A Note on Categorial Grammar, Disharmony and Permutation

Crit Cremers
Leiden University, Department of General Linguistics
P.O. box 9515, 2300 RA Leiden, The Netherlands
cremers@rullet.leidenuniv.nl

Disharmonious Composition (DishComp) is definable as

$\mathbf{X/Y\ Y\backslash Z \Rightarrow X\backslash Z \quad Y/Z\ X\backslash Y \Rightarrow X/Z}$

(and is comdemned by Carpenter 1998: 202 and Jacobson 1992: 139ff)

Harmonious Composition (HarmComp) is defined as

$\mathbf{X/Y\ Y/Z \Rightarrow X/Z \quad Y\backslash Z\ X\backslash Y \Rightarrow X\backslash Z}$

(and is generally adored)

Lambek Calculus (Lambek) has the following basis:

axiom: $\mathbf{X \Rightarrow X}$
rules: *if* $\mathbf{X\ Y \Rightarrow Z}$ *then* $\mathbf{X \Rightarrow Z/Y}$
and $\mathbf{Y \Rightarrow Z\backslash X}$
if $\mathbf{X \Rightarrow Z/Y}$ *then* $\mathbf{X\ Y \Rightarrow Z}$
if $\mathbf{X \Rightarrow Z\backslash Y}$ *then* $\mathbf{Y\ X \Rightarrow Z}$

Permutation Closure of language L (PermL)

PermL = { s | s' in L and s is a permutation of s'} and L $\subseteq$ PermL

(but nice languages are not PermL for any L)

Fact 1

DishComp is not a theorem of Lambek but HarmComp is

(as you can easily check)

Fact 2

DishComp + Lambek = Lambek + Permutation = undirected Lambek (Moortgat 1988, Van Benthem 1991; Lambek is maximal, but contextfree)

$\Leftrightarrow$

For any assignment A of categorial types to the atoms of language L, if Lambek recognizes L under A, Lambek + DishComp recognizes PermL under A

(so disharmony is always too much for Lambek)

Generalized Composition (GenComp) (Joshi *et al.* 1991, Steedman 1990)

primary type	secondary type	composition
$\mathbf{X/Y}$	$\mathbf{(..(Y \mid Z_1)..) \mid Z_n \Rightarrow}$	$\mathbf{(..(X \mid Z_1)..) \mid Z_n}$
secondary type	primary type	composition
$\mathbf{(..(Y \mid Z_1)..) \mid Z_n}$	$\mathbf{X\backslash Y}$	$\mathbf{\Rightarrow (..(X \mid Z_1)..) \mid Z_n}$

while | is \ or / and is conserved under composition.

(Summarizing combinatory categorial grammar:)

Fact 3

GenComp entails DishComp

(and you need it for the famous crossing dependencies in Dutch, but)

Fact 4

It is **not** the case that for any assignment A of categorial types to the atoms of language L, if GenComp recognizes L with respect to A, GenComp recognizes PermL with respect to A

(as you can see from:)

MIX

MIX = PermTRIPLE, where TRIPLE = $\{a^n b^n c^n\colon n > 0\}$

(- which is more than mildly context-sensitive; Joshi et al. 1991 - and)

Fact 5

Consider the assignment A_b of categories to the lexicon {a,b,c} s.t. A_b(a) = a, A_b(c) = c, A_b(b) = { (s/a)/c, ((s/a)/c)/s,

…, ((s\c)/s)\a, …((s\s)\c)\a, (s\c)\a}, i.e. $A_b(b)$ = {s|x|y, s|v|w|t | {x,y} = {a,b}, {v,w,t} = {a,c,s} and | is \ or /}; b, then, is said to be fully functional, since it has all relevant functional types.

GenComp does not recognize MIX with respect to assignment A_b.

For example: GenComp does not derive *baaccb* and *abaaccbcb* with respect to A_b

Fact 6

Let $A_{bc}(a) = A_b a$, $A_{bc}(b) = A_b(b)$, $A_{bc}(c)$ = { (s/a)/b, ((s/a)/b)/s, …, ((s\b)/s)\a, …((s\s)\b)\a, (s\b)\a } (both b and c are fully functional).

GenComp recognizes MIX with respect to assignment A_{bc}.

(Now consider the grammar exhibiting the following features.)

Primitive Cancellation Constraint

X/Y Y ⇒ X iff Y is primitive

(- in order to be more restrictive - and)

Directed Stacks (example)

(((X\Y)/W)\U)/V is written as X\[U,Y]/[V,W]

(- in order to be more transparent - and)

Transparent Primary Category (examples)

X\[A]/[Y,B] Y\[C]/[D] ⇒ X\[A,C]/[B,D] or
X\[A]/[Y,B] Y\[C]/[D] ⇒ X\[C,A]/[B,D] or
X\[A]/[Y,B] Y\[C]/[D] ⇒ X\[A,C]/[D,B] or
X\[A]/[Y,B] Y\[C]/[D] ⇒ X\[C,A]/[D,B]

(- in order to gain expressivity - make GenComp into)

Categorial List Grammar (CatListGram)

(Cremers 1993 and at fonetiek-6.leidenuniv.nl/hijzlndr/delilah.html)

GenComp + Primitive Cancellation Constraint + Directed Stacks + Transparent Primary Category

(but nevertheless)

Fact 7

Fact 4, Fact 5 and Fact 6 also hold *mutatis mutandis* for CatListGram. In these aspects, CatListGram and GenComp are weakly equivalent.

CONCLUSIONS

None of the additional characteristics for CatListGram affects the weak capacity of a categorial grammar; i.e.:

- exclusive cancellation of primitives does not affect recognition capacity
- maintaining more than one argument stack does not affect recognition capacity
- merging argument stacks of primary and secondary category does not affect recognition capacity

and it takes more than disharmony to induce permutation closure.

References

Benthem, J. van, *Language in Action*, North Holland, 1991

Carpenter, B., *Type-Logical Semantics*, MIT Press, 1997

Cremers, C., *On Parsing Coordination Categorially*, HIL diss, Leiden University, 1993

Jacobson, P., 'Comment Flexible Categorial Grammars', in: R. Levine (ed.), *Formal grammar: theory and implementation*, Oxford Univ. Press, 1991, p. 129 - 167

Joshi, A.K., K. Vijay-Shanker, D. Weir, 'The Convergence of Mildly Context-Sensitive Grammar Formalisms', in: P. Sells, S.M. Shieber, T. Wasow (eds), *Foundational Issues in Natural Language Processing*, MIT Press, 1991, pp. 31 - 82

Moortgat, M., *Categorial Investigations*, Foris, 1988

Steedman, M., 'Gapping as Constituent Coordination', *Linguistics and Philosophy 13*, p. 207 - 263