An Interpretation of Nominative Arguments, Voice-Affixes and Verb Stems in Tagalog

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In Tagalog, the main dialect spoken in the Philippines, the stem of each verb v can combine with different voice-affixes (VA). Semantically, VAs differ in three respects. First, the argument of a given phrase that is determined as subject depends on the VA with which the verb combines. Second, not each VA can combine with each stem and third the interpretation of a sentence depends on the VA. An analysis of these phenomena is developed in an extension of Dynamic Event Semantics (DES) (Naumann 1998b, Naumann 1999, Naumann and Mori 1998) that combines Event Semantics and Dynamic Logic. The basic intuition underlying DES is that non-stative verbs express changes. A change is either an object (event) or a transformation of state: a state s at which a condition Q does not hold is transformed to a state s' at which Q holds. Structures for the theory therefore contain both a domain E of events and a domain S of states. In Latrouite 1999 DES was extended by assigning to elements from E complex transformations of states instead of simple ones. It was shown how this extension can beused to explain the aspectual restrictions imposed by VAs. In the present paper it is shown how the other two semantic functions of a VA - determination of the subject (topic) and dependency of the interpretation on the VA - can be analyzed in DES.

0.1 Data and Evidence

In Tagalog each verb stem v can combine with a certain number of voice affixes(VA). Traditionally, these affixes (actor voice affixes: ‘um-’, ‘mag-’; objective voice affixes: ‘-in’, ‘-an’, ‘i-’) have been said to identify the semantic role of the nominative argument (subject) of the sentence. Yet, as data taken from English 1997 show, they determine the aspectual interpretation of the verb.These aspectual phenomena cannot be derived from the voice affixes‘ characterization in terms of semantic role as shown in Latrouite 1998 and Ramos 1971. First, in many cases the interpretation of the sentence depends on the VA with which the verb combines. E.g., affixation of the Goal voice affix (GV)‘-in’ to the stem /kain/ (‘eat’) in (1:1) requires the object eaten (i.e. the fish) to be completely consumed, affixation of the locative voice affix (LV) ‘-an’ yields apartitive reading, (1:3), whereas for the Actor voice affix (AV) ‘um-’ either of the two interpretations is possible, (1:1).

(1) 1.*K-um-ain ka ng isda*
Eat-AV Nom:you Gen fish (Eat at least part of the fish!)
2.*Kain-in mo ang isda*
Eat-GV Gen:you Nom fish (Eat the fish (completely)!)
3.*Kain-an mo ng isda ang plato*
Eat-LV Gen:you Gen fish Nom plate (Eat some/a part of the fish from the plate!)

On the other hand, for other stems like /kuha/ ‘take’ the interpretation is independent of the particular VA.

(2) 1.*K-um-uha ka sa kaniya ng lapis*
Take-AV Nom:you Dat:he Gen pencil (Get the pencil from him!)
2.*Kun-in mo sa kaniya ang lapis*
Take-GV Gen:you Dat:he Nom pencil (Get the pencil from him!)

3.*Kun-an mo siya ng lapis*
Take-LV Gen:you Nom:he Gen pencil (Get a pencil from him!)

Second, not each verb stem can combine with each VA. E.g., Point-verbs like /katok/ 'knock' only occur with the objective VA '-in' whereas the objective VA'-an' is excluded as the examples in (3) show.

(3) 1.*Katuk-in mo ang pinto*
Knock-GV Gen:you Nom door (Knock at the door!)
2.**Katuk-an mo ang pinto*
Knock-LV Gen:you Nom door (Knock at the door!)

Third, a particular class of verbs admits both the VA '-in' and the VA '-an',yet the meaning varies according to the VA. An example is given by /sunod/.

(4) 1.*Sund-an mo siya*
Follow-LV Gen:you Nom:he (!Follow him!)
2.*Sund-in mo siya*
Follow-GV Gen:you Nom:he (Obey him!)

Whereas /sunod/ means 'to physically follow' if it combines with the VA'-an', it means 'to obey' if it combines with '-in'. Fourth, the object that is determined as subject, i.e. the object denoted bythe nominative argument, in most cases the *ang*-phrase, depends on the VA, independently of the particular interpretation of the sentence.

(5) 1.*K-um-uha ka sa kaniya ng lapis*
Take-AV Nom:you Dat:he Gen pencil ((You) get the pencil from him!)
2.*Kun-in mo sa kaniya ang lapis!*
Take-GV Gen:you Dat:he Nom pencil (Get the pencil from him!)
3.*Kun-an mo siya ng lapis*
Take-LV Gen:you Nom:he Gen pencil (Get a pencil from him!)

If the VA is 'um', it is the actor that is denoted by the ang-phrase, whereas for the VA '-in' it is the object taken and for the VA '-an' it is the source from which some object is taken that is determined as subject.

0.2 Changes as Objects and Changes as Transformations of States

Dynamic Event Semantics (DES), Naumann 1998b, Naumann 1999 and Naumann and Mori 1998, is based on the intuition that non-stative verbs like 'eat' express changes. The intuitive notion of a change comprises at least two aspects that are complementary to each other: (i) something (an object: action, event) which brings about the change; (ii) something (a result) which is brought about by the change and which did not hold before the change occurred. In (i) 'change' is understood as the result that is brought about, i.e. in the sense that is captured by(ii), whereas in (ii) 'change' is meant as the object that brings about the result. The second aspect can be described as a transformation of state (TS). Before the change occurred, the world was in a particular state, say s, at which some condition Q did not hold, whereas after the change has occurred, the world is in a state s' at which Q does hold.

