**Serial verb constructions and covert coordinations in Edo**
**An analysis in a dynamic frame theory**

**Data and central issue.** Edo is a language spoken in Central Nigeria and belongs to the Kwa-family, in which serial verb constructions (SVCs) are a characteristic part of the grammar. Summarizing the existing consensus, [Aik06] defines an SVC as a monoclausal sequence of verbs which act together as a single predicate, without any overt marker of coordination or subordination and a single value for tense and aspect. For Edo, Aikhenvald's definition must be strengthened in two respects: SVCs have only one subject and at least one internal argument is shared by the verbs. A central difference in Edo is that between a consequential SVC and a covert coordination (CC), [Ste01]. Consider the following two examples taken from [BS99, p.3].

(1) a. Òzó ghá gbè ẹ̀wé khiẹ́n.
Ozo FUT hit goat sell
'Ozo will kill the goat and sell it.' Consequential SVC (CSVC)

b. Òzó ghá gbè ẹ̀wé khiẹ́n ùhùnmwùn érẹ́n.
Ozo FUT hit goat sell head its
'Ozo will kill the goat and sell its head.' Covert Coordination (CC)

In a CSVC the verbs are either transitive or ditransitive. The subjects and direct objects are always identified with each other, i.e. they are coreferential. By contrast, an indirect object of a ditransitive verb is never identified with any argument of the other verb. In particular, the indirect objects are not identified if both verbs are ditransitive.

(2) Úyi hàé Ìsọ̀kẹ̀n íghó dó-rhié.
Uyi pay Isoken money steal
'Uyi paid Isoken the money and stole it.' [Ste01, p.137]

Despite the fact that the subjects are always identified, it is not possible to have a subject pronoun before V2 in a CSVC, (3-a). This restriction does not hold for a CC, as shown by (3-b).

(3) a. Òzó$_i$ mú èmá (*Ọ́$_i$) kpẹ̀ẹ́.
Ozo carry drum he beat [Ste01, p.64]

b. Òzó$_i$ gbọ́ọ́ ívìn Ọ́$_i$ bòló ọ́kà.
Ozo plant coconut he peel corn
'Ozo planted coconut and he peeled the corn.' [Ste01, p.65]

If the object arguments in a CC are coreferential, there is a pronoun after the second verb, (4-a). For a CSVC, such a pronoun is not admissible. (4-b) can only be interpreted as a CC, having the same meaning as (4-a).

(4) a. Òzó$_i$ lé ízẹ̀$_j$ Ọ́$_i$ rrí ọ́rè$_j$.
Ozo cook rice he eat it
'Ozo cooked rice and he ate it.' [Ste01, p.65]

b. *Òzó le ize$_i$ rri ore$_i$.
Ozo cook rice eat it [Ste01, p.65]

Semantically, CSVCs and CCs differ in the following respect. For a CSVC, the action expressed by the first verb is done with the intention to carry out an action expressed by the second verb. For example, (1-a) can only be true if Ozu killed the goat with the intention of selling it afterwards. If he killed the goat by accident or decided to sell it only after the killing, (1-a) is false. No corresponding restriction exists for a CC. For example, (4-a) is true if Ozu cooked the rice and ate it afterwards.

**Informal outline of the analysis: basic assumptions.** The semantic theory to be presented in this talk is based on the following assumptions: (i) the semantic relation expressed by CSVCs and CCs in Edo is based on coherence relations which, in turn, are defined as complex relations between events; (ii) these relations are defined in terms of typed attribute-value pairs in a frame theory which is used to semantically model proper names, common nouns and verbs. **CSVCs CCs and coherence relations.** The semantic characterization of CSVCs and CCs in the previous section has shown that they differ in the way the events described by the verbs in both constructions are related to each other. These differences are located at at least two different levels: mereological and (constraints on) participants. Underlying the semantic interpretation of a CSVC is a plan (see [Bit01]). The events described by the verbs in this construction are part of an intended plan, given by an event $e$, which consists of $n$ component events $e_1, \ldots, e_n$ as its constituent (material) parts s.t. $e_i \sqsubseteq e$ and $e_i < e_j$ for $i < j$ and $\bigsqcup e_i = e$. Hence, an event $e$ is related to two are more events which are linearly ordered and each of which is a material part of $e$. By contrast, for a CC, only two events are related s.t. the first temporarily precedes the second and, therefore, the two events are mereologically disjoint. In addition to these differences at event structure there is a difference w.r.t. how the participants in the events are related to each other. Whereas in the case of a planned event the actor and the theme are always identical, for a CC only the actors are required to be coreferential. This characterization suggests modelling the relation expressed by CSVCs and CCs in terms of *coherence relations* (CR). One way of modelling such relations is in terms of complex relations between events. We use frame theory to implement this idea. In particular, we assume that event frames for verbs in Edo have an attribute COHERENCE RELATION which specifies a possible relation to the next event described in the text (discourse). The values of this attribute are of type **plan** and **list**. Each type has the attribute MEREOLOGICAL RELATION which specifies the mereological relation between the event at the root of the frame and the current topic event. For a CR of type **plan**, the former is a proper material part of the latter whereas in the case of a CR of type **list** the two are disjoint. Constraints on participants are modeled by requiring the corresponding thematic relations to have the same values.

