

The Semantics of *Before* and Negative Polarity

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The goal of this paper is two-fold: (i) to develop a semantics of *before* which can properly account for the (non-)occurrence of "negative" expressions and negative polarity items (NPIs, henceforth) in *before*-clauses, and (ii) to give a unified semantic account of the distribution of NPIs in Korean and Japanese. As for the semantics of *before*, extending Landman's (1991) and Valencia, van der Wouden, and Zwarts' (1994), we claim that *before* be interpreted as denoting an anti-additive function ("more negative" than simple monotone decreasing ones) with a restricted domain, i.e., the set of "(temporally) incremental" propositions. Based on the semantics of *before* and its counterparts in Korean and Japanese, we identify a type of NPI available in anti-additive contexts, which supports the semantic typology of NPIs proposed by Nam (1994) and van der Wouden (1994).

1. *Before* as an anti-additive function

Temporal connectives in natural language have traditionally been treated as a propositional operator. So *before* and *after* among others have been claimed to denote a binary propositional operator which assigns a specific temporal relation between two propositions. This section first reviews some naive views to the semantics of *before/after*, then shows how Landman (1991) and Valencia, van der Wouden and Zwarts (1994) give a better semantics to *before* inspired by Ladusaw's (1979) generalization of NPI licensing conditions.

1.1. Naive Semantics of *before* and *after*

Luce (1966) gives converse interpretations to *before* and *after*, based on the following sentences.

- (1) a. The Archduke was shot before the Russians mobilized their troops.
b. The Archduke was shot. Then the Russians mobilized their troops.
c. The Russians mobilized their troops after the Archduke was shot.

(1a-c) are claimed to have the same truth conditions, i.e., the event of Archduke's being shot temporally precedes the mobilization of Russians' troops. Thus Luce (1966) interprets *P before Q* ($P\#Q$) and *Q after P* as follows:

- (2) a. $P\#Q$ is true if and only if there is a pair of times t and t' such that t precedes t' and $P(t)$ and $Q(t')$.
b. $P\#Q$ is true if and only if either *P before Q* is true or *Q after P* is true.

The semantics given above assumes that *before* and *after* are to be interpreted as a binary propositional operator, i.e., a function mapping two propositions into a truth value. (2b) claims that *P before Q* and *Q after P* have the same truth conditions. We note the following inference rules Luce (1966: 37) suggests:

- (3) If X is a proposition and $(P \rightarrow Q)$ is valid for the logic, then
 - a. from $(P\#X)$ we may infer $(Q\#X)$, and
 - b. from $(X\#P)$ we may infer $(X\#Q)$.

Suppose P = 'John and Mary left the party' and Q = 'John left the party', so $P \rightarrow Q$, and let X = 'Bill arrived.' Then we can check if the above inference rules hold for natural usage of *before* in English: (4) below shows (3a) gives a valid inference, but (5) denies the inference pattern of (3b).

- (4) a. John and Mary left the party, before Bill arrived. *entails*
b. $\models$ John left the party, before Bill arrived.
- (5) a. Bill arrived before John and Mary left the party. *does not entail*
b. $\not\models$ Bill arrived before John left the party.

Notice that the inference rules in (3) are actually monotonicity claims on the propositions conjoined by *before*. That is, (3a) claims that the *before*-clause ($\#X$) be interpreted as monotone increasing on the other clause (P/Q), and (3b) claims that the connective *before* ($\#$) itself be interpreted as monotone increasing on the proposition denoted by the clause following *before* (P/Q). The entailment pattern in (5), however, does not endorse the second monotonicity claim of (3b). We will return to this problem shortly with reference to NPI-licensing in *before*-clauses.

Let us now briefly review Anscombe's (1964) semantics of *before* and *after*, which is slightly different from Luce's (1966). As noted in Valencia et al (1994), Anscombe (1964) suggests that *before* may be analysed as an anti-additive function in certain contexts, but she discards the analysis due to the problem of "repetition".¹ Thus, Anscombe proposes the following:

- (6) Anscombe (1964)
 - a. Q after P is true if and only if there are times t and t' such that t precedes t' and $P(t)$ and $Q(t')$.
 - b. P before Q is true if and only if there are times t and t' such that t precedes t' and $P(t)$, $\neg Q(t)$, and $Q(t')$.

According to (6), *before* and *after* are not interpreted as denoting the converse of each other, i.e., P before Q does not entail Q after P . Further, the truth conditions of *before* require Q to be false at the time when P is true. Anscombe's semantics of *before/after*, however, predicts a wrong entailment relation for *before*-clauses. That is, (6a) guarantees the entailment illustrated in (7a), but (7b) shows, contrary to the prediction of (6b), we do not get the entailment.

- (7) a. Mary arrived after John left.
entails $\models$ John left and Mary arrived
- b. John left before Mary arrived.
entails $\models$ John left; *but*
does not entail $\not\models$ Mary arrived.

