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Conditionals and inferential connections: A hypothetical inferential theory☆

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ABSTRACT

Intuition suggests that for a conditional to be evaluated as true, there must be some kind of connection between its component clauses. In this paper, we formulate and test a new psychological theory to account for this intuition. We combined previous semantic and psychological theorizing to propose that the key to the intuition is a relevance-driven, satisficing-bounded inferential connection between antecedent and consequent. To test our theory, we created a novel experimental paradigm in which participants were presented with a soritical series of objects, notably colored patches (Experiments 1 and 4) and spheres (Experiment 2), or both (Experiment 3), and were asked to evaluate related conditionals embodying non-causal inferential connections (such as "If patch number 5 is blue, then so is patch number 4"). All four experiments displayed a unique response pattern, in which (largely determinate) responses were sensitive to parameters determining inference strength, as well as to consequent position in the series, in a way analogous to belief bias. Experiment 3 showed that this guaranteed relevance can be suppressed, with participants reverting to the defective conditional. Experiment 4 showed that this pattern can be partly explained by a measure of inference strength. This pattern supports our theory's "principle of relevant inference" and "principle of bounded inference," highlighting the dual processing characteristics of the inferential connection.

1. Introduction

Conditionals are sentences of the form "If φ, [then] ψ," with φ called "the antecedent" and ψ, "the consequent."[2] The functions of conditionals are many and varied. For instance, we use "if" when we want to think hypothetically about non-actual possibilities (Evans & Over, 2004); we use "if" to express causal relations (Cummins, 1995; Cummins, Lubart, Alksnis, & Rist, 1991; Over, Hadjichristidis, Evans, Handley, & Sloman, 2007) or probabilistic relations (Evans, Handley, & Over, 2003; Oberauer & Wilhelm,

☆ The supplemental materials as well as all data and all analysis scripts are available at: https://osf.io/3uajq/.

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[2] Unless stated otherwise, "conditional" refers to *indicative* conditionals. Indicative conditionals are conditionals whose antecedent is in the indicative mood. They are standardly contrasted with subjunctive conditionals, whose antecedent is in the subjunctive mood. In this paper, we are only concerned with indicative conditionals, although in Experiment 2 we address a possible subjunctive reading of some of our materials.

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2003); and we use "if" to express pragmatic functions such as inducement or advice (Beller, Bender, & Kuhnmünch, 2005; Evans, Neilens, Handley, & Over, 2008; Fillenbaum, 1976, 1986), and to generate novel normative rules (Elqayam, Thompson, Wilkinson, Evans, & Over, 2015). It is no wonder, then, that the study of conditionals has engaged psychologists and philosophers alike. Without a good theory of conditionals, we have no hope of understanding human reasoning or decision making. In this paper, we address what is arguably *the* most central question in the study of conditionals, to wit, how the antecedent connects to the consequent. Specifically, we will be concerned with how people's judgments of the truth values of conditionals vary as a function of the link between antecedent and consequent.

Intuitively, when we state a conditional, we expect that the antecedent would be relevant to the consequent. For example, there is something odd about the following conditionals:

(1) a. If Isaac Newton preferred apples over oranges, then he got his best ideas while walking.
b. If Winston Churchill did not sleep the night before D-Day, then he considered a career as a sculptor early on in life.

These conditionals appear odd in that the truth of their antecedent seems irrelevant to their consequent. There is no intelligible notion of dependency in which Newton's having gotten his best ideas while walking could be said to have depended on whether he preferred apples over oranges, and similarly for (1b): whether the young Churchill considered a career as a sculptor can hardly have depended on how he slept the night before D-Day.

Although both dependency and relevance have played key roles in psychological theories of conditionals (e.g., Evans & Over, 2004; Oaksford & Chater, 1994), there has been no systematic effort to explore the psychological mechanisms that make sentences such as

(2) If global warming continues, then parts of England will be flooded.

seem plausible, where sentences such as (1a) and (1b) are not. In this paper, we will formulate and support a psychological account of the relation between antecedent and consequent, to explain why conditionals like (1a) and (1b) strike us as odd, and what this tells us about the psychological mechanisms underlying our understanding of conditionals. To do this, we propose a new theory that combines insights from two main theoretical accounts: the philosophical account of inferentialism, and the psychological theory of hypothetical thinking.

Where virtually all semantics of conditionals define the truth values of conditionals as functions of the truth values of the conditionals' antecedents and consequents (whether in the actual world or also in other possible worlds), inferentialism is the only semantics that makes the existence of an inferential connection between antecedent and consequent a requirement for the truth of a conditional. Inferentialism, in other words, builds the requirement of a connection into the *meaning* of the word "if," thereby straightforwardly accounting for the felt oddness of conditionals such as (1a) and (1b). It is not that these conditionals appear odd because they are semantically defective. A sentence can appear perfectly fine while still being semantically defective—the world may simply fail to cooperate. According to inferentialism, (1a) and (1b) appear odd because they are semantically defective for a reason that could easily have been avoided: it is (typically) under our control to compose conditionals whose component parts stand in an inferential relationship to one another.

Hypothetical thinking theory (Evans, 2006, 2007a, 2010) is a dual-process theory positing two types of processes: fast, resource-frugal, and intuitive processes, and slow, analytic processes. The former generate the most relevant, single mental representation; the latter can then intervene to revise or even reject the initial representation, but this is a lazy, bounded process, meaning that the initial representation tends to be adopted unless compelling reasons for revision exist.

Our blend of inferentialism with dual processing, and more specifically with hypothetical thinking theory, allows us to hypothesize that the connection between antecedent and consequent is an inferential one, governed by relevance and bounded by satisficing. We state this theory in detail in a separate section, and present evidence in its favor from four experiments. But we begin by reviewing the main extant psychological accounts of conditionals, with some reference along the way to relevant philosophical accounts as well.

2. Theories of conditionals

2.1. Mental model theory and the material conditional account

Philosophical theorizing about the semantics for conditionals has long been dominated by the material conditional account, as advocated by, among others, Grice (1989), Jackson (1979), and Lewis (1976). According to this account, the truth conditions of a conditional are those of the corresponding material conditional: "If φ, ψ" is false if φ is true and ψ is false, and it is true in all other cases. Although the material conditional has several advantages, it has also been criticized for sanctioning a number of counter-intuitive inferences. Most famously, it gives rise to the so-called paradoxes of the material conditional: it validates the intuitively invalid inference of "If φ, ψ" from not-φ (e.g., the inference of "If Bill Gates went bankrupt, he is a billionaire" from "Bill Gates did not go bankrupt"), as well as the intuitively equally invalid inference of "If φ, ψ" from ψ (e.g., the inference of "If Bill Gates went bankrupt, he is a billionaire" from "Bill Gates is a billionaire"). It is fair to say that this account is no longer considered as the received doctrine among philosophers working on conditionals.

In psychology, the state of the art is similar, in that few psychological theories formulated past the turn of the century take the material conditional account as their starting point. The one exception is mental model theory, in which the basic (i.e., abstract)

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