**Coherence relations trigger expectations.** After processing the first VP in a CSVC or a CC, a comprehender does not yet know what the relation to the next event will be. The event described by this part can either be a part of a larger plan as in (1-a) where the killing is done with the intention of selling the goat, or it simply is the first event in a succession of events with a shared actor, as in (1-b). However, (s)he knows that this relation will be exactly one of these two possibilities. This knowledge is used by her/him to non-deterministically extend the current information state with those three possibilities so that the next part of the construction is interpreted in relation to this event. How can a decision be made between the two possibilities? **Pronouns as indicators of coherence relations.** Recall from the first section that in a CSVC shared arguments are never overtly realized by a pronoun on the $n$-th verb for $n > 1$. Indirect objects of ditransitive verbs are realized by proper names or common nouns since they can never be coreferential. By contrast, in a CC coreference of the actor role can be marked by a pronoun and coreference of theme roles is marked by a pronoun after the second verb. Hence, a pronoun is an indicator of a list scenario and excludes a plan scenario. This is similar to the way a word in English can be an indicator of a particular coherence relation in English. For example, [KR13] found that in a context 'Amanda amazed Brittany because ...' with the implicit causality verb 'amaze' the connective 'because' is an indicator of an **explanation** relation since it raises the probability for this coherence relation to (almost) 1. Hence, if after processing say 'Ozu le ize' a pronoun is encountered ('O'), the comprehender knows that the speaker describes a list scenario and not a scenario of type **plan**. If no pronoun is encountered, both types of coherence relations (**plan** as well as **list**) remain options. It is only the region after the second verb which allows for a decision. If a pronoun is encountered, the scenario described must be of type **list**, and of type **plan** otherwise. Thus, one function of a pronoun consists in eliminating possibilities related to coherence relations.

**Outline of the formalization.** We define a probabilistic dynamic update semantics with frames. **Models.** A probabilistic world model with frames is a tuple $\langle W, D, I, \{f_{d,\sigma,w}\}_{d\in D,\sigma\in\Sigma,w\in W}\rangle$. $W$ is a finite set of possible worlds which is used to represent (epistemic) uncertainty. An example is the uncertainty w.r.t. to the value of the COHERENCE RELATION-attribute in event frames. The domain $D = \{D_\sigma\}_{\sigma\in\Sigma}$ is the union of finite domains $D_\sigma$ based on a partially ordered sort hierarchy $\langle\Sigma, \sqsubseteq_\Sigma\rangle$ with basic sorts like 'event' ($e$) or 'individual' ($d$). $D$ is structured by a (material) part relation $\sqsubseteq$. $F = \{f_{d,\sigma,w}\}_{d\in D,\sigma\in\Sigma,w\in W}$ is the domain of frames. Each frame is of a sort $\sigma$ and is a (generated) submodel of a possible world $w$, namely, the information associated with a particular object $d$ in that world which is the root of the frame. $F_w$ is the set of frames in world $w$ and $f_{w,d}$ is the frame in $w$ with root $d$. A frame is related to a set of relations on $D \times D$. Each relation $R$ corresponds to a finite path (chain of attributes) $\geq 0$ starting at the root $d$. The domain of $R$ is given by the source-sort of the first attribute in the path and the range of $R$ by the target-sort of the last attribute in the path. For path of length 0, one defines the shift: $\lambda Q_\sigma.\lambda x.\lambda y.Q_\sigma(x) \wedge x = y$. Each $R$ must always be satisfied at the root. Hence, a frame $f_w$ with root $d$ corresponds to a complex property $Q_{f_w} = Q_0 \cap Q_1 \cap \ldots \cdot Q_n$ s.t. each $Q_i$ is the domain of a relation $R$ and one has $Q_{f_w}(d)$ is true in $w$ iff $Q_i(d)$ is true in $w$ for each $1 \leq i \leq n$. Using this fact, we define a relation $\theta$ s.t. $Q \in \theta(f)(d)$ iff $Q(w)(d)$. $\theta(f)(d) = \sigma$ means that $Q_f(d)$ is of type $\sigma$. $\theta(f)(d)\pi$ denotes the set of properties which hold at the end of path $\pi$ in the frame $f$ with root $d$.

