Optimal Completion and Implicatures of Complex Sentences — A Game Theoretic Approach

Anton Benz

Centre for General Linguistics, Berlin, Germany,
benz@zas.gwz-berlin.de,
WWW home page: http://www.anton-benz.de

Abstract. Due to their intensive discussion, implicatures of complex sentences became a kind of benchmark for testing different frameworks of Gricean pragmatics. In this paper we present a game theoretic account based on the principle of optimal completion. This principle was introduced in [1] in order to explain relevance implicatures of certain apparently irrelevant answers. We provide a foundation for this principle in *expected noise* models, and show how these models can be applied to the case of complex scalar implicatures.

Key words: scalar implicatures of complex sentences, optimal completion, expected noise, game theory, preferential models.

1 Introduction

Implicatures of complex sentences have been intensively discussed over the last years, in particular in connection with the debate between *globalism* and *localism* [5, 6, 8]. The following examples are taken from [14]:

(1) **a)** Kai had the broccoli or some of the peas last night.
+> Kai didn't have the broccoli and some of the peas last night.
+> Kai didn't have all of the peas last night.
b) Some of the children found some of their parents.
+> Some but not all of the children found some but not all of their parents.

If we apply the standard theory of scalar implicatures [11] to this example, we run into the following problem: *some* is part of a scale $\langle$*all, some*$\rangle$, hence the utterance of e.g. (1a) should implicate that '*Kai had the broccoli or all of the peas last night*' is false; however, this not only implies that Kai didn't have all of the peas but also that he had no broccoli. The predicted implicature is too strong.

Still one of the best accounts of implicatures in complex sentences is Sauerland's paper [14]. Two components are crucial to his theory: a generalised notion of scalar alternatives, and a consistency based incremental strengthening of implicatures. For example, the scale activated by the simple disjunction $A \vee B$

consists of the elements A, B, and $A \wedge B$, and the partial order $A \vee B \prec A, B \prec A \wedge B$.[1] An utterance of $A \vee B$ implicates the negation of the speaker's knowledge of all stronger alternatives, i.e. $A \vee B +\!\!> \neg KA$, $\neg KB$, $\neg K(A \wedge B)$ (*weak implicatures*). Then, in a second step, the *strong* implicatures of the form $K\neg X$ which are consistent with $A \vee B$ and all weak implicatures are added. This consistency based strengthening of the implicature leads to $K\neg(A \wedge B)$. With the usual assumption that knowledge implies factuality, we arrive at the desired implicature $\neg(A \wedge B)$.

Although Sauerland's model is simple and quite successful, one would like to see an explanation of implicatures which is embedded into a broader foundational framework. Game theoretic approaches have been developed because they allow explaining pragmatic phenomena from general assumptions about rational agents, but until recently they could not cope with such complex examples as those studied by Sauerland and others. The dissertation by Franke [7] is the first serious exception to this general claim. In this paper, we present an account of implicatures of complex sentences based on *Expected Noise* (EN) models introduced in [3].

Almost all game theoretic explanations of scalar implicatures are based on the assumption that addressees when facing ambiguous expressions choose the interpretation which the speaker most probably wanted to express. In addition they have either to assume that the speaker's choice of forms is restricted to a linguistically given set of alternatives, e.g. [7], or that the choice of unambiguous forms like '*some but not all*' comes with exceedingly high costs, e.g. [10]. In this paper, we present an approach which dispenses with all three assumptions. More precisely, we assume (1) that costs of forms are nominal, i.e. they are so small that they are negligible in comparisons to costs or benefits gained by propositional content; (2) that addressees always have the possibility to react with a clarification request which comes with nominal costs and induces the speaker to provide a maximally informative answer; and (3) that their strategies are robust against certain expected *noisy* speaker strategies. Efficient clarification requests have the effect that addressees don't gamble when interpreting sentences, and therefore remove most but not all ambiguities. This framework was first introduced in [1] and further worked out in [3].

Instead of specifying a set of scalar alternatives, we start out with literal communication, and specify for each situation θ a set $\mathcal{N}_\theta$ of forms which may be produced if the speaker makes *mistakes* of a certain kind. We call $\mathcal{N}_\theta$ a *noise* set. The presence of noise will push the speaker's and hearer's strategy pair for literal communication out of equilibrium and into a new equilibrium. The new equilibrium strategy then explains what is traditionally called *scalar* implicatures.

One way to solve the coordination problem posed by interpretation games is to literally express what one intends to express. For example if $\varphi_{\exists\neg\forall}$ says that

[1] In order to avoid over-generation, Sauerland has to use a technical trick which prevents a sentence A from standing in a scalar relation to $A \wedge B$ for arbitrary sentences B.

some but not all boys came to the party, the speaker can say that '*some but not all*' ($F_{\exists\neg\forall}$) came. If we assume that raising complexity leads to rising costs, even if they are nominal, then more complex forms will not be produced by the speaker. The set of answers which are optimal for some utterance situation compatible with the hearer's knowledge is then $\mathcal{O}p_{\varphi_{\exists\neg\forall}} = \{F_\forall, F_{\exists\neg\forall}, F_{\neg\exists}\}$. Furthermore, $F_\exists, F_{\neg\forall} \notin \mathcal{O}p_{\varphi_{\exists\neg\forall}}$. It remains to make an assumption about the expected noise. If the speaker is *lazy*, he may omit parts of his form. Let $F \lhd_\varphi G$ hold, if (1) F is a form which results from G by omitting (possibly) some constituent of G, and (2) G expresses φ, and (3) if F expresses ψ, then $\varphi \to \psi$. The speaker's laziness can be captured by the noise set $\mathcal{N}_\varphi = \{F \mid \exists G \in \mathcal{O}p_{\varphi_{\exists\neg\forall}}\ F \lhd_\varphi G\}$. For example, $\mathcal{N}_{\varphi_{\exists\neg\forall}} = \{F_{\exists\neg\forall}, F_\exists, F_{\neg\forall}\}$. Now, for these noise sets it can be shown that the new stable equilibrium is such that $F_\exists$ and $F_{\neg\forall}$ will be interpreted as $\varphi_{\exists\neg\forall}$. Intuitively, the reason is that $F_\exists$ and $F_{\neg\forall}$ can be *uniquely completed* to an optimal form. Therefore, we call the principle which can be derived from these noise sets the *principle of optimal completion.*

For (1a), however, we need an extra idea. We need an additional mechanism for handling situations in which the speaker is not a domain expert. This will be done by adding the nonmonotonic component for implicature suspension introduced in [2]. This means, we assume that speakers *normally* are experts. A disjunction will then lead to a cancellation of the expert assumption and change the relevant set of optimal answers. This will be integrated in the model which we outlined before.

