1. Introduction

In some recent articles David Makinson and I have argued that the areas of nonmonotonic logic and belief revision are very closely related (see Makinson and Gärdenfors 1990, Gärdenfors 1990, 1991, and Gärdenfors and Makinson 1991). In particular, we show in Gärdenfors (1991), and Gärdenfors and Makinson (1991) how various forms of nonmonotonic inferences can be given a unified treatment in terms of how expectations are used in reasoning.

The guiding idea is that when we try to find out whether $\beta$ follows from $\alpha$, the background information that we use for the inference does not only contain what we firmly believe, but also information about what we expect in the given situation. For instance, if we know that someone is a Spanish woman, we anticipate her to be dark and temperamental. Such expectations can be expressed in different ways: by default assumptions, statements about what is normal or typical, etc. These expectations are not full beliefs but defeasible in the sense that if the premise $\alpha$ is in conflict with some of the expectations, we don't use them when determining whether $\beta$ follows from $\alpha$.

I want to show that expectations are the same kind of information as 'full' beliefs; the difference is that they are more defeasible than those beliefs. Consequently, the expectations used in nonmonotonic inferences need no special notation, but they can be expressed in the same language as regular beliefs. This is one side of the unified treatment of nonmonotonic reasoning. For simplicity I shall work with a standard propositional language $L$ which will be assumed to be closed under applications of the boolean connectives $\neg$ (negation), $\land$ (conjunction), $\lor$ (disjunction), and $\rightarrow$ (implication). We will use $\alpha$, $\beta$, $\gamma$, etc. as variables over sentences in $L$. It is also convenient to introduce the symbols $T$ and $\bot$ for the two

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1The material in this paper draws heavily on Gärdenfors (1991), Gärdenfors and Makinson (1991) and Balkenius and Gärdenfors (1991).
sentential constants "truth" and "falsity". We will assume that the underlying logic includes classical propositional logic and that it is compact.

All the different expectations will be formulated in L. In contrast to many other theories of nonmonotonic reasoning there are thus no default rules or other additions to the basic language, such as modal operators, that will be used to express the defeasible forms of information.

The key idea can be put informally as follows:

\[ \alpha \text{ nonmonotonically entails } \beta \text{ iff } \beta \text{ follows logically from } \alpha \text{ together with 'as many as possible' of the set of our expectations as are compatible with } \alpha. \]

In order to makes this more precise, we must, of course, specify what is meant by 'as many as possible'. But before turning to technicalities, let me illustrate the gist of the analysis by a couple of examples. \( \alpha \text{ nonmonotonically entails } \beta \) will be denoted \( \alpha \vdash \beta \) as usual.

**Example 1:** Let the language L contain the following predicates:

- \( Sx: x \text{ is a Swedish citizen} \)
- \( Ix: x \text{ has Italian parents} \)
- \( Px: x \text{ is a protestant} \)

Assume that the set of expectations contains \( Sb \rightarrow Pb \) and \( Sb \land Ib \rightarrow \neg Pb \), for all individuals \( b \). Assuming that the set of expectations is closed under logical consequences it also contains \( Sb \rightarrow \neg Ib \) and, of course, the logical truth \( Sb \land Ib \rightarrow Sb \). If we now learn that \( b \) is a Swedish citizen, that is \( Sb \), this piece of information is consistent with the expectations and thus we can conclude that \( Sb \vdash Pb \) according to the recipe above.

On the other hand, if we learn both that \( b \) is a Swedish citizen and has Italian parents, that is \( Sb \land Ib \), then this information is inconsistent with the set of expectations and so we cannot use all expectations when determining which inferences can be drawn from \( Sb \land Ib \). The most natural expedient is to give up the expectation \( Sb \rightarrow Pb \) and the consequence \( Sb \rightarrow \neg Ib \). The contracted set of expectations which contains \( Sb \land Ib \rightarrow \neg Pb \) and its logical consequences, in a sense (to be made precise below), contains 'as many as possible' of the sentences in the set of expectations that are compatible with \( Sb \land Ib \). So, by the general rule above, we have \( Sb \land Ib \vdash \neg Pb \). This shows that \( \vdash \) is indeed a nonmonotonic inference operation.

**Example 2:** Let us suppose that L contains the following predicates:

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1This idea is related to the idea of 'minimal change' within the theory of belief revision (see Gärdenfors (1988), pp. 66-68).