Structures for DES are based on a domain E of events, together with a partial ordering $\sqsubseteq_E$, the material part of relation, a domain S of states and a domain O of 'ordinary' objects that are related in a particular way to each other. Two functions $\alpha : E \rightarrow S$ and $\omega : E \rightarrow S$ assign to each event $e \in E$ its beginning point $\alpha(e)$ and end-point $\omega(e)$, respectively. Together, $\alpha(e)$ and $\omega(e)$ determine the execution-sequence $\tau(e) = (\alpha(e), \omega(e)) = \{s \in S | \alpha(e) \leq Ss \leq S\omega(e)\}$,where $\leq S$ is a linear ordering on the domain S. The domain E is sorted by a set $\mathbf{P} = \{Pv | v \in VERB\}$ of unary relations on E where the label set $VERB$ is a subset of the verbs in the lexicon of the underlying language, e.g. Tagalog or English. $\mathbf{T} = \{T_{pr} | pr \in PROP\}$ is a set of relations on $O \times S$, on which the relationship between E and O is based. Basically, each event-type P_v determines a set of properties. This relationship is captured by a function γ that assigns to each P_v a subset of **T:** $\gamma(P_v) \subseteq \mathbf{T}$. If $T_{pr} \in \gamma(P_v)$, then for a $d \in O$ $Q = T_{pr}(d)$ is a possible result (condition) that an event $e \in P_v$ can bring about on its execution-sequence $\tau(e)$ with respect to d. The relationship between a change as an object and a change as a TS is in general not one - one but rather one - many, i.e. an event e brings about not only one result but many. Consider an event e of type 'John eat a fish'. The initial actions executed by John, e.g. his bodily movements and opening his mouth, correspond to initial stages e' of e that are not of type 'eat'.[1] Only after John swallowed at least part of the fish an event of this type occurred. This condition is related to a decrease of the mass of the fish (due to the swallowing). Eventually, the last piece of the fish is swallowed and the fish has disappeared. Thus, to an event of eating a fish by John correspond three transformations of states: (a) the result effected by the initial actions performed by John: Q_1, (b) partial decrease of the mass of the fish (due to swallowing part of the fish): Q_2,(c) complete decrease of the mass of the fish: Q_3. Each of the three results is evaluated on the execution-sequence $\tau(e)$ of events e of type P_{kain} which bring them about in a particular way: (i) if Q_1 holds at a state s in $\tau(e)$, then it also holds at all states s' such that $\alpha(e) <_S s' \leq_S s$; (ii) if Q_2 holds at a states in $\tau(e)$, then it holds at all states s' such that $\alpha(e) <_S s' \leq_S s$ and s' is the end-point $\omega(e')$ of an initial stage e' in P_{kain} of e, (iii) if Q_3 holds at a state in $\tau(e)$, then it holds for no state s' such that $\alpha(e) <_S s' \leq Ss$. These ways in which the results are evaluated characterize different types of results. In (6) these results are formally defined (note that a result is of a particular type only relative to an event-type P_v).[2]

(6) 1.$Prefix_{<_S}$ -closedness of a result Q relative to an event-type P_v

$$\forall Q[Prefix_{<_S} - closed_v(Q) \leftrightarrow \forall s, e[e \in P_v \wedge s \in \tau(e) \wedge s \in Q \rightarrow \forall s'[\alpha(e) <_S s' \leq_S s \rightarrow s' \in Q]]]$$

2.$Prefix_v$-closedness of a result Q relative to an event-type P_v

$$\forall Q[Prefix_v - closed_v(Q) \leftrightarrow \forall s, e[e \in P_v \wedge s \in \tau(e) \wedge s \in Q \rightarrow \forall s', e'[\alpha(e) <_S s' \leq_S s' \wedge prefix(e', e) \wedge \omega(e') = s' \wedge e' \in P_v \rightarrow s' \in Q]]]$$

3.$Non - prefix_{<_S}$ -closedness of a result Q relative to an event-type P_v

$$\forall Q[Non - prefix <_S -closed_v(Q) \leftrightarrow \forall s, e[e \in P_v \wedge s \in \tau(e) \wedge s \in Q \rightarrow \forall s'[\alpha(e) <_S s' <_S s \rightarrow s' \notin Q]]]$$

In the sequel the following more intuitive names for the types of results will be used: $prefix_{<_S} - closed$ results are called $s - minimal$; $prefix_v$-closed results $w - minimal$ and non-prefix$_{<_S}$ -closed results maximal. [3]If a result Q of a particular type is required to be true at the end-point of an event $e \in P_v$, it is evaluated on $\tau(e)$ in a particular way. The way Q is evaluated corresponds to a (variant of a) dynamic mode from Dynamic Modal Logic, de Rijke 1993. In DES a dynamic mode is defined as a function from $\varsigma(E) \times \varsigma(S)$ to $\varsigma(E)$ (for details on the exact relationship between dynamic modes in DML and the way they are defined in DES see Naumann 1999a, Naumann 1999). In (7), three examples of dynamic modes are given and the relationship between types of results and dynamic modes is shown in Table 1.

[1]Note that it is not necessary to assume that the event e' is a material part of e. Alternatively, one can take e' to be a presupposed event that preceeds e.

[2]In some cases the definitions given in (6), in particular that of a non-prefix$_{<_S}$ -closed result,are too weak. In Latrouite 1999 an appropriate definition is given that proceeds by first defining the corresponding types at the level of properties Q, in terms of which the types of results are defined in a second step; see Naumann 1999 for details.

[3]See also the Appendix.

(7) 1.$Min-BEC_{<_S} = def.\lambda P \lambda Q \lambda e[e \in P \cap \alpha(e) \wedge Q \wedge \omega(e) \in Q \wedge \forall s[\alpha(e) <_S s <_S \omega(e) s \notin Q]]$
2.$Con-BEC = def : lambdaP \lambda Q \lambda e[einP \wedge \alpha(e) = \in Q \wedge \omega(e) \in Q \wedge \forall e'[prefix^*(e', e) \wedge e' \in P \rightarrow !(e') inQ]]$
3.$Con - BEC_{<_S} = def : \lambda P \lambda Q \lambda e[einP \wedge \alpha(e) = \in Q \wedge \omega(e) \in Q \wedge \forall s[\alpha(e)_{<_S} s <_S \omega(e) \rightarrow s \in Q]]$

(8) $\forall e; e'[prefix^*(e'; e)[e' vEe \wedge \alpha(e) = \alpha(e') \wedge \omega(e') <_S \omega(e)]]$

Table 1

type of result	dynamic mode
$prefix_s$-closed	$Con - BEC_{<_S}$
$prefix_v$-closed	$Con - BEC$
$non - prefix_{<_S}$-closed	$Min - BEC_{<_S}$

The relationship between types of results and dynamic modes is only a correspondence because a result can be of a particular type but it is not evaluated according to the corresponding dynamic mode. If the execution sequence of an event $e \in P_v$ is a singleton, then $\alpha(e) = \omega(e)$ holds. But the three dynamic modes require the result to be evaluated differently at the beginning- and the end-point of e. Formally, a TS can be defined as a pair $(Q; (s; s'))$ consisting of a result Q and a pair of states $(s; s')$ such that $s \notin Q$ and $s' \in Q$. To each dynamic mode DM in (7) corresponds a variant DM* that is a function from $\varsigma(E) \times \varsigma(S)$ to $\varsigma(S \times S)$.

(9) 1.$Min - BEC^* <_S = def : \lambda P \lambda Q \lambda ss' \exists e[e \in P \wedge \tau(e) = (s; s') \wedge \alpha(e) \notin Q \wedge \omega(e) \in Q \wedge \forall s[\alpha(e) <_S s <_S \omega(e) \rightarrow s \neq Q]]$
2.$Con - BEC^* = def : \lambda P \lambda Q \lambda ss' \exists e[e \in P \wedge \tau(e) = (s; s') \wedge \alpha(e) \notin Q \wedge \omega(e) \in Q \wedge \forall e'[prefix^*(e'; e) \wedge e' \in P \rightarrow !(e') \in Q]]$
3.$Con - BEC^* <_S = def : \lambda P \lambda Q \lambda ss' \exists e[e \in P \wedge \tau(e) = (s; s') \wedge \alpha(e) = 2Q \wedge \omega(e) \in Q \wedge \forall s[\alpha(e) <_S s <_S \omega(e) \rightarrow s \in Q]]$

For an event $e \in P_v$ with $\tau(e) = (s; s')$ one has: $(Q; e) \in DM(P_v)$iff$(Q; (s; s')) \in DM^*(P_v)$.

