The Role of Processes in Dynamic Semantics

1. Introduction. Set-based model-theoretic accounts of clause interpretation are bifurcated in interpreting main versus argument clauses: main clauses denote a truth value in a model, while argument clauses are interpreted as propositional, fact, or event arguments of predicates. They also face a problem of polymorphism for anaphora with clausal antecedents: the same clause can serve as antecedent for an anaphor denoting a proposition, a fact, a situation, or an event, depending on the context of the anaphor (Asher 1993, 2005). These problems can be solved within dynamic semantics (Groenendijk and Stokhof 1990) along lines proposed, but rejected, by Moltmann (2003). This talk shows that a dynamic semantic approach can handle these and other issues in clause interpretation, and furthermore, that it provides for the identification of covert modality in clause interpretation, which realizes itself as evidentiality in main clauses, and as lexical variation in the strength of the ascription for complement clauses to propositional attitude predicates. The interaction of negation with the modal operator explains the lower interpretation of negation (LIN) observed in the "Neg-Raising" interpretation of some of these ascriptions, and accounts for the range of predicates with which LIN is obtained in a way that is more satisfactory than other accounts. However, the analysis cannot be fully expressed in terms of sets and relations. The modal operator applies to a process of information state update, and the interaction with negation in the analysis of LIN depends on the definition of a dual process. Processes must be taken to be primitive elements of the model, irreducible to sets and relations, and the logic must be extended to integrate processes with other logical operations.

2. Interpreting main clauses. Following Groenendijk, Stokhof, and Veltman (1996), define a possibility to be a possible world together with a referent system designed to keep track of the relationship between variables in the logic and individuals in the domain of the model which are pertinent to that world. Let an information state be a set of possibilities sharing a referent system. Given a clause S, let φ be the translation of S into the logical language **L**. Then the information update potential (IUP) of S, written as $[\varphi]$, is defined as the function which maps information state s to information state $s[\varphi]$, obtained by deleting from s all possibilities incompatible with φ. The process of dynamic update of s to $s[\varphi]$ will be written as, $s :> s[\varphi]$. A main clause is interpreted as an assertion of modalized update of the information state s_o shared by the speaker and his or her addressee(s); in effect, the speaker is asserting that s_o must, should, or might be updated to $s_o[\varphi]$, according to deontic conditions for information state update shared by the speaker and addressee(s): SHOULD_{D} ($s_o :> s_o[\varphi]$). An adaptation of Kratzer's (1981, 1991) theory of modal interpretation is invoked to make this precise, akin to Bhatt's (2000, 2006) analysis of infinitival clauses, in terms of a deontic modal base for information state update and an ordering source. Main clauses are thus interpreted with an overtly expressed or implicit modal evidential condition.

3. Interpreting clausal arguments. A propositional attitude ascription is interpreted as the speaker urging the information state update of s_o in a very particular fashion, namely, through the update of the information state s_1 attributed by speaker and addressee(s) to the subject of the ascription, by the IUP $[\varphi]$ of the complement clause; thus, $s_1 :> s_1[\varphi]$.The propositional attitude predicate implicitly modalizes this update condition, with lexical variation in modal strength, as shown in (1).

(1) a. *Alex is sure that* S b. *Alex thinks that* S c. *Alex conjectures that* S
$\text{MUST}_{\text{D},w,\mathbf{a_1}}$ ($s_1 :> s_1[\varphi]$) $\text{SHOULD}_{\text{D},w,\mathbf{a_1}}$ ($s_1 :> s_1[\varphi]$) $\text{MIGHT}_{\text{D},w,\mathbf{a_1}}$ ($s_1 :> s_1[\varphi]$)

The fullest expression of an attitude ascription describes a cognitive state e experienced by the subject, characterized across possible worlds by the modalized update condition, as in (2).

(2) $\exists e$ [believe (e)(w) & Experiencer (a_1)(e)(w) &
$\forall w'$[believe (e)(w') & Experiencer (a_1)(e)(w'): $\text{SHOULD}_{\text{D},w',\mathbf{a_1}}$ ($s_1 :> s_1[\varphi]$)]]

Ascriptions with verbs of assertion (*assert*, *claim*, *say*) are interpreted similarly but in terms of update of an information state s_i attributed to the speaker's addressee(s) a_i. This provides for several dimensions of lexical variation. The strength of the

ascription varies with the modal operator, as in (1). An ascription with *regret*, a predicate of emotional reaction, describes an event jointly characterized by a deontic modal update condition on $s_1 :> s_1[\varphi]$, and a bouletic modal condition on $s_1 :> s_1[\sim\varphi]$. A factive ascription is one which presupposes that $s_o = s_o[\varphi]$.

