Scorekeeping for Conversation-Construction

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Abstract

In this paper, we try to lay the foundation for an informational model of human conversations that formally specifies, for each stage of a conversation, what information is or is not made available to conversants through various forms of "cuings" that occur in the conversation. Squarely facing the fact that multiple lines of cuings often co-occur and interact with each other in the course of an actual conversation, we classify, illustrate, and mathematically characterize their interactions on the basis of Barwise and Seligman's general theory of information flow (1997).

A conversation is what conversants construct. Thus, to explain the construction of a conversation is to explain the conversants' behaviors. We may try to do the latter in various ways. With "conversation analysts" (e.g. Sacks et al. 1974), we may appeal to some social conventions that the participants actually attend to and comply with. Or with "discourse analysts" (e.g. Labov and Fanshel 1977), we may appeal to general rules specifying possible sequences of speech acts. Or we might combine two approaches (Traum 1994) or take still another approach.

Whatever path we may take, such an endeavor must involve or presuppose some explanation of *what information is or is not available to the conversants at a given stage of the conversation.* For example, the application of a particular item of the turn-exchange rules would crucially depend on the information available to conversants about the turn-occupancy state at the point; likewise, depending on what information is assumed to be available to a conversant concerning the prior sequence of speech acts, the sequencing rules on speech acts predict different behaviors of the participant. In most cases, theorists manage to correctly *guess* the available information to a participant (by "putting themselves in his or her position") to make specific predictions about the conversant's behaviors. This practice, however, runs the risk of trivializing whatever theory one may have

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about conversants' behaviors. Any behavioral theory concerning conversations must be augmented by some independent models of how certain information becomes available to conversants at each stage of a conversation.

Information becomes available to conversants in different ways. Some information is directly accessible through perception; some from memory; still other through sheer imagination or random guessing. However, a great amount of information crucial to conversation constructions becomes available by being *conveyed*, or *cued*, by some other facts holding in conversations. (We will discuss a number of examples later.) Our goal is to obtain a model of what we intuitively grasp as information cuings in conversations and formally specify, for each stage of a conversation, what information is and is not made available to conversants through these cuings. Such a model should capture a large, functionally important part of the mechanisms through which information becomes exploitable by conversants for the construction of a conversation.

This paper consists of four sections. Section 1 will give a clearer picture of the intended model by specifying its intended coverage. We will introduce the notion of "meta-communication," as opposed to that of "base-communication," to highlight the class of phenomena to be covered by our model, though largely ignored by the standard semantic studies. Section 2 will start developing an actual model of conversational cuings. We will motivate the conception of information conveyance to be adopted as the basis for our model, and present a mathematical formulation of the conception due to Barwise and Seligman (1997). We will then show how we apply it to characterize the actual instances of cuings, including "dynamic cuings," found in conversations.

The model presented in section 2 is "basic," in the sense that it only covers a single thread of cuing that occurs in conversations. In an ordinary conversation, however, it is a rule rather than an exception that *multiple threads of cuings co-occur and interact with each other*. They may occur *parallely*, *redundantly*, or *complementarily*; a single fact may cue more than one pieces of information *multiply*; a cuing that usually works may be *blocked* by some intervening fact, and may become a *mis-cuing*; one line of cuing may *conflict* with another and may *override* it, while both may *collapse* together. Facing these phenomena squarely, we will devote section 3 to informally classify the nine forms of cuing-interaction mentioned above and section 4 to show how we can formally model each of these forms by slightly extending the basic tools introduced in section 2.

1 Envisioning the Model

Our model aims to capture all kinds of information conveyances, or cuing relations, so far as they are relevant to the construction of a conversation. In this respect, it should be able to provide a formal, unifying framework for the several traditions of empirical works, including: the works of Kendon (1967), Duncan (1974), Beattie et al. (1982), Koiso et al. (1996), and others on information cuings related to turn-exchanges in conversations; the works of Gumperz (1982), Auer and di Luzio (1993), and others on what they call "contextualization cues"; and Geluykens and Swerts (1994), Swerts et al. (1994), Pierrehumbert and Hirschberg (1990), and Nakajima and Allen (1992) on the cuing functions of prosodic features of speech.

In another respect, our project is a rather ambitious generalization of what formal semanticists have been doing on "linguistic" meaning, and as such, it is a partial realization of what Barwise and Perry (1983) in their book (1983). To facilitate the discussion of this point, we introduce the distinction between "base-communication" and "meta-communication" in the kinds of information conveyances found in conversations.

1.1 Meta-Communication

Borrowing an idea from situation semantics (Barwise and Perry 1983) or more originally from Austin (1950), let us assume that typically in uttering a declarative sentence, a speaker describes a particular situation, called the *described situation.* This lets us define a *topic situation* of a conversation as a situation described by some conversant in some utterance during the conversation. Typically, when one talks about a "communication" in a conversation, one means a conveyance of information about a topic situation of the conversation. We call this level of communication a *base-communication* of the conversation. Take, for example, the following brief conversation, originally cited in Goodwin and Goodwin (1993):[1]

Nancy: **Jeff** made an asparagus pie
it was s : : **so** [: **goo** : d.
Tasha: [I love it. °Yeah I love that.

Nods
Tasha starts to withdraw gaze

In this conversation, Nancy describes an event, t, in which she ate an asparagus pie made by Jeff. Tasha describes a slightly different situation, t', concerning the relationship between her and Jeff's asparagus pie in general. In our terms, t and t' are topic situations of this strip of conversation, and the conveyances of information about t and t' made by the sentential utterances in the conversation, namely, the conveyances of the information that Jeff made an asparagus pie in

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[1] Here, boldface indicates some form of emphasis, which may be signaled by changes in pitch and/or amplitude. The left bracket marks the point at which one speaker's talk overlaps the talk of another, and the degree sign ° indicates that the talk following it is spoken with noticeably lowered volume.

t, that it was so good in t, and that Tasha loves Jeff's asparagus pie in t', are base-communications.

However, not all conveyances of information in a conversation are base-communications. They are not even typical. More typical are conveyances of information *about the conversation itself, as opposed to its topic situations.* We call this kind of information conveyances *meta-communications* in conversations. For example, according to the analysis by Goodwin and Goodwin (1993), the cited conversation involves at least the following conveyances of information at the meta-level:

1. Nancy's use of the intensifier "so" conveys the information that some adjective of assessment will follow it.
2. The enhanced prosody of "so" conveys the information that she is highly involved in assessing Jeff's asparagus pie.
3. The nods accompanying Tasha's first utterance convey the information that the statement that she is making agrees with Nancy's earlier assessment of Jeff's asparagus pie.
4. The early start of Tasha's first utterance and the nods accompanying it convey the information that Tasha is highly involved in praising Jeff's asparagus pie in agreement with Nancy.
5. The choice of text in Tasha's second utterance ("Yeah I love that") conveys the information that she still appreciates what is being talked about.
6. The lowered volume and the shift of gaze from Nancy during Tasha's second utterance convey the information that she is now withdrawing from the activity of praising Jeff's pie.[2]

Notice that in each case, the conveyed information is not about the situation, t, in which Nancy ate Jeff's pie, nor about the situation, t', concerning Tasha's attitude toward Jeff's asparagus pies in general. Rather, the information is about the conversation situation itself: it is about the next lexical item to be uttered (item 1), about the intensity of Nancy's involvement in the current activity (items 2), about the direction to which Tasha's first statement is going (item 3), and about the changing intensity of Tasha's involvement in the current activity (item 4, 5, and 6). The items 1–6 are therefore instances of meta-communication in our taxonomy.