0.3 The Interpretation of Verbs in DES

0.3.1 The Classification of Verbs

Verbs v can be classified on the basis of (i) the *types* of results that are determined by the corresponding event-types P_v, (ii) the number of results of a given type that are determined by P_v and (iii) the sort to which the event-types P_v belong. E.g., accomplishment-verbs like 'kain' determine all three types of results. P_{sunod_f} , the subset of P_{sunod} that corresponds to the meaning of 'to follow', does not define a maximal result but only an $s-$minimal and a $w-$minimal one. Three different sorts of event-types are distinguished: an event-type P_v is P-atomic if no proper initial stage (prefix) e' of an event e belonging to P_v is of this type too: $P - Atomic(P_v), \forall e[e \in P_v \rightarrow \neg \exists e'[prefix^*(e'; e) \wedge e' \in P_v]]$; an event-type P_v is instantaneous if each of its elements has an execution sequence that consists of a single state (i.e., the beginning point is identical to the end point: $\alpha(e) = \omega(e)$), Naumann 1999b. Instantaneous and P-atomic event-types together form the atomic event-types. Finally, an event-type P_v is non-atomic if it is not P-atomic and if the execution sequence of each of its elements is not a singleton. Event-types of sort Accomplishment and Activity are non-atomic. Examples for P-atomic event-types are those corresponding to Transfer-verbslike 'kuha' and 'buy'. Point- and Achievement-verbs like 'katok' and 'reach', respectively, correspond to instantaneous event-types. From the definition of P-atomicity it follows that for this sort the distinction between $w-$minimal and maximal results collapses: each $w-$minimal result is maximal and vice-versa. This property distinguishes the (non $s-$minimal) results assigned to verbs of this class from those results assigned to verbs belonging to the class of Accomplishments or Activities where neither $w-$minimal results are maximal nor maximal results $w-$minimal. Maximal results that are not $w-$minimal (and not $s-$minimal) are called strongly maximal (s-maximal) whereas maximal results that are also weakly minimal (and not $s-$minimal) are called weakly maximal (w-maximal). A result that is $w-$minimal but not maximal (and not $s-$minimal) will be called w*-minimal in the sequel. Transfer-verbs determine two w-maximal results. For instantaneous event-types, i.e., the event-types corresponding to Achievement- and Point-verbs, the distinction between the three basic types collapses: they are indistinguishable because the execution-sequences are singletons. If it is required that a result Q hold at the end-point of an event e belonging to an instantaneous event-type, it vacuously holds at all points in between $\alpha(e)$ and $\omega(e)$ (because there are no such points); thus, the result is $s-$minimal. By the same argument Q is maximal because it vacuously fails to hold at all intermediate points. Finally, Q is $w-$minimal because it holds, again vacuously, at the end-points of all proper prefixes e' of e. Results that are $s-$minimal, $w-$minimal and maximal will be called min-max. The classification based on the three criteria is given in Table 2.

Table 2	s-min.	w^*-mina	min-max	w-max.	s-max.
Acco. (kain)	+	+	-	-	+
Act. ($sunod_f$)	+	+	-	-	+
Transfer (kuha)	+	-	-	(+)2	-
Point/Ach. (katok)	+	-	+	-	-

0.3.2 Objects and Changes

Each basic event type P_v determines for each of its elements e a set $Res(P_v; e)$ of results that e can possibly bring about. These results are linearly ordered interms of (i) the temporal order in which they are brought about based on the relation 'not before' and (ii) implicational relations. The ordering that results if only the first criterion is applied is $\leq_v$. The ordered set of results constitutes $e's$ event structure (ES). Each result that is an element of $Res(P_v; e)$ is brought about with respect to at least one object that participates in e. E.g., if e is of type 'John eat a fish', the results are brought about with respect to John and the fish. John is assigned both the $s-$minimal result (e.g. his mouth is open) and a $w*$-minimal one (part of the fish is in his stomach) whereas the fish is assigned a $w*$-minimal result (its mass partly decreased) and the s-maximal one (its mass is zero). In the case of an event e of type 'Bill push the cart' Bill is assigned the $s-$minimal result (his actions towards the cart which bring about a change of location with respect to Bill or a part of Bill's body, e.g. his arms) and possibly a $w*$-minimal one (Bill traverses a non-empty path) whereas the cart is assigned only a $w*$-minimal result (the cart traverses a non-empty path). For an event e of type 'John give the book to Mary' both the book and Mary are assigned a w-maximal result and no $s-$minimal one such that it is not possible to distinguish them on this basis. The difference between these two objects is that the book is assigned two w-maximal results (John does not have the book; Mary does have the book) whereas Mary is assigned only one (Mary does have the book), Naumann and Mori 1998. The Actor John is assigned the $s-$minimal result (corresponding to his movements towards Mary which bring about a change of location with respect to John) and a w-maximal one (John does not have the book). Furthermore, both results are w-maximal, and are therefore equivalent with respect to the ordering $\leq_v$. They can be distinguished on the basis of implicational relations. 'Mary does have the book' (Q) implies 'John does not have the book' (Q') but not vice versa, i.e., $Q \subseteq, Q' \wedge Q' \not\subseteq Q$ holds. Using implicational relations in addition to the temporal relation 'not before' gives rise to a more fine-grained ordering $\leq_v^*$ (compared to $\leq_v$): $Q \leq_v^* Q'$ iff $Q <_v Q' \vee [Q =_v Q' \wedge Q' \subseteq Q]$. If for two w-maximal results Q and Q' $Q = vQ'$ and $Q <_v^* Q'$ holds, Q is called the w-max1 result whereas Q' is the w-max$_2$result. With the more fine-grained ordering $\leq_v^*$ one gets: Actor (John): s-min and w-max$_1$; Recipient (Mary): w-max$_2$ and Object transferred (book): w-max$_1$ and w-max$_2$. Similarly, it is possible to distinguish the two w-maximal results defined for an event e in P_{kuha}. If d' is possessed by d'', this implies that $d(\neq d'')$ does not have d'. The other direction does not hold because d can have given d ' to some $d''' \neq d''$ or simply have thrown d' away. Thus, $Q' \subseteq Q$ holds,where Q' corresponds to the result that d is possessed by d''. The aspectual relevance of this inclusion lies in the fact that the stronger result but not the weaker one can be used as the minimal result that events of type P_{kuha} must bring about. If for an event e, Q but not Q' holds at $\omega(e)$, e cannot be of type P_{kuha}. The relationship between an event-type P_v, an event e in P_v, an object $d \in O$ participating in e and a result Q that e can bring about with respect to d is captured by a function $\Delta : \Delta(P_v)(e)(d)$ is the set of results that e can bring about relative to $d(\Delta(P_v)$ is abbreviated to $\Delta_v)$. For each $Q \in \Delta_v(e)(d)$ it is required that $Q = Q(d)$ for some $Q \in \lambda(P_v)$. The set $Res(P_v, e)$ can be defined in terms of $\Delta : Res(Pv; e) = \{Q|\exists d[Q \in \Delta_v(e)(d)]\}$.