1.2. NPIs in *before*-clauses

Before we propose a refined semantics of *before*, let us note Heinämäki (1972) and Ladusaw's (1979) observation on the distribution of NPIs in *before*-clauses. Thus,

- (8) a. John read the book before anyone else ever did.
- b. John finished the work before Mary did yet.

Ladusaw takes sentential connectives as binary relations among propositions, so *before*, *after*, *while*, and *if* are assigned the same semantic type of $\langle\langle s, t \rangle, \langle\langle s, t \rangle, t \rangle\rangle$. He proposes a generalized law governing the distribution of NPIs in English:

- (9) Ladusaw (1979)
NPIs are only licensed if they are in the scope of a downward entailing (monotone decreasing) operator.

(10) Definition:

Let $\langle \mathbf{A}, \leq \rangle$ and $\langle \mathbf{B}, \leq \rangle$ be two Boolean algebras.

$f \in [\mathbf{A} \rightarrow \mathbf{B}]$ is *monotone decreasing* iff for all $a, b \in \mathbf{A}$,

if $a \leq b$, then $f(b) \leq f(a)$.²

Downward entailing (or monotone decreasing) operators are those traditionally characterized as negative expressions, and due to the above definition, the following tests identify those expressions:

- (11) 'came to the party late' $\leq$ 'came to the party'
- a. *The boy didn't* come to the party
→ The boy didn't come to the party late
 - b. *No boy* came to the party
→ No boy came to the party late.
 - c. *At most three boys* came to the party
→ At most three boys came to the party late.
 - d. *At least three boys* came to the party
- / → At least three boys came to the party late.
 - e. *Every boy* came to the party.
- / → Every boy came to the party late.

Negation marker *not* is a typical expression denoting a decreasing function, and noun phrases like *no boy* and *at most three boys* also denote decreasing functions. (11d,e), however, show that the noun phrases like *at least three boys* and *every boy* do not denote a decreasing function. Now we can see the following data support Ladusaw's (1979) generalization (9). That is, the negative polarity item *anything* can only occur in decreasing contexts (12a-c) but not in (12d,e).

- (12)
- a. The boy *didn't* tell us anything about it
 - b. *No boy* told us anything about it
 - c. *At most three boys* told us anything about it
 - d. **At least three boys* told us anything about it
 - e. **Every boy* told us anything about it

Ladusaw (1979) also discusses sentential connectives, thus characterizes their semantics in terms of monotonicity. Consider the following:

- (13)
- a. John left the party. *entails*
 - b. $\models$ Someone left the party.
- (14)
- a. Mary arrived **after** someone left the party. *does not entail*
 - b. $\not\models$ Mary arrived **after** John left the party.
- (15)
- a. Mary arrived **before** someone left the party. *entails*
 - b. $\models$ Mary arrived **before** John left the party.
- (16)
- a. Mary cried **if** someone left the party. *entails*
 - b. $\models$ Mary cried if John left the party.

Due to the definition (10), we identify *before/if* but not *after* as denoting a monotone decreasing function. Then Ladusaw's generalization predicts the following as it is the case in English.

- (17)
- a. *Mary arrived **after** *anyone* left the party.
 - b. Mary arrived **before** *anyone* left the party.
 - c. **If** *anyone ever* catches on to us, we're in trouble.

Ladusaw also extends his generalization to account for the unavailability of NPIs in the consequent clause of conditional sentences (i.e., the second argument/ proposition of *if*) or in *only if*-clause as shown in the following:

- (18) a. ***If** Mary spills the beans, then *anyone* will ever stop us.
 b. **Only if** John agrees to pay will *anyone* sing.
 c. ***Only if** *anyone* agrees to pay will John sing.

1.3. Landman (1991): *before* as an anti-additive function

As we noted in 1.1, Luce (1966) and Anscombe (1964) do not characterize *before* as monotone decreasing but as increasing.³ Based on Ladusaw's generalization of NPI-distribution, Landman's (1991) formalization interprets the connective *before* as denoting a monotone decreasing function.

(19) Landman (1991: 143)

The semantics of *p before q*: $pBq(t_0)$

$$pBq(t_0) \text{ iff } \exists t_1 < t_0 [p(t_1) \wedge \forall t_2 [t_2 < t_0 \wedge q(t_2) \rightarrow t_1 < t_2]]$$

(19) correctly predicts that *p before q* does not entail *q*: i.e., *John left before Mary arrived* does not entail *Mary arrived*. The semantics also interprets *before* as denoting a decreasing function. Thus without proof we note the following:

- (20) If $q \rightarrow q'$, then $pBq'(t_0) \rightarrow pBq(t_0)$

Landman's semantics in (19) is actually similar to the following characterization by Anscombe (1964:10):

- (21) "p before q" means "There was some time at which p such that every time at which q was after it"

Anscombe was aware of the problem of "repetition" as illustrated in the following quote: "He studied his appearance in the glass before he used the telephone" may well be a true piece of narrative; it does not at all suggest that he studied his appearance in the glass before he ever in his life used the telephone." (Anscombe 1964: 13) Valencia et al (1994) solve this problem by restricting the temporal domain to a definite time span *I*, and revise Landman's semantics (19) as follows:

- (22) $pBq(I, t_0) \text{ iff } \exists x \in I [x < t_0 \wedge p(x) \wedge \forall y \in I [y < t_0 \wedge q(y) \rightarrow x < y]]$

Further, Valencia et al (1994) prove that Landman's semantics interprets *before* as denoting an anti-additive function defined below:

- (23) Definition: Let $\langle \mathbf{A}, \leq \rangle$ and $\langle \mathbf{B}, \leq \rangle$ be two Boolean algebras.