As this example already suggests, the conveyance of information at the meta-level can be triggered by a variety of facts holding in a conversation, and these

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[2] Apparently, the cuings in item 5 and 6 go in the opposite directions. According to Goodwin and Goodwin (1993), Tasha is skillfully using this parallel cuing to change the topic of conversation without a blunt termination of the current activity. We will return to this point in section 3.

"cuing" facts convey a variety of information about the conversation situation. To give a feel of the diversity of the phenomena, the following table shows a partial list of possible cuing facts and cued information involved in meta-communication, as they are reported in the literature.

Cuing Facts

Linguistic factors

- Text of speech (e.g. choice of texts; parts of speech; particular syntactic constructions)
- Power and power shifts in speech
- Pitch and pitch contour in speech
- Speed and speed shifts (acceleration and deceleration)
- Rhythmic pattern (e.g. intra- and inter-turn isochrony)
- Code-switches to different "speech styles", dialects, or foreign languages

Extra-linguistic factors

- Posture (e.g. sitting upright; facing the body toward the addressee)
- Body movement (e.g. nodding; clapping hands, rocking)
- Gaze direction and movements (e.g. gaze aversion; eye-contact)

Cued Information

About conversation-organization

- Turn exchanges (completion and continuation of a turn; so-called "transition relevance place")
- Boundaries of the information being expressed at the base-level
- Topic shifts and continuation
- Types of "core" speech acts being engaged (e.g. informing; checking; requesting)
- Global types of activities being engaged (e.g. telling a joke; teasing)

About the conversants

- Participation status and role constellation
- Attitudes toward the information being expressed, the activity being engaged, and the topic being dealt with
- Emotional states (e.g. embarrassment)
- Gender, ethnicity, and social status

1.2 Comparison to the Semantic Project

We now use the notion of meta-communication to compare the coverage of our intended model and that of the standard semantic studies. We consider dynamic semantics as a sample of rather recent tradition of semantics.

According to Lewis (1979), a conversation c is a game, with a publicized "scoreboard." The scoreboard is constantly updated as c proceeds, by a participant's utterances and other events in c. The information publicized on the board in turn constrains each participant's subsequent actions, by determining their conformity to the participant's local goal and the global conversation rules. Lewis did not make it explicit, but given the aforementioned distinction between base-communication and meta-communication, we can conceptually distinguish two kinds of information thus publicized: information about the topic t of c and information about c itself. Thus at a given stage of c, there are two scoreboards (or two parts of a scoreboard), s_t and s_c, that exhibit the respective kinds of information. Given an event e in c, then, two different updates by e are conceivable: $s_t \overset{e}{\mapsto} {s_t}'$ and $s_c \overset{e}{\mapsto} {s_c}'$.

Historically, dynamic semanticists (Kamp 1981, Heim 1982, Groenendijk and Stokhof 1991) focused on utterances of some expressions of a natural language in c, and studied how they update scoreboards about the topic of c. Thus, their concerns were in the tertiary relation $s_t \overset{e}{\mapsto} {s_t}'$, where updating events e are confined to utterances of some linguistic units and s_t and ${s_t}'$ are scoreboards about c's main topic. Some authors, including Lewis himself and Stalnaker (1978), emphasized that the update potentials of utterances may depend on conversational parameters such as speaker, addressee, referential salience, and point of reference. Thus, they were interested in a slightly different relation, $\langle s_c, s_t \rangle \overset{e}{\mapsto} {s_t}'$. Even in their cases, however, the focus was on the shift from s_t to ${s_t}'$.[3] This confinement of attention to base-communications is only natural, since the project's main concern was *interpretation* of a linguistic unit, namely, the information carried by an utterance by virtue of its syntactic features, and in most cases, the information carried in that way is concerned with the *topic* of the utterance.

Now, the purpose of our project is to capture all forms of information conveyances functionally significant to the construction. Given that, it is imperative that our model cover the conveyances of information about the conversation situation itself (meta-communication), as well as the conveyances of information about the topic situation (base-communication). In the above terms, we need keep track of the shift, $s_c \overset{e}{\mapsto} {s_c}'$ or $\langle s_c, s_t \rangle \overset{e}{\mapsto} {s_c}'$, of the publicized information about the conversational situation c, as well as that of the publicized information about the topic t of c.

In fact, it is at this point where our project is in stark contrast to the standard semantic endeavor. On the one hand, the "meanings" of the syntactic features of an utterance is typically determined by some *conventionalized* semantic rules. Furthermore, a conveyance of information by virtue of the syntactic features of an utterance is typically *intended* by the speaker of the utterance. As a result, the coverage of the standard semantic study of language use has been typically confined to a very special class of information conveyances occurring in conversations: the class of *intentional* and *conventional* conveyances of information done through the *syntactic features* of utterances.

On the other hand, as the previous example from Goodwin and Goodwin (1993) already shows, an information conveyance at the meta-level is often *unintentional*: the cuing to Nancy's heightened involvement in the current activity by her use of prosodically enhances "so" (item 2) is not necessarily intended by her. Furthermore, an information conveyance at the meta-level is often mediated by signals whose meanings do *not* require the existence of *conventionalized* semantic rules: the cuing to Tasha's withdrawal from the current activity by her gaze aversion (item 6) is certainly not based on some conventional rules that determine

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[3] Actually, Lewis mentions the possibility of some dog's starting to run during a conversation, and discusses how that event would affect the referential salience of the dog in question. In our taxonomy, his discussion is concerned with an update of s_c, rather than an update of s_t, and thus makes an exception to the present generalization.

the meaning of the gaze aversion. Finally, an information conveyance is often mediated by *non-syntactic features* of speech (item 2 again, where the prosodic features of speech plays the role) and even by non-verbal events (item 6 again, where Tasha's gaze shift plays a role).[4]

Barwise and Perry (1983) demanded that "linguistic meaning should be seen within this general picture of a world teeming with meaning" (p. 16), and that "a semantic theory must account for how language fits in to the general flow of information" (p. 45). In dealing with meta-communications as well as base-communications, we are forced to view linguistic meaning within a much wider range of information conveyances occurring in a conversation situation, especially, in relation to non-conventional and non-intentional conveyances of information at the meta-level. In this respect, our project is a generalization of standard semantics to the direction that situation semanticists once envisioned.

2 Basic Model

The discussions in the last section naturally lead us to the question, "What is a conveyance of information, anyway?" Or more specifically to our purpose, what is it for a piece of information to be cued in a conversation? Without a prior determination on this point, no claims on the existence or non-existence of particular lines of cuing would be contentful, and no model of conversational cuings would be empirically testable.