0.4 The Interpretation of the Voice Affixes

In section (1) it was shown that a VA has at least two semantic functions. It determines both the subject of a sentence and the particular interpretation the sentence (or the corresponding VP) has (e.g. partive vs. non-partitive). The set of results $Res(P_v; e)$ 'spawns' a maximal possible transformation of state that can be brought about by e if all elements of this set are realized. This maximal transformation of state is the 'join' of the transformations that correspond to the elements of $Res(P_v; e)$ according to the dynamic modes that are assigned to the results with respect to their type.

The two functions of a VA can both be defined in terms of $Res(P_v; e)$. Intuitively, they can be formulated as follows.

1. each VA determines for an event e in P_v a subset of $Res(P_v; e)$ as admissible results and requires e to bring about at least one element Q from this subset. This means that at the level of P_v a voice affix maps P_v to one of its subsets: $\forall d_1 ... \forall d_n \forall e[!d_1, ..., d_n; e >\in [[VA]](P_v) \rightarrow [[VA]](P_v)(d_1)...(dn)\theta P_v$
2. each d participating in e is uniquely determined by a subset of $Res(P_v; e)$ that can be defined in terms of (i) the types of results that are assigned to it and (ii) a (temporal) maximality or a minimality condition with respect to condition (i); the subject determined by a VA is singled out by a particular subset (plus, possibly, a maximality or minimality condition).

0.4.1 The Determination of the Result

The differences in interpretation depending on the VA with which a stem combines show that an event need not bring about all the results that belong to $Res(P_v, e)$. On the other hand, each event $e \in P_v$ is required to bring about at least a result that is sufficient for it to be of type P_v. Such results are called $v-$closed $(prefix(e'; e) = def : prefix^*(e', e) \vee e = e')$.

(10) $\forall Q[closed_v(Q) \Leftrightarrow \forall e \forall e' \forall d[\Delta(e)(d)(Q) \wedge prefix(e', e) \wedge \rightarrow (e') \in Q \rightarrow e' \in P_v]]$

What types of results are v-closed depends on the event-type. For Accomplishments, Activities and Transfer-verbs $w-$minimal and maximal results are $v-$closed, whereas $s-$minimal ones are not. For these verbs the requirement therefore excludes that only an $s-$minimal result is brought about. In the case of Achievement- and Point-verbs, for which the distinction between the three basic types collapses, all types of results are v-closed (see Latrouite 1999 and Naumann and Mori 1998 for details). For the three VA's discussed in this article one gets the following requirements.

(i) 'um-' requires an event e at least to be of type P_v; this requirement is satisfied if e brings about at least one result that is v-closed. This VA does therefore not restrict P_v because this requirement is satisfied by each element of P_v. On the other hand, no v-closed result is excluded so that'um-' does not uniquely determine a particular result.

(ii) '-in' requires an event e to bring about a maximal result Q. It does not matter whether Q is s-maximal, w-maximal or min-max. From this requirement it immediately follows that verbs of sort Accomplishment,Transfer, Achievement and Point admit this VA because the corresponding event-types determine this type of result. Stative verbs and Activity-verbs, on the other hand, do not admit 'in-' because no maximal result is determined (an example is given by P_{sunod_f} ; see section (5) for details)

(iii) '-an', finally, requires an event e to brinng about a result Q that is (a) non-prefix-closed$_v$, i.e. w-minimal or maximal (b) not prefix$_{<_S}$-closed$_v$, i.e. s-minimal and (c) minimal with respect to $\leq_v$ among the set of results that satisfy conidtions (i) amd (ii). The second condition admits $w*$-maximal, w-maximal, s-maximal and min-max results. If condition (i) is taken into account, min-max resutls are excluded because they are also s-minimal. From this requirement it immediately follows that '-an' in not admissible for verb stems of sort Achievement and Point because their corresponding event-types only determine the latter type of results. The third condition excludes s-maximal results because whenever an event-type determines this type of result, it also determines a $w*$-minimal one (examples are (incremental) Accomplishment-verbs), which (properly) precedes the s-maximal one according to $\leq_v$. The necessity to exclude $s-$maximal result as admissible arises from the partitive reading one gets for '-an' for Accomplishment-verbs like 'kain'. As a consequence, the admissible results for this voice affix are $w*$-minimal and w-maximal result (the formal names of which are $prefix^*_v - closed$ and $w - non - prefix_{<_S} - closed$, respectively; see the appendix for formal definitions.)

These requirements are formulated in terms of function NS^{VA} that map an event-type P_v and a set of states Q to a subset of $P_v(NS^{VA}(P_v)$ is abbreviated to $NS^{VA}_v; \delta^*_v(e)(Q) = def.\exists d.\delta_v(e)(d)(A))$

(11) $1.NS^{um}_v(Q) = \{e|[\delta a^*_v(e)(Q) \wedge closed_v(Q)]\}$
$2.NS^{um}_v(Q) = \{e|[\delta a^*_v(e)(Q) \wedge non - prefix_{<_S} - closed_v(Q)\}$
$3.NS^{um}_v(Q) = \{e|[\delta a^*_v(e)(Q) \wedge [prefix^*_v - closed_v(Q) \vee w - non - prefix_{<_S} - closed_v(Q)\}$

In terms of (11:3) the admissibilty condition imposed by '-an' can be formulated in the following way. Recall that $w*$-minimal and w-maximal results are both w-minimal and not s-minimal. As each basic event-type P_v determines one result that is $prefix_{<_s} - closed$, it follows that '-an' is admissible only for event-types that determine at least two types of results that do not coincide, ie., that are not $\leq_v$-equivalent. If the relationships between types of results determined by a P_v are taken into account, this condition is equivalent to that given in (12).

(12) $\forall Q[Q \in Res(P_v, e) \rightarrow [closed_v(Q) \Leftrightarrow prefix^*_v - closed_v(Q)]] \wedge \exists Q \exists Q'[Q \in Res(P_v, e) \wedge Q' \in Res(P_v, e) \wedge closed_v(Q) \wedge \neg prefix_{<_S} - closed_v(Q \wedge closed_v(Q')) \wedge \neg(Q' =^*_v Q)$

The subset $Res^{VA}(P_v, e)$ of $Res(P_v, e)$ that corresponds to $NS^{VA}(P_v, e)$ is defined in (13).