$f \in [\mathbf{A} \rightarrow \mathbf{B}]$ is *anti-additive* iff for all $a, b \in \mathbf{A}$, $f(a \vee b) = f(a) \wedge f(b)$.

(That is, $f(a \text{ or } b) \leftrightarrow f(a) \text{ and } f(b)$.)

We note without proof that due to the definitions (10) and (23), the anti-additive functions are a subset of the monotone decreasing functions, so anti-additive functions are "more negative" than simple decreasing functions.

2. Semantic Typology of NPIs

Since Ladusaw (1979) proposed a principle of NPI-licensing, there has been much work on the syntactic/semantic behavior of various NPIs in different languages. Zwarts (1990) among others has developed a semantic typology of NPIs which classifies them in terms of their licensing contexts. He distinguishes two types of NPIs in Dutch, German and English: one includes those which can occur in any decreasing contexts, and the other those which cannot occur in all decreasing contexts but only in some of them. For example, as shown below, *yet* in English can occur under negation and with an NP like *no boy*, but not with an NP like *at most three boys*. Recall that *any* can occur in any of the decreasing contexts.

- (24) a. The boy didn't tell us the story *yet*
 b. **No boy** has told us the story *yet*
 c. ***At most three boys** have told us the story *yet*

He observes the same constraints in Dutch and German, so *hoeven* 'need' in Dutch can be licensed by decreasing expressions, but *ook maar iets* 'anything (at all)' can only occur in the contexts corresponding to (24a,b) in English. Zwarts characterizes the difference between (24a,b) and (24c) in terms of degree of negative quantificational force, so the contexts of (24a,b) are claimed to be anti-additive as defined in (23). By definition (23), we can also identify the negation *not* and NPs like *no boy* as anti-additive functions, which is illustrated in the following data.

- (25) a. John didn't sing or dance. $\leftrightarrow$ John didn't sing and John didn't dance.
 b. No boy sang or danced. $\leftrightarrow$ No boy sang and no boy danced.
 c. At most three boys sang or danced. $\rightarrow, \leftarrow$
 At most three boys sang and at most three boys danced.

Thus, Zwarts distinguishes two types of NPIs due to the relative negative force of their licensors: (i) "Weak" NPIs which are licensed by *monotone decreasing* expressions (e.g., *any*, *ever* in English; *hoeven* 'need' in Dutch; *brauchen* 'need' in German), and (ii) "Strong" NPIs which are licensed by *anti-additive* expressions (e.g., *yet* in English; *ook maar iets* 'anything (at all)' in Dutch; *auch nur irgendwas* 'anything (at all)' in German).

Nam (1994) and Van der Wouden (1994), further, report that there is another type of NPI which require more negative licensors than anti-additive ones, i.e., *anti-morphic* functions defined below:

- (26) Definition: Let $\langle \mathbf{A}, \leq \rangle$ and $\langle \mathbf{B}, \leq \rangle$ be two Boolean algebras.
 $f \in [\mathbf{A} \rightarrow \mathbf{B}]$ is *anti-morphic* iff for all $a, b \in \mathbf{A}$,
 $f(a \vee b) = f(a) \wedge f(b)$. [i.e., $f(a \text{ or } b) \leftrightarrow f(a) \text{ and } f(b)$], and
 $f(a \wedge b) = f(a) \vee f(b)$. [i.e., $f(a \text{ and } b) \leftrightarrow f(a) \text{ or } f(b)$].⁴

- (27) a. John didn't sing and dance. $\leftrightarrow$ John didn't sing or John didn't dance.
 b. No boys sang and danced. $\leftarrow, \nrightarrow$ No boys sang or no boys danced.

One may easily notice that anti-morphic functions are a subset of anti-additive functions, and so a subset of decreasing functions. As shown in (27), negation markers in natural language represent a typical type of anti-morphic expression, but NPs like *no boy* is not anti-morphic. Nam (1994) claims that Korean/Japanese NPIs in (28) can only be licensed by anti-morphic expressions, and Van der Wouden (1994) also points out that *mals* 'tender' in Dutch and *a bit* in English require an anti-morphic licensor.

- (28) a. [Korean/K]⁵ *amwu-Noun-to* 'any Noun', *NP-pakkey* 'anyone but NP'
 b. [Japanese/J] *daremo* 'anybody', *NP-sika* 'anyone but NP'

These NPIs are named "strongest NPIs", which require more negative licensors than "strong NPIs" in Zwarts' typology. Thus, now we have the NPI-typology of three different types: *weak*, *strong*, and *strongest* NPIs.