In Section 2, we provide a brief review of Sauerland's work. In Section 3, we introduce interpretation games, and in Section 4 models with expeted noise. Finally, in Section 5, we apply these models to complex sentences.

2 Implicatures of complex sentences I

As explained in the introduction, we use Sauerland's [14] paper as a benchmark article against which we test our own model. We are interested in implicatures arising from complex sentences as shown in (1). Classical examples of sentences giving rise to scalar implicatures are[9, 11]:

(2) **a)** Some of the boys came to the party. +>Not all of the boys came to the party.
b) John or Peter came to the party. +>it is not the case that John and Peter came to the party.

The standard theory of scalar implicatures is based on the assumption that the speaker made a choice between a list of expressions belonging to a *scale*, i.e. a list of expressions ordered according to logical strength. The scales relevant for the examples in (2) are $\langle$*all, some*$\rangle$ and $\langle$*and, or*$\rangle$. In the first example, the speaker had a choice between *some* and *all.* As *all* would have made the sentence more informative, the speaker must have had a reason not to say *all.* If he is an expert and tries to be as informative as possible, then the probable reason is that he believes *all* to make the sentence false. In scalar accounts of implicatures, this reasoning is assumed to be grammaticalised in the sense that the presence of a scalar expression automatically leads to the inference that the corresponding sentences with stronger expressions are false. This provides the correct predictions for (2). If the logical complexity of the sentences rises, the limits of this account become evident, as we have seen in Example 1a.

As mentioned before, two components are crucial in Sauerland's theory: a generalised notion of scalar alternatives, and a consistency based incremental strengthening of implicatures. In addition, the definition of scalar alternatives makes use of a technical trick which blocks certain unintended alternatives.

Sauerland's generalised definition of *scalar alternative* still is based on the notion of *scale*. Scales must be given as primitives in our lexicon. They are sequences of expressions $\langle \alpha_0, \ldots, \alpha_n \rangle$ which are ordered according to decreasing logical strength. A sentence ψ is a *one–step alternative* of ϕ if the following two conditions hold: (1) $\phi \neq \psi$; (2) there are scalar expressions α and α' which both occur on the same scale C such that ψ is the result of replacing one occurrence of α in ϕ with α'. A sentence ψ is a *scalar alternative* of ϕ if there is a sequence $\langle \phi_0, \ldots, \phi_n \rangle$ with $n \geq 0$, $\phi_0 = \phi$, and $\phi_n = \psi$ such that, for all i with $1 \leq i \leq n$, ϕ_i is a one–step alternative of ϕ_{i-1}. Implicatures are derived from the notion of scalar alternatives and entailment relations [14, p. 374]: $\neg\psi'$ is an *implicature* of ψ if the following three conditions hold: (1) ψ' is a scalar alternative of ψ, (2) ψ' entails ψ, (3) ψ does not entail ψ'. We apply these definitions to the following more simple examples:

(3) **a)** Kai had the broccoli and some of the peas last night. (ψ)
b) It is not the case that Kai ate some of the peas. (ϕ)

In (3a), (ψ') '*Kai had the broccoli and all of the peas last night*' is a scalar alternative of ψ which also satisfies the entailment conditions for scalar implicatures. Hence, $\neg\psi'$ is implicated. As ψ is true, it follows with $\neg\psi'$ that '*Kai did not have all of the peas last night.*' In (3b), (ψ') '*It isn't the case that Kai ate all of the peas*' is a scalar alternative of ψ. However, ψ implies ψ', hence the entailment condition is violated, and $\neg\psi' \equiv$ '*Kai ate all of the peas*' is not implicated.

In order to handle example (1a), Sauerland has to use a technical trick: He has to make $A \vee B, A, B, A \wedge B$ scalar alternatives if A and B are part of conjunctions or disjunctions without making A and $A \wedge B$ scalar alternative for arbitrary A and B. For example, if the sentence is '*Kai had the broccoli*' (A), then A should not stand in the scalar alternative relation to '*Kai had the broccoli and the beans*,' as this would entail that an utterance of A implicates the falsity of B for arbitrary sentences B. However, if the sentence is (1a), then A should stand in the scalar alternative relation to $A \wedge B$. The trick is to assume that $A \vee B$ is in fact an alternative to the formulas $A \boxed{\mathrm{L}} B$ and $A \boxed{\mathrm{R}} B$ which are defined such that $A \boxed{\mathrm{L}} B$ is true iff A is true, and $A \boxed{\mathrm{R}} B$ is true iff B is true.

We now can turn to Example (1a) '*Kai had the broccoli or some of the peas last night*'. ($B(\exists)$) '*Kai had some of the peas last night*' is a scalar alternative to (1a), and therefore also to ($B(\forall)$) '*Kai had all of the peas last night.*' As the scalar entailment conditions are satisfied, it follows that (1a) implicates that Kai did not have all of the peas. This provides the correct prediction with respect to $B(\exists)$. But what about (A) '*Kai had the broccoli*'? A is a scalar alternative to $A \vee B(\exists)$ which satisfies the entailment conditions; hence, $\neg A$ should be implicated. This prediction is too strong. To overcome this problem, Sauerland introduces a principle of consistency based incremental strengthening of implicatures. First, if ψ' is a scalar alternative of ψ which satisfies the entailment conditions, then he assumes that the *primary* or *weak* implicature is not $\neg\psi'$ but $\neg\Box\psi'$ with $\Box\psi'$ meaning that the speaker knows ψ'. A weak implicature $\neg\Box\psi'$ is strengthened to the *secondary* or *strong* implicature $\Box\neg\psi'$ if the strong implicature is consistent with the literal meaning of ψ and all its weak implicatures. For Example (1a), this means that (1a) has the weak implicatures $\neg\Box A$, $\neg\Box B(\exists)$, $\neg\Box B(\forall)$, $\neg\Box(A \wedge B(\exists))$, and $\neg\Box(A \wedge B(\forall))$. It is easy to see that $\neg\Box A$ cannot be strengthened to $\Box\neg A$, as this would entail in conjunction with the semantic content $\Box(A \vee B(\exists))$ that $\Box B(\exists)$, in contradiction to the weak implicature $\neg\Box B(\exists)$. However $\neg\Box B(\forall)$ can be strengthened to $\Box\neg B(\forall)$. As knowledge entails truth, it follows that $\neg B(\forall)$, i.e. that Kai had not all of the peas.