(13) $\forall Q[Q \in Res^{VA}(P_v, e) \Leftrightarrow e \in NS^{VA}(P_v, Q)$

The requirement that is imposed by a VA on the results is formulated in (14).

(14) $\exists Q[Q \in Res^{VA}(P_v, e) \wedge \omega(e) \in Q]$

According to (14), only those events $e \in P_v$ are denoted by a complex predicate consisting of a verb stem and a voice affix that bring about at least one result from the subset of results $Res^{VA}(P_v, e)$ determined by the affix.

0.4.1.1 The Determination of the Subject

The second function of a VA consists in determining the subject of a sentence.

The subject cannot be defined in terms of thematic relations. For instance, the VA '-in' determines both incremental themes, for the stem /kain/, transferred objects for the stem /kuha/ and goals for the stem /akyat/ as subjects (for details, see Latrouite 1998, Latrouite 2000).

(15) Kun-in mo sa kaniya ang lapis! (Get the pencil from him!) subject= transferred object

Kain-in mo ang isda! (Eat the fish!) subject = incremental themec. Akyat-in mo ang kanya-ng kuwarto! (Go up to his room!) subject = goal

As will be shown below, in DES it is possible to uniquely discern participants of an event e in P_v in terms of the dynamic structure that is spawned by $Res(P_v, e)$ together with maximality or minimality conditions.A first criterion that is used to uniquely single out a participant d of e is based on the types of result to which d is related to e. This first criterion could equally be formulated in terms of dynamic modes that correspond to particular types of results because results of the same type are assigned the same dynamic modes. Let $[d]_i^v 1 \leq i \leq 3$, be the set of objects participating in $e \in P_v$ that are assigned a result of type i, where T_i is one of the three types defined in (6)).

(16)1.$[d]\theta_{v_i} e = \{d | \exists Q[Q \in \Delta_v(e)(d) \wedge T_i(Q)]\}$

$[d]_i^v; e$ need not be a singleton such that on the basis of (single) types of results or even sets of types of results objects participating in e need not be distinguishable. For instance, for an event $e \in P$ push both the object that is pushed, e.g. a cart, and the Actor who does the pushing are assigned a w^*-minimal result (both traverse a non-empty path). Consequently, these two participants cannot be distingushed in terms of w*-minimal results. It is not possible to argue that the cart can be distinguished from the Actor by not being assigned an $s-$minimal result, i.e., the Actor is that object which is assigned both an $s-$ and a w^*-minimal result whereas the cart is assigned only a w^*-minimal result. Such a definition is not applicable to many other Activity-verbs like 'shave' for instance which admit of reflexive uses as in 'John shaved himself'. In this particular case the Actor is identical to the Undergoer. As a consequence the Undergoer is assigned an $s-$minimal result too. But this is excluded on the purported definition given above.

The solution to this problem consists in the observation that the Undergoer is that object which is assigned a w^*-minimal result and which is involved latest in the event among those objects that are assigned a w^*-minimal result. These condition imposes a maximality condition on the object denoted by the internal argument. This condition is formulated with respect to the temporal-dynamic dimension. It can be made precise in terms of results that are assigned to participants. If an object d is involved as the latest with respect to some condition (e.g. being assigned a w^*-minimal result), then to all other objects d' that satisfy this condition is assigned a result Q that precedes all results Q' assigned to d, where 'precedes' is defined in terms of the ordering $\leq_v^*$ on the set of results. As the object denoted by the internal argument is assigned only the $w*$-minimal result whereas the Actor is assigned the $s-$minimal result besides the $w*$-minimal one and as the $s-$minimal one precedes the $w*$-minimal one according to $\leq_v^*$, it follows that the Actor is excluded because it does not satisfy the maximality condition. This condition is satisfied by the object denoted by the internal argument such that it is the Undergoer. If both objects are identical, as in the case of a reflexive construction like 'shave oneself', there is only one object that is assigned the $w*$-minimal result, which trivially satisfies the maximality condition and which therefore, then, is the Undergoer. As this object is also assigned the $s-$minimal condition, it is in addition the Actor.

In (17) a set of semantic roles is defined according to the two criteria from above (these roles are relativized to an event-type P_v such that $e \in P_v$; an unrelativized role is defined as the union of the relativized ones, see the appendix for a formal definition).

(17)
1.$Role_v^1(e, d)$ just in case d participates in e and (i)d is assigned an $s-$minimal result and (ii) d is minimal with respect to condition (i)
2.$Role_v^2(e, d)$ just in case d participates in e and (i) d is assigned a $w*$-minimal result and (ii) d is maximal with respect to condition (i)
3.$Role_v^3(e, d)$ just in case $Role_v^2(e, d)$ and d is assigned an s-maximal result
4.$Role_v^4(e, d)$ just in case d participates in e and (i) d is assigned two $w-$maximal results, a w-maximal$_1$ and a w-maximal$_2$ one
5.$Role_v^5(e, d)$ just in case d participates in e and (i) d is assigned exactly one w-maximal result Q, (ii) Q is w-maximal$_2$ and (iii) d is maximal with respect to conditions (i) and (ii)
6.$Role_v^6(e, d)$ just in case d participates in e and (i) d is assigned exactly one w-maximal result Q, (ii) Q is w-maximal$_1$ and (iii) d is maximal with respect to condition (i) and (ii)

The roles in (17) define what is called the *dynamic component* of a *semantic role* (SR) such that it can be viewed as a partial definition of the SR. It is therefore not excluded that besides the dynamic ones other properties, like causation or volition for instance, define the SR. The definitions are given in (18).

(18) 1.$\theta_{Act_v}(e,d) \rightarrow Role^1_v(e,d)$
2.$\theta_{UG_v}(e,d) \rightarrow Role^2_v(e,d)$
3.$\theta_{UG_{inc_v}}(e,d) \rightarrow Role^3_v(e,d)$
4.$\theta_{BO_{max_1} \wedge max_{2_v}}(e,d) \rightarrow Role^4_v(e,d)$
5.$\theta_{BO_{max_{2_v}}}(e,d) \rightarrow Role^5_v(e,d)$
6.$\theta_{BO_{max_{1_v}}}(e,d) \rightarrow Role^6_v(e,d)$

