlation to cause actually is.

An important, practical project for future work would be to try to distil insights from such techniques into 'critical questions' that can be readily communicated in everyday settings.

3.7 Summary

In concluding the overview of types of causal arguments, it is worth drawing attention to several aspects of present typology. First, it is notable how varied and diverse causal argument is, reflecting the central role considerations of causality take in human thinking. Notable also are the differences between attempts at systematization: the typology drawn from corpus analysis (Sect. 3.1 above) is much richer than the scheme-based literature concerning evidence

for causes themselves. At the same time, the scheme-based tradition makes clear how much arguing *from* causes there is, and that causal argument is not only often hypothetical or counter-factual, but also makes reference to the utilities of putative outcomes in the service of deciding on courses of action. This suggests that a pre-dominant focus within the causal cognition literature on causal learning will arguably miss important aspects of causal cognition, and it sits well with recent attempts to move the focus of psychological research on causal cognition beyond some of the dichotomies that have dominated the field in the past (see also Oaksford, this volume, and Gerstenberg & Lagnado, this volume).

At the same time, it is clear that much work remains to be done at the theoretical level of typologies. For one, a single, integrated typology of causal argument would seem desirable. It is only when one has a clear overview of a target phenomenon that one can hope to build adequate theories of it. Typologies aim at both completeness and systematization. The former determines the scope of a theory, the latter goes hand in hand with theory development itself, because systematization is about discerning patterns or crucial dimensions of variation across cases. Consequently, the mere fact that there is no comprehensive, systematic typology of causal argument illustrates that causal argument is still poorly understood. Both traditions surveyed here still appear to underappreciate the variety of causal argumentation "out there": the fact that there is comparatively little overlap between Oestermeier and Hesse's (2000) analysis and the large, scheme-based compendium of Walton et al. (2008) raises the possibility that there are further types of causal argument that both have missed.

Finally, it is apparent that much of the research on types of causal argument also has explicitly normative concerns. Normative considerations are valuable, not only because they afford standards of comparison for rational, computational analysis of human behaviour (see e.g., Anderson, 1990; and in the context of causation specifically e.g., Griffiths & Tenenbaum, 2005; Sloman & Lagnado, 2005), but because the quality of people's everyday thinking and arguing is of immediate practical concern. The emphasis within the scheme-based tradition on 'critical questions' and the explicit links to improving critical thinking and argument reflects a worthy goal. At the same time, however, the above survey makes clear the diversity of nor-

mative approaches that presently prevails, ranging from the informal to formal, and spanning non-classical logics as well as probability theory. A unified perspective would clearly be desirable. Before returning to normative issues in the final section of this chapter, however, we next survey the extent of empirical work on causal argument.

4. Causal Argument and Cognition

While there is little empirical work under the header of 'causal argument' per se, the breadth of causal argument-types identified above, and the importance of causality to our everyday reasoning, suggest there should nevertheless be considerable amounts of relevant psychological research. And, on closer inspection, there is a sizeable body of research whose investigative topic is reasoning or argumentation that happens to involve causality. In particular, investigations of causal arguments and people's ability to deal with them are reported in the literature on the development of argumentation skills, on science arguments, as well as consequentialist argument and reasoning. In the following we provide brief examples of each.

4.1 Causal conditionals

Reasoning with conditionals, particularly *logical* reasoning with conditionals, is a topic of longstanding research within cognitive psychology (see e.g., Oaksford & Chater, 2010a for an introduction). Within this body of work one can find a number of studies investigating conditionals—that is, 'if … then statements'—and potential logical inferences from these for specifically causal materials.

Most of this research has centred on four argument forms: *modus ponens* (MP), *modus tollens* (MT), *affirming the consequent* (AC) and *denying the antecedent* (DA) – exemplified in Table 1 below. Only two of these—MP and MT—are logically valid, that is, when their premises are true, the truth of their conclusions follows by logical necessity. However, the longstanding finding is that people fail to distinguish appropriately between the different schemes when asked about logical validity (e.g., Marcus & Rips, 1979). Moreover, for conditional inference and other forms of logical reasoning such as syllogistic reasoning, there are

countless demonstrations that people's inferences are affected not just by the formal (logical) structure of the inference, which is the only relevant aspect for their validity, but also by specific content (e.g., Evans, Barston, & Pollard, 1983; Oaksford, Chater & Larkin, 2000).

Table 1. Key forms of inference involving conditionals

	Informal	Classical Logic	Logically valid?
Modus ponens (MP)	If p, then q p therefore, q	$p \rightarrow q$ p |-- q	yes
Modus tollens (MT)	If p, then q Not q Therefore, not p	$p \rightarrow q$ $\neg q$ |-- $\neg p$	yes
Denying the antecedent (DA)	If p, then q Not p Therefore, not q	$p \rightarrow q$ $\neg p$ |-- $\neg q$	no
Affirming the consequent (AC)	If p, then q q Therefore, p	$p \rightarrow q$ q |-- p	No

Much of the empirical and theoretical debate about conditional reasoning has focussed on the issue of the appropriate normative standard against which participants' responses should be evaluated. Classical logic renders natural language 'if ..then' as the so-called material conditional of propositional logic, and much early research on logical reasoning within psychology adopted this normative perspective (e.g., Wason, 1968). Both philosophers (e.g., Edgington, 1995) and psychologists (e.g., Oaksford & Chater, 1994; Evans & Over, 2004), however, have argued that this is an inappropriate formalization of what people mean with natural language 'if ..then', both conceptually and empirically. This has given rise to alternative, in particular probabilistic, interpretations of the conditional (in which case factors such as believability need no longer constitute an inappropriate bias).

