*Discourse relations with temporal import: A proof of definitional adequacy*

**0. *Intro*:** Discourse relations have proved to be insightful for explaining a wide range of natural language phenomena (e.g. Hobbs 1990, Kehler 2002, Asher & Lascarides 2003, Rhode & Horton 2014). While the class of proposed relations is rather diverse, those that have temporal import have a common property: they are typically defined in terms of eventualities (*ibid*). The goal of this talk is to make headway in understanding what kind of an event structure is needed to adequately define such discourse relations. Our contribution is a proof that the structure <*pre-state*, *process*, *change*, *post-state*> is sufficient to define two discourse relations with temporal import, while a more traditional tri-partite structure of, e.g. Moens & Steedman (1988) is not. Besides offering independent evidence for a particular event structure, our proof offers a novel methodology for how to investigate definitional adequacy of discourse relations.

**1. *Background*:** Webber (1988:67) used (1)-(2) below to show that event structure is linked to discourse structure. The ELABORATION relation links (1a) and (1b) because the event in (1b) is understood to be part of the event in (1a): the latter is the *process* of the former. (2a) and (2b), however, are linked via the ENABLE relation which characterizes an inference whereby one event (e.g. entering a florist shops) makes the occurrence another (e.g. picking out roses) possible (cf. OCCASION in Hobbs 1990). According to Webber, this inference arises in (2) because the event in (2b) is now understood to be part of the *post state* of the event in (2a). A related inference involves cause-effect, viz. (3). We follow Asher & Lascarides 2003 in assuming that this inference is characterized by a distinct discourse relation, which we call "CAUSE", and ask the following two questions: Given two consecutive discourse segments $\sigma_1$, $\sigma_2$, (i) when does CAUSE($\sigma_1$,$\sigma_2$) and ENABLE($\sigma_1$,$\sigma_2$) hold? and (ii) what can we infer about the relationship between the event structures of $\sigma_1$, $\sigma_2$ when CAUSE($\sigma_1$,$\sigma_2$) and ENABLE($\sigma_1$,$\sigma_2$) hold?

**(1)a.** *John bought some flowers.* **b.** *He picked out three red roses, two white ones and one pale pink.*

**(2)a.** *John went into the florist shop.* **b**. *He picked out three red roses, two white ones and one pale pink.*

**(3)** *John pushed Max. He fell.*

**2. *Def. of* CAUSE:** We argue that CAUSE($\sigma_1$,$\sigma_2$) holds only when $\sigma_1$,$\sigma_2$ describe *dynamic* eventualities (viz. (3), which describes a pushing and a falling), and propose that CAUSE relies on a connection between two *change* components that are part of an event structure that also contains a *process* and a *post-state* (cf. Moens & Steedman's 1988 tri-partite, event nucleus structure). To that end, we propose Def. 1 below, which says that event nuclei $n_1$ and $n_2$ stand in a causal relation $R$ if the actual change component that is part of $n_1$ (denoted by $\mathsf{c}(n_1)$) and the actual change component that is part of $n_2$ (denoted by '$\mathsf{c}(n_2)$') are such that it is necessary that if the first occurs (denoted by '$\mathrm{o}(\mathsf{c}(n_1))$'), so does the second. Since strict implications cannot be inferred from material implications, Def. 1 does not apply to, e.g. (1), which describes temporally co-occurring eventualities. We also propose that whenever $R$ holds between $n_1$, $n_2$, the discourse describing $n_1$, $n_2$ exemplifies CAUSE, whether or not there is a language user who actually recognizes it, viz. Def. 2:

**Def. 1:** $R(n_1,n_2)$: $\lambda n_1\lambda n_2.\Box(\mathrm{o}(\mathsf{c}(n_1)) \rightarrow \mathrm{o}(\mathsf{c}(n_2)))$[1] **Def. 2:** $R(n_1,n_2) \vdash$ CAUSE($\sigma(n_1)$, $\sigma(n_2)$)

**3. *Causation & enablement*:** We suggest that since the actual occurrence of the effect entails its possibility, we may assume that instances of the causal relation $R$ entail instances of the enablement relation $E$. Thus, we impose the following general postulate: $\forall n_1,n_2$: $R(n_1,n_2) \vdash E(n_1,n_2)$. Moreover, analogous to Def. 2, we assume **Def. 3:** $E(n_1,n_2) \vdash$ ENABLE($\sigma(n_1)$, $\sigma(n_2)$).

