

# Belief Changes with Indexical Information\*

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## Abstract

In everyday reasoning, we commonly face new pieces of information and also, sometimes, conflicts between information. *Belief Revision* and *Updates* deal with it. However, when the new piece of information contains an *indexical* expression, some special features concerning their context-sensitivity should be considered since the content of a sentence containing an indexical is given by a character function and a context. Although this is a work in progress, the ultimate goal of this work is to provide a proper account of how one ought to revise or update one's beliefs given indexical information and context change.

## 1 Introduction

There are many situations in which we face new information and are forced to revise our previously obtained conclusions. Loosely speaking, *defeasible reasoning* allows us to work with general conditions and concepts without adding rules that cover all possible exceptions and yet have a valid conclusion. Moreover, it is possible to present several everyday scenarios in which we reason under incomplete, generalized or outdated information, and some of those situations involve expressions the contents of which are determined based on the context of utterance. Being more specific, those expressions are known as demonstratives or *indexicals*<sup>1</sup>. According to Kaplan, *Indexicals* are expressions the *content* of which is determined by a *character* function and its references change from context to context [5]. Indexicals caught the philosopher's attention for many reasons since there is no consensus on how to deal with them in traditional literature. In particular, incorporate indexicals in *Belief Revision* theories or in *Belief Update* processes is a challenge.

### 1.1 Revisions and Updates

*Dynamics of Belief* occur when we change our epistemic attitudes towards a belief. According to Gärdenfors [3], *Belief Revision* is a formal process that can be used to modify a knowledge base when new information is acquired. We have three possible major changes: *expansion* – occurs when new information is added without removing any information previously accepted or obtained; *contraction* – occurs when it is necessary to give up some information; and *revision* – is the attempt to change the knowledge base as little as possible in order to incorporate new information.

One of the most well-known systems to deal with belief revision is **AGM**, proving us a number of postulates to deal, in particular, with contraction functions and revision functions. Besides belief revision, different processes lead to *Belief Updates*. While *Revisions* occur when we incorporate new information to the Belief Set, *Updates* consist of bringing the belief

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<sup>1</sup>There are some specific differences between *demonstratives* and *indexicals* in Kaplan's account. However, in the present work, we will use the terms as interchangeable.

set to the specific date when the world changes. Del Val and Shoham [1] point out about distinguishing “distinguishing between belief *revision* and belief *update*; loosely speaking, the former says that the beliefs may have been wrong and in need of revision, whereas the latter says that the beliefs were correct, but the world has in the meanwhile evolved and the beliefs must be updated.” [1].

There are some major differences between *Revisions* and *Updates*. As Katsuno and Mendelzon point out, one major difference is that there is no way to eliminate an inconsistency by using an update method, although you can by using revision [6]. Moreover, as they state: “The second and more important difference between revision and update is that, in the case of update, a different ordering is induced by each model of  $\psi$ , while for revision, only one ordering is induced by the whole of  $\psi$ . This “local” behaviour of update, contrasted with the “global” behaviour of revision, is essential to the difference between the two operators.[6] “. There are a number of examples that show that revision and updates are different processes and, although in some cases they lead to the same results, there might be changes in other cases. Moreover, that are many examples where indexical information is added to a belief set or, yet, the context might have changed such a more qualitative approach to the well known *Sleeping Beauty Problem*.

## 1.2 Indexicals

Indexicals are linguistic expressions whose references shifts from context to context, according to Kaplan [5], and include expressions such as *Today*; *Yesterday*; *Here*; *That*; *Now*; *Tomorrow*; expressions of the form *This F*, and so on. A *context* is, intuitively, a “possible occasion of use” of a sentence and it is essential to determine the content of a sentence. Therefore, if we have different contexts, then we will have different contents. Each indexical occurrence is associated with both a *character* function and a *content*. Informally, the character is set by linguistic conventions and often is interpret as the “rule of use” of the demonstrative, while the content is interpreted as the “concept”, according to Perry [8].

Perry [8] provides us a short list of temporal and other indexicals to elucidate what kind of play those expressions play on a utterance. For instance, “an utterance  $u$  of “*today*”” refers to the day on which  $u$  occurs”; “an utterance  $u$  of *yesterday*”” refers to the day before the day on which  $u$  occurs”; “an utterance  $u$  of “*I*”” refers to the speaker of  $u$ ”; “an utterance  $u$  of “*here*”” refers to the place at which  $u$  occurs”, and so on. Moreover, according to Perry [7], indexicals such as *I*, *Here*, *Now* gives to the speaker information about “*who* he was, *where* he was, and *when* he was” [7]. He calls these “self locating beliefs”.

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Self-locating beliefs, in turn, show us that the location in time seems to be very important when updating. Elga shows that “the manner in which an agent counts hew own temporal location as relevant to the truth of some proposition can change over time.” [2]. This seems to be extremely relevant when (temporal) indexicals are involved, in particular, since the content of an indexical expression and, therefore, its truth-value, is closely related to the world and time of the context. However, temporal issues are not explicit stated on Belief Revision nor in Belief Update as del Val and Shoham point out, updates were thought to “reflect changes that have taken place in the world over time, the update problem (like that of belief revision) is formulated using a language incorporating no model of time or change.” [1].

The temporal issues seem to be starting point to properly incorporate indexical information into a belief change theory: Schulz, for instance, presents the problem of the dynamics of

indexical belief on the uncertainty ”about our location in time and space”[10]. Considering Kaplan’s Logic of Demonstratives [5], only when indexicals occur in *proper contexts* it is possible to give a proper account on their contents. However, there are many situations where we face *improper contexts* such as *unknown* agent, time or position; or even *imprecise* information about an element of the context. Contexts change as well and the restriction on arguments within the same context is challenged by Radulescu [9] as he offers an alternative to **LD**: The Logic of Indexicals. Moreover, uncertainty also leads to possible defeasible reasoning situations and poses a problem not only to **LD** but also to Updating Beliefs. As Halpern states, “Agents continually obtain new information and then must update their beliefs to take this new information into account. How this should be done obviously depends in part on how uncertainty is represented” [4].

On one hand, it seems that in order to formalize situations where one should rationally *Revise/Update* one’s beliefs given indexical information we will need more than just traditional **AGM** (Belief Revision) or **KM** (Belief Update), since they do not offer a proper account to deal with the special context-sensitivity of indexical information. The formal system presented by Kaplan [5], the *Logic of Demonstratives* (or simply, **LD**), on the other hand, doesn’t properly deal with defeasible reasoning or improper contexts in general. So how ought one to revise or update one’s beliefs given indexical information and context change?

The present work intends to present and explore some background considerations towards some central issues concerning how one ought to revise or update one’s beliefs considering the context sensitivity of indexicals. With that purpose, some initial considerations from the analysis of some examples and situations such as those in which one cannot keep track on context change or those in which new information that might change the agent’s belief set is added. Furthermore, this work intends to suggest some possible solutions to those issues considering the problems faced by **LD**, **AGM** and **KM** systems.

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