One aspect that has figured here is that natural language conditionals often involve causal connections (see also, Oaksford, this volume). Cummins et al. (1991) examined specifically how participants' judgments of the conclusion of a conditional argument, differed systematically as a function of the number of alternative causes and disabling conditions that characterized the causal relationship (as benchmarked in a pre-test with different participants) and did so in potentially different ways for each the four classic forms: MP, MT, AC, and DA. For example, people were presented with arguments such as

"If my finger is cut, then it bleeds. My finger is cut. Therefore, it bleeds."

or

"If I eat candy often, then I have cavities. I eat candy often.

Therefore, I have cavities."

Here, so Cummins et al., it is presumably easier to think of disabling conditions for the second example (cavities) than it is for the first (bleeding finger), and one might expect people's judgments of conclusion strength to be sensitive to this. In keeping with this, participants' judgments were found to vary systematically with the number of alternative causes and disabling conditions. Conclusions of arguments based on conditionals with few alternative causes or few disabling conditions, in particular, were *more* acceptable than conclusions based on those with many. Moreover, Cummins et al. showed that both the number of alternative causes and possible disabling conditions affected the extent to which the conditional (if … then) was interpreted as a bi-conditional (if and only if), or not.

Subsequent work has also attempted to distinguish competing accounts of logical reasoning using specifically causal materials (e.g., Quinn & Markovits, 1998; Verschueren, N., Schaeken, W., & d'Ydewalle, 2005; Ali, Chater & Oaksford, 2011; for an overview see also Oaksford & Chater, 2010b).

Recent work, particularly the sophisticated analyses provided by Singmann, Klauer and Over (2014), finds robust evidence only for an interpretation of the conditional as a conditional probability, but finds no evidence that participants' judgments of conclusion probability

are sensitive to 'delta P' ($(P(q|p) - P(q|\neg p))$, a quantity that has figured prominently in accounts of causal learning (see e.g., Sloman, 2005; Over, Hadjichristidis, Evans, Handley & Sloman, 2007; see also Over: this volume). Whether this result will prove robust in subsequent work remains to be seen, but it highlights the potential for work on causal argument to complement the results from other, more familiar, paradigms for investigating the psychology of human causal learning and causal understanding. Argument evaluation tasks may provide independent evidence in the context of rival accounts of lay peoples' understanding of causation as found in decades of causal learning studies.[6]

4.2. Consequentialist argument

Recent years have also seen increasing empirical interest in another form of conditional, namely consequentialist arguments. Evans, Neilens, Handley, and Over, (2008) investigated a variety of conditionals expressing conditional tips, warnings, threats, and promises. For example, 'If you go camping this weekend (p) then it will rain (q)', is a clear warning *not* to go camping. From the decision-theoretic perspective mentioned above, the higher $P(q|p)$, and the more negative the utility associated with the consequent, U(q), that is, rain, the more persuasive should be a conditional warning to the conclusion that action p should not be taken, $\neg p$, that is, you should not go camping. Evans et al. found that participants' judgments of persuasiveness varied in the predicted way as a function of costs and benefits of antecedent (p) and conclusion (q) as well as the conditional probability ($P(q|p)$) linking the two. These effects held for both positive (tips, promises) and negative (warnings, threats) consequentialist arguments.

Corner, Hahn and Oaksford (2011) provided an empirical examination of a particular type of consequentialist argument: slippery slope arguments such as 'if voluntary euthanasia is legalised, then in the future there will be more cases of "medical murder"'. Slippery slope

[6] It should be noted in this context that Sloman and Lagnado (2005) have argued for qualitative differences between conditional and causal reasoning. However, Oaksford and Chater (2010b) argue that the seeming empirical differences observed by Sloman and Lagnado (2005) are due to inadvertent differences in causal strength. The results of Ali et al. (2011) are in keeping with that suggestion.

arguments are a type of warning and are distinct merely in the type of (implied) mechanism that underlies P(*q*|*p*). In particular, for many slippery slope arguments a gradual shift of category boundaries is at play (on other forms of slippery slope arguments see, e.g., Volokh, 2003): the act of categorising some instance (say: voluntary euthanasia) under a more general predicate (here: legal medical intervention) is assumed to lead inevitably to other items (e.g., involuntary euthanasia or 'medical murder') eventually falling under the same predicate.

Corner et al. examined not only effects of utility on the perceived strength of slippery slope arguments, but also examined a specific mechanism underlying the conditional probability *P(q|p).* Specifically, they examined the causal mechanism involved in 'sorites' type slippery slope arguments, namely 'category boundary reappraisal': Current theories of conceptual structure typically agree that encountering instances of a category at the category-boundary should extend that boundary for subsequent classifications, and there is a wealth of empirical evidence to support this (e.g., Nosofsky, 1986). Building on this, Corner et al. (2011) showed how people's confidence in classifications of various acts as instances of a particular category was directly related to their degree of endorsement for corresponding slippery slope arguments, and that this relationship is moderated by similarity. Slippery slope arguments from one instance to another were viewed as more compelling, the more similar the instances were perceived to be.

The Corner et al. studies demonstrate how the conditional probability *P(q|p)* that influences the strength of consequentialist arguments as a type of cause-to-effect argument may be further unpacked. The same is true for a recent study by Maio et al. (2014) that experimentally examined a particular type of hypothetical consequentialist causal argument that appeals to fundamental values. Specifically, Maio et al. investigated 'co-value argumentation', which appeals to furthering one value because doing so will further another. The following quote by George W. Bush provides an example: "I will choose freedom because I think freedom leads to equality" George W. Bush (see Anderson, 1999, as cited in Maio et al. 2014).

Numerous examples of this argument-type are found, ranging from Plato—'equality leads to friendship'— to Howard Greenspan who argued that "Honesty leads to success in life and business" (examples cited in Maio et al. 2014).