2.1 The Concept of Information Flow

Intuitively speaking, whenever a piece of information is said to be conveyed in a conversation, there is some fact, a "cuing fact," in the conversation, and it somehow tells you that some other fact holds in or outside the conversation. But under what conditions does one fact *tell* you that another fact also holds? One natural answer is, "When there is some kind of regularity between two facts that enforces the second fact to hold when the first fact holds." In fact, this is the idea underlying the theories of information flow developed by Dretske (1981), Barwise and Perry (1983), and Barwise and Seligman (1996). Thus, "the transmission of information requires, not simply a set of de facto correlations, but a network of nomic dependencies between condition at the source and the properties of the signal" (Dretske 1981, pp. 76–77); the "systematic constraints are what allow one situation to contain information about another" (Barwise and Perry 1983, p.

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[4] This does not mean that an information conveyance at the meta-level can never be of an intentional, conventional, and linguistic kind. So-called "discourse markers" (Schiffrin 1987) such as "oh," "well," and "y'know" seem to convey information at the meta-level, while being conventional kinds of signs that are often used intentionally.

94); “information flow results from regularities in a distributed system” (Barwise and Seligman 1996, p. 8).

In addition to the plausibility of this conception on its own right, there are several theoretical and practical merits in adopting it as the basis of our model, with information cuings in conversations viewed as a special case of information flow. First, this conception gives us a handle of developing a empirically testable model of information cuings in conversations. For, under this conception, to claim that there is a cuing relation between two facts is to claim that there is a regular relationship between them, and the latter is something to be established by some statistical analysis of a conversation corpus or of the experimental results. It is no longer in the discretion of a theorist's introspection whether some fact cues another in conversations.

Secondly and perhaps more importantly, this conception lets us nicely separate the issue of information cuings from the issue of how conversants, with their varying cognitive abilities, exploit the cuings in question. In our view, the first is an issue of the environment in which the cognitive agent is placed, and the second is the issue of the interaction between cognitive agents and their informational environments. It is certainly important, and eventually necessary for our purpose, to investigate the latter issue. However, you can hardly talk about the interaction of an agent and the informational environment without knowing what the environment is like.

To see this point more clearly, suppose we adopted some non-objective view of information conveyances, say, the conception that sees a cuing not as the matter of a regularity over the environment, but as the matter dependent on an agent's attention to it and his or her process of “interpreting” it. Then, the investigation of cuings in conversations would become intertwined with a number of issues of the agent's cognitive abilities and processes. This, it seems to us, is analogous to the mistake of trying to understand the ways a person can use a library without investigating what facility the library provides—how many books are owned, how they are arranged in the stacks, what the check-out policy is, and so on. The non-objective view of information cuing would lead to a conflation of the issue of the informational environment and the issue of the agent's interactions with it.

2.2 Barwise and Seligman on Information Flow

Thus, we adopt the conception of information as the matter of regularities governing the environment. Barwise and Seligman (1996) has recently proposed a theory, called “channel theory,” in which this conception of information flow is formulated in a mathematically precise manner. We will now present their model of information flow in some detail, in order to build our model of conversational cuings on its basis.

The following three notions, *classification*, *constraint*, and *infomorphism*, are basic building blocks of their theory:

Definition 1 (Classification) A *classification* $\boldsymbol{A} = \langle \mathrm{tok}(\boldsymbol{A}), \mathrm{typ}(\boldsymbol{A}), \models_A \rangle$ consists of

1. a set $\mathrm{tok}(\boldsymbol{A})$ of objects to be classified, called the *tokens of* $\boldsymbol{A}$,
2. a set $\mathrm{typ}(\boldsymbol{A})$ of objects used to classify the tokens, called the *types of* $\boldsymbol{A}$,
3. a binary relation $\models_A$ between $\mathrm{tok}(\boldsymbol{A})$ and $\mathrm{typ}(\boldsymbol{A})$.

Definition 2 (Constraint) Let $\boldsymbol{A}$ be a classification. A *sequent* in $\boldsymbol{A}$ is a pair $\langle \Gamma, \Delta \rangle$ of sets of types of $\boldsymbol{A}$. We say that Γ *entails* Δ in $\boldsymbol{A}$, written $\Gamma \vdash_A \Delta$, iff every token a of $\boldsymbol{A}$ that is of every type in Γ is of at least one type in Δ. If $\Gamma \vdash_A \Delta$ then the pair $\langle \Gamma, \Delta \rangle$ is called a *constraint* supported by the classification $\boldsymbol{A}$.

Definition 3 (Infomorphism) An *infomorphism* $f : \boldsymbol{A} \rightleftarrows \boldsymbol{C}$ from $\boldsymbol{A}$ to $\boldsymbol{C}$ is a contravariant pair of functions $f = \langle f^{\wedge}, f^{\vee} \rangle$ satisfying the condition:

$$c^{f^{\vee}} \models_A \alpha \text{ iff } c \models_C \alpha^{f^{\wedge}}$$

for each token $c \in \mathrm{tok}(\boldsymbol{C})$ and each type $\alpha \in \mathrm{typ}(\boldsymbol{A})$.

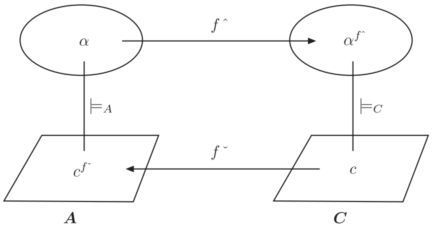

Figure 1

The main function of an infomorphism $f : \boldsymbol{A} \rightleftarrows \boldsymbol{C}$ is to let us express a fact in the classification $\boldsymbol{A}$ as an equivalent fact in the classification $\boldsymbol{C}$. More specifically, if α is a property of the $f^{\vee}$-value of a token c, then we may take $\alpha^{f^{\wedge}}$ as the "corresponding" property interpreted as a property of the token c. This is guaranteed by the bi-conditional in the above definition. Thus, intuitively, $c^{f^{\vee}} \models_A \alpha$ can be taken as a fact that the f-value of c is of type α; in contrast, $c \models_C \alpha^{f^{\wedge}}$ is a fact that the token c is of type of having its f-value be of type α. These are equivalent, yet distinct facts. And that we can translate a fact about the value of a token c under some function into an equivalent fact about c itself will have crucial technical importance in Barwise and Seligman's theory.[5]

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[5] When no confusion is likely, we will suppress the superscripts $^{\wedge}$ and $^{\vee}$ for the up- and down-functions in an infomorphism, writing "α^f" and "c^f" for "$\alpha^{f^{\wedge}}$" and "$c^{f^{\vee}}$" for example.

Definition 4 (Channel) A *channel* $\mathcal{C}$ is an indexed family $\{f_i : \boldsymbol{A}_i \rightleftarrows \boldsymbol{C}\}_{i \in I}$ of infomorphisms with a common codomain $\boldsymbol{C}$, called the *core* of $\mathcal{C}$. The tokens of $\boldsymbol{C}$ are called *connections*; a connection c is said to *connect* the tokens c^{f_i} for $i \in I$. A channel with index set $\{0, \ldots, n-1\}$ is called an *n-ary* channel.

