Rigid and Flexible Quantification in Plural Predicate Logic*

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1 Introduction

(1) Verkuyl (1972), Krifka (1998) a.o.:

a. John ate { apples / applesauce } for an hour.
b. *John ate { two apples / two cups of applesauce } for an hour.

(2) Zucchi & White (2001); Filip (2008), a.o.: "quantization puzzle"

a. *John ate some apples for an hour.
b. *John ate less than three apples for an hour.
c. *John ate a quantity of apples for an hour.

(3) { Trees / *Some trees } grow for miles around this castle. (Moltmann 1991)

(4) He read { poetry / *something } a lot. (Mittwoch 1982)

(5) John wrote { copy / an article } for the *Times*. (Mittwoch 1982)

(6) a. All the guests are French.
b. *All the guests are { some / five / ten or less } French.

(7) Zucchi p.c. to van Geenhoven 2005:

a. Jim hit a golf ball into the lake for an hour.
b. Jim hit a golf ball into the lake every five minutes for an hour.

2 Rigidity in Plural Predicate Logic

(8) $g[x]h :=$ for any variable v, if $v \neq x$ then $g(v) = h(v)$
(Assignments g and h differ at most with respect to the value assigned to x.)

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(9)

G	...	x	y	...
g_1	...	Ann	Bill	...
g_2	...	Carlos	Ann	...
g_3	...	Ann	Carlos	...

(10) $G[x]H := \forall g \in G \exists h \in H$ such that $g[x]h$ and $\forall h \in H \exists g \in G$ such that $g[x]h$

(11)

H	...	x	y	z	...
h_1	...	Ann	Bill	David	...
h_2	...	Carlos	Ann	Eva	...
h_3	...	Ann	Carlos	Flora	...
h_4	...	Ann	Carlos	George	...

(12) $G[x!]H := G[x]H$ and $h(x) = h'(x)$ for any $h, h' \in H$

(13)

H	...	x	y	z	...
h_1	...	Ann	Bill	David	...
h_2	...	Carlos	Ann	David	...
h_3	...	Ann	Carlos	David	...
h_4	...	Ann	Carlos	David	...

(14) Interpretation of atomic formulae

a. $[\![R(x_1,...x_n)]\!]^G = T$ iff for all $g \in G$, $\langle g(x_1),...g(x_n)\rangle \in \mathfrak{I}(R)$
b. $[\![x_1 = x_2]\!]^G = T$ iff for all $g \in G$, $g(x_1) = g(x_2)$

(15) Interpretation of sentential connectives

a. $[\![\neg\phi]\!]^G = T$ iff $[\![\phi]\!]^G = F$
b. $[\![\phi \wedge \psi]\!]^G = T$ iff $[\![\phi]\!]^G = T$ and $[\![\psi]\!]^G = T$
c. $[\![\phi \vee \psi]\!]^G = T$ iff $[\![\phi]\!]^G = T$ or $[\![\psi]\!]^G = T$

(16) Domain-level cardinality

a. $[\![x = n]\!]^G = T$ iff for all $g \in G$, $|g(x)| = n$
b. $[\![x \leq n]\!]^G = T$ iff for all $g \in G$, $|g(x)| \leq n$
c. $[\![x \geq n]\!]^G = T$ iff for all $g \in G$, $|g(x)| \geq n$

(17) Rigid and flexible quantification

a. $[\![\exists^{\text{flex}}x[\varphi](\psi)]\!]^G = T$ iff $[\![\varphi \wedge \psi]\!]^H = T$ for some H such that $G[x]H$
b. $[\![\exists^{\text{rigid}}x[\varphi](\psi)]\!]^G = T$ iff $[\![\varphi \wedge \psi]\!]^H = T$ for some H such that $G[x!]H$

3 Solving the quantization puzzle: application to *for*-adverbials

(18) a. John ate apples for an hour.
b. *John ate two apples for an hour.

(19) a. $[_{\text{DP}}\ \emptyset^x$ apples$](\varphi) \rightsquigarrow \exists^{\text{flex}}x[^*\text{apple}(x)](\varphi)$

b. $\text{two}^x[\text{apples}](\varphi) \rightsquigarrow \exists^{\text{rigid}}x[{}^*\text{apple}(x) \wedge |x| = 2](\varphi)$

(20) $\text{for an hour}^{t,t'}(\varphi) \rightsquigarrow \exists^{\text{rigid}}t[\text{hour}(t) = 1](\exists^{\text{flex}}t'[t' <_\tau t \wedge t =_\oplus t'](\varphi))$

(21) $[\![x =_\oplus y]\!]^G = T$ iff $\bigoplus\{g(x) : g \in G\} = \bigoplus\{g(y) : g \in G\}$

(22) John ate apples for an hour $\rightsquigarrow$
$\exists^{\text{rigid}}t[\text{hours}(t) = 1](\exists^{\text{flex}}t'[t' <_\tau t \wedge t =_\oplus t'](\exists^{\text{flex}}x[{}^*\text{apple}(x)]({}^*\text{eat}(j,x,t'))))$

(23)

H	...	t	t'	x	...
h_1	...	9pm-10pm	9pm-9:10pm	apple_1	...
h_2	...	9pm-10pm	9:10pm-9:40pm	$\text{apple}_2 \oplus \text{apple}_3$	...
h_3	...	9pm-10pm	9:40pm-10pm	apple_4	...