'Success', 'freedom', 'equality', and 'honesty' are terms that exemplify what social psychologists consider to be instances of fundamental values that are universally used to guide and evaluate behaviour (Schwartz, 1992; Verplanken and Holland, 2002). As consequentialist arguments, their strength should depend both on the strength of the causal connection between antecedent and conclusion value, and the antecedent value's importance.

With respect to causal connections, psychological research on fundamental values has provided evidence that our value systems are structured, that is, they display internal ordering. This ordering is based on the fact that actions taken in pursuit of a particular value will have psychological, practical, and social consequences that may be either compatible or incompatible with the pursuit of another value (for empirical evidence concerning the psychological relevance of this structure see e.g., Schwartz, 1992; Schwartz & Boehnke, 2004; Maio et al., 2009).

From this, one can derive predictions about the strength of arguments that combine values. Opposing values are classed as such because the actions taken in their respective pursuit may conflict, that is, pursuing one of two opposing values likely impinges negatively on the pursuit of the other. Conversely, values that fulfil similar motives will be positively correlated in terms of the consequences of actions one might take in their pursuit. Finally, values that are orthogonal will be more or less independent.

These relations—comparative incompatibility, compatibility, and independence—translate directly to systematic differences in causal relatedness and hence conditional probabilities: two opposing values will be negatively correlated, similar values will be positively correlated, and orthogonal values will be independent. Expressed in probabilistic terms, a causal perspective can thus provide clear predictions about the relative convincingness of different consequentialist arguments that combine any given two values. Co-value argumentation involving opposing values should give rise to less convincing arguments than using or-

thogonal values, and similar values should be even more convincing. In keeping with the causal basis, Maio et al. (2014) found this pattern confirmed both in ratings of argument persuasiveness and in proclaimed intention to vote for a political party on the basis of a manifesto that had manipulated co-value argument. These results not only underscore the importance of causal considerations to people's evaluation of everyday arguments in the practical domain of values. They also provide an extreme example of the degree of abstraction in causal argument and the sparsity of the underlying causal models that people are willing to engage with in arguments about real world relationships.

4.3 Causal argument and causal thought: Kuhn (1991)

Finally, we discuss what is arguably the central study on causal argument to date, even though it is not explicitly billed as an investigation of causal argument. Kuhn's (1991) monograph "The Skills of Argument" is a landmark investigation of people's ability to engage in real world argument, across the lifespan and across different levels of educational background. Kuhn's fundamental premise is that thinking ability is intrinsically tied to argumentation ability, to the extent that reasoning may just seen as a kind of 'arguing something through with oneself'. Furthermore, Kuhn maintains that thinking (and with it argumentation) abilities are far less well understood than one might expect. This is because of the focus within most of cognitive psychology on lab based experimentation, frequently involving highly artificial, stylised materials, which leave unanswered questions about how people fare in actual everyday argument, limitations that are compounded by the fact that participants are typically drawn from undergraduate samples. Kuhn's (1991) study of argument skills sought to redress this balance by getting people from range of backgrounds (with both college and non-college level education), and a range of ages (teens, 19-29; 40-49; and 60-69 years of age; for studies of younger children see Kuhn, Amsel & O'Loughlin, 1988) to engage in argument generation and evaluation for a series of real world topics that actually matter to them, but for which they would also have varying levels of expertise. Crucially, from the perspective of the researcher interested in causation and causal arguments, all three topics concerned causes: what causes

prisoners to return to crime after they are released; what causes children to fail school; and what causes unemployment.

In a series of structured interviews, Kuhn and colleagues asked participants to provide an initial causal explanation or theory of the phenomenon in question. They then asked participants to provide evidence for those theories, but consider also alternative causes and what kinds of evidence would count for or against them. Responses were coded with a modified version of the Toulmin framework described above into 'theories', 'supporting evidence', and 'opposing argumentation' (alternative theories, counter-arguments, rebuttals).

Kuhn found considerable variation in argument skill across participants. In particular, a sizeable number of participants were unable to generate genuine evidence for any of their theories across the three topics (29%) or generate an alternative theory (8%). Furthermore, where there were failures to generate real evidence, evidence was poorly differentiated from the theory itself.

Where participants supplied causal arguments for their preferred theories, only a minority offered genuine evidence that makes reference to covariation. Other forms of genuine evidence found were evidence from analogy, causal generalisations, and discounting or elimination of alternative causes. At the other extreme (non-evidence) participants seemed willing to treat the effect itself as evidence of the cause or even to deny the need for evidence altogether.

This serves to underscore earlier points about the sparsity of causal models in (at least some contexts) of real world argument and Kuhn's findings seem reminiscent of Keil's work on the 'illusion of explanatory depth' (see e.g., Keil, 2003). At the same time, it is striking that comparatively few participants showed clear insight into the importance of manipulation in establish causal relationships in the arguments they supplied.

Limitations were also apparent also in participants' evaluation of evidence given to them. In a second session, the same group of participants was presented with evidence designed intentionally to be largely non-diagnostic. Examples are given in Fig. 3 below:

Table 8.1. *Underdetermined evidence*

Crime topic

Pete Johnson is someone who has spent a good portion of his adult life in prison. He was first convicted of a crime at age 14, when he took part in the theft of a newspaper stand. He began serving his first prison sentence at age 18, after being convicted on several charges of auto theft and robbery. He remained in a medium-security state prison until the age of 20. After he was released on parole, he returned to live with his mother in the same neighborhood where he had grown up and began to look for a job. After 3 months out of jail, he took part in the robbery of a grocery store. He was caught and convicted and returned to prison. Since then, Pete has served three more prison sentences for different crimes, with only brief periods out of prison between sentences.