3 Interpretation games

For modelling scalar implicatures, we consider interpretation games in which the speaker S wants to communicate some formula φ which he knows to be true to the hearer. First, nature chooses a possible world v, and the speaker's private knowledge. Second, the speaker sends a form F to the hearer, and finally the hearer guesses which formula φ the speaker wanted to communicate. They are successful if the hearer H correctly guesses φ, else they have no success. In addition, small costs which depend on the complexity of the forms F are added. The speaker's private knowledge, which is in game theory called the speaker's *type*, can be identified with a pair $\theta = \langle\varphi, K_s\rangle$ consisting of the formula φ which the speaker intends to communicate, and a set K_s of possible worlds which represents the speaker's knowledge about the state of the world. We always assume that the speaker has true knowledge, i.e. that $v \in K_s$, and that he only wants to communicate what he believes to be true, i.e. that $K_s \models \varphi$. The final success of the conversation is measured by a utility measure u which only depends on φ, F, and the formula ψ chosen by the hearer.

$$\begin{array}{ccccc}
\text{state: world } v & & H \text{ decides} & & \text{evaluation} \\
\downarrow & & \downarrow & & \downarrow \\
\bullet & \xrightarrow{F} & \bullet & \xrightarrow{\psi} & \bullet \\
\uparrow & & \uparrow & & \uparrow \\
S \text{ knows: } \varphi, K_s & & H \text{ knows: } F & & \text{utility } u(\varphi, F, \psi)
\end{array}$$

In game theory, the behaviour of agents is modelled by their *strategies*, i.e. probability distributions which tell us which actions the players will choose in their different information states; e.g. $S(F|\varphi, K_s)$ is the probability with which the speaker chooses form F given that he knows K_s and intends to communicate

φ. With Lewis [12] we assume that the meaning of a sentence F is defined by the signalling behaviour of the language community, i.e. F means ψ because the population conventionally interprets F as ψ. For a given interpretation game, this means that the language community interprets F by ψ, and that a speaker, if he wants to communicate ψ, will choose a form F for which is interpreted as ψ. We write $|F|$ for the formula by which form F is conventionally interpreted. Conventionality of $|\,.\,|$, therefore, imposes the following conditions on speaker and hearer strategies:

1. *Speaker strategy*: $S(F|\varphi, K_s) > 0 \Rightarrow |F| = \varphi$.
2. *Hearer strategy*: $H(\psi|F) > 0$ *iff* $|F| = \psi$.

Given these conditions, it is clear that interpretation games have a trivial solution: the speaker always chooses a form with minimal complexity which semantically expresses the intended formula:

$$S(F|\varphi, K_s) > 0 \textit{ iff } F \in \{F \mid |F| = \varphi \wedge \forall G\,(|G| = \varphi \rightarrow c(F) \leq c(G))\}. \quad (3.1)$$

Clearly, the strategy pair (S, H) is a *Nash equilibrium*; i.e. if the speaker knows that the hearer follows interpretation strategy H, he has no interest to change to any other strategy than S, and if the hearer knows that the speaker follows signalling strategy S, then he also has no interest to change his strategy. An even stronger result holds: ignoring the costs of forms, (S, H) is weakly Pareto dominating all other strategy pairs; i.e. no other strategy pair (S', H') can provide higher payoff than (S, H).[2] This trivial solution for interpretation games seems to offer little to the explanation of implicatures in complex sentences. As we will see in the next section, this judgement is premature.

We work with the following definition of interpretation games:

Definition 1 *An* interpretation game *is a game* $\langle \Omega, \Theta, P, \mathcal{F}, \mathcal{L}, u, |\,.\,| \rangle$ *with:*

1. *Ω: is a finite set of possible worlds.*
2. *$\mathcal{F}$: is a set of natural language sentences from which the speaker chooses his utterance.*
3. *$\mathcal{L}$: is a set of first–order formulas from which the addressee chooses his interpretation.*
4. *Θ: is a set of speaker types representing his private knowledge. The elements of Θ are pairs $\langle \varphi, K_s \rangle$ for which:*
   (a) $\varphi \in \mathcal{L}$ is the formula which the speaker intends to communicate.
   (b) $K_s \subseteq \Omega$ represents the speaker's knowledge about the world.
5. *$|\,.\,|$: is a function which maps the set of natural language sentences onto the set of formulas; $|F|$ represents the semantic meaning of a form F.*

[2] If we take costs of signalling into account, then more efficient strategy pairs may exists. For example, assume that speaker and hearer follow (S, H) except that the speaker utters the vowel a instead of the most frequent sentence F, and the hearer interpret a by $|F|$. This new strategy is more efficient. We cannot exclude such strategy pairs.

6. *u: is a utility measure which maps the elements of $\Phi \times \mathcal{F} \times \Phi$ to real numbers. We assume that u can be decomposed as follows:*

$$u(\varphi, F, \psi) = \delta(\varphi, \psi) - c(F), \tag{3.2}$$

with $\delta(\varphi, \psi) = 1$ iff $\varphi = \psi$, and $\delta(\varphi, \psi) = 0$ else, and $c(F) > 0$ but nominal.[3]

7. *P: is a probability distribution over $\Omega \times \Theta$. $P(v, \varphi, K_s)$ is the probability with which the speaker who knows K_s wants to communicate φ in world v. We assume:*

$$P(v, \varphi, K_s) > 0 \Rightarrow v \in K_s \wedge K_s \models \varphi. \tag{3.3}$$

That $|F|$ maps $\mathcal{F}$ *onto* Φ means that every formula can be expressed in natural language. As our intended applications are scalar implicatures, this assumption is unproblematic.

The definition of interpretation game implicitly contains a representation of the Gricean cooperative principle. We assume that the utility measure u is shared by S and H, which means that there is no conflict of interest between them, and that they both consider the same outcomes successful. The definition also represents a second Gricean maxim: the maxim of quality. This maxim is represented by the assumption that the speaker only intends to communicate what he believes to be true. We have not yet represented the maxim of quantity. We do it by assuming that the speaker can intend to communicate φ only if φ is among the strongest formulas which he believes to be true. This means, we assume (3.3) and:

$$P(v, \varphi, K_s) > 0 \text{ then, if } K_s \models \psi \text{ and } \psi \to \varphi, \text{ then } \varphi \to \psi. \tag{3.4}$$

This condition will be relaxed later.