(29) Typology of NPIs

I. **Weak** NPIs--licensed by a decreasing function

English: *any*, *ever*, etc.

Dutch: *hoeven* 'need'

German: *brauchen* 'need'

II. **Strong** NPIs--licensed by an anti-additive function

English: *yet*

Dutch: *ook maar iets* 'anything (at all)'

German: *auch nur irgendwas* 'anything (at all)'

Korean: *teisang* 'anymore', *kulehkhey* 'so much'

sonkalak hana kkattakha- 'lift a finger'

Japanese: *soreizyoo* 'anymore', *mayu hitotsu ugokasu* 'lift a finger'

III. **Strongest** NPIs--licensed by an anti-morphic function

English: *a bit*, *either*

Korean: *amwuto* ('anyone'), *amwu-CN-to* ('any CN'),

NP-pakkey ('anyone/anything but NP')

Japanese: *daremo* ('anyone'), *NP-sika* ('anyone/anything but NP')

Due to the definitions of *decreasing/anti-additive/anti-morphic* functions, we see that the strongest NPIs are a subset of strong NPIs, and strong NPIs are a subset of weak NPIs. The above typology also identifies strong NPIs as well as strongest ones in Korean and Japanese.

3. Strong NPIs in Korean and Japanese

In 1.2, we saw NPIs can occur in *if/before*-clauses, and in 1.3, following Landman (1991), we characterized *before* as denoting an anti-additive function. Now let us see in more detail what NPIs in Korean and Japanese can occur in such contexts. We will see that the conditional *if*-clauses show parallel behaviour with *before*-clauses. (29) below repeats the examples we saw in 1.2, and (30) shows *teisang/soreizyoo* 'anymore' can occur in *before*-clauses as well as in *if*-clauses.

(29) a. **If** *anyone ever* catches on to us, we're in trouble.

b. Mary arrived **before** *anyone* left the party.

(30) a. *teisang* akhwatoy-**ki.ceney** pyengwen-ey ka-seyyo [Korean]

soreizyoo waruku.naru **maeni** byooin-ni iki-nasai [Japanese]

anymore worsen-**before** hospital-to go-Imp.

'Please go to hospital before it gets worse.'

b. na-lul *teisang* koylophi-**myen** ttena.keyss.ta [Korean]

watashi-o *soreizyoo* zyamasi-**tara** kaeri.masu [Japanese]

I-Acc anymore bother-did.**if** leave/return

'If you bother me anymore, I will leave.'

c. **teisang* akhwatoy-ess-ta [Korean]

**soreizyoo* waruku.nat.ta [Japanese]

anymore worsen-Past

'*it has got worse anymore.'

Notice also in the following that idiomatic NPIs like English *lift a finger/budge an inch* etc. co-occur with anti-additive expression in Korean and Japanese.

- (31) a. *sonkalak hana kkattakha-ki.ceney* [Korean]
 finger one move-**before**
mayu hitotsu ugokasu maeni [Japanese]
 eyebrow one move **before**
 'Before I lift a finger, ...'
- b. *sonkalak hana kkattakha-myen* [Korean]
 finger one move-**if**
mayu hitotsu ugokasi-tara [Japanese]
 eyebrow one move-**if**
 'If you lift a finger, ...'

Another strong NPI in Korean is *kulehkey*⁶ 'so much'(with no deictic sense), which is also licensed in *if/before*-clauses.

- (32) a. *nay mal-i kulehkey tut-ki silh-umyen cikum ttena-seyyo* [Korean]
 my words-Nom.so.much listen-ing hate-if now leave-imp
 b. *?moshi kikuno-ka amari iya-nara kaette kudasai* [Japanese]
 if listening-Nom so hate-if leave.ing please
 'If you hate so much to listen to me, please leave now.'
 c. *nalssika kulehkey chuwe-ci-ki.ceney i il-ul kkuthnay-ya.hapnita* [Korean]
 weather-Nom.so.much cold-before this work-Acc finish-must
 d. *(?)amari samuku naru maeni kono shigoto-o oe-nakute.wa* [Japanese]
 so cold become before this work-Acc finish-must
 'Before it gets so cold, we have to finish this work.'

The strong NPIs so far have been shown to be available in *if/before*-clauses, but the strongest ones are not available in these contexts. (33) illustrate *amwuto/ daremo* 'anyone' and *NP-pakkey/NP-sika* 'anyone but NP' are not allowed in *before* or *if*-clauses.⁷

- (33) a. *??na-nun amwuto o-ki.ceney mom-ul swumki.ess.ta* [Korean]
 I-Top anyone come-before body-Acc hide-Past-Decl
 **daremo kuru maeni mi-o kakushi.ta* [Japanese]
 anyone come before body-Acc hide-Past
 'I hid myself before anyone came.'
- b. **manil amwuto ka-myen, nay-ka kakeyssta*
 **moshi daremo iku-nara watashi-ga iku*
 if anyone go-if/then I-Nom go
 'If anyone goes, I will go.'
- c. **John-pakkey o-ki.ceney, ...*
 **John-sika kuru-maeni, ...*
 John-anyone.but come-before ...
 'before anyone but John comes, ...'