School topic

David Bell is a child who has shown a continuing failure to learn in school. David is 10 years old and repeating second grade. He also repeated first grade because of his poor work. David lives with his parents and younger sister in a medium-sized city. Since age 5, he has attended the elementary school in the family's neighborhood. David had great difficulty in learning to read and now reads only when he is required to and has trouble recognizing all but very simple words. David does no better in math than he does in reading. He dislikes schoolwork of any kind. Often he spends his time in the classroom daydreaming or talking to other children. David finds the work his teacher gives the children to do uninteresting. He says that he would rather spend his time doing other things.

Fig. 3, sample 'evidence' from Kuhn (1991).

This evidence contains descriptions with little information that could be used to infer causal relationships. Though this was recognized by some participants (Question: "What do you think is the cause of Peter's return to crime?" Response: "there's nothing in here that suggests a cause" pg. 207) sizeable numbers of others did perceive the passages to be evidence for a particular causal mechanism, and possibly even more surprisingly, expressed great certainty concerning their preferred cause.

In all of this, participants showed variations across topics, seemingly as a function of familiarity with the domain, but there was greater consistency in performance than would be expected by chance. In particular, there was consistency also with what Kuhn and colleagues deem 'epistemological perspectives', that is, more general beliefs participants had about

knowledge, and the extent to which different people might reasonably hold different views, without endorsing a relativism so total that all knowledge is seen as 'mere opinion'. Finally, for both epistemological perspectives and argument skills there was statistical evidence of influence only from educational background, not gender or age.

Follow up research by Sa, Kelley, Ho and Stanovich (2005) that again examined self generated causal theories for the crime and education topics, elicited in a very similar structured interview, confirmed the sizeable variation in participants' argument skills.

5. Causal Argument: a Research Agenda

From our survey of extant research it should be clear that causal argument presents a rich field of inquiry, but one that is presently still under-developed. In the final sections, we draw together what appear to us as the main themes and strands for future research.

One strand, on which much else rests, is the issue of typologies of causal argument. The first thing to emerge from the survey of types of causal arguments identified in the literature is the extraordinary richness of causal argument. People argue daily both about causes and from causes, and these arguments concern not just they way things presently are, but also future possibilities and actions. This also gives many causal arguments an intrinsic link with utilities and valuations.

For the argumentation theorist, there is clearly more work to be done here: it is unclear whether even the extensive list drawn up above exhausts the range of different types of causal argument to be found in everyday and specialist discourse. This question of typology (and its completeness) matters because only with a full sense of the many different ways in which causes figure in argument, and thus in everyday life, can one hope to have a complete picture of the psychology of causal reasoning.

The case for an intimate connection between reasoning and argumentation has been well made (Kuhn, 1991; Mercier & Sperber, 2011), and argumentation not only provides a window into reasoning abilities, it may also be a crucial factor in shaping them.

In the context of typologies, important theoretical questions remain about what should count as a distinct 'type' of argument, both normatively and descriptively, and why (see Hahn & Hornikx, in press).

Much work also remains to be done with respect to the normative question of what makes a given type of causal argument 'good' or 'strong'. This matters to researchers who are interested in the development and improvement of skills –whether these be argumentation theorists, developmental and educational psychologists, or researchers interested in science communication, to name but a few. It matters also to anyone concerned with human rationality, whether from a philosophical or a psychological perspective; and, given the benefits of rational analysis and computational level explanation to understanding human behaviour (e.g., Anderson, 1990) it should matter also to any psychologist simply interested in psychological processes (see also, Hahn, 2014).

As seen in Section 3 above, there is presently no fully worked out, coherent normative picture on causal argument. The literature is both fragmented in terms of approach and preferred formalism (or even whether formal considerations are necessary at all). The notion of 'critical questions' has educational and practical merit, but the present depth of these falls considerably behind what could be developed on the basis of extant formal frameworks such as causal Bayesian networks (e.g., Pearl, 2000).

A comprehensive normative treatment of causal argument seems a genuine cognitive science project, that will need contributions from a number of fields, including artificial intelligence, and philosophy. It offers also the possibility of a more comprehensive and more effective treatment of causal argument in computational argumentation systems (see e.g., Rahwan, Zablith & Reed, 2007; Rahwan & Simari, 2009). At the same time, it must be stressed that there is a considerable amount of work required before anything like a comprehensive normative treatment of causal argument might be achieved. There are aspects, such as causal inference, for which there already exist formal approaches that have a reasonable claim to normative foundations, such as causal Bayesian Networks. However, these presently still leave many factors relevant to causal argument largely unaddressed. In particular, only recently

have researchers started to concern themselves with normative questions involved in the transition between causal models, as become necessary, for example, on *learning* new conditionals (Hartmann subm.).

Only with a clear normative understanding can questions of human competence in causal argument be fully addressed. At present, the evidence on human skill in dealing with causation is rather mixed. While humans may do very well in lab-based contingency learning tasks (but see also Kuhn, 2007), and do rather well in causal inference involving explicit verbal descriptions such as those presented in causal conditional reasoning tasks, thinking and arguing about complex real world materials (even frequently encountered ones for which people possess considerable amounts of relevant knowledge) such as in Kuhn's (1991) study, seem to be another matter.

Both the sizeable individual differences in Kuhn's (1991) study, and her finding that, although there is consistency, the degree of competence expressed seems to vary with familiarity of topic and materials, suggest that skills are more or less readily expressed according to context So a fuller understanding of causal reasoning should understand also what particular aspects contribute to success or failure.

Kuhn's (1991) study serves also to highlight a distinction that has been drawn elsewhere in the literature on causal reasoning, namely that between causal structure and causal strength (Griffiths & Tenenbaum, 2005). Examination of competence in dealing with causality needs consideration not only of the circumstances under which people draw inferences about causal structure, but how strong they consider causal relations (and the supporting evidence) to be.