4 Models with expected noise

Speakers may make mistakes. These mistakes may be expected by speaker and hearer. In fact, that these mistakes are expected may be part of the common ground. Expected noise models are an attempt to model the effects of such commonly expected mistakes. These mistakes may origin from whatever reason; hence, the representation of noise in expected noise models is very little restricted. Assume that $\mathscr{G}$ is an interpretation game and (S, H) is any given equilibrium of the game. For each speaker type θ the strategy S will define a set $\mathcal{O}p_\theta$ of forms which he will produce with positive probability, i.e. $\mathcal{O}p_\theta = \{F \mid S(F|\theta) > 0\}$. Any kind of mistakes, or *noise*, will change the speaker strategy S to a strategy $\widetilde{S}$ which assigns positive probability to the forms in the set $\mathcal{N}_\theta = \{F \mid \widetilde{S}(F|\theta) > 0\}$. An expected noise model for interpretation games is an interpretation game together with sequences of sets $\mathcal{O}p_\theta$ and $\mathcal{N}_\theta$:

[3] *Nominality* can be made precise as follows: fist the speaker calculates a set of optimal forms using only δ; second, he chooses from these optimal forms one with minimal costs. Nominality of costs means that $c(F)$ is negligibly small compared to δ.

Definition 2 (EN model) *An* expected noise (EN) *model for interpretation games, is a triple* $\langle \mathscr{G}, (\mathcal{O}p_\theta)_{\theta\in\Theta}, (\mathcal{N}_\theta)_{\theta\in\Theta}\rangle$ *for which*

1. $\mathscr{G} = \langle \Omega, \Theta, P, \mathcal{F}, \mathcal{L}, u, |\,.\,|\rangle$ *is an interpretation game.*
2. $(\mathcal{O}p_\theta)_{\theta\in\Theta}$ *is a sequence of sets* $\mathcal{O}p_\theta \subseteq \mathcal{F}$.
3. $(\mathcal{N}_\theta)_{\theta\in\Theta}$ *is a sequence of sets* $\mathcal{N}_\theta \subseteq \mathcal{F}$.

In the following, we write $\langle \mathscr{G}, \mathcal{O}p_\theta, \mathcal{N}_\theta\rangle$ instead of $\langle \mathscr{G}, (\mathcal{O}p_\theta)_{\theta\in\Theta}, (\mathcal{N}_\theta)_{\theta\in\Theta}\rangle$.

How should the hearer react to the presence of noise? We add *efficient clarification requests* to the hearer's set of actions. By *efficiency* we mean that clarification requests come with nominal costs and guarantee an answer from the speaker which is free of noise. As clarification requests come with additional costs, even though they are nominal, it is the best response to interpret utterance F by φ iff F can only be uttered in situations in which the speaker intended to communicate φ. This means, that choosing φ as interpretation of F is the best response if φ is the unique element of:

$$\mathscr{B}(F) := \bigcap \{\{\varphi^\theta\} \mid F \in \mathcal{N}_\theta \wedge \exists v P(v,\theta) > 0\}. \tag{4.5}$$

If $\mathscr{B}(F)$ is empty, then the hearer cannot be sure how to interpret F. Hence, a clarification request is the best response. For a given EN model $\mathfrak{E}$ let $\mathcal{N}(\mathfrak{E})$ be the set of all $F \in \mathcal{F}$ for which $\mathscr{B}(F)$ has one element:

$$\mathcal{N}(\mathfrak{E}) := \{F \mid \mathscr{B}(F) \neq \emptyset\}. \tag{4.6}$$

This leads to a new hearer strategy in EN models for interpretation games. Let $\mathfrak{E} = \langle \mathscr{G}, \mathcal{O}p_\theta, \mathcal{N}_\theta\rangle$ be an EN model and (S, H) a given strategy pair for the interpretation game $\mathscr{G}$. Let $\mathfrak{cr}$ denote the clarification request. Then, the hearer will follow the strategy $\overline{H}$ defined as follows:

$$\overline{H}(\varphi|F) = 1 \textit{ iff } F \in \mathcal{N}(\mathfrak{E}) \wedge \varphi \in \mathscr{B}(F), \text{ and } \overline{H}(\mathfrak{cr}|F) = 1 \textit{ iff } F \notin \mathcal{N}(\mathfrak{E}) \tag{4.7}$$

For this new strategy, the speaker has the possibility to improve his original strategy S by intentionally choosing forms which otherwise could only be produced under the influence of noise. Let $\bar{c}_\theta := \min\{c(F) \mid F \in \mathcal{N}_\theta \cap \mathcal{N}(\mathfrak{E})\}$, and:

$$\mathrm{Op}^{\mathfrak{E}}_\theta := \{F \in \mathcal{N}_\theta \cap \mathcal{N}(\mathfrak{E}) \mid c(F) = \bar{c}_\theta\}. \tag{4.8}$$

This is the set of all forms of minimal complexity which will be interpreted as intended given the speaker's type θ. This leads to the improved speaker strategy $\overline{S}$ defined as follows:

$$\overline{S}(F|\theta) = \begin{cases} |\mathrm{Op}^{\mathfrak{E}}_\theta|^{-1} & \text{if } F \in \mathrm{Op}^{\mathfrak{E}}_\theta \\ 0 & \text{otherwise} \end{cases}. \tag{4.9}$$

Clearly, the strategy pair $(\overline{S}, \overline{H})$ is at least a weak equilibrium of $\mathscr{G}$, the hearer strategy strongly dominates all other hearer strategies in the presence of the noise characterised by $\mathfrak{E}$, and $\overline{S}$ as a strategy against $\overline{H}$ is strongly dominating all strategies S' which produce forms which could not be produced by $\overline{S}$.

5 Implicatures of complex sentences II

In the last section, we introduced EN models. In this section, we apply them to implicatures in complex sentences. We will see that we need an extension of the model for example (1a). We start with the simpler examples (2) and (3a).

5.1 Complex sentences without disjunction

Underlying an EN model is an interpretation game $\mathscr{G} = \langle \Omega, \Theta, P, \mathcal{F}, \mathcal{L}, u, |\,.\,| \rangle$. For Sauerland's examples, we can assume that the relevant set of forms $\mathcal{F}$ are sentences of the form: '*Kai had the broccoli,*' '*Kai had some of the broccoli,*' '*Kai had all of the broccoli,*' '*Kai had the peas,*' '*Kai had some of the peas,*' '*Kai had all of the peas,*' and connections built from these sentences with the help of '*and,*' '*or,*' '*it is not the case that...*'. In addition, we may have sentences like '*Some of the people had some of the broccoli,*' '*All of the people had some of the broccoli,*' etc. We use suggestive notation as e.g. $F_\forall$, $F_{\exists\neg\forall}$, $F_{\neg\exists}$ for these sentences. Accordingly, we denote the corresponding logical formulas by $\varphi_\forall$, $\varphi_{\exists\neg\forall}$, $\varphi_{\neg\exists}$, etc. About the costs $c(F)$ we only need to assume that the relations $c(F) < c(G)$ correspond to the intuitive differences of complexity.