Given that an infomorphism lets us express a fact in its domain classification as a fact in its codomain classification, an indexed family of infomorphisms with a common codomain should let us express a fact in the domain of *each* infomorphism in the family as a fact in the common codomain. To be more precise, let $\boldsymbol{C} = \{f_i : \boldsymbol{A}_i \rightleftarrows \boldsymbol{C}\}_{i \in I}$ be a channel and let c be a particular token in the core classification $\boldsymbol{C}$. Then, for an arbitrary component classification $\boldsymbol{A}_i$, we can express a fact $c^f \models_{A_i} \alpha$ in $\boldsymbol{A}_i$ as the fact $c \models_C \alpha^f$ in the core classification $\boldsymbol{C}$.

Combine this idea with the notion of constraint on classifications, or more specifically, with the notion of constraint on the core classification $\boldsymbol{C}$ of the channel $\boldsymbol{C}$. Then we can express the constraints governing the classification relations $\models_{A_i}$ of various component classifications $\boldsymbol{A}_i$ of the channel $\mathcal{C}$ in terms of the constraints on the core classification $\boldsymbol{C}$.

To be more specific, let $\mathcal{C} = \{f_i : \boldsymbol{A}_i \rightleftarrows \boldsymbol{C}\}_{i \in I}$ be an information channel, with $k, l, m, n \in I$. Let a, b, d, g be tokens and $\alpha, \beta, \delta, \gamma$ be types of component classifications $\boldsymbol{A}_k, \boldsymbol{A}_l, \boldsymbol{A}_m, \boldsymbol{A}_n$ of $\mathcal{C}$ respectively. Then, if $\alpha^{f_k} \vdash_C \delta^{f_m}$ holds[6], this means that for each token a in A_k, if it is of type α, then each token in A_m connected to a by some connection c in $\boldsymbol{C}$ is of type δ. Also, if $\{f_l\hat{}(\beta), f_m\hat{}(\delta)\} \vdash_C f_n\hat{}(\gamma)$, it means that for each pair of tokens b in $\boldsymbol{A}_l$ and d in $\boldsymbol{A}_m$, if b is of type β and d is of type δ, then each token g in $\boldsymbol{A}_n$ connected to b and d by some connection c in $\boldsymbol{C}$ is of type γ. Furthermore, if $f_l\hat{}(\beta) \vdash_C \{f_n\hat{}(\gamma), f_k\hat{}(\alpha)\}$, it means that for each token b in A_l, if it is of type β, then for each pair of tokens g in $\boldsymbol{A}_n$ and a in $\boldsymbol{A}_n$, if g and a are connected to b by some connection c in $\boldsymbol{C}$, then either g is of type γ or a is of type α. Thus, a channel can be taken as a mathematical model of a system of constraints governing the distributions of types in various components of a complex system (such as conversations).

Now, if a flow of information is a matter of a constraint, then we should be able to use a channel to model the flows of information that can hold among various components of a complex system. This is the main idea underlying Barwise and Seligman's theory of information flow. Here is their informal characterization of information flow:

> Suppose that the token a is of type α. We say that a's being of type α *carries the information that b is of type β*, relative to the channel $\mathcal{C}$, if a and b are connected in $\mathcal{C}$ and if the translation α' of α entails the translation β' of β in the classification $\boldsymbol{C}$ of the connections of $\mathcal{C}$. (Barwise and Seligman 1996, p. 32.)

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[6] More accurately, this constraint should be written as "$\{\alpha^{f_k}\} \vdash_C \{\delta^{f_m}\}$." We are omitting the curly braces for a singleton in describing a constraint.

For some reason, we do not find a more precise version of this characterization in their book. The passage is specific enough to let us flesh it out in more formal terms, though. We use the auxiliary notion of "proposition" for that purpose:

Definition 5 (Proposition) A *proposition in* a classification $\boldsymbol{A}$ is a triple $\langle a, \alpha, \boldsymbol{A} \rangle$, written $[a \models_A \alpha]$, consisting of a token a of $\boldsymbol{A}$, a type α of $\boldsymbol{A}$, and $\boldsymbol{A}$ itself. When $a \models_A \alpha$, we sometimes call $[a \models_A \alpha]$ a *fact in* $\boldsymbol{A}$.

Then we translate the above passage into the following characterization of information flow:

Definition 6 (Information Flow) Suppose $a \models_A \alpha$. The fact $[a \models_{A_k} \alpha]$ is said to *carry the information* $[d \models_{A_m} \delta]$*, relative to* $\mathcal{C}$, iff there is a connection $c \in \text{tok}(\boldsymbol{C})$ such that:

- $c^{f_k} = a$ and $c^{f_m} = d$,
- $\alpha^{f_k} \vdash_C \delta^{f_m}$.

In this conception, information-carrying is *veridical*: if a fact $[a \models_{A_k} \alpha]$ carries the information $[d \models_{A_m} \delta]$, then $d \models_{A_m} \delta$. This follows immediately from the fundamental property of infomorphism described in definition 3.

2.3 Cuings in Conversations

Our fundamental hypothesis is that these notions of channel and information flow are suitable to characterize all cuings, including both base- and meta-communications, that are functionally significant for conversation constructions. The following examples, although not completely worked out, will serve as an adequate indication of how do we go about applying our tools to model the particular instances of cuings in conversations.

Recall Nancy and Tasha's conversation discussed in section 1. Item 2 of Goodwin and Goodwin's analysis claims that the enhanced prosody of Nancy's "so" cues her heightened involvement in the ongoing activity (of assessing Jeff's asparagus pie). To capture the kind of cuings described here, we might posit a channel $\mathcal{C} = \{f_i : \boldsymbol{A}_i \rightleftarrows \boldsymbol{C}\}_{i \in \{0,1\}}$ with the component classification $\boldsymbol{A}_0$ of various units of utterances according to their prosodic features and the component classification $\boldsymbol{A}_1$ of conversants at different times according to their participation status. The connections in $\boldsymbol{C}$ will connect utterances and the utterers at some specific times.

Now let $a \in \text{tok}(\boldsymbol{A}_0)$ be the utterance of "so" by Nancy, and $b \in \text{tok}(\boldsymbol{A}_1)$ be Nancy at the time when she makes a. Let $\alpha \in \text{typ}(\boldsymbol{A}_0)$ be the type of prosody that a has, and $\beta \in \text{typ}(\boldsymbol{A}_1)$ be the type of heightened participation that b is in. Then, $a \models_{A_0} \alpha$. In our model, the claim in item 2 is translated to the claim that the fact $[a \models_{A_0} \alpha]$ cues $[b \models_{A_1} \beta]$ relative to $\mathcal{C}$. That is, there is a connection c in $\boldsymbol{C}$ that connects a and b and the constraint $\alpha^{f_0} \vdash_{\boldsymbol{C}} \beta^{f_1}$ holds in $\boldsymbol{C}$. Here, the existence of c that connects a and b simply means the fact that the utterance a is made by Nancy b at a particular time. The constraint $\alpha^{f_0} \vdash_{\boldsymbol{C}} \beta^{f_1}$ is roughly equivalent to saying that whenever an utterance has the enhanced prosodic feature α, the utterer is in the heightened participation status β. Our claim is that these two conditions correctly captures the content of item 2.