In generating and evaluating causal arguments, there are three distinct ways in which reasoners might go wrong, exemplified in Fig. 4 below:

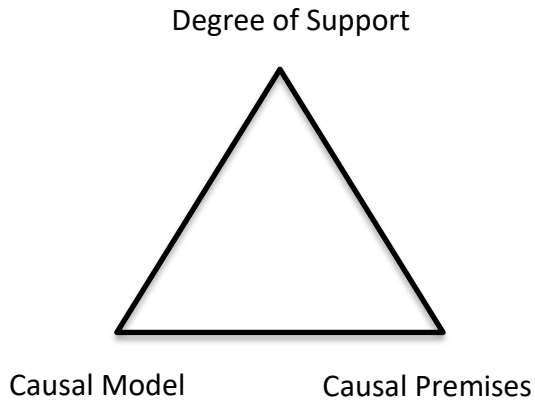


Fig. 4: Schematic representation of the alignment between causal-premises, causal-model, and a subjective degree of support. Perfect alignment of all three elements maps onto a equilateral triangle, as shown here, while imperfections gives rise to angles deviating from 60 degree angles.

Specifically, causal arguments should be evaluated with respect to how well they align the causal-premises (of the argument) with a causal-model and a subjective degree of support (Fig. 4).

Kuhn's study suggests that, for some people at least, judgments of causal strength may be considerably exaggerated, in that individual aspects of what are clearly complex multi-factorial problems (such as unemployment) are selectively picked out and treated as 'the cause'. Even more worrying, however, are the high levels of certainty that many of Kuhn's participants exhibit, even in the face of largely undiagnostic evidence, suggesting also that failures with respect to 'degree of support' may be more prevalent than one would want.

In all of this, it remains to be fully understood what features people attend to both in establishing and manipulating causal models, what role argument plays in this (given also that much of our knowledge derives from the testimony of others, Coady, 1994), and what weight people attach to these. It also seems important to understand how detailed or sparse people's causal models are in many real world contexts, and how this interacts with argument evalua-

tion. To achieve this, there is a need for integration of research on causal learning, causal inference, and causal argument.

At the same time, as we have stressed throughout this chapter, the study of causal argument offers unique opportunities for insight into causal cognition, and work on causal argument offers methodological approaches that complement lab-based studies in a number of important ways. Examination of real world argument is possible not just through structured interviews such as those of Kuhn and colleagues, but also through the direct analysis of corpora of extant speech and text.

Since argumentation is a pervasive linguistic activity and causal reasoning is frequent in arguing, linguistic data for the study of causal reasoning are readily available for instance in a number of freely accessible linguistic text corpora (For an overview of such corpora, see Xiao (2008) or Lee (2010). As Oestermeier & Hesse's (2000) study illustrates, corpus analysis does not require a prior determination of variables, and is thus well-suited for explorative research into natural language argumentation. In particular, corpora may be assumed to provide a fairly unbiased empirical basis for specific research questions probed because they have been recorded independently of those questions (see Schütze, 2010, 117). Thus, language corpora could be used to study linguistic behavior in more or less natural environments.

Linguistic text corpora also come in many shapes and sizes. Some are restricted to written language (and, as in the case of books and articles, may reflect repeated careful editing), while others contain spoken language. Corpora thus not only make available argumentation in more or less natural environments, but also contain argumentation more or less produced "on the fly."

Two general strategies for making use of text corpora can be distinguished. Corpus-*driven* research uses them in explorative fashion under minimal hypotheses as to the linguistic forms that may be relevant to a given research question (also known as "letting the data speak *first*"); corpus-*based* research, in contrast, uses them to verify or falsify specific hypotheses regarding the use of natural language on the basis of extant theories of linguistic forms (see Biber, 2010).

While it is fairly straightforward to use corpora to gain access to *some* data that may well exhibit a larger slice of the real-world use of the language of causality, there are limits to studying causal argumentation in this way. First, an *exhaustive* list of the linguistic means to express causality is unlikely to be forthcoming, as there are several ways to express a causal connection through coordination with terms not specifically marked for expressing causality (exemplified in this very sentence through the use of 'as', which may be read causally, or not). As Oestermeier & Hesse observe: "In verbal arguments, reasons and conclusions can be easily distinguished if connectives like 'because', 'therefore', 'so' or other explicit markers are used" (Oestermeier & Hesse 2000, 65). However, the sheer number of such markers testifies to an astonishingly wide variety of linguistic forms that can be employed to express *some* sort of causal connection, and thus figure in causal reasoning. The perhaps most frequent linguistic form is the subordination of clauses by means of (linguistic rather than logical) conjunctions such as 'because', 'since', 'as', etc. (see Altenberg, 1984; Diessel & Hetterle 2011). But a variety of causative verbs, adverbs, adjectives and prepositions can also be used to express causal connections (for an overview, see Khoo, Chan & Niu, 2002).

Moreover, causality can also be encoded in text organization, and so pertains to organizational principles that are reconstructable only at levels of discourse higher than the sentence level (Altenberg, 1984; Achugar & Schleppegrell, 2005). Not only may causal premises thus be left implicit (see Sect. 3.1); the relevant causal connection itself need not be evident on the linguistic surface Accordingly, we lack sufficient criteria to trace *all* causal phenomena contained in a given corpus through software that queries corpora for linguistic forms or structures. So, one retains an unknown number of false negatives among the results, and conversely, as is the case with 'because' itself, some of the linguistic means for indicating causal relationships also have other roles than simple causal connection.

Nevertheless, corpora make for an excellent tool in studying natural language argumentation. Specifically, we think it worthwhile to examine further the communicative circumstances that are typical of different argument schemes. This would provide an entry point for investigation of the extent to which causal arguments in actual discourse meet the norms of

the causal argument schemes they might be thought to manifest. It might, arguably, also provide information about the persuasiveness of different types of causal argument. In particular, the frequency of the causal mechanism argument type (see Oestermeier & Hesse, 2000 and section 3.1 above) may well be indicative of the prevalence of a certain model of causality that lay people endorse. Corpus data might then, for example, provide an empirical basis for establishing whether the mechanistic argument type is in fact associated with a specific model of causality, and to examine the association of other argument types with specific causal models.