We have seen that the optimal strategies in the interpretation game are, for the hearer, to interpret forms literally, and, for the speaker, to choose the cheapest form which literally expresses what he intents to communicate (3.1). Let (S, H) be this strategy pair. The choice of form only depends on the intended formula φ. This means for the EN model $\langle \mathscr{G}, \mathcal{O}p_\theta, \mathcal{N}_\theta \rangle$ that the sets $\mathcal{O}p_\theta$ are the sets $\{F \mid S(F|\theta) > 0\}$, and that $\mathcal{O}p_\theta = \mathcal{O}p_{\theta'}$ iff $\varphi^\theta = \varphi^{\theta'}$.

We explain quantity implicatures as the effect of the speaker's tendency to produce forms which miss some information which would be necessary to make it optimal for literal communication. More specifically, we assume that the speaker may only omit some *conjunct* of the optimal form. Let $F \lhd G$ hold, iff

1. G expresses φ,
2. F results from G by (possibly) omitting some conjunct of G.

For example, the following relations hold:

$$F_\exists, F_{\neg\forall}, F_{\exists\neg\forall} \lhd F_{\exists\neg\forall}, \text{ and } F_\exists, F_{\neg\forall}, F_\exists \wedge F_{\neg\forall} \lhd F_\exists \wedge F_{\neg\forall}. \tag{5.10}$$

The definition implies that if F expresses ψ, and G expresses φ, then $F \lhd G$ implies $\varphi \to \psi$. We assume that the noise only depends on the formula which the speaker intends to communicate. This leads to the noise sets:

$$\mathcal{N}_\theta = \{F \mid \exists G \in \mathcal{O}p_\theta \; F \lhd G\}. \tag{5.11}$$

This (almost) completes the definition of the EN model $\mathfrak{E}$. As we have seen, starting from literal communication, the noise described in (5.11) leads to a new strategic equilibrium $(\overline{S}, \overline{H})$. In this equilibrium, speaker and hearer will only use and interpret forms from $\mathcal{N}(\mathfrak{E})$. Intuitively, this is the set of all forms which can be *uniquely completed* to an optimal form in the union of the $\mathcal{O}p_\theta$. Therefore, if the noise set is defined by a relation $\lhd$ which specifies which parts of a form may be omitted, we call the principle that says that forms in $\mathcal{N}(\mathfrak{E})$ are completed to forms in $\mathcal{O}p$ the *principle of optimal completion* [1].

We first consider an example similar to (2): '*Kai had some of the broccoli*' ($F_\exists$). Let us for now assume that the speaker may only intend to express $\varphi_{\neg\exists}$, $\varphi_{\exists\neg\forall}$, or $\varphi_\forall$. Then the speaker following strategy S can only produce $F_{\neg\exists}$, $F_{\exists\neg\forall}$, or $F_\forall$. It is $\mathcal{N}_{\varphi_{\neg\exists}} = \{F_{\neg\exists}\}$, $\mathcal{N}_{\varphi_{\exists\neg\forall}} = \{F_{\exists\neg\forall}, F_\exists, F_{\neg\forall}\}$, and $\mathcal{N}_{\varphi_\forall} = \{F_\forall\}$. Clearly, $\mathcal{N}(\mathfrak{E})$ is simply the union of these $\mathcal{N}_\varphi$. The EN model then predicts that $\overline{H}(\varphi_{\exists\neg\forall}|F_\exists) = 1$, and that a speaker following $\overline{S}$ will produce $F_\exists$ if he intends to communicate $\varphi_{\exists\neg\forall}$. Here, we have to assume that the costs $c(F_{\neg\forall})$ are higher than $c(F_\exists)$.

Next, we consider an example corresponding to (1b) '*Some of the people ate some of their broccoli*' ($F_{\exists|\exists}$). We write $\exists^!$ short for *some but not all*, and $\emptyset$ for *none*. We find the following combinations:

	$\emptyset$	$\exists^!$	$\forall$
$\emptyset$	$\varphi_{\emptyset\|\emptyset}$	$\varphi_{\emptyset\|\exists^!}$	$\varphi_{\emptyset\|\forall}$
$\exists^!$	$\varphi_{\exists^!\|\emptyset}$	$\varphi_{\exists^!\|\exists^!}$	$\varphi_{\exists^!\|\forall}$
$\forall$	$\varphi_{\forall\|\emptyset}$	$\varphi_{\forall\|\exists^!}$	$\varphi_{\forall\|\forall}$

	$\emptyset$	$\exists^!$	$\forall$
$\emptyset$	$F_{\emptyset\|\emptyset}$	$F_{\emptyset\|\exists^!}$	$F_{\emptyset\|\forall}$
$\exists^!$	$F_{\exists^!\|\emptyset}$	$F_{\exists^!\|\exists^!}$	$F_{\exists^!\|\forall}$
$\forall$	$F_{\forall\|\emptyset}$	$F_{\forall\|\exists^!}$	$F_{\forall\|\forall}$

(5.12)

For the forms F, we assume that the quantifier $\exists^!$ is the conjunction '*some but not all*'. Due to the possessive pronoun, the first quantifier always takes scope over the second quantifier. Hence, $|F_{\exists|\exists}| = \varphi_{\exists|\exists}$, $|F_{\exists|\forall}| = \varphi_{\exists|\forall}$, $|F_{\exists^!|\forall}| = \varphi_{\exists^!|\forall}$, etc.

In this section, we assume that the speaker is a domain expert, i.e. K_S is always a singleton set $\{v\}$. We assume further that the speaker can only express a formula which is maximally informative, i.e. we assume (3.4). We will relax this condition later.