Depending on the class of cuings that one wants to model, one need equip one's channel with different sets of component classifications and different kinds of connections for our channel. To capture the cuings triggered by the textual features of utterances, for example, one may want the classification of utterances according to their textual features, along with another classification that represents the sort of things cued by them. To obtain a subtler model of the cuings triggered by prosody of speech, one may want three different classifications of utterances for their power, pitch, and speed, rather than a single classification of utterance prosody ($\boldsymbol{A}_0$ above). Also, one may want the classification of various units of utterances according to the global or local speech acts performed by them, that of hand movements according to their trajectories and speeds, that of conversants at different times according to their belief states, or that of turn-exchange states at different times according to their occupancy status.[7]

With the conception of information flow in definition 6, we can also capture what may be called "dynamic cuings" in conversations. There occur a great number of events during a conversation. A goat may come into the room (Stalnaker 1978) and a dog may jump up (Lewis 1979) during the conversation. Less dramatic examples are movements by conversants such as inhalation and exhalation, change of gaze directions, iconic and non-iconic gestures, and utterances of grammatical or ungrammatical texts. In many instances of these conversational events, it is possible to tell, either predictively and retrospectively, the event's outcome from its initial condition and the features of the event itself. We call the information conveyance involved in such a case a *dynamic cuing*.

Our framework accommodates dynamic cuings in the following way. First, we assume that the component classifications of our channel are divided into (a) the "state" classifications that classify various states in conversations (such as turn-occupancy states, conversants' emotional states, and their participation status at different times) and (b) the "event" classifications that classify various events occurring in conversations (such as the ones cited above). Secondly, we assume that for each *state* classification $\boldsymbol{A}_j$ for our channel $\mathcal{C} = \{f_i : \boldsymbol{A}_i \rightleftarrows \boldsymbol{C}\}_{i \in I}$, there are a pair of special infomorphisms $in_j : \boldsymbol{A}_j \rightleftarrows \boldsymbol{C}$ and $out_j : \boldsymbol{A}_j \rightleftarrows \boldsymbol{C}$. Then we

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[7] For each classification thus posited, one may assign various kinds of objects as its types: real numbers for pitch, power, and speed of utterances, sets of quadruples of real numbers for trajectories, sets of possible worlds for belief states, situation types or infons in situation theory for turn-occupancy status, and so on. The notion of classification is entirely general, and allows any set of objects as the type set for a classification, scientifically sophisticated or not.

can characterize a dynamic cuing in the following way:

Definition 7 (Dynamic cuing) Let $\boldsymbol{A}_k$ and $\boldsymbol{A}_m$ be state classifications and $\boldsymbol{A}_l$ be an event classification. Suppose there is a connection c in $\boldsymbol{C}$ such that $c^{{in_k}^{\vee}} = a$, $c^{{f_l}^{\vee}} = b$, and $c^{{out_m}^{\vee}} = d$.

- (Case A) Suppose $a \models_{A_k} \alpha$. The fact $[a \models_{A_k} \alpha]$ cues the information $[d \models_{A_m} \delta]$ *dynamically*, relative to $\mathcal{C}$, iff $\alpha^{{in_k}^{\wedge}} \vdash_C \delta^{{out_m}^{\wedge}}$.
- (Case B) Suppose $b \models_{A_l} \beta$. The fact $[b \models_{A_l} \beta]$ cues the information $[d \models_{A_m} \delta]$ *dynamically*, relative to $\mathcal{C}$, iff $\beta^{{f_l}^{\wedge}} \vdash_C \delta^{{out_m}^{\wedge}}$.

This characterization of dynamic cuing is a direct application of the general idea of dynamic information flow (Barwise and Seligman 1996) to conversational cuings. Intuitively, if there is a connection c such that $c^{{in_k}^{\vee}} = a$, $c^{{f_l}^{\vee}} = b$, and $c^{{out_m}^{\vee}} = d$, this means that a is an initial state for the event b that results in a final state d. Thus, Case A is where the fact $[a \models_{A_k} \alpha]$ about the initial state a of the event b carries the information $[d \models_{A_m} \delta]$ about the outcome d of the event b, and Case B is where the fact $[b \models_{A_l} \beta]$ about the event b itself carries the information $[d \models_{A_m} \delta]$ about the outcome d.[8]

Unfortunately, we do not have space to fully discuss many interesting examples of conversational cuings captured in this definition. To list a few, Duncan (1974), Beattie et al. (1982), and Koiso et al. (1996) study the features of an utterance that indicate whether the current speaking turn ends with the utterance or still continues after it. The relevant features are the pitch, the power, and the choice of a lexical item at the end of the utterance in question, and they dynamically cue an outcome of the utterance (whether the current turn ended or still continues). In a similar vein, Sacks, Schegloff, and Jefferson (1974) points out that it is crucial for smooth turn-exchanges that a hearer can project, from various features of an utterance, the next possible point of turn-shift (so-called "transition relevance place") before the utterance actually reaches the point. For a rather different kind of application of definition 7, consider the classifications $\boldsymbol{A}_k$ and $\boldsymbol{A}_m$ above to be a single state classification, say $\boldsymbol{G}$, which classifies the common-ground (or "t-scoreboard" defined in section 1.2) at different times of conversations. Then, we can talk about the regularities from the initial condition of the common-ground to the effect of an utterance event on the common-ground due to the event's particular features. We conjecture that this would let us embed the works in dynamic semantics in our general framework.

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[8] Of course, it is possible that the facts $[a \models_{A_k} \alpha]$ and $[b \models_{A_l} \beta]$ *work together* to cue the information $[d \models_{A_m} \delta]$ and it would a special case of "complementary cuing" we characterize later in section 4.

3 Interactions of Cuings in Conversations

So far, we have found that with suitable choices of component classifications and of connections, the concept of information carrying introduced above can be applied to model the simple form of cuings occurring in conversations, including dynamic cuings. To obtain a realistic view of the class of information available to conversants through cuings in conversation, however, it is not enough to posit a unary or binary channel that only captures a single route of cuings in conversations. Rather, we have to conglomerate a number of component classifications into a single channel to capture the *interactions of multiple threads of cuings during a conversation*. This task is not as easy as it may first appear, mainly because of a number of rather intricate forms of cuing interaction. In this section, we classify and illustrate the nine intricate forms of cuings interactions found by the present authors or reported in the literature.

A. **Parallel Cuing**: different facts in a conversation convey different pieces of information *parallely*.

B. **Redundant Cuing**: different facts in a conversation convey the same piece of information *redundantly*.

C. **Multiple Cuing**: a single fact in a conversation conveys *multiple* pieces of information.

D. **Complementary Cuing**: multiple facts cue a piece of information in combination, while they do not do so separately.

Example 1: parallel cuing. Recall items 5 and 6 in the example discussed in section 1 (Goodwin and Goodwin 1993). There, the text of Tasha's statement cues her appreciation of the activity of praising Jeff's pies, while her gaze direction and the volume of her voice cues that she is no longer involved in the activity as before. Tasha seems to skillfully use this parallel cuing to propose the change of topic or activity without abruptly terminating the activity initiated by her co-participant.