4. The Semantics of *Before* with a Restricted Domain

4.1 Conditional *if* as an anti-additive function

Traditional semantics of *if* interprets it to be an anti-morphic function as well as an anti-additive one. One can easily test this with the "material implication" reading of *if* as follows:

(34) *if p then q*: " $p \rightarrow q$ "

a. $(p \vee p') \rightarrow q$
iff $\neg(p \vee p') \vee q$
iff $(\neg p \wedge \neg p') \vee q$
iff $(\neg p \vee q) \wedge (\neg p' \vee q)$
iff $(p \rightarrow q) \wedge (p' \rightarrow q)$
[thus, anti-additive]

b. $(p \wedge p') \rightarrow q$
iff $\neg(p \wedge p') \vee q$
iff $(\neg p \vee \neg p') \vee q$
iff $(\neg p \vee q) \vee (\neg p' \vee q)$
iff $(p \rightarrow q) \vee (p' \rightarrow q)$
[thus, anti-morphic]

c. Given $p \rightarrow p'$, if $(p \rightarrow q)$, then $(p' \rightarrow q)$ [thus, decreasing]

Then why doesn't the conditional *if* license strongest NPIs like *amwuto/daremo*? First we can easily see from the following that *-myen* (and *moshi-nara*) 'if-then' denotes an anti-additive function in Korean (and Japanese). That is, (35a) and (35b) entail each other, following the anti-additive pattern of (34a) above.

- (35) a. pi-ka o-**kena** nwun-i o-**myen** kion-i ttelecinta
rain-Nom come-**or** snow-Nom come-**if** temperature-Nom fall
'If it rains or it snows, the temperature goes down.'
 $\leftrightarrow$
b. pi-ka o-myen kion-i ttelec-i-**ko**, nwun-i o-myen kion-i ttelec-i-n-ta
fall-**and**
'If it rains the temperature goes down, and if it snows the temperature goes down.'

We note, however, that the actual use of *if* does not seem to derive an anti-morphic function, which is contrary to the calculation of material implication in (34b) above. That is, we do not readily find the interpretation pattern of (34b) in the actual use of *if*. The following illustrate this mismatch.

- (36) a. pi-ka o-**ko** palami pwul-**myen** kion-i ttelec.i.nta
rain-Nom come-**and** wind-Nom blow-**if** temperature-Nom fall
'If it rains and wind blows, the temperature falls down.'
 $\leftarrow, \nrightarrow$
b. pi-ka o-myen kion-i ttelec-i-**kena** ('or'), palami pwul-myen kion-i ttelec.i.nta
'If it rains or if wind blows, the temperature falls down.'
- (37) a. John-**hako** Mary-ka o-**myen**, ssawum-i ilena.n.ta
John-**and** Mary-Nom come-**if** fight-Nom happens
'If John and Mary come, there happens to be a fight.'
 $\leftarrow, \nrightarrow$
b. John-i-o-**myen** ssawumi ilena-**kena** ('or'), Mary-ka o-**myen** ssawumi ilena.n.ta
'If John comes there happens to be a fight, or if Mary comes there happens to be a fight.'

In (36) and (37), (b) sentences entail (a) sentences, but not in the other direction. Thus *-kiceney* 'before' in Korean is not interpreted as an anti-morphic function. This mismatch between the logical interpretation in (34) and the actual use of *if* seems to come from the *scalar implicature* that the conditional sentences induce. That is, when one asserts "if p then q," the assertion, due to some contextually determined scale, implicates that "given $(p \rightarrow p')$, then $\neg(p' \rightarrow q)$." Consider the following:

- (38) If John publishes three papers a year, he would get a good job.
implicates
'If John publishes only two papers a year, he would not get a good job.'

This scalar implicature of cause does not show up for all conditionals, but if a scale is postulated by context, the implicature naturally arises. Now returning to the problem of (36-37), the lack of anti-morphic interpretation of *if* can be accounted for by the scalar implicature of conditionals. In (36a) above, *if*-clause contains 'it rains and wind blows', and this entails both 'it rains' and 'wind blows', so due to the scalar implicature, the whole sentence implicates 'if only it rains the temperature *does not* fall down' and 'if only wind blows the temperature *does not* fall down.' Therefore, *if* does not denote an anti-morphic function, which accounts for the fact that strongest NPIs are not allowed in *if*-clauses.