In short, corpus analysis may provide a valuable complement to both the experimental and interview based methodologies that empirical studies of causal argument have seen.

6. Conclusions

Causal argument, we hope the reader is now convinced, represents an important topic in its own right: the practical relevance of argumentation to everyday life is enormous, and, theoretically, a good case has been made that argumentation skills are deeply interconnected with reasoning skills (e.g., Kuhn, 1991; Mercier & Sperber, 2011; Hahn & Oaksford, 2007a). Given further the breadth of argument involving causation that can be seen in everyday life (as surveyed in the typologies above) causal argument deserves far more consideration than it has, to date, received. Last but not least, a greater understanding of causal argument, both theoretically and empirically, is likely to provide new impetus to the understanding of causal cognition.

References

Achugar, M., Schleppegrell, M. J. (2005): Beyond connectors. The construction of cause in history textbooks. *Linguistics and Education,* 16 (3), 298–318.

Ali, N., Chater, N., & Oaksford, M. (2011). The mental representation of causal conditional reasoning: Mental models or causal models. *Cognition, 119*(3), 403–418.

Altenberg, B. (1984): Causal Linking in Spoken and Written English. In: *Studia Linguistica, 38* (1), 20–69.

Anderson, J. R. (1990). *Cognitive psychology and its implications*. WH Freeman/Times Books/Henry Holt & Co.

Bennett, J. (2003). *A Philosophical Guide to Conditionals*. New York: Oxford University Press.

Biber, D. (2010). Corpus-Based and Corpus-Driven Analyses of Language Variation and Use. In: B. Heine & H. Narrog (ed): *The Oxford Handbook of Linguistic Analysis* (pp. 159–191). Oxford: Oxford University Press.

Coady, C. A. J. (1994). *Testimony*. Oxford University Press.

Corner, A., & Hahn, U. (2013). Normative theories of argumentation: are some norms better than others? *Synthese*, *190*(16), 3579-3610.

Corner, A., & Hahn, U. (2013). Normative theories of argumentation: are some norms better than others?. *Synthese*, *190*(16), 3579-3610.

Cummins, D. D., Lubart, T., Alksnis, O., & Rist, R. (1991). Conditional reasoning and causation. Memory and Cognition, 19(3), 274–282.

Diessel, H. & Hetterle, K. (2011). Causal Clauses. A Crosslinguistic Investigation of Their Structure, Meaning, and Use. In: Peter Siemund (ed.): *Linguistic Universals and Language Variation* (pp. 23–54). Berlin: Mouton de Gruyter (Trends in linguistics, 231).

Dowe, P. (2000). *Physical Causation.* New York: Cambridge University Press.

Edgington, D. (1995), 'On Conditionals', *Mind*, 104, 235–329.

Elqayam, S.,Thompson, V.A., Wilkinson, M.R., Evans, J. St. B. T., Over, D.E. (2015), Deontic introduction: A theory of inference from is to ought. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, Vol 41(5), 1516-1532.

Evans, J. (1975). St. BT, & Over, DE (2004). If. Oxford: Oxford University Press.

Evans, J. S. B., Barston, J. L., & Pollard, P. (1983). On the conflict between logic and belief in syllogistic reasoning. *Memory & Cognition*, *11*(3), 295-306.

Evans, J., Neilens, H., Handley, S., & Over, D. (2008). When can we say 'if'? *Cognition*, *108*(1), 100–116.

Garssen, B.J. (2001). Argument schemes. In: Eemeren, F.H. van (ed). *Crucial concepts in argumentation theory* (pp. 81-99). Amsterdam, Amsterdam University Press.

Goodwin, J. (2007). Argument has no function. *Informal Logic*, *27*(1), 69-90.

Gordon, T. F., Prakken, H., & Walton, D. (2007). The Carneades model of argument and burden of proof. *Artificial Intelligence*, *171*(10), 875-896.

Govier, T. (1982). What's wrong with slippery slope arguments?. *Canadian Journal of Philosophy*, *12*(2), 303-316.

Grennan, W. (1997). *Informal Logic*. Kingston, McGill-Queen's University Press.

Griffiths, T. L., & Tenenbaum, J. B. (2005). Structure and strength in causal induction. *Cognitive Psychology*, *51*(4), 334–384.

Hahn, U. (2011). The Problem of Circularity in Evidence, Argument, and Explanation. *Perspectives on Psychological Science*, *6*(2), 172–182.

Hahn, U. (2014). The Bayesian boom: good thing or bad?. Frontiers in Cognitive Science, 5, Article 765.

Hahn, U., & Hornikx, J. (2015). A normative framework for argument quality: argumentation schemes with a Bayesian foundation. *Synthese*, 1-41

Hahn, U., & Oaksford, M. (2006). A Bayesian approach to informal argument fallacies. *Synthese*, *152*(2), 207-236.

Hahn, U., & Oaksford, M. (2007a). The Rationality of Informal Argumentation: A Bayesian Approach to Reasoning Fallacies. *Psychological Review*, *114*, 704–732.

Hahn, U. & Oaksford, M. (2007b) The burden of proof and its role in argumentation. *Argumentation*, *21*, 39-61.

Hahn, U., & Oaksford, M. (2012). Rational argument. *The Oxford handbook of thinking and reasoning*, 277-298.

Hahn, U., Oaksford, M. & Harris, A.J.L. (2013). Testimony and argument: A Bayesian perspective. In: Zenker, F. (ed). *Bayesian Argumentation* (pp. 15-38). Dordrecht: Springer.