**4. *Def. of* ENABLE:** Intuitively, John's flower picking in (2b) was possible because he was in the florist shop, i.e. the post state of entering the shop was necessary for him to start the process of picking. Further evidence for this claim is that (2) becomes incoherent if (2a) were to describe a process: *#John was walking into the florist shop. He picked out three red roses*...Based on such data, we offer Def. 4 below as a minimal requirement on the enablement relation $E$: $E$ holds between $n_1$,$n_2$,

[1] One may wonder why we don't opt for the following alternative strategy: upon hearing a two-segment discourse consisting of $\sigma_1$, $\sigma_2$, we conclude that they exemplify CAUSE if there are two essential properties F and G such that the event $\boldsymbol{n_1}$ described by $\sigma_1$ has F, the event $\boldsymbol{n_2}$ described by $\sigma_2$ has G, and the occurrence of an F-event necessarily triggers the occurrence of a G-event. In the talk, we prove that Def. 1 is equivalent to such a strategy.

if the presence of the post state (s) of $n_1$ is necessary for the process (p) of $n_2$.

**Def. 4:** $E(n_1,n_2)$: $\lambda n_1 \lambda n_2.\Box(\mathrm{o}(\mathrm{p}(n_2)) \rightarrow \mathrm{o}(\mathrm{s}(n_1)))$

**5. *Outline of Proof 1*:** Given Def. 1-4, we predict: $\forall n_1,n_2{:}\Box(\mathrm{o}(\mathrm{c}(n_1)) \rightarrow \mathrm{o}(\mathrm{c}(n_2))) \vdash \Box(\mathrm{o}(\mathrm{p}(n_2)) \rightarrow \mathrm{o}(\mathrm{s}(n_1)))$. Clearly, we need further axioms to support this entailment. In the talk, we derive the necessary axioms by answering the following question: what set of reasonable axioms $\Omega$ is required such that for an arbitrary possible world $w$, if $\mathrm{o}(\mathrm{c}(n_1)) \rightarrow \mathrm{o}(\mathrm{c}(n_2))$ holds, then $\mathrm{o}(\mathrm{p}(n_2)) \rightarrow \mathrm{o}(\mathrm{s}(n_1))$ holds as well. To avoid uninteresting solutions, we place three constraints on $\Omega$ and prove that there exists the following unique solution for $\Omega{:}\{\Box(\neg\mathrm{o}(\mathrm{c}(n_1)) \rightarrow \mathrm{o}(\mathrm{s}(n_1))), \Box(\mathrm{o}(\mathrm{p}(n_2)) \rightarrow \neg\mathrm{o}(\mathrm{c}(n_2)))\}$. We observe that the structural regularity expressed by $\Box(\mathrm{o}(\mathrm{p}(n_2)) \rightarrow \neg\mathrm{o}(\mathrm{c}(n_2)))$ is absurd: it is equivalent to the claim that a nucleus cannot have a process and a change component together, thereby excluding accomplishments from the set of possible nuclei.

**6. *Revision*:** This negative result forces us to revise one or more of our previous assumptions. We believe that Def. 1-3 can and should be retained. As for Def. 4, we believe that it's the best we can do given the assumed event structure. However, if we follow Hobbs (1990), Klein (1994), Asher & Lascarides (2003), Tatevosov (2007), Ramchand (2008), Varasdi (2014), among many others and enhance our event structure with *pre-states,* then we can reach definitional adequacy. To that end, we revise Def. 4 to say that two nuclei $n_1,n_2$ stand in the enablement relation $E$ if it's necessary that the post-state ($\bar{\mathrm{s}}$) of $n_1$ implies the pre-state ($\underline{\mathrm{s}}$) of $n_2$: **Def. 5:** $E(n_1, n_2)$: $\lambda n_1 \lambda n_2.\Box(\mathrm{o}(\bar{\mathrm{s}}(n_1)) \rightarrow \mathrm{o}(\underline{\mathrm{s}}(n_2)))$.