4.2 Anti-additive *before* in Korean and Japanese

Now let us consider sentences with a *before*-clause. As discussed in section 3, Strong NPIs naturally occur in *before*-clauses in Korean, and further we noted that strongest NPIs like *amwu*-Noun-to 'any Noun' and NP-*sika* 'anyone but NP' are not available in *before*-clauses in Korean and Japanese. This paper accounts for this by identifying *-ki.ceney* ('before') in Korean and *maeni* ('before') in Japanese as denoting an anti-additive function but not as an anti-morphic one. Consider the following entailment pattern in English:

- (39) a. John left the party **before** Mary **or** Bill arrived. $\leftrightarrow$
 b. John left the party **before** Mary arrived **and**
 John left the party **before** Bill arrived.
 (40) a. John left the party **before** Mary **and** Bill arrived. $\rightarrow, \leftarrow$
 b. John left the party **before** Mary arrived **or**
 John left the party **before** Bill arrived.

(39a) entails (39b), and vice versa, thus we see that *before* interprets as an anti-additive function defined in (23). However, (40) show that *before* does not denote an anti-morphic function defined in (26). Notice that in (40) the entailment fails in the direction from (b) to (a), but (a) entails (b). This asymmetry in entailment direction was also identified in (36a,b) and (37a,b) which contain an *if*-clause. But the direction of entailment is now reversed in (40), i.e., in (36) and (37), (b) sentences entail (a) sentences, whereas in (40), (a) entails (b), but not vice versa. We have already noted that the failure of entailment in (36) and (37) is due to the scalar implicature of conditionals, but such scalar implicature does not arise in *before*-clauses. Thus (41a) does not implicate (41b).

- (41) a. *twu sikan-i cina-ki.ceney ku il-ul kkuthnay-ass-ta*
 two hour-Nom elapse-**before** that work-Acc finish-Past-Decl
 'I finished the work, before two hours elapsed.'
 b. *han sikan-i cina-ki.ceney ku il-ul kkuthnay-ci.mos-ha-ass-ta*
 one hour-Nom elapse-**before** that work-Acc finish-**not**-do-Past
 'I couldn't finish the work, before one hour elapsed.'

The following sentences also show that *-ki.ceney* ('before') in Korean denotes an anti-additive function as *before* in English does:

- (42) a. *Bill-ina Mary-ka o-ki.ceney John-i ttenassta*
 Bill-**or** Mary-Nom come-**before** John-Nom left
 'John left before Bill or Mary came.'
 $\leftrightarrow$
 b. *Bill-i o-ki.ceney John-i ttena-ass-ko, Mary-ka o-ki.ceney John-i ttenassta*
 'John left before Bill came, and John left before Mary came.'

(42a) and (42b) entail each other, thus we have that *-ki.ceney* ('before') denotes an anti-additive function. And further, as illustrated in 3, *-ki.ceney*, *-maeni* and *before* license strong NPIs, which approves Landman's (1991: 143) semantics of *before* discussed in section 1.

4.3 Domain Restriction on the function of *before*

Now let us consider why negative expressions are not available in *before*-clauses. It has been reported but not properly accounted for that *before*-clauses do not allow overt negation in it, so (43a) below is ungrammatical. Furthermore, (43b-e) illustrate that other NPs like *John-man* 'only John', *John-ppayko ta* 'everyone but John', *kikkeshayya/cenghwakhi sey salam* 'at most/exactly three people', *pan-ih*a 'less than half' make the sentences sound bad and meaningless.

- (43) a. *John-i an o-ki.ceney Mary-ka ttena-ass-ta
 John-Nom not come-before Mary-Nom leave-Past-Decl
 '*Mary left, before John didn't come.'
- b. *John-man o-ki.ceney Mary-ka ttena.ass.ta
 John-only come-before Mary-Nom left
 '*Mary left, before only John came.'
- c. *John-ppayko ta o-ki.ceney Mary-ka ttena.ass.ta
 John-except all come-before Mary-Nom left
 '*Mary left, before everyone but John came.'
- d. *kikkeshayya/*cenghwakhi sey salam-i o-ki.ceney Mary-ka tenaassta
 at.most/exactly three person-Nom come-before Mary-Nom left
 '*Mary left, before at most/exactly three people showed up.'
- e. *haksayngtul-i pan-ih-a-ka o-ki.ceney swuep-i sicaktoy.ess.ta
 students-Nom half-less-than-Nom come-before class-Nom started
 '*The class started before less than half the students showed up.'

These NPs are either non-monotonic⁸ ('only John', 'exactly three people') or monotone decreasing ('at most three people', 'less than half the students'). However *before*-clauses naturally allow monotone increasing NPs as shown in the following:

- (44) a. John-i o-ki.ceney Mary-ka ttena.ass.ta
 John-Nom come-before Mary-Nom left
 'Mary left, before John came.'
- b. haksayng.tul-i ta o-ki.ceney swuep-i sicaktoy.ess.ta
 students-Nom all come-before class-Acc started
 'The class started before every student showed up.'⁹
- c. haksayng.tul-i pan-isang o-ki.ceney swuep-i sicaktoy.ess.ta
 students-Nom half-more come-before class-Acc started
 'The class started before more than half the students came.'
- d. dases salam-i/to o-ki.ceney Mary-ka ttena.ass.ta
 five person-Nom/even come-before Mary-Nom left
 'Mary left, before five people showed up.'