According to (17a), the Actor is that participant who is assigned the $s-$minimal result and who is minimal with respect to this property. As the $s-$minimal result is assigned to exactly one participant of an event, the latter condition can in fact be dropped because the first condition already singles out a unique object (see Naumann and Mori 1998 for details). The internal arguments of (transitive) Accomplishment- and Activity-verbs are both Undergoers in the sense of (17b). Those of Accomplishment-verbs satisfy in addition (17c), i.e., they are incremental UGs (Themes)[4].. Note that the maximality conditionin the definition of $Role^2_v$ excludes the Actor if (s)he is distinct from the UG because if both are assigned a $w-$minimal result that is not maximal (and, possibly, a maximal result), the Actor is assigned in addition the $s-$minimal result which means that (s)he is involved in the event before the UG and therefore fails to satisfy the maximality condition. The roles assigned to the direct and oblique arguments of Transfer-verbs like /kuha/ and /bigay/ are called *maximal boundary object* (BO_{max}), (17d-f), respectively. They can be distinguished on the number of w-maximal results they are assigned and the sort of the w-maximal result. The object that is transferred, e.g. the book given or taken, is assigned both w-maximal results determined by the corresponding event-type whereas the object denoted by the oblique argument is assigned only one (see the appendix for examples). According to these definitions, each object that bears some TR_v to an event e in P_v is assigned a result, i.e., it undergoes a change. This follows from the definitions of the different roles $Role^i_v$ in (17). Thus, in a sense each object that is assigned a result is an UG in the traditional sense. In terms of the SRs defined in (17) further SRs can be defined that generalize those in (18).E.g., a generalized Undergoer can be defined as the union of the relations $UG, BO_{max_1} \wedge max_2, BO_{max_2}$ and BO_{max_1}. For verbs v with corresponding event-types P_v that are instantaneous, the objects participating in e are discerned on the basis of the presupposed event e'. They cannot be discerned on the basis of results that hold on the execution-sequence of e because all types of results collapse such that one rests, in effect, with a single type that does not admit to distinguish more than one object.If the objects are discerned with respect to e', this means that the semantic roles that are assigned to participants of e are the value of those roles for thepresupposed event e', i.e. the θ_{v_i} are defined in terms of the corresponding roles t, i for the event-type of the presupposed event. This yields (19).[5]

(19) $\theta_{v_i}(e,d) iff \exists e'[presup(e,e') \wedge P_v(e) \wedge \theta_i(e',d)]$

(19) can be generalized to all basic event-types by assuming that for events that do not presuppose other events $presup(e,e)$ holds. There is the following relationship between the set of admissible results de-termined by a VA and the object d denoted by the ang-phrase ($Res_d(P_v,e) = \{Q|Delta_v(e)(d)(Q)\}$ is the set of all results assigned to d).

(20) $Res^{VA}(P_v,e) \cap Res_d(P_v,e) \neq \theta$

[4]SR is short for θ_{SR}

[5]Note that in effect $\theta_i(e',d)$ must be relativized to a basic event-type P'_v . This can beachieved by using $P(P) \wedge P = P'_v \wedge \theta_{v'_i}(e,d)$ for some v' that is determined by e and $P_v(P = \{P_v|v \in VERB\})$. An alternative solution consists in defining semantic roles not as functional relations on $O \times E$ but on $\varsigma(E) \times O \times E$. This makes first the dependence on an event-type explicit and can be used even if the event-type of e' is not a basic one.

According to (20), the object d that is denoted by the ang-phrase must be assigned a result that is admissible for the VA.

The object d participating in an event $e \in P_v$ that is determined as subject by the voice affixes are determined by the following condition.

(21) 1.'um-': the object d that is assigned the $s-$minimal result, i.e., the object that is assigned the semantic role $Role^1_v(\theta_{Act_v})$ with respect to e

2.'-in': the object d that is assigned all v-closed results

3.'-an': the object d such that (i)d is assigned a maximal element Q from $Res(P_v, e)$ with respect to $\leq_v$, (ii) d is assigned the least number of maximal elements from $Res(P_v, e)$ among the objects participating in e that are assigned a maximal element from $Res(P_v, e)$ and (iii) d is maximal with respect to condition (i)

0.4.2 The Interpretation of the VA

In Tagalog, a verb stem does not subcategorize for an n-tuple of arguments, Himmelmann 1987. A verb stem v is therefore interpreted in DES as the corresponding event-type P_v, (22:1).Voice affixes are interpreted as mapping basic event-types P_v to relations on On times E (i.e., they are polymorphic, for v an n-place verb, the result of applying the interpretation of a VA to the interpretation of v is a relation on $O^n \times E$). In (22), $\mu(P_v)$ is the set of semantic roles which is defined for P_v, for F see below and Naumann 2000.

(22) 1.$[[v]] = P_v$

2.$[[um-]](P_v) = \lambda d_1...\lambda d_n \lambda e \exists Q \exists d[e \in P_v \wedge \theta_{v_i}(e, d_i) \wedge \omega(e) \in Q \wedge e \in NS^{sum}_v) \wedge Subject(P_v, e, d) \wedge d = \iota d'.F_{um}(\mu(P_v))(e) = d']$

3.$[[-in]](P_v) = \lambda d_1...\lambda d_n \lambda e \exists Q \exists d[e \in P_v \wedge \theta_{v_i}(e, d_i) \wedge \omega(e) \in Q \wedge e \in NS^{in}_v(Q) \wedge Subject(P_v, e, d) \wedge d = \iota d'.F^{in}(\mu(P_v))(e) = d']$

4.$[[-an]](P_v) = \lambda d_1...\lambda d_n \lambda e \exists Q \exists d[e \in P_v \wedge \theta_{v_i}(e, d_i) \wedge \omega(e) \in Q^e \in NS^{an}_v(Q) \wedge Subject(P_v, e, d) \wedge d = \iota d.F^{an}(\mu(P_v))(e) = d' \wedge \forall Q'[NS^{*-an}_v(Q')(e) \rightarrow \omega(e) \notin Q']]$

The additional condition in the interpretation of '-an' makes sure that for(incremental) Accomplishment-verbs like /kain/ the s-maximal result is not brought about such that one gets a partitive reading. $NS^{*-an}(P_v)(Q)$ is defined as follows ($Q \in \Delta^* v(e)$iff$\exists d \neq \Delta v(e)(d)(Q)) \neq NSd^a, an(P_v)(Q) = fe|Q \in \Delta^*_v(e) \wedge non-prefix-closed_v(Q) \wedge \forall Q''[NS^{an}_v(Q'')(e) \rightarrow \neq (Q'' =^*_v Q)]\}$. According to the first condition, Q is either w^*-minimal, w-maximal or s-maximal.

The last condition requires, in addition, that Q is not v^*-equivalent to an element of the set of admissible results determined by '-an'. As all elements of $Res^{an}(P_v, e)$ are either w^*-minimal or w-maximal, it follows that exactlythe s-maximal results are singled out (if this type of result is determined at all). Thus, the requirement $\forall Q'[NS^{an}_v(Q')(e) \rightarrow \omega(e) \notin Q']$ in the interpretation of '-an' excludes that an s-maximal result is brought about. The requirement $\forall Q'[NS^*_v(Q')(e) \rightarrow \omega(e) \notin Q']$ can equivalently be formulated as $\forall Q'[Q' \in (Res^*-an(P_v, e) \cap Res^{an}(P_v, e)) \rightarrow \omega(e) \notin Q']$.