**7. *Outline of Proof 2*:** Given Def. 1-3 and Def. 5, we now predict: $\forall n_1,n_2{:}\ \Box(\mathrm{o}(\mathrm{c}(n_1)) \rightarrow \mathrm{o}(\mathrm{c}(n_2))) \vdash \Box(\mathrm{o}(\bar{\mathrm{s}}(n_1)) \rightarrow \mathrm{o}(\underline{\mathrm{s}}(n_2)))$. As before, we would like to find a set of reasonable axioms $\Omega$ such that for an arbitrary possible world $w$, if $\mathrm{o}(\mathrm{c}(n_1)) \rightarrow \mathrm{o}(\mathrm{c}(n_2))$ holds, then so does $\mathrm{o}(\bar{\mathrm{s}}(n_1)) \rightarrow \mathrm{o}(\underline{\mathrm{s}}(n_2))$. Assuming the same constraints on $\Omega$, we prove that there exists the following unique solution for $\Omega{:}\{\Box(\mathrm{o}(\bar{\mathrm{s}}(n_1)) \rightarrow \mathrm{o}(\mathrm{c}(n_1))), \Box(\mathrm{o}(\mathrm{c}(n_2)) \rightarrow \mathrm{o}(\underline{\mathrm{s}}(n_2)))\}$. The first constraint states that a post-state can only occur if there is a change component in the nucleus. The second constraint states that pre-states are obligatorily required by changes. In the talk, we argue that both constraints are plausible because they allow us to classify Vendler classes, while preserving Moens & Steedman's insight.

**8. *Prediction:*** As an example, we propose that semelfactives describe a pre-state and a change. Given Def. 1 and 5, we thus predict that a discourse that opens with a semelfactive description could give rise to CAUSE but not ENABLE, unless the semelfactive is coerced into an achievement, which describes a post-state (in addition to a pre-state and a change). This prediction is borne out. (4) exemplifies CAUSE, while (5) could be understood as exemplifying ENABLE, e.g. the pushing of the button led to the release of the lock, thereby enabling the officer to open the door. In such a case, however, *push the button* describes a post-state and would be classified as an achievement.

(4) *The guard pushed the button. The light flashed.* (5) *The guard pushed the button. The officer opened the door.*

**9. *Change:*** Interestingly, some researchers (e.g. Ramchand 2008, Tatevosov 2007) who have adopted the pre-state/post-state dichotomy have disregarded *change* from their proposed event structures, assuming that the pre-state/post-state dichotomy presupposes *change*. However, we consider *at*-phrases such as *The plane landed at 12:00 sharp* and argue, based on Altshuler & Schwarzschild's (2012) characterization of states, that if change is not explicitly encoded, problems arise with locating the moment of change with the help of the two neighboring states.

**10. *Conclusion:*** The main contribution of our talk is a proof that the structure <*pre-state*, *process*, *change*, *post-state*> is sufficient to define CAUSE and ENABLE. We end the talk by discussing whether other discourse relations with temporal import could be defined using this event structure and whether we could use the proposed event structure to derive a constrained typology of relations.

**11. *References*:** Altshuler, D. & Schwarzschild, R. 2012. Moment of change, cessation implicatures and simultaneous readings, *SuB* 17. Asher, N. & A. Lascarides. 2003. *Logics of Conversation*. Hobbs, J. 1990. *Literature & Cognition*. Kehler, A. 2002. *Coherence, Reference and the Theory of Grammar*. Klein, W. 1994. *Time in Language*. Ramchand, G. 2008. *Verb meaning and the lexicon: A first phase syntax*. Rohde, H. & W. Horton. 2014. Anticipatory looks reveal expectations about discourse relations, *Cognition*. Tatevosov, S. 2007. Subevental structure and non-culmination, *Empirical issues in syntax and semantics 7*. Varasdi, K. Making progressives: Necessary conditions are sufficient, *Journal of Semantics* 31.