Hamblin, C. L. (1970). *Fallacies*. London: Methuen.

Hamby, B. (2013). Libri ad nauseam: the critical thinking textbook glut. *Paideusis*, 21 (1), 39-48.

Hansen, H. (2002). The Straw Thing of Fallacy Theory: The Standard Definition of 'Fallacy'. *Argumentation*, *16*(2), 133-155.

Harding, H.F. (1952). The age of danger: Major speeches on American problems. New York: Random House.

Hart, H. L. A., & Honoré, T. (1985). *Causation in the Law, 2nd edition*. Oxford University Press.

Hastings, A. C. (1962). A Reformulation of the Modes of Reasoning in Argumentation. Unpublished doctoral dissertation, Northwestern University.

Hitchcock, D., & Wagemans, J. (2011). The pragma-dialectical account of argument schemes. In B. Garssen & A. F. Snoeck Henkemans (eds.), *Keeping in touch with pragma-dialectics* (pp. 185-205). Amsterdam: John Benjamins.

Honoré, A. (2010), "Causation in the Law", *The Stanford Encyclopedia of Philosophy*, Edward N. Zalta (ed.), URL = <http://plato.stanford.edu/archives/win2010/entries/causation-law/>.

Inch, E. S., & Warnick, B. H. (2009). *Critical thinking and communication: The use of reason in argument* (6th ed.). Pearson.

Illari, P., & Russo, F. (2014). *Causality: Philosophical Theory meets Scientific Practice*. Oxford: Oxford University Press.

Keil, F. C. (2003). Folkscience: coarse interpretations of a complex reality. *Trends in Cognitive Sciences*, *7*(8), 368–373.

Khoo, C., Chan, S. & Niu, Y. (2002): The Many Facets of the Cause-Effect Relation. In: R. Green, C.A. Bean und S.H. Myaeng (ed.): *The Semantics of Relationships. An Interdisciplinary Perspective. Dordrecht:* Springer Netherlands (Information Science and Knowledge Management, 3), 51–70.

Kienpointner, M. (1992). Alltagslogik: Struktur und Funktion von Argumentationsmustern. Stuttgart-Bad Cannstatt: Friedrich Frommann.

Kuhn, D., Amsel, E., & O'Loughlin, M. (1988). *The development of scientific reasoning skills*. Orlando, CA: Academic.

Kuhn, D. (1991) *The skills of argument*. Cambridge: Cambridge University Press.

Kuhn, D. (2007): Jumping to Conclusions. Can People Be Counted on to Make Sound Judgments? In: *Scientific American Mind* (February/March), 44–51.

Lee, David Y. W. (2010): "What Corpora Are Available?" In: M. McCarthy & A. O'Keeffe (eds.) *Corpus Linguistics*. London; New York: Routledge, 107–121.

Lewis, D. (1973). *Counterfactuals*. Oxford: Blackwell.

Lombrozo, T. (2007). Simplicity and probability in causal explanation. *Cognitive Psychology*, *55*(3), 232–257.

Mackie, J. L. (1965). Causes and conditions. *American Philosophical Quarterly*, 245-264.

Maio, G.R., Hahn, U., Frost, J-M., Kuppens, Rehman, T.N., & Kamble, S. (2014) Social Values as Arguments: Similar is Convincing. *Frontiers in Psychology*.

Maio, G. R., Pakizeh, A., Cheung, W., and Rees, K. J. (2009). Changing, prim- ing, and acting on values: effects via motivational relations in a circular model. *J. Pers. Soc. Psychol. 97*, 699–715.

Marcus, S. L., & Rips, L. J. (1979). Conditional reasoning. *Journal of Verbal Learning and Verbal Behavior, 18*(2), 199–223.

Mercier, H., & Sperber, D. (2011). Why do humans reason? Arguments for an argumentative theory. *Behavioral and brain sciences*, *34*(02), 57-74.

Nosofsky, R. M. (1986). Attention, similarity, and the identification- categorization relationship. *Journal of Experimental Psychology: General, 115*, 39–57.

Oaksford, M., & Chater, N. (1994). A rational analysis of the selection task as optimal data selection. *Psychological Review*, *101*(4), 608.

Oaksford, M. & Chater, N. (2010a). Cognition and conditionals: An introduction. In M. Oaksford and N. Chater (eds), *Cognition and conditionals*: *Probability and logic in human thinking* (pp. 3-36). Oxford: Oxford University Press.

Oaksford, M., & Chater, N. (2010b). Causation and conditionals in the cognitive science of human reasoning. *Open Psychology Journal*, *3*, 105-118.

Oaksford, M., Chater, N., & Larkin, J. (2000). Probabilities and polarity biases in conditional inference. *Journal of Experimental Psychology Learning Memory and Cognition, 26*(4), 883–899.

Oaksford, M., & Hahn, U. (2004). A Bayesian approach to the argument from ignorance. *Canadian Journal of Experimental Psychology/Revue canadienne de psychologie expérimentale*, *58*(2), 75.

Oestermeier, U. & Hesse, F.W. (2000): Verbal and visual causal arguments. *Cognition 75 (*1), 65–104.

Over, D. E., Hadjichristidis, C., Evans, J. S. B. T., Handley, S. J. & Sloman, S. A. (2007). The probability of causal conditionals. *Cognitive Psychology*, 54(1): 62-97.

Pearl, J. (1988). *Probabilistic Reasoning in Intelligent Systems: Networks of Plausible Inference*. San Mateo, CA: Morgan Kaufmann.

Pearl, J. (2000; 2009). *Causality models, reasoning, and inference* (2. ed.). Cambridge: Cambridge University Press.