Following Latrouite 1998, Latrouite 2000 it is assumed that the order of arguments in (22) is the same for each voice affix. This means that if the maximal number of arguments is n, then there is an n-tuple $< d_1, ..., d_n >$ such that $[[VA]](P_v)(d_1)...(dn)(e) = 1$, independently of the particular voice affix VA. As shown in A. Latrouite 2000, $< d_1, ..., d_n > = < \theta_{v_1}(e), ..., \theta_{v_n}(e) > (where \theta_{v_i}(e) = \iota d.\theta_{v_i}(e, d))$ and the order of the t, v_i is identical to the orderingof the semantic roles that are defined for P_v. *Subject* is a non-functional relation on $\varsigma(E) \times E \times O$ that holds between basic event-types P_v and events $e \in P_v$ and $ad \in O$ if d is a participant of e and satisfies the condition imposed by a voice affix VA on the subject. For details of how F_{VA} is defined and on the exact relationship between semantic roles andthe set of results determined by a VA see Naumann 2000.

0.5 Verbs with Meaning Variance

In contrast to P_{kain} and P_{kuha}, P_{sunod} defines two different types of (maximal) execution-sequences: one that is P-atomic and one that corresponds to that defined by event-types of sort activity. Elements of P_{sunod} that are denotedby expressions with meaning 'to obey' are assigned the first type (they belong to P_{sunod_o}) whereas events denoted by expressions with meaning 'to follow' are assigned the second type (they belong to P_{sunod_f}). One has: $P_{sunod} \cup [P_{sunod_f} = P_{sunod}$ and $P_{sunod} \cap P_{sunod_f} = \theta$. Meaning variance of a verb stem like /sunod/ is explained as resulting from the possibility of bringing about a result in different, dynamically non-equivalent ways. For 'eat' the result that must be brought about only holds at the endpoint of an event, i.e., it can be assigned a unique type: it is an s-maximal result. This uniqueness need not always be the case. Consider the result 'the actions of d are dependent on those of d'' $(= Q)$. Bringing about this result can be done by either deciding to carry out the instructions (orders) of d' $(= Q_1)$ or by traversing a path that has the same direction as that traversed by d' $(= Q2)$.These two instances of Q differ in the way they are brought about. Q_2 is similar to the result that characterizes verbs of motion: a non-empty path must be traversed. In addition, it is required that the path has the same direction as the path traversed by d'. This result holds at intermediate states of the execution sequence of an event that brings it about such that it is $w-$minimal. Q_1, on the other hand, is an s-maximal or a min-max result because it only holds at the end point of an event (the decision process). Tagalog and English differ in the way the conditions on the result that must be brought about are determined. In English the result is required to be maximal with respect to $\leq_v$ and to have a unique type. This requirement is violated if a verb in English were assigned the result Q the type of which depends on the particular instance that is brought about. Therefore, the two ways of bringing about Q are assigned not to one but to two different verbs, namely 'obey' $(Q_1)$and 'follow' (Q_2). It is assumed that P_{sunod} only determines the general result Q such that the meaning of the stem comprises both instances, i.e., it is underspecified with respect to the two instances Q_1 and Q_2. Which instance is selected depends on the requirement that is imposed by a VA. As '-in' requires the result to be maximal (non-prefix$_{<_S}$ -closed), it follows that Q must be realized by its subtype Q_1 because then that this requirement is satisfied. The VA '-an', on the other hand, selects the subtype Q_2 because it is w*-minimal, a type of result that is admissible for this VA, whereas Q_1 is excluded because it is neither $w*$-minimal nor $w-$maximal. In (23) the interpretation of /sunod/ for the voice affixes '-in'and '-an' are given using the types of the admissible result.

(23) 1.$[[in]](P_{sunod}) = \lambda d_1 \lambda d_2 \lambda e \exists Q[e \in P_{sunod} \wedge \theta_{sunod_i}(e, d_i) \wedge non - prefix_{<_S} - closed(Q) \wedge \omega(e) \in Q]$
2.$[[an]](P_{sunod}) = \lambda d1 \lambda d \in \lambda e \exists Q[e \in P_{sunod} \wedge \theta_{sunod_i}(e, d_i) \wedge [prefix^*_v - closed_v(Q) \vee w - non - prefix_{<_S} - closed_v(Q)] \wedge \omega(e) \in Q]d$

0.6 Appendix

0.6.1 Formal Definitions of further Types of Result

In (24) further types of results are defined in terms of the three basic ones defined in (6) above.

(24) 1.$\forall Q[prefix^*_{<_S} - closed_v(Q) \Leftrightarrow prefix_{<_S} - closed_v(Q) \wedge \neg non - prefix_{<_S} - closedv(Q)]$
2.$\forall Q[prefix^{**}_{<_S} - closed_v(Q) \Leftrightarrow prefix_{<_S} - closed_v(Q) \wedge non - prefix_{<_S} - closed_v(Q)]$
3.$\forall Q[prefix^*_v - closed_v(Q) \Leftrightarrow \neg prefix_{<_S} - closed_v(Q) \wedge prefix_v - closed_v(Q) \wedge : non - prefix <_S -closed_v(Q)]$
4.$\forall Q[w - non - prefix_{<_S} - closed_v(Q) \Leftrightarrow \neg prefix_{<_S} - closed_v(Q) \wedge prefix_v - closed_v(Q) \wedge non - prefix_{<_S} - closed_v(Q)]$
5.$\forall Q[s - non - prefix <_S -closed_v(Q) \Leftrightarrow \neg prefix_{<_S} - closed_v(Q) \wedge \neq prefix_v - closed_v(Q) \wedge non - prefix <_S -closed_v(Q)]$

$6.\forall Q[non-prefix-closed_v(Q) \Leftrightarrow prefix^*_v-closed_v(Q)w-non-prefix_{<_S}-closed_v(Q) \vee s-non-prefix <_S -closed_v(Q)]$

In the table below the correspondence between the offical names and the more intuitive names used in the text is given.

s-minimal	prefix$_{<_s}$ -closed
s^*-minimal	prefix$^*_{<_S}$ -closed
w^*-maximal	prefix$^*_v$-closed
min-max	prefix$^{**}_{<_S}$ -closed
w-maximal	w-non-prefix$_{<_S}$ -closed
z-maximal	s-non-prefix$_{<_S}$ -closed

0.6.2 Formal Definitions of the Semantic Roles

In a first step a set of functional relations on E times O is defined: these relations,called semantic roles, are relativized to an event-type P_v.