*Information states in a frame theory.* An information state $s$ consists of a set of possibilities $i$. A possibility $i$ consists of a world $w$, two stacks (following Incremental dynamics, [vE01]) and two functions $\gamma_1$ and $\gamma_2$. The stack $c_1$ assigns values to discourse parameters which are variable. Examples are speech time, speaker, hearer etc. In the present context we are interested in the parameter 'topic event', which is assumed to be located at the 0-th position of $c_1$. The stack $c_2$ consists of those objects which are introduced by common nouns, proper names and verbs. The function $\gamma$ assigns to each element $o$ of $c_2$ a frame $f \in F_w$ s.t. $o$ is the root of $f$. We define two projection functions (see also [Bit01]): $p_i$ which yields the $i$-th element on a stack counted from the top of the stack, i.e. $p_0(c)$ is the top element of $c$. The projection function $p_\sigma$ yields the restriction of the stack to objects of type $\sigma$. $p_i(p_\sigma(c))$ is the $i$-th object of type $\sigma$ on stack $c$. The distinction between the topic event, which belongs to $c_1$, and the current top-most event, which is an element of $c_2$, is motivated by the following reasons: (i) in case of a plan scenario the topic event is the planned event $e$ which remains constant while its component events are (successively) introduced on the stack $c_2$; by contrast, in a list scenario the topic event is changed with each new verb because the events are not related at the mereological level; (ii) it is used to implement the mereological relation between two events in a plan and list scenario and (iii) arguments provide information about the top-most event on the $c_2$ stack, independently of the mereological relation to other events either. The functions $\gamma_1$ and $\gamma_2$ assign to each element on $c_1$ and $c_2$ its frame $f_w$ in the world $w$ of the possibility $i$.

*Update operations.* We provide simplified versions of the most important update operations The difference between the way commons (and proper names) and verbs function is reflected in having two update operations.

*Update operations for common nouns and proper names.* The update operation for cn's and pn's $s[d]$ is a domain extension operator, similar to $s[x]$ in other update semantics. The difference lies in the fact that each element on the stack is paired with a frame. The definition is $s[d] = \{\langle w', c'_1, c'_2, \gamma'_1, \gamma'_2\rangle \mid \exists n \exists i = \langle w, c_1, c_2, \gamma_1, \gamma_2\rangle \in s \wedge w = w' \wedge \gamma'_1 = \gamma_1 \wedge c'_1 = c_1 \wedge c'_2 = c_2\hat{}d \textit{ for } d \in D_d \wedge \gamma'_2(c'_2[i]) = \gamma_2(c_2[i]) \textit{ for } 0 \leq i \leq n-1 \wedge n = |c_2| \wedge \gamma'_2(c'_2[n]) = f_{w,d}\}$.