Some attitude ascriptions can have a more minimal interpretation, as a statement of a deontic update condition according to the subject's deontic criteria, as in (1a,b,c). Ascriptions with predicates of assertion and emotional reaction don't have this interpretation since they assert the existence of an event or emotional state.

4. Lower interpretation of negation. (3a) can be interpreted with wide scope negation, as denying the attribution to the senator of belief that she has enough votes to win; but it also has an interpretation with a lower interpretation of negation (LIN), as ascribing a belief that the senator does not have enough votes to win. (3b) lacks the interpretation with LIN.

(3) a. The senator doesn't believe that she has enough votes to win.
b. The senator doesn't say/claim/insist/regret that she has enough votes to win.

The interpretation without LIN is the result of negating a formula such as (2). The availability of LIN correlates with the availability of the more minimal interpretations of the sort given in (1). Consider (4) with LIN; on the more minimal interpretation, the unnegated counterpart is interpreted as (5).

(4) The governor isn't sure she has enough votes for the bill.

(5) $\text{MUST}_{D,w,\mathbf{a_1}}\ (s_1 :> s_1[\varphi])$

If the information state update condition is a relation, $\text{UD}(s_1, \varphi)$, then the negation of (5), upon reducing $\text{MUST}_{D,w,\mathbf{a_1}}$ to its dual modal under negation, would be as in (6).

(6) $\sim \text{MUST}_{D,w,\mathbf{a_1}}\ (\text{Up}(s_1, \varphi)) \equiv \text{MIGHT}_{D,w,\mathbf{a_1}}\ (\sim\text{UD}(s_1, \varphi))$

But this is not the interpretation of (4) with LIN. To obtain LIN, we must define the dual process to $(s :> s[\varphi])$. The update $(s :> s[\varphi])$ is the process of casting out of s all possibilities incompatible with φ. It's dual, $(s :> s[\varphi])^{\perp}$, is the process of casting out of s all possibilities **compatible** with φ (≡ casting out all possiblities incompatible with $\sim\varphi$), so, $(s :> s[\varphi])^{\perp} = (s :> s[\sim\varphi])$. In general, if Ψ is a process, and M a modal,

(7) $\sim \text{M}\ (\Psi) \equiv \text{M}^{\perp}\ (\Psi)^{\perp}$

Thus, (4) is interpreted as (8), the correct result.

(8) $\sim \text{MUST}_{D,w,\mathbf{a_1}}\ (s_1 :> s_1[\varphi]) \equiv \text{MIGHT}_{D,w,\mathbf{a_1}}\ (s_1 :> s_1[\sim\varphi])$

In standard "Neg-raising" examples, as discussed by Horn (1978, 1989), the matrix predicate has strength just above the mid-point of its scale. These predicates are distinguished by the fact that their modal operators are nearly their own duals. For example, LIN in *She doesn't believe she will win*, is obtained by negation of $\text{SHOULD}_{D,w,\mathbf{a_1}}\ (s_1 :> s_1[\varphi])$, where $\text{SHOULD}_{D,w,\mathbf{a_1}}$ is interpreted in terms of the generalized quantifier **most**. Examples such as (9) demonstrate that $\mathbf{most}^{\perp}$ is $\mathbf{most}^{-}$, a slightly weaker version of **most**.

(9) A: Most citizens trust the President now.
B: That's not true; most don't. (= $\mathbf{most}^{-}$: half or more don't).

Thus, $\sim \text{SHOULD}_{D,w,\mathbf{a_1}}\ (s_1 :> s_1[\varphi]) \equiv \text{SHOULD}^{-}_{D,w,\mathbf{a_1}}\ (s :> s[\sim\varphi])$. The present account therefore extends "Neg-raising" to predicates such as *be sure* and *imagine* (as in, *I don't imagine they like me*, meaning I am quite sure they don't). It's main advantage over Horn's (1978, 1989) account is that it correctly predicts that the predicates which permit LIN are exactly the ones which can be interpreted as a bare modalized update condition, as in (1), and that those which describe an event or cognitive state, interpreted as in (2), don't permit LIN. Verbs of assertion, which describe an event, do not permit LIN. Furthermore, when the matrix clause is modified by a manner adverbial, LIN is blocked, as in (10) below.

(10) The governor doesn't strongly believes that she has enough votes. (no LIN)

This follows since the manner adverbial requires the presence of e, on Davidsonian accounts. (Alternatively, on the account of Keenan and Faltz 1985, manner adverbials are predicate modifiers which modify the matrix predicate, requiring (2).)

Conclusion. The account hinges on the availability of processes as irreducible arguments of modal operators. This requires processes alongside sets and relations in the mode.