(25) $1.Role^1_v(e,d) \Leftrightarrow \exists Q[\Delta_v(e)(d)(Q) \wedge prefix^* <_S -closed_v(Q)]$
$2.Role^*_v(e,d) \Leftrightarrow \exists Q[\Delta_v(e)(d)(Q) \wedge prefix^*_v - closed_v(Q)]$
$3.Role^2_v(e,d) \Leftrightarrow Role^{2*}_v(e,d) \wedge Max_{Role^{2*}_v}(e,d)$
$4.Role^3_v(e,d) \Leftrightarrow Role^2_v(e,d) \wedge \exists Q[\Delta_v(e)(d)(Q) \wedge s-non-prefix_{<_S} - closedv(Q)]$
$5.Role^4_v(e,d) \Leftrightarrow \exists Q \exists Q'[\Delta_v(e)(d)(Q) \wedge \Delta_v(e)(d)(Q') \wedge w-non-prefix_{<_S} - closed_v(Q) \wedge w-nonprefix_{<_S} - closed_v(Q') \wedge : \neg(Q =^*_v Q')]$
$6.Role^{5*}_v(e,d) \Leftrightarrow \exists Q[\Delta_v(e)(d)(Q) \wedge w-non-prefix_{<_S}-closed_v(Q) \wedge \forall Q'[\Delta_v(e)(d)(Q') \wedge w-non-prefix_{<_S} - closed_v(Q') \rightarrow Q' = Q] \wedge \forall Q''[\Delta^*_v(e)(Q'') \wedge w-non-prefix_{<_S} - closed_v(Q'') \rightarrow Q'' \leq^*_v Q]]$
$7.Role^5_v(e,d) \Leftrightarrow Role^5 *_v (e,d) \wedge MaxRole^{5*}_v(e,d)$
$8.Role^{6*}_v(e,d) \Leftrightarrow \exists Q[\Delta_v(e)(d)(Q) \wedge w-non-prefix_{<_S}-closed_v(Q) \wedge \forall Q'[\Delta_v(e)(d)(Q') \wedge w-non-prefix_{<_S} - closed_v(Q') \rightarrow Q' = Q] \wedge \forall Q''[\Delta^*_v(e)(Q'') \wedge w-non-prefix <^*_v -closed_v(Q'') \rightarrow Q \leq^* vQ'']]$
$9.Role^6_v(e,d) \Leftrightarrow Role^{6*}_v(e,d) \wedge Max_{Role^{6*}_v}(e,d)$

$Max_{R^{n*}_v}$ is defined as follows:

(26) $Max_{R^n_{v_v}}(e,d) = def : \forall d' \forall Q'[\Delta_v(e)(d')(Q') \wedge R^n_v(e,d') \rightarrow \exists Q''[\Delta_v(e)(d')(Q'') \wedge \forall Q'''[\Delta_v(e)(d)(Q''') \rightarrow Q'' \leq_v Q''']]]$

Intuitively, $Max_{R^n_v}(e,d)$ means that for all participants d' of e that are assigned the results determined by Rn^*_v is involved not earlier than d'. As was said above, a role $Role^n_v$ is relativized to an event-type P_v. The corresponding unrelativized role is defined as the union of the relativized ones.

(27) $Role^n = [\cup_{v \in VERB} Role^n_v$

•examples for the different types of results

(28) 1.d_1 eats d_2

d_1: is assigned the prefix* $<_S$ -closed result ($Role^1_{eat}$)

d_2: is assigned the prefix$^*_v$-closed result and the s-non-prefix$_{<_S}$ -closed result ($Role^3_{eat}$), this is also true of d_1, but d_2 is maximal w.r.t. this property; therefore d_2 is assigned Role$^3_{eat}$ w.r.t. to e (in the definition only the maximality w.r.t. the prefix$^*v$-result is required which is sufficient to discern d_2 from d$_1$)

2.$d1$ pushes d_2

d_1: is assigned the prefix* $<_S$ -closed result ($Role^1_{push}$)

d_2: is assigned the prefix$^*_v$-closed result ($Role^{2*}_{push}$); this result is also assigned to d_1 but only d_2 is maximal w.r.t. this property ($Role^2_{push}$)

3.d_1 takes d_2 from d_3 (the objects are different)
d_1: is assigned the prefix$^* <_S$ -closed result ($Role^1_{take}$)
d_2: is assigned two $w-$non-prefix$<_S$ -closed results ($Role^4_{take}$)
d_3: is assigned only one w-non-prefix$<_S$ -closed result that is not maximal with respect to $\leq^*_v$ ($Role^6_{take}$)d.
4.d_1 gives d_2 to d_3 (the objects are different)
d_1: is assigned the prefix$^*_{<_S}$ -closed result ($Role^1_{give}$)
d_2: is assigned two w-non-prefix$_{<_S}$ -closed results ($Role^4_{give}$)
d_3: is assigned only one w-non-prefix$<_S$ -closed result that is maximal with respect to $\leq^*_{xv}$ ($Role^5_{give}$)

0.6.3 Formal Definition of the Subject determined by a Voice Affix

In (28)-(30) formal definitions of the subject determined by the voice affixes are given ($\Delta'_v(e)(d) iff \exists Q : \Delta_v(e)(d)(Q)$).

(29) 'um-': $\iota d \exists Q[\Delta_v(e)(d)(Q) \wedge prefix^* <_S -closed_v(Q)]$

(30) '-in': $\iota d[\Delta'_v(e)(d) \wedge \forall Q[Q \in Res(P_v, e) \wedge closed_v(Q) \rightarrow \Delta_v(e)(d)(Q)]]$

(31) '-an': $\iota d \exists Q[\Delta_v(e)(d)(Q) \wedge \forall Q'[Q' \in Res(P_v, e) \rightarrow Q' \leq_v Q] \wedge \forall d' \forall Q'[\Delta_v(e)(d)(Q') \wedge \forall Q''[Q'' \in Res(Pv, e) \rightarrow Q'' \leq_v Q'] \rightarrow |Res_{d_{max}}(P_v, e)| \leq |Res_{d_{max}}(P_v, e)|] \wedge \forall d'' \forall Q''[\Delta_v(e)(d'')(Q'') \wedge \forall Q'''[Q''' \in Res(P_v, e) \rightarrow Q''' \leq_v Q''] \wedge \forall d''' \forall Q'''[\Delta_v(e)(d''')(Q''') \wedge \forall Q''''[Q'''' \in Res(P_v, e) \rightarrow Q'''' \leq_v Q'''] \rightarrow |Res_{d''_{max}}(P_v, e)| \leq |Res_{d'''_{max}}(P_v, e)|] \rightarrow \exists Q'[\Delta_v(e)(d'')(Q') \wedge \forall Q''[\Delta_v(e)(d)(Q'') \rightarrow Q' \leq_v Q'']]]]$

In (30) $Res_{d_{max}}(P_v, e) = \{Q | \Delta_v(e)(d)(Q) \wedge \forall Q'[Q' \in Res(Pv, e) \rightarrow Q' \leq_v Q]\}$.

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