The first column of Table 1 shows the different formulas which the speaker might want to express.[4] Some of the formulas are equivalent. The second column shows the form which the speaker has to use if he communicates literally. The third column shows the forms which are optimal in the EN model. They are the forms which a speaker who follows strategy $\overline{S}$ will use. The prediction is that the hearer following strategy $\overline{H}$ will interpret them by the formulas in the first column. We can see that the speaker should never use the form $F_{\exists|\exists}$: '*Some of the people had some of their broccoli.*' This disappointing result should not make us dismiss the whole approach. Let us see why our model makes this prediction. $F_{\exists|\exists}$ cannot be used because it is a sub–form of three complete optimal forms: $F_{\exists^!|\forall} \wedge F_{\exists^!|\exists^!} \wedge F_{\exists^!|\emptyset}$, $F_{\emptyset|\forall} \wedge F_{\exists^!|\exists^!} \wedge F_{\exists^!|\emptyset}$ and $F_{\exists^!|\forall} \wedge F_{\exists^!|\exists^!} \wedge F_{\emptyset|\emptyset}$. Hence, the model predicts that the hearer, who has to guess the full intended formula, will

[4] The implicit assumption is that he cannot express stronger formulas as e.g. '*Tom had half of his broccoli, and Mary had two spoons of hers.*' In order to make clear that the '*but not all*' part is of interest to us, I wrote e.g. $\varphi_{\emptyset|\forall} \wedge \varphi_{\exists^!|\exists^!} \wedge \varphi_{\exists^!|\emptyset}$ instead of using the logically equivalent formula $\varphi_{\emptyset|\forall} \wedge \varphi_{\exists|\exists} \wedge \varphi_{\exists|\emptyset}$. This has no effect on the analysis.

formula φ	$\mathcal{O}p_\theta$	$\mathrm{Op}_\theta^{\mathfrak{E}}$
$\varphi_{\forall\|\forall}$	$F_{\forall\|\forall}$	$F_{\forall\|\forall}$
$\varphi_{\emptyset\|\forall} \wedge \varphi_{\forall\|\exists}$	$F_{\emptyset\|\forall} \wedge F_{\forall\|\exists}$	$F_{\emptyset\|\forall} \wedge F_{\forall\|\exists}$
$\varphi_{\forall\|\exists!}$	$F_{\forall\|\exists!}$	$F_{\forall\|\exists!}$
$\varphi_{\forall\|\emptyset}$	$F_{\forall\|\emptyset}$	$F_{\forall\|\emptyset}$
$\varphi_{\exists!\|\forall} \wedge \varphi_{\exists!\|\exists!} \wedge \varphi_{\exists!\|\emptyset}$	$F_{\exists!\|\forall} \wedge F_{\exists!\|\exists!} \wedge F_{\exists!\|\emptyset}$	$F_{\exists\|\forall} \wedge F_{\exists\|\exists} \wedge F_{\exists\|\emptyset}$
$\varphi_{\emptyset\|\forall} \wedge \varphi_{\exists!\|\exists!} \wedge \varphi_{\exists!\|\emptyset}$	$F_{\emptyset\|\forall} \wedge F_{\exists!\|\exists!} \wedge F_{\exists!\|\emptyset}$	$F_{\emptyset\|\forall} \wedge F_{\exists\|\emptyset}$
$\varphi_{\exists!\|\forall} \wedge \varphi_{\emptyset\|\exists!} \wedge \varphi_{\exists!\|\emptyset}$	$F_{\exists!\|\forall} \wedge F_{\emptyset\|\exists!} \wedge F_{\exists!\|\emptyset}$	$F_{\emptyset\|\exists!}$
$\varphi_{\exists!\|\forall} \wedge \varphi_{\forall\|\exists}$	$F_{\exists!\|\forall} \wedge F_{\forall\|\exists}$	$F_{\exists\|\forall} \wedge F_{\forall\|\exists}$
$\varphi_{\exists!\|\forall} \wedge \varphi_{\exists!\|\exists!} \wedge \varphi_{\emptyset\|\emptyset}$	$F_{\exists!\|\forall} \wedge F_{\exists!\|\exists!} \wedge F_{\emptyset\|\emptyset}$	$F_{\emptyset\|\emptyset}$

Table 1. *Some of the people had some of their broccoli.*

react with a clarification request. $F_{\exists|\exists}$ does not tell him whether $F_{\emptyset|\forall}$ '*No one had all of his broccoli*' and $F_{\emptyset|\emptyset}$ '*No one had none of his broccoli*' are true. This prediction seems to be correct. Let us consider another example: the form $F_{\forall|\exists}$. It is also predicted not to be optimal. If the speaker intends to communicate $\varphi_{\forall|\exists!}$, the third row tells us that he cannot say $F_{\forall|\exists}$ but has to say $F_{\forall|\exists!}$. The reason is that $F_{\forall|\exists}$ also occurs as a sub–form of the formula second from bottom. This entails that the hearer cannot infer from an utterance of $F_{\forall|\exists}$ that $F_{\emptyset|\forall}$, and therefore the speaker has to say $F_{\forall|\exists!}$. This means, '*Everyone ate some of his broccoli*' does not implicate that '*Everyone ate some but not all of his broccoli.*' This prediction seems plausible. Also the other predictions seem plausible, e.g. that $F_{\emptyset|\forall} \wedge F_{\exists|\emptyset}$ should implicate that $(F_{\exists|\exists})$ some had some of their broccoli. The forms $F_{\forall|\emptyset}$, $F_{\emptyset|\exists!}$, and $F_{\emptyset|\emptyset}$ seem to be problematic because they are difficult to verbalise, and hence are very marked. There are alternatives which are easier to produce, e.g. '*Everyone ate either all of his broccoli or nothing.*'

The exclusion of speakers who only want to partially describe the situation seems to be the reason why $F_{\exists|\exists}$ is not among the optimal forms. Else, the predictions seem correct. Therefore, we extend our model with such speakers. This means that we have to adjust condition (3.4). Let $\mathcal{L}^i$ be the set of all formulas φ which satisfy the condition of (3.4); i.e. which satisfy $K_s \models \psi$ and $\psi \to \varphi$, then $\varphi \to \psi$. We capture the possibility of speakers who only intend to partially characterisation the situation by assuming (3.3) and:

$$P(v, \varphi, K_s) > 0, \text{ then } \exists \psi \in \mathcal{L}^i \, \varphi \lhd \psi, \tag{5.13}$$

where $\varphi \lhd \psi$ means that φ results from ψ by possibly omitting some conjunct from ψ. *Conjunct* has to be understood such that e.g. the following relations hold: $\varphi_{\exists|\exists}, \varphi_{\exists|\neg\forall}, \varphi_{\exists|\exists!} \lhd \varphi_{\exists|\exists!}$, and $\varphi_{\emptyset|\forall}, \varphi_{\forall|\exists}, \varphi_{\emptyset|\forall} \wedge \varphi_{\forall|\exists} \lhd \varphi_{\emptyset|\forall} \wedge \varphi_{\forall|\exists}$.