Example 2: redundant cuing. According to the analysis in Koiso, Shimojima, and Katagiri (1997), a deceleration of speech that occurs in information-giving utterances in Japanese conveys the information that a new unit of information starts at that point, while an acceleration cues that there is no opening of an information unit. This means that the opening or non-opening of an information unit is often redundantly cued, since in most cases, it is also cued by the textual features (such as the opening or non-opening of new sentences or clauses) of the utterances in question. In fact, redundant cuings are very common in conversations, working as the "fail-safe" device for conveyance of information (Erickson and Schultz 1982).

Example 3: multiple cuing. According to Couper-Kuhlen (1991), when the speech rate of a particular turn-sequence is significantly greater or slower than those of the surrounding sequence, it means that the sequence in question is a "side sequence," namely, a sequence engaged in an activity (typically the repair of some communication problem) subordinate to the main activity of the conversation. Couper-Kuhlen also claims that if the sequence is accelerated rather than decelerated, it means that the subordinate activity in question is something urgent, such as the repair of a serious communication problem that potentially damages some conversant's "face." Thus, the single fact of an accelerated turn-sequences indicates two pieces of information.

Example 4: Complementary. Recall item 4 in the analysis of Nancy and Tasha's conversation discussed in section 1. There, the early start of Tasha's first utterance and the nods accompanying it seem to *work together* to convey the information that Tasha is highly involved in praising Jeff's asparagus pie in agreement with Nancy (item 4). Neither the early start not the nods, taken by itself, seems to cue the Tasha's heightened involvement strongly enough.

Example 5: Complementary. According to Erickson and Shultz (1982) and Auer (1993), abrupt changes in the power and pitch of speech, in the speaker's posture, and in the frequency of accompanying eye-contacts convey the information that the speaker is engaged in a new type of activity. It seems that the changes in more than one of these parameters collectively cue the change of activity. The change in no single parameter cues it strongly enough.

These forms of cuing involves two or more "concurrent" lines of cuings in different configurations. In particular, the concurrent lines of cuings involved in a parallel, redundant, or multiple cuing are *independent* in its cuing force—the holding of each as a cuing line does not require the presence of the other line of cuing. In contrast, a *complementary* cuing is a case in which two cuing facts are involved without making independent lines of cuing. The question is how we differentiate the complementary cuing from the cases of concurrent cuings, especially from redundant cuings. What is it for two facts to *work together* to convey a piece of information? How should we understand the *contribution* of each fact in the collaboration?

E. Cuing Blockage: a fact in a conversation that *normally* conveys a piece of information does not do so in the presence of some other fact in the conversation.

F. Mis-Cuing: a line of cuing that *normally* conveys accurate information conveys misinformation in certain circumstances.

G. Cuing Conflict: two facts in a conversation convey incompatible pieces of information.

- **H. Cuing Collapse**: two line of cuings occur, and both lines of cuing cease to convey the piece of information that they normally convey.
- **I. Cuing Override**: two line of cuings occur, and only one line of cuing ceases to convey the piece of information that it normally conveys.

Example 9: Blockage. As we mentioned, Koiso, Shimojima, and Katagiri (1997) claim that a deceleration of speech rate in information-giving utterances cues the opening of an information unit. They also reported that this cuing is blocked if the deceleration is exceptionally great in degree, or it is preceded by a filler, or it is preceded or succeeded by a long pause. In such a context, we simply think the speaker is stammering, rather than opening an information unit.

Example 10: Mis-cuing. When a communication problem occurs in a conversation, conversants typically initiates a repair and then actually repair the deficiency (Sacks, Schegloff, and Jefferson 1974). According to Couper-Kuhlen (1991), if the turn for repair initiation or actual repair is rhythmically integrated with the previous turn, it normally means that the communication problem being addressed is a simple, acoustical problem (such as the occurrence of a disturbing noise), as opposed to a serious, potentially face-threatening problem (such as the misuse of a technical expression). However, Couper-Kuhlen also shows that the rhythmic integration can mis-cue that the relevant problem is not serious one, while in fact the problem is serious one. Thus, the default cuing by the rhythmic integration can be *abused* to camouflage the seriousness of the problem.

Example 11: Conflict and Override. According to Koiso et al. (1996), a flat pitch and power at the final part of an utterance cues the continuation of the current turn after the utterance in question. The data show that this cuing sometimes conflicts with, and is overridden by the use of a verb in the imperative mood in the same place, which cues the end of the current turn.

Example 12: Conflict and Collapse. In contrast, the same data (Koiso et al. 1996) show that the cuing to a turn-continuation by the use of an adverb and the cuing to a turn-end by a decrease of the power of speech collapse and the message becomes equivocal, when both occur at the same place of an utterance.

All of these forms of cuings are instances of what may be called "default cuings," where a line of cuing that *normally* conveys accurate information may or may not work in some exceptional circumstances. The main challenge is to specify the sense in which a line of cuing that *normally* conveys accurate piece of information, while allowing the possibility that it may be blocked in some *exceptional* circumstances.

4 Modeling the Cuing Interactions

We will see in this section that the basic notions introduced in section 2 are sufficient to model the first four forms of cuing interactions (A–D) described in the last section, while modeling the last five forms of cuing interactions (E–I) requires an extension of our tool kit with the notion of “refinement” (Barwise and Seligman 1997).

4.1 Cuing Interactions: A–D

Let $\mathcal{C} = \{f_i : \boldsymbol{A}_i \rightleftarrows \boldsymbol{C}\}_{i \in I}$ be an information channel, with $k, l, m, n \in I$. Let a, b, d, g be tokens and $\alpha, \beta, \delta, \gamma$ be types of component classifications $\boldsymbol{A}_k$, $\boldsymbol{A}_l$, $\boldsymbol{A}_m$, $\boldsymbol{A}_n$ of $\mathcal{C}$ respectively. (We will assume this setting for all the definitions that follow.)

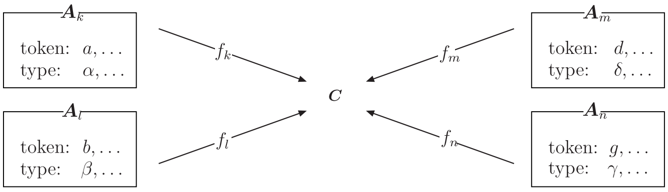

Figure 2

Definition 8 (Parallel, redundant, and multiple cuing) Suppose the fact $[a \models_{A_k} \alpha]$ carries the information $[d \models_{A_m} \delta]$ and the fact $[b \models_{A_l} \beta]$ carries the information $[g \models_{A_n} \gamma]$, relative to $\mathcal{C}$.