Perelman, C., & Olbrechts-Tyteca, L. (1969). *The New Rhetoric*, trans. John Wilkinson and Purcell Weaver. Notre Dame, Ind.: University of Notre Dame Press.

Prakken, H. & Renooij, S. (2001). Reconstructing causal reasoning about evidence: a case study. In B. Verheij, A.R. Lodder, R.P. Loui & A.J. Muntjewerff (Eds.), *Legal Knowledge and Information Systems. JURIX 2001: The Fourteenth Annual Conference* (pp. 131-142) (12 p.). Amsterdam, The Netherlands: IOS Press.

Quinn, S., & Markovits, H. (1998). Conditional reasoning, causality, and the structure of semantic memory: Strength of association as a predictive factor for content effects. *Cognition*, *68*(3), B93-B101.

Rahwan, I. & Simari, G.R. (2009). *Argumentation in Artificial Intelligence*. Springer Publishing Company, Inc.

Rahwan, I., Zablith, F., & Reed, C. (2007). Laying the foundations for a world wide argument web. *Artificial Intelligence*, *171*(10-15), 897–921.

Ramsey, F. P. (1931). Truth and Probability; The Foundation of Mathematics and Other Logical Essays.

Sá, W. C., Kelley, C. N., Ho, C., & Stanovich, K. E. (2005). Thinking about personal theories: individual differences in the coordination of theory and evidence. *Personality and Individual Differences*, *38*(5), 1149–1161.

Salmon, W. (1984). Scientific explanation and the causal structure of the world. Princeton: Princeton University press.

Savage, L. J. (1954). *The Foundations of Statistics*. New York, Wiley.

Schupbach, J. N., & Sprenger, J. (2011). The Logic of Explanatory Power. *Philosophy of Science, 78*(1), 105–127.

Schütze, C. T. (2010): Data and Evidence. In: K. Brown, A. Barber und R. J. Stainton (eds.): *Concise Encyclopedia of Philosophy of Language and Linguistics.* Amsterdam et al.: Elsevier, S. 117–123.

Schwartz, S. H. (1992). Universals in the content and structure of values: theoretical advances and empirical tests in 20 countries. Adv. Exp. Soc. Psychol. 25, 1–65.

Schwartz, S. H. & Boehnke, K. (2004). Evaluating the structure of human values with confirmatory factor analysis. *J. Res. Pers. 38*, 230–255.

Singmann, H., Klauer, K. C., & Over, D. (2014). New normative standards of conditional reasoning and the dual-source model. *Frontiers in Psychology, 5*.

Sloman, S., & Lagnado, D. (2005). Do we 'do'? *Cognitive Science, 29*, 5–39.

Toulmin, S. E. (1958; 2003). *The Uses of Argument* (update edition). Cambridge: Cambridge University Press.

van Eemeren, F. H., & Grootendorst, R. (2004). *A systematic theory of argumentation: The pragma-dialectical approach*. Cambridge: Cambridge University Press.

van Eemeren, F. H., & Kruiger, T. (1987). Identifying argumentation schemes. *Argumentation: Perspectives and approaches*, 70-81.

van Fraassen, B. (1989). *Laws and symmetry*. Oxford University Press.

van Gelder, T. J., Bissett, M., & Cumming, G. (2004). Cultivating Expertise in Informal Reasoning. *Canadian Journal of Experimental Psychology*, *58*, 142-152.

Verheij, B. (2003). Artificial argument assistants for defeasible argumentation. *Artificial Intelligence, 150*(1), 291-324.

Verplanken, B., and Holland, R. W. (2002). Motivated decision making: effects of activation and self-centrality of values on choices and behavior. *Journal of Personality and Social Psycholology, 82,* 434–447.

Verschueren, N., Schaeken, W., & d'Ydewalle, G. (2005). A dual-process specification of causal conditional reasoning. *Thinking & Reasoning*, *11*(3), 239-278.

Volokh, E. (2003). The mechanisms of the slippery slope. *Harvard Law Review*, 116, 1026–1137.

von Aufschaiter, C., Erduran, S., Osborne, J. & Simon, S. (2008) Arguing to Learn and Learning to Argue: Case Studies of How Students' Argumentation Relates to Their Scientific Knowledge. *Journal of Research in Science Teaching 45 (1)* 101-131.

Walsh, C.R., Hahn, U. & DeGregorio, L. (2009) Severe Outcomes and their Influence on Judgments of Causation. *Proceedings of the 31st Annual Meeting of the Cognitive Science Society.* pp. 550-554.

Walton, D. N. (1988). Burden of proof. *Argumentation*, *2*(2), 233-254.

Walton, D. N. (1996). *Argument Structure: A Pragmatic Theory* (Toronto Studies in Philosophy).

Walton, D. N. (2000) *Scare Tactics: Arguments That Appeal to Fear and Threats*. Dordrecht: Kluwer.

Walton, D. N. (2010). Why Fallacies Appear to be Better Arguments Than They Are. *Informal Logic, 30*(2), 159-184.

Walton, D. N., Reed, C., & Macagno, F. (2008). *Argumentation Schemes*. Cambridge: Cambridge University Press.

Wason, P. C. (1968). Reasoning about a rule. *Quarterly Journal of Experimental Psychology*, 20, 273-281.

Weisberg, J. (2009). Locating IBE in the Bayesian framework. *Synthese*, *167*(1), 125–143.

Willingham, D. (2007). Critical thinking: Why is it so hard to teach? *American Educator*, 31(2), 8–19.

Xiao, Richard (2008): "Well-Known and Influential Corpora", in: A. Lüdeling & M. Kytö (eds.) (2008–2009) *Corpus Linguistics: An International Handbook*. (2 Vols.) Berlin; New York: de Gruyter (Handbücher zur Sprach- und Kommunikationswissenschaft; 29), Vol. 1: 383–457.