Table 2 shows in its first column the forms which the speaker had to produce for literally describing the full situation, and in the last column the forms predicted by the EN model in Table 1. The central column is the interesting one. It shows the minimal forms which can be produced and interpreted in the new EN model.[5]

[5] I omitted all forms of the type $F_{\exists|\neg\forall}, F_{\neg\forall|\exists}, F_{\neg\forall|\forall}$, etc.

	$\mathcal{O}p_\theta$	*partial* $\mathrm{Op}_\theta^{\mathfrak{E}}$	$\mathrm{Op}_\theta^{\mathfrak{E}}$
1.	$F_{\forall\|\forall}$	$F_{\forall\|\forall}$	$F_{\forall\|\forall}$
2.*a*)	$F_{\emptyset\|\forall} \wedge F_{\forall\|\exists}$	$F_{\emptyset\|\forall},\ F_{\forall\|\exists}$	$F_{\emptyset\|\forall} \wedge F_{\forall\|\exists}$
2.*b*)	$F_{\forall\|\exists!}$	$F_{\forall\|\exists!}$	$F_{\forall\|\exists!}$
3.	$F_{\forall\|\emptyset}$	$F_{\forall\|\emptyset}$	$F_{\forall\|\emptyset}$
4.	$F_{\exists!\|\forall} \wedge F_{\exists!\|\exists!} \wedge F_{\exists!\|\emptyset}$	$F_{\exists\|\forall},\ F_{\exists\|\exists},\ F_{\exists\|\emptyset}$	$F_{\exists\|\forall} \wedge F_{\exists\|\exists} \wedge F_{\exists\|\emptyset}$
5.	$F_{\emptyset\|\forall} \wedge F_{\exists!\|\exists!} \wedge F_{\exists!\|\emptyset}$	$F_{\emptyset\|\forall},\ F_{\exists\|\exists},\ F_{\exists\|\emptyset}$	$F_{\emptyset\|\forall} \wedge F_{\exists\|\emptyset}$
6.	$F_{\exists!\|\forall} \wedge F_{\emptyset\|\exists!} \wedge F_{\exists!\|\emptyset}$	$F_{\exists\|\forall},\ F_{\exists\|\emptyset}$	$F_{\emptyset\|\exists!}$
7.*a*)	$F_{\exists!\|\forall} \wedge F_{\forall\|\exists}$	$F_{\exists\|\forall},\ F_{\forall\|\exists}$	$F_{\exists\|\forall} \wedge F_{\forall\|\exists}$
7.*b*)	$F_{\exists!\|\forall} \wedge F_{\exists!\|\exists!} \wedge F_{\emptyset\|\emptyset}$	$F_{\exists\|\forall},\ F_{\exists\|\exists},\ F_{\emptyset\|\emptyset}$	$F_{\emptyset\|\emptyset}$

Table 2. *Some of the people had some of their broccoli.*

We again find that $F_{\forall|\exists}$ does not implicate $F_{\forall|\exists!}$. But for $F_{\exists|\exists}$ the situation has changed. It now implicates that $F_{\exists!|\exists!}$, i.e. that '*Some but not all of the people had some but not all of their broccoli.*' This is the desired result. Furthermore, it is predicted that $F_{\exists|\exists}$ does not implicate whether or not $F_{\exists!|\forall}$ or $F_{\exists!|\emptyset}$ are true or not. This follows from the fact that, for both formulas, we can find a row containing it and $F_{\exists|\exists}$ and another row containing $F_{\exists|\exists}$ and its negation.

5.2 Complex sentences with disjunction

In this section, we discuss Example (1a), repeated here as (4):

(4) Kai had the broccoli or some of the peas last night.

The first problem is that our model predicts that an expert speaker can never produce a disjunction as there are always stronger alternatives namely the two parts of the disjunction. We have to explain how a disjunction can be licensed. It is here that we use the ideas introduced in [2]: The class of optimal answers is calculated relative to a system of preferential models, such that assertions which are optimal in preferred models are excluded from use in less preferred models. Preferential models are pairs $\langle \mathcal{M}, < \rangle$ for which $\mathcal{M}$ is a partition of the set of speaker types Θ, and $<$ a well-founded partial order. For $M, M' \in \mathcal{M}$, $M' < M$ means that M' is preferred over M, or *more normal* than M. This means that preferential models will represent the normality assumptions about the expert status of the speaker. We distinguish the following disjoint subsets of Θ: the set $M_{A,B}$, and the sets $M_\emptyset$ and $M_{\sqsubseteq B}$. In $M_{A,B}$, the speaker is expert about both broccoli (A) and peas (B). In $M_\emptyset$ and $M_{\sqsubseteq B}$, the speaker does not know whether Kai had broccoli or peas; but in $M_{\sqsubseteq B}$, the speaker can make a judgement about the possible amount of peas Kai could have eaten. It seems plausible, that the latter knowledge is less expected than total ignorance. We ignore all other speaker types, and assume that the speaker normally is an expert. This leads to the following preferential order:

$$M_{A,B} < M_\emptyset < M_{\sqsubseteq B} \tag{5.14}$$

The crucial idea is the assumption that, if the speaker is in M, he cannot use forms which are optimal in some $M' < M$. Let $\text{Op}^{\mathfrak{E}}_\theta(M')$ be defined for $M' < M$, and let $\mathcal{L}^M := \mathcal{L} \setminus \bigcup_{M'<M} \text{Op}^{\mathfrak{E}}_\theta(M')$, then we set for $\theta \in M$:

$$\text{Op}^{\mathfrak{E}}_\theta(M) := \textit{ the set of minimally complex forms } F \in (\mathcal{N}_\theta \cap \mathcal{N}(\mathfrak{E})) \setminus \mathcal{L}^M. \quad (5.15)$$

$\text{Op}^{\mathfrak{E}}_\theta$ is the set of all forms which are optimal according to an underlying EN model $\mathfrak{E} = \langle \mathscr{G}, \mathcal{O}p_\theta, \mathcal{N}_\theta \rangle$. Hence, $\text{Op}^{\mathfrak{E}}_\theta(M)$ is the set of all forms which are optimal after excluding all forms which are optimal for some preferred M'.