1. The facts $[a \models_{A_k} \alpha]$ and $[b \models_{A_l} \beta]$ cue $[d \models_{A_m} \delta]$ and $[g \models_{A_n} \gamma]$ *parallely*, relative to $\mathcal{C}$, iff $[a \models_{A_k} \alpha] \neq [b \models_{A_l} \beta]$ and $[d \models_{A_m} \delta] \neq [g \models_{A_n} \gamma]$.
2. The facts $[a \models_{A_k} \alpha]$ and $[b \models_{A_l} \beta]$ cue $[d \models_{A_m} \delta]$ *redundantly*, relative to $\mathcal{C}$, iff $[a \models_{A_k} \alpha] \neq [b \models_{A_l} \beta]$ and $[d \models_{A_m} \delta] = [g \models_{A_n} \gamma]$.
3. The fact $[a \models_{A_k} \alpha]$ cues $[d \models_{A_m} \delta]$ and $[g \models_{A_n} \gamma]$ *multiply*, relative to $\mathcal{C}$, iff $[a \models_{A_k} \alpha] = [b \models_{A_l} \beta]$ and $[d \models_{A_m} \delta] \neq [g \models_{A_n} \gamma]$.

Note that the characterizations of parallel and redundant cuings above do not require the tokens a and b of the cuing facts $[a \models_{A_k} \alpha]$ and $[b \models_{A_l} \beta]$ to be temporarily concurrent. In our framework, temporarily divergent facts can still make parallel and redundant cuings (as we desired in section 3).

Contrast these case of “concurrent” cuings with the following case of “combinatorial cuing”:

Definition 9 (Combinatorial cuing) Suppose $a \models_{A_k} \alpha$ and $b \models_{A_l} \beta$. The facts $[a \models_{A_k} \alpha]$ and $[b \models_{A_l} \beta]$ cue the information $[d \models_{A_m} \delta]$ *in combination*, relative to $\mathcal{C}$, iff:

- there is a connection c in $\boldsymbol{C}$ that connects a, b, and d,
- $\{\alpha^{f_k}, \beta^{f_l}\} \vdash_C \delta^{f_m}$.

The combinatorial cuing and the redundant cuing are conceptually different in that the latter implies that each of the involved facts $a \models_{A_k} \alpha$ and $b \models_{A_l} \beta$ cues the information $d \models_{A_m} \delta$ while the former has no such implication.[9]

In fact, we can characterize what we called "complementary cuing" as a case of combinatorial cuing in which neither fact involved in the cuing cues by itself.

Definition 10 (Complementary cuing) Suppose $a \models_{A_k} \alpha$ and $b \models_{A_l} \beta$. The facts $[a \models_{A_k} \alpha]$ and $[b \models_{A_l} \beta]$ complement each other to cue the information $[d \models_{A_m} \delta]$, relative to $\mathcal{C}$, iff:

- $[a \models_{A_k} \alpha]$ and $[b \models_{A_l} \beta]$ cue $[d \models_{A_m} \delta]$ in combination, relative to $\mathcal{C}$,
- $\alpha^{f_k} \not\vdash_C \delta^{f_m}$ and $\beta^{f_l} \not\vdash_C \delta^{f_m}$.

4.2 Cuing Interactions: E–I

Barwise and Seligman's theory allows more than one channel to be associated with an environment, making the class of information flows holding in an environment relative to the specific channel in focus. The following notion of refinement, due to Barwise and Seligman (1996), is intended to capture the relationship between two channels such that one embodies a stricter system of constraints than the other while being "continuous" with the other in all the other respects.

Definition 11 (Refinement) Let $\mathcal{C} = \{f_i : \boldsymbol{A}_i \rightleftarrows \boldsymbol{C}\}_{i \in I}$ and $\mathcal{C}' = \{g_i : \boldsymbol{A}_i \rightleftarrows \boldsymbol{C}'\}_{i \in I}$ be channels with the same component classifications $\boldsymbol{A}_i$. A *refinement* infomorphism r from $\mathcal{C}'$ to $\mathcal{C}$ is an infomorphism $r : \mathcal{C}' \rightleftarrows \mathcal{C}$ such that for each i, $f_i = r \circ g_i$, that is, the following diagram commutes:

$$\begin{tikzcd}
 & \boldsymbol{C}' \arrow[dr, "r"] & \\
\boldsymbol{A}_i \arrow[ur, "g_i"] \arrow[rr, "f_i"] & & \boldsymbol{C}
\end{tikzcd}$$

Figure 3

The channel $\mathcal{C}'$ is a *refinement of* the channel $\mathcal{C}$ if there is a refinement r from $\mathcal{C}'$ to $\mathcal{C}$.

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[9] The reader may well wonder if there is any kind of cuing that stands to the corresponding relationship to the multiple cuing as the combinatorial cuing stands to the redundant cuing. Theoretically, we can define the notion of *distributed cuing* as the case in which:

- there is a connection in $\boldsymbol{C}$ that connects a, d, and g,
- $\alpha^{f_k} \vdash_C \delta^{f_m}$ and $\alpha^{f_k} \vdash_C \gamma^{f_n}$.

However, we have not yet explored what real phenomena, if any, of conversation cuings can be characterized by means of this notion.

The commutativity of the above diagram dictates that the refined channel $\mathcal{C}'$ and the "de-refined" channel $\mathcal{C}$ behave in exactly the same way so far as the connections and the types that are linked by the infomorphism r are concerned. Yet $\mathcal{C}'$ and $\mathcal{C}$ may behave differently in other connections and types. In particular, a connection in $\boldsymbol{C}'$ that is not the r-value of any connection in $\boldsymbol{C}$ may behave strange, and may become an exception to a constraint that is respected by all connections in $\boldsymbol{C}$. Thus, the following does *not* generally hold:

> For every sequent $\langle\Gamma, \Delta\rangle$ in the core classification of $\mathcal{C}'$, if $r\hat{}(\Gamma) \vdash_C r\hat{}(\Delta)$, then $\Gamma \vdash_{C'} \Delta$.

It is in this sense that a refined channel $\mathcal{C}'$ embodies a stricter system of constraint than the "de-refined" channel $\mathcal{C}$ while being continuous with it.

Using this idea, we can characterize default cuings in the following way:

Definition 12 (Default cuing) Suppose $a \models_{A_k} \alpha$ and $b \models_{A_l} \beta$ and that there is a connection $c \in \mathit{tok}(\boldsymbol{C})$ that connects a, b, and d. The fact $[a \models_{A_k} \alpha]$ cues the information $[d \models_{A_m} \delta]$ *in default* of the fact $[b \models_{A_l} \beta]$, relative to $\mathcal{C}$, iff:

- there is a channel $\mathcal{C}^* = \{h_i : \boldsymbol{A}_i \rightleftarrows \boldsymbol{C}\}_{i \in I}$ such that:
  - $\mathcal{C}$ is a refinement of $\mathcal{C}^*$,
  - $\alpha^{h_k} \vdash_{C^*} \delta^{h_m}$,
  - token$(\alpha^{h_k}) \neq \emptyset$,
- For all $c' \in \mathit{tok}(\boldsymbol{C})$, if $c' \models_C \alpha^{f_k}$ and $c' \not\models_C \delta^{f_m}$ then $c' \models_C \beta^{f_l}$.

The existence of a de-refined channel $\mathcal{C}^*$ in the first main clause of the definition guarantees that by ignoring some proper set of the cases in which a fact of the type α holds, we could consider the constraint from α to δ to hold. Given the assumption that a is connected to d, this means that there is a definite sense in which the fact $[a \models_{A_k} \alpha]$ normally carry the information $[d \models_{A_m} \delta]$ *normally* holds. The second clause says that if the regularity $\alpha^{h_k} \vdash_C \delta^{h_m}$ ever fails, it is when a fact of the type β co-occurs. We propose that this correctly capture the case we would describe as "$[a \models_{A_k} \alpha]$ cues $[d \models_{A_m} \delta]$ in default of $[b \models_{A_l} \beta]$."