(24) John ate two apples for an hour $\rightsquigarrow$
$\exists^{\text{rigid}}t[\text{hours}(t) = 1](\exists^{\text{flex}}t'[t' <_\tau t \wedge t =_\oplus t']$
$(\exists^{\text{rigid}}x[{}^*\text{apple}(x) \wedge |y| = 2]({}^*\text{eat}(j,x,t'))))$

(25)

H	...	t	t'	x	...
h_1	...	9pm-10pm	9pm-9:10pm	$\text{apple}_1 \oplus \text{apple}_2$	...
h_2	...	9pm-10pm	9:10pm-9:40pm	$\text{apple}_1 \oplus \text{apple}_2$	...
h_3	...	9pm-10pm	9:40pm-10pm	$\text{apple}_1 \oplus \text{apple}_2$	...

(26) some^x [apples] $(\phi) \rightsquigarrow \exists^{\text{rigid}}x[{}^*\text{apple}(x) \wedge |x| > 1](\varphi)$

(27) $[\![\sigma x(\varphi)(\psi)]\!]^G = T$ iff for some H such that $G[x!]H$, $[\![\varphi]\!]^H = T$ and $[\![\psi]\!]^H = T$, and there is no H' such that $G[x!]H'$ and $[\![\varphi]\!]^{H'} = T$ and $h(x) <_e h'(x)$ for some $h \in H$ and $h' \in H'$

(28) $\text{less than three}^x[\text{apples}](\varphi) \rightsquigarrow \sigma x({}^*\text{apple}(x) \wedge \varphi)(|x| < 3)$

4 Adding distributivity

(29) John found a flea (on his dog) every day for a year.

(30) a. $[\![\text{M}_x[\varphi](\psi)]\!]^G = T$ iff $[\![\varphi \wedge \psi]\!]^H$ for some H such that $G[x]H$ and there is no H' such that $G[x]H'$ where $[\![\varphi]\!]^{H'} = T$ and $H(x) \subsetneq H'(x)$

b. $[\![\text{D}x(\varphi)]\!]^G = T$ iff $[\![\varphi]\!]^{G_{x=a}}$ for each a such that for some $g \in G$, $g(x) = a$

(31) $\text{every}^{t''}_{t'}[\text{day}](\varphi) \rightsquigarrow \text{M}_{t''}[\text{day}(t'') \wedge t' \cap t'' \neq \emptyset](\text{D}_{t''}(\varphi))$

(32) (29) $\rightsquigarrow \exists^{\text{rigid}}t[\text{years}(t) = 1](\exists^{\text{flex}}t'[t' <_\tau t \wedge t =_\oplus t'](\text{M}_{t''}$
$[\text{day}(t'') \wedge t'' \cap t' \neq \emptyset](\text{D}_{t''}(\exists^{\text{rigid}}x[{}^*\text{flea}(x)]({}^*\text{find}(j,x,t''))))))$

(33)

H	t	t'	t''
h_1	2016	Jan-Mar	day_1
h_2	2016	Feb-May	day_2
...	...	...	...
h_1	2016	Oct-Dec	day_{365}

$\xrightarrow{D_{t''}}$

t''	x
day_1	flea_1

t''	x
day_2	flea_2

...

t''	x
day_{365}	flea_n

5 Application to constructions other than *for*-adverbials

(34) a. Trees grow for ten miles around this castle.
b. *Some trees grow for ten miles around this castle.

(35) $\text{for ten miles around this castle}^{s,s'}(\varphi) \rightsquigarrow$
$\exists^{\text{rigid}}s[\text{ten-miles-around-this-castle}(s)](\exists^{\text{flex}}s'[s' <_\sigma s \wedge s =_\oplus s'](\varphi))$

(36) (34a) $\rightsquigarrow \exists^{\text{rigid}}s[\text{ten-miles-around-the-castle}(s)](\exists^{\text{flex}}s'[s' <_\sigma s \wedge s =_\oplus s']$
$(\exists^{\text{flex}}x[{}^*\text{tree}(x)]({}^*\text{grow}(x,s'))))$

(37) (34b) $\rightsquigarrow \exists^{\text{rigid}}s[\text{ten-miles-around-this-castle}(s)](\exists^{\text{flex}}s'[s' <_\sigma s \wedge s =_\oplus s']$
$(\exists^{\text{rigid}}x[{}^*\text{tree}(x)]({}^*\text{grow}(x,s'))))$

(38) a. *Two sentinels are posted for ten miles around this castle.
b. Two sentinels are posted every 100 feet for ten miles around this castle.

(39) He read { poetry / *something } a lot.

(40) John wrote { copy / an article } for the *Times*.

(41) a. All the guests are French.
b. *All the guests are ten or less French.

(42) $\text{all}^{x'}_x[\varphi](\psi) \rightsquigarrow \exists^{\text{rigid}}x[\varphi(x)](\exists^{\text{flex}}x'[x' <_e x \wedge x =_\oplus x'](\psi(x')))$

(43) a. (41a) $\rightsquigarrow \exists^{\text{rigid}}x[{}^*\text{guest}(x)](\exists^{\text{flex}}x'[x' <_e x \wedge x =_\oplus x']$
$(\exists^{\text{flex}}y[{}^*\text{French}(y)](x' = y)))$
b. (41b) $\rightsquigarrow$ etc.

(44) a. (41b) $\rightsquigarrow \exists^{\text{rigid}}x[{}^*\text{guest}(x)](\exists^{\text{flex}}x'[x' <_e x \wedge x =_\oplus x']$
$(\exists^{\text{rigid}}y[{}^*\text{French}(y)](x' = y)$