The difference between (43) and (44) comes about due to the negative force of *before*. Then how can we properly characterize the negative force of *before*? First we note in (43-44) that the subject NP in a *before*-clause determines the quantificational force of the proposition. (45) below defines a property of propositions, which can distinguish (44) from (43) above.

- (45) Defintion: Suppose a proposition *f* denotes a function mapping from situations into truth values. Then *f* is (temporally) **incremental** iff for all situations *s* and *s'*, if *f*(*s*) is true and *s* temporally precedes *s'*, then *f*(*s'*) is true.

The definition takes a proposition as denoting a function from situations into truth values.¹⁰ Informally speaking, temporally incremental propositions do not turn to be false in future (the relevant time period must be restricted by context) if they are true at the present. For example, the

NP *haksayng.tul-i ta* 'every student' in (44b) renders the clause 'all the students came' to be "temporally incremental".

Here we need some elaboration of the temporal precedence order ($\leq_t$) among situations. But, for simplicity, let us assume that the order holds among situations ranging over a set of time intervals, which is determined by context.¹¹ Now suppose f = 'more than half of the students came' is true in s , and $s \leq_t s'$, i.e., s temporally precedes s' , then in s' , f should be true. Moreover, in s' , all the students may have come, therefore f is (temporally) incremental proposition. By analogy, one might easily figure out the other propositions in *before*-clauses of (44a-d) are incremental.

However, the propositions in *before*-clauses of (43a-e) are not incremental. For example, (43c) contains the proposition y = 'everyone but John came', where 'everyone but John' denotes a non-monotonic quantifier. If y is true in s and $s \leq_t s'$, then y might be false in s' . For John might have come in s' , so y is false in s' , but 'every student came' is true, instead. Now we have the following generalization, which accounts for why negative expressions are not available in *before*-clauses.

(46) Proposition: *before* denotes an anti-additive function which maps "temporally incremental" propositions into predicate modifiers.

In other words, the function denoted by *before* has its domain restricted to incremental propositions.¹² This semantic property of *before* reveals a new aspect of negative quantification, namely "complementarity" of negation. We have identified anti-additive and anti-morphic expressions in natural language. A prototype of anti-morphic expression is negation itself, which observes both of De Morgan's Laws, i.e., anti-additivity and anti-multiplicativity. However another difference between negation (anti-morphism) and *before/if* is the following: Negation preserves "complementarity", but neither of *before* or *if* does.

(47) Definition: Let f be a function from $\mathbf{A}$ into $\mathbf{B}$, where $\mathbf{A}$ and $\mathbf{B}$ are boolean algebras. Then f preserves complementarity iff for all $a \in \mathbf{A}$, $f(\neg a) = \neg(f(a))$.

Natural language seems to exploit "double negation" in one way or another, and the negation is interpreted as preserving complementarity. Thus for example, Korean has the following expressions for double negation.

- (48) a. John-i an o-ci.anh-ass-ta
John-Nom not come-not-Past-Decl
'It was not the case that John didn't come.'
b. John-un Mary-lul po-ko.sip-ci.anh-cianh-ass-ta
John-Top Mary-Acc see-want-not-not-Past-Decl
'It was not the case that John didn't want to see Mary.'

The property of preserving complementarity is in fact a condition for "homomorphism", but it is also a crucial property of negation. In any event, this property distinguishes negation from other anti-additive functions, so we can see that the semantics of *if* or *before* does not derive a function which preserves complementarity. Furthermore, as we saw above *before* do not allow negative expressions in its clause, so to be interpreted as denoting a function with a restricted domain, as stated in (46).

4.4 Strong NPIs in other anti-additive contexts

We have so far characterized conditional *if* and temporal *before* as anti-additive functions. This section illustrates some other contexts with an anti-additive expression which licenses strong

NPIs. First of all, pseudo-conditional clauses headed by *-ato/eto*, *-nunteyto*, *-telato* ('even if/though') in Korean are proper candidates, so we have the following contexts licensing NPIs:

- (49) a. *teisang pi-ka o-ato kyengki-nun kyeysoktoy-lkepni*
 anymore rain-Nom come-**though** game-Top continue-will
 'The game will continue, even if it rains anymore.'
 b. *pi-ka kulehkey manhi o-ass-nunteyto*
 rain-Nom so much come-Past-**though**
kyengki-nun kyeysoktoy.ess.ta
 game-Top continued
 'Even though it rained so much the game continued.'
 c. *sonkalak hana kkattakha-ato cwuki-kess-tako hyeppakha.ass.ta*
 finger one lift-**though** kill-will-Comp threatened
 'He threatened he would kill me, even though I just lifted a finger.'
- (50) a. *pi-ka o-kena nwun-i o-ato kuil-ul swi-ci.anh-ass-ta*
 rain-Nom come-**or** snow-Nom come-**though** the work-Acc cease-not-Past
 'He didn't stop doing the work, even if it rained or it snowed.'
 ↔
 b. *pi-ka o-ato ku il-ul swi-ci.anh-ass-ko ('and'),*
nwun-i o-ato ku il-ul swi-ci.anh-ass-ta
 'He didn't stop doing the work, even if it rained, and he didn't
 do so even if it snowed.'