*Update operation for events in CSVS and CCs.* The combination of two verbs or clauses in an SVC or a CC is modeled as an update operation (compare the interpretation of '.' in dynamic semantics as function composition of information states: $\lambda p \lambda q \lambda s \lambda s'.\exists s''.p(s)(s'') \wedge q(s'')(s')$). The update operation is a conditional one: it extends the stack $c_2$ by an event which is required to satisfy the value of the COHERENCE RELATION-attribute of the (so far) top-most event at the root of its frame and it changes the topic event depending on the type of the CR. Constraints between stack elements are expressed using $\theta$. For example, $\theta(\gamma_2(c_2[n]))(c_2[n]) = \theta(\gamma_2(c_2[n-1]))(c_2[n-1])(\text{COHERENCE RELATION})$ requires the newly introduced event to have the same value as the value of the COHERENCE ATTRIBUTE of the event at the previous position. $\theta(\gamma_1(c_1[0]))(c_1[0])(\text{MEREOLOGICAL RELATION}) = \theta(\gamma_2(c_2[n]))(c_2[n))(\text{COHERENCE RELATION})(\text{MEREOLOGICAL RELATION})$ requires the relation between the topic event and the top-most event to respect the mereological relation set up by the COHERENCE RELATION-attribute. The update operation is defined as follows: $s[e] = \{\langle w', c'_1, c'_2, \gamma'_1, \gamma'_2\rangle \mid \exists n \exists m \exists i = \langle w, c_1, c_2, \gamma_1, \gamma_2\rangle \in s \wedge w = w' \wedge c'_2 = c_2\hat{}e \textit{ for } d \in D_e \wedge \gamma'_2(c'_2[i]) = \gamma_2(c_2[i]) \textit{ for } 0 \leq i \leq n-1 \wedge n = |c_2| \wedge m = |c_1| \wedge \gamma'_2(c'_2[n]) = f_{w,e} \wedge \theta(\gamma_2(c_2[n]))(c_2[n]) = \theta(\gamma_2(c_2[n-1]))(c_2[n-1])(\text{COHERENCE RELATION}) \wedge \theta(\gamma_1(c_1[0]))(c_1[0])(\text{MEREOLOGICAL RELATION}$

$\theta(\gamma_2(c_2[n]))(c_2[n))(\text{COHERENCE RELATION})(\text{MEREOLOGICAL RELATION}) \wedge \textit{ if } \theta(\gamma_2(c_2[n]))(c_2[n]) = \textbf{list} \wedge \theta(\gamma_2(c_2[n-1]))(c_2[n-1])(\text{COHERENCE RELATION}) = \textbf{list} \textit{ then } c'_1[0] = c'_2[n] \wedge c'_1([i]) = c_1([i]) \wedge \gamma'_1(c'_1[0]) = \gamma'_2(c_2[n]) \wedge \gamma'_1(c'_1[i]) = \gamma_1(c_1[i]) \textit{ for } i \neq 0 \textit{ else } c'_1 = c_1 \wedge \gamma'_1 = \gamma_1\}$.

*Update operation for pronouns.* The update operation for pronouns is the sequential composition of three update operations. Similar to DRT, pronouns push a new object on $c_2$. this is modeled by $s[d]$. Next, it is tested whether the relation between the top-most and the previous event is of type **list**: $s[CR] = \{\langle w', c'_1, c'_2, \gamma'_1, \gamma'_2\rangle \mid \exists m \exists i = \langle w, c_1, c_2, \gamma_1, \gamma_2\rangle \in s : w = w' \wedge c'_1 = c_1 \wedge m = |c_1| \wedge \gamma'_1 = \gamma_1 \wedge c'_2 = c_2 \wedge \gamma'_2 = \gamma_2 \wedge \theta(\gamma_2(c_2[n-1]))(c_2[n-1]) = \textbf{list} \wedge \theta(\gamma_2(c_2[n-2]))(c_2[n-2])(\text{COHERENCE RELATION}) = \textbf{list}\}$. In the probabilistic setting of [KR13] $s[CR]$ implements the raising of $pr(CR)$ to 1 in the equation $pr(\textit{pronoun} = \textit{referent}) = \sum_{CR \in CRs} pr(CR) \cdot pr(\textit{pronoun} = \textit{referent}|CR)$. This update operation, therefore, has the effect of eliminating one particular type of value from the COHERENCE RELATION attribute. The third update operation uses the fact that a pronoun, being an argument, is always related to a particular thematic relation *TR*. The constraint imposed by $s[TR]$ requires the values of the *TR*-attribute of the current event and the previous event to be the same: $s[Tr] = \{\langle w', c'_1, c'_2, \gamma'_1, \gamma'_2\rangle \mid \exists i = \langle w, c_1, c_2, \gamma_1, \gamma_2\rangle \in s : w = w' \wedge c'_1 = c_1 \wedge c'_2 = c_2 \wedge \gamma'_1 = \gamma_1 \wedge \gamma'_2 = \gamma_2 \wedge \theta(\gamma_2(c_2[n-1]))(c_s[n-1])(\text{TR}) = \theta(\gamma_2(c_2[n-2]))(c_s[n-2])(\text{TR})\}$. This implements the fact that in Edo using a probabilistic setting like that of [KR13] $pr(\textit{pronoun} = \textit{referent}|\textit{list})$ is 1 for a pronoun in a given argument position.


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