For showing how disjunctions can be licensed, we can ignore $M_{\sqsubseteq B}$. If the speaker's type is in $M_{A,B}$, optimal forms are always conjunctions, and we are in the situation of the previous sub–section. Hence, a disjunction triggers a transition from $M_{A,B}$ to at least $M_\emptyset$. We assume that the following additional sub–formula relations hold, and that the sub–form relation is extended analogously:

$$\varphi \lhd \psi \Rightarrow \chi \vee \varphi \lhd \chi \vee \psi \text{ and } \varphi \vee \chi \lhd \psi \vee \chi. \quad (5.16)$$

Table 3 shows the formulas which the speaker can intend to communicate in $M_\emptyset$ and in $M_{A,B}$. As there is a one–one correspondence between literally used forms and formulas, we omit these forms. The second column of Table 3 shows their sub–forms. For $M_\emptyset$, the speaker can only intend to communicate $\varphi_{A\vee\exists B}$ as all other disjunctive formulas involve a judgement about the possible amount of peas Kai could have eaten.

	partition & formula φ	$F \lhd \mathcal{O}p_\theta$
1.	$M_\emptyset$ & $\varphi_{A\vee\exists B}$	$F_{A\vee\exists B}$
2.	$M_{A,B}$ & $\varphi_{A\wedge\forall B}$	$F_{A\wedge\forall B}, F_A, F_{\forall B}$
3.	$M_{A,B}$ & $\varphi_{A\wedge\exists B}$	$F_{A\wedge\exists B}, F_A, F_{\exists B}$
4.	$M_{A,B}$ & $\varphi_{A\wedge\exists^! B}$	$F_{A\wedge\exists^! B}, F_{A\wedge\exists B}, F_A, F_{\exists^! B}, F_{\exists B}$
5.	$M_{A,B}$ & $\varphi_{A\wedge\emptyset B}$	$F_{A\wedge\emptyset B}, F_A, F_{\emptyset B}$

Table 3. *Kai had the broccoli or some peas last night.*

$F_{A\vee\exists B}$ only appears as sub–form of $F_{A\vee\exists B}$. Hence, the model predicts that $F_{A\vee\exists B}$ does *not* implicate $\varphi_{A\vee\exists^! B}$. I think this surprising result is correct. Let us consider a minimal variation of (4):

(5) Kai had the broccoli or some peas last night. ($F_{A\vee\exists B}$)

This sentence does indeed not implicate whether or not Kai ate all of the peas. Table 3 explains the implicatures of sentence (5) rather than (4). But how then do we explain (4)? Obviously, there is a feature which is not yet represented. We assume that the forms with '*of*' are more complex synonyms of the forms without '*of*.' Let us write $F_{\exists\sqsubseteq B}$ for '*Kai ate some* of *the peas*', $F_{\exists^!\sqsubseteq B}$ for '*Kai ate some but not all* of *the peas*', etc. That they are synonyms of the previous forms means that $|F_{\forall\sqsubseteq B}| = \varphi_{\forall B}$, $|F_{\exists\sqsubseteq B}| = \varphi_{\exists B}$, etc. We extend the sub–form relation such that:

$$F_{\exists\sqsubseteq B}, F_{\exists B} \lhd F_{\exists\sqsubseteq B},\ F_{A\vee\exists\sqsubseteq B}, F_{A\vee\exists B} \lhd F_{A\vee\exists\sqsubseteq B}, \text{ etc.} \quad (5.17)$$

Table 4 shows the effect of adding the more complex synonyms with '*of.*' The second column shows the optimal forms for literal communication. As the new synonyms are more complex, they are avoided by the speaker. But if he intends to communicate the amount of peas Kai may have eaten, we assume that the synonyms are elements of the noise sets. This is indicated by the brackets around the respective form. In line 3, $F_{A\vee\exists B}$ is not in $\mathrm{Op}_\theta^{\mathfrak{C}}(M_{\sqsubseteq B})$ because it is a possible

	partition & formula	$\mathcal{O}p_\theta$	*partial* $\mathrm{Op}_\theta^{\mathfrak{C}}$
1.	$M_\emptyset$ & $\varphi_{A\vee\exists B}$	$F_{A\vee\exists B}$	$F_{A\vee\exists B}$
2.	$M_{\sqsubseteq B}$ & $\varphi_{A\vee\forall B}$	$(F_{A\wedge\forall\sqsubseteq B},)\ F_{A\vee\forall B}$	$F_{A\vee\forall B}$
3.	$M_{\sqsubseteq B}$ & $\varphi_{A\vee\exists^! B}$	$(F_{A\wedge\exists^!\sqsubseteq B},)\ F_{A\vee\exists^! B}$	$F_{A\wedge\exists\sqsubseteq B}, F_{A\vee\exists^! B}$
4.	$M_{\sqsubseteq B}$ & $\varphi_{A\vee\emptyset B}$	$(F_{A\wedge\emptyset\sqsubseteq B},)\ F_{A\vee\emptyset B}$	$F_{A\vee\emptyset B}$

Table 4. *Kai had the broccoli or some of the peas last night.*

optimal utterance in the $M_\emptyset$ situation, and hence excluded by (5.15). Only the more complex forms $F_{A\wedge\exists\sqsubseteq B}$ and $F_{A\vee\exists^! B}$ are left. As this is the only situation in which $F_{A\wedge\exists\sqsubseteq B}$ is optimal, the model predicts that $F_{A\wedge\exists\sqsubseteq B}$ implicates that $\varphi_{A\vee\exists^! B}$! This concludes our discussion of complex sentences with disjunction.

6 Some concluding remarks

Instead of a summary, we briefly want to compare our model with Sauerland's. Apart from the obvious fact that our model is based on game theory and Sauerland's is not, there are two major differences which we want to highlight here: one concerns the role of linguistic scales, and the other the nature of nonmonotonicity built into the models. To start with the latter, Sauerland assumes an incremental, consistency based strengthening of implicatures from '*the speaker does not know* φ' to '*the speaker does know that* $\neg\varphi$.' This strengthening happens by *default.* In contrast, our model represents normality assumptions by *preferential models*, i.e. interpretation happens in the most preferred set of possible words which are consistent with world knowledge. It has been argued that there is a fundamental differences between these two types of nonmonotonic logic [13, 4], and, in particular, that preferential models are what is appropriate for modelling normality assumptions [4]. The use of preferential models has the effect that strengthening does not automatically follow from consistency with what is known. However, the significance of this difference has yet to be explored.

For the role of scalar alternatives, we want to stress again that there is no equivalent notion in our model. For example, the speaker can freely choose between sentences '*Some of the boys came to the party,*' '*Some boys came to the party,*' '*Some but not all of the boys came to the party,*' '*Some but not all boys came to the party,*' '*All of the boys came to the party,*' '*All boys came to the party,*' '*None of the boys came to the party,*' etc. Costs for these sentences may differ slightly, but the differences are never large enough for the speaker or hearer that they may want to gamble in order to avoid them. This is probably the most remarkable difference to classical accounts. This also sets it apart from previous game theoretic accounts, e.g. [10, 7].

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