(50a) and (50b) entail each other, which shows that the NPI-licensor *-ato* 'even though' is interpreted as an anti-additive function. Now the following show that comparative constructions license strong NPIs, and that they are interpreted as anti-additive, i.e., (52a) entails (52b) and vice versa. Comparative marker *-pota/-yori* 'than' in Korean/Japanese can take an NP or a clausal complement.

- (51) a. *teisang Ithaca-ey memwul.nun.kes-pota* [Korean]
 b. *soreizyoo Ithaca-ni iru-yori* [Japanese]
 anymore Ithaca-ey stay.comp -**than**
 'rather than staying in Ithaca anymore'
 a-. Seoul-lo ppalli tolaka-nun.kes-i coh-kess-ta
 b-. Seoul-ni kaetta-noo-ka ii
 Seoul-to soon return-comp-Nom good
 'we'd better go back to Seoul soon'
- (52) a. John-**ina** Mary-**pota** Bill-i te khu-ta
 John-**or** Mary-**than** Bill-Nom more tall-Decl
 'Bill is taller than John or Mary.'
 ↔
 b. John-pota Bill-i te khu-**ko**, Mary-pota Bill-i te khu-ta
 'Bill is taller than John, **and** Bill is taller than Mary.'

Universal quantification induces an anti-additive context, which licenses NPIs in relative clauses headed by *every*-Noun in English. So for instance, NPIs *ever/any* are licensed in a relative clause in (53), and (54) shows the relative clause with *every*-Noun derives a anti-additive context, i.e., (a) entails (b) and vice versa.

- (53) Every one who has *ever* been to *any* of Russian cities loves it.
 (54) a. Every student who missed more than three homeworks or
 one midterm will fail in this course.

- b. Every student who missed more than three homeworks and
every student who missed one midterm will fail in this course.

One way of expressing the universal quantification in Korean is to use a "floated quantifier" *motwu/ta* 'all' after an NP. Usually the NP is Topic-marked with the particle *-nun/un*, which is often exploited for a generic statement. Thus (55) below illustrates this construction induces an anti-additive context, and (56) shows that the construction licenses a strong NPI *teisang* 'anymore' in Korean.

- (55) a. swukcey-lul twu-pen an nay-ess-**kena** sihem-ul han-pen
homework-Acc two-time not submit-Past-**or** test-Acc one-time
an po-un haksayng-un **motwu/ta** nakceyha-ul.kepnita.
not take-Rel. student-Top **all** fail-will
'Every student who didn't turn in homework twice or who didn't take a test
will fail in the course.'
- ↔
- b. swukcey-lul twu-pen an nay-un haksayng-**hako** sihem-ul
submit-Rel. student-**and**
han-pen an po-un haksayng-un **motwu/ta** nakceyha-ul.kepnita.
take-Rel. student-Top **all**
'Every student who didn't turn in homework twice and
every student who didn't take a test will fail in the course.'
- (56) *teisang* kyelsekha-nun haksayng-un **motwu/ta** sengcek-ul
anymore be.absent-Rel. student-Top **all** credit-Acc
pat-ul.swu.eps-ta
receive-cannot-Decl
'Every student who is absent from the class anymore cannot get a credit.'

5. Concluding Remarks

Ladusaw's (1979) formal generalization on the NPI licensing conditions has inspired more explicit and refined semantic characterization of NPI licensors. This paper identifies *before/if* (and their counterparts in Korean and Japanese) as NPI licensors and interprets them, following Landman (1991) and Valencia *et al* (1994), as denoting an anti-additive function. Among the NPIs available in those contexts are *teisang*[K]/*soreizyoo*[J] 'anymore', *kulehkey*[K]/*amari*[J] 'so (much)', and idiomatic NPIs in Korean and Japanese corresponding to *lift a finger* or *budge an inch*. Due to the NPI typology in Nam (1994) and van der Wouden (1994), the NPIs licensed in those contexts belong to the type of "strong" NPIs.

Furthermore, this paper observes a semantic constraint on *before*-clauses, i.e., negative expressions are not available in the clauses, and identifies the constraint in terms of the domain restriction of *before*: That is, *before*-clauses are interpreted as denoting an anti-additive function which maps "temporally incremental" propositions into predicate modifiers.

We have illustrated various contexts where strong NPIs can occur in Korean, among which the conditional and pseudo-conditional clauses, we claim, interpret as an anti-additive function. The paper notes that *before* and *if* behave differently in the entailment patterns of conjoined sentences containing them.

FOOTNOTES

¹Valencia *et al* (1994) resolve the problem by restricting the temporal domain determined by the context. We will come back to this problem in section 3.

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