Note that this definition allows two possibilities: (1) $\alpha^{f_k} \vdash_C \delta^{f_m}$ does hold, and the fact $[a \models_{A_k} \alpha]$ genuinely carries the information $[d \models_{A_m} \delta]$ relative to $\mathcal{C}$, and (2) $\alpha^{f_k} \vdash_C \delta^{f_m}$ does not hold:

Definition 13 (Cuing survival) Suppose $[a \models_{A_k} \alpha]$ cues $[d \models_{A_m} \delta]$ in default of $[b \models_{A_l} \beta]$. The default cuing by $[a \models_{A_k} \alpha]$ to $[d \models_{A_m} \delta]$ *survives* $[b \models_{A_l} \beta]$ in $\mathcal{C}$ iff $\alpha^{f_k} \vdash_C \delta^{f_m}$.

It follows that the default cuing by $[a \models_{A_k} \alpha]$ to $[d \models_{A_m} \delta]$ is a genuine case of information flow if and only if it survives the fact $[b \models_{A_l} \beta]$. Of course, the more interesting case is where a default cuing does not survive, and fails to be a genuine information flow. The cases of mis-cuing and cuing override, collapse, and conflict discussed in section 3 all involve some "blocked" default cuings.

Definition 14 (Overriding and collapse)

1. The cuing by $[a \models_{A_k} \alpha]$ to $[d \models_{A_m} \delta]$ *overrides* the cuing by $[b \models_{A_l} \beta]$ to $[g \models_{A_n} \gamma]$ in $\mathcal{C}$ iff the cuing to $[d \models_{A_m} \delta]$ by $[a \models_{A_k} \alpha]$ survives $[b \models_{A_l} \beta]$ in $\mathcal{C}$, and the cuing to $[g \models_{A_n} \gamma]$ by $[b \models_{A_l} \beta]$ does not survive $[a \models_{A_k} \alpha]$ in $\mathcal{C}$.
2. The cuings *collapse* in $\mathcal{C}$ iff the cuing to $[d \models_{A_m} \delta]$ by $[a \models_{A_k} \alpha]$ does not survive $[b \models_{A_l} \beta]$ in $\mathcal{C}$ either.

Although a blocked default cuing cannot be a genuine information flow, it does not follow that the information conveyed in it is inaccurate. Thus, the case of mis-cuing discussed in section 3 is only a special case of cuing blockage:

Definition 15 (Mis-cuing) Suppose $a \models_{A_k} \alpha$. The fact $[a \models_{A_k} \alpha]$ *mis-cues* $[d \models_{A_m} \delta]$, relative to $\mathcal{C}$, iff:

- the default cuing by $[a \models_{A_k} \alpha]$ to $[d \models_{A_m} \delta]$ is blocked by some fact in some component classification of $\mathcal{C}$,
- $d \not\models_{A_m} \delta$.

We intend to characterize a cuing conflict as a case in which inconsistent propositions are conveyed by two default cuings. But what is it for a set of propositions to be inconsistent within a channel?

Definition 16 (Inconsistency) Let $\Re$ be a set of propositions in component classifications of the channel $\mathcal{C}$. $\Re$ is *inconsistent in* $\mathcal{C}$ iff:

- there is no connection $c \in \mathrm{tok}(\boldsymbol{C})$ such that, for every $[t \models_{A_j} \theta]$ in $\Re$, c connects t and $c \models_C \theta^{f_j}$.
- there is a connection $c \in \mathrm{tok}(\boldsymbol{C})$ such that, for every $[t \models_{A_j} \theta]$ in $\Re$, c connects t.

The first clause says that the propositions in $\Re$ never co-occur, which is reasonable as a condition for inconsistency. The second clause excludes the case in which the propositions in $\Re$ never co-occur simply because their tokens are not connected. Without that clause, for example, *any* pair of propositions whose tokens are not connected would become inconsistent. But such a pair of propositions are unrelated, and therefore do not exclude each other. In our conception, such a pair is consistent, rather than inconsistent.

The definition also prevents any set $\Re$ of *facts* from being inconsistent. For, if there is no connection $c \in \mathrm{tok}(\boldsymbol{C})$ that connects t for every $[t \models_{A_j} \theta]$ in $\Re$, then $\Re$ is not inconsistent by definition 16; if there is such a connection c, then from the fundamental property of infomorphism, $c \models_C \theta^{f_j}$ for every $[t \models_{A_j} \theta]$ in $\Re$, and hence $\Re$ is not inconsistent.

This notion of inconsistency lets us define cuing conflict in the following way:

Definition 17 (Cuing conflict) The cuing to $[d \models_{A_m} \delta]$ by $[a \models_{A_k} \alpha]$ and the cuing to $[g \models_{A_n} \gamma]$ by $[b \models_{A_l} \beta]$ *conflict*, relative to $\mathcal{C}$, iff:

- $[a \models_{A_k} \alpha]$ cues $[d \models_{A_m} \delta]$ in default of $[b \models_{A_l} \beta]$ relative to $\mathcal{C}$,
- $[b \models_{A_l} \beta]$ cues $[g \models_{A_n} \gamma]$ in default of $[a \models_{A_k} \alpha]$ relative to $\mathcal{C}$,
- The set $\{[d \models_{A_m} \delta], [g \models_{A_n} \gamma]\}$ is inconsistent.

Neither the cuing override nor the cuing collapse implies that the two default cuings involved are conflicting. On the other hand, if two default cuings conflict, then either they collapse or one overrides the other. For otherwise, both cuings would be genuine information flows, and both of the cued propositions would be facts. Since no set of facts are inconsistent, this contradicts the assumption.

In this section, we have only given pairwise characterizations of cuing override, cuing collapse, and cuing conflict. Generalizations into set-wise definitions should be obvious.

5 Conclusion

We have been trying to lay the foundation for an informational model of human conversations that predict, for each stage of a conversation, what information has or has not been available to conversants through various forms of information conveyances in the conversation. We paid special attention to the cases in which multiple lines of cuings interact with each other, and tried to characterize them on the basis of Barwise and Seligman's theory of channels (1996).

We argued that a satisfactory model should generalize the standard semantics study of language use to cover meta-communications, as well as base-communications, that occur in conversations. We pointed out that this generalization requires us to see linguistic meaning as an instance of the much wider variety of information conveyances in conversations, including non-intentional, non-conventional, and non-linguistic kinds.

On the technical side, we found that the notion of channel in Barwise and Seligman's theory (1996) lets us build a model that is (a) general enough to cover various kinds of conversational cuings, including dynamic ones, under the common conception of information flow and (b) fine-grained enough to differentiate the cases of parallel, redundant, multiple, and complementary cuings found in conversations. Furthermore, extending the basic model with the notion of refinement, we could model rather intricate interactions of cuings that involve default cuings, namely, the cases of mis-cuing, cuing blockage, override, collapse, and conflict.

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