# **Uncertainty and Prediction in Relativized Structures across East Asian Languages** Zhong Chen, Jiwon Yun, John Whitman, John Hale **Department of Linguistics, Cornell University**

## Introduction

Entropy Reduction (Hale, 2006) is a complexity metric that quantifies the amount of information a word contributes towards reducing structural uncertainty. This certainty level depends on weighted, predictive syntactic analyses that are "still in play" at a given point. This poster uses Entropy Reduction to derive reported processing contrasts in Korean, Chinese and Japanese relativized structures.

## Korean

## **Experimental Observation:**

SBJ Relatives > OBJ Relatives (Kwon, 2010)

## **ER Modeling:**

#### Subject Relatives (SR) **Comprehension difficulty prediction** W5 W6 W4 협박하 의원 이 유명해졌다. <sup>▼</sup> ] ■ SR □ OR threaten-ADN senator NOM became famous 'The senator who threatened the reporter became famous. **Object Relatives (OR)** W5 W6 W3 W4 협박한 의원 이 유명해졌다. 기자 reporter NOM (OBJ) threaten-ADN senator NOM became famous 'The senator who the reporter threatened became famous.' 0.1 0. 0.0 0.0 W3 W2 W4 Analysis W1 "N" W2 "N Acc" 0.51 "N Nom N Acc Vt" whole matrix C 0.27 "N Acc Vt" pro in matrix SBJ 0.09 "N Acc Vt" 0.17 "N Acc Vadj N Nom N Acc Vt" 0.05 "N Acc Vadj N Nom N Acc Vt" pro in adjunct SBJ SR 0.11 "N Acc Vadn N Nom N Acc Vt" 0.03 "N Nom N Acc Vadn N Acc Vt" SR in matrix OBJ SR in matrix SBJ 0.03 "N Acc Vadn N Nom N Acc Vt" W1 "N" W2 "N Nom"

0.51 "N Nom N Acc Vt" whole matrix C 0.75 "N Nom N Acc Vt" SBJ-pro in matrix C 0.09 "N Acc Vt" SBJ-pro in adjunct C 0.05 "N Acc Vadj N Nom N Acc Vt"  $\longrightarrow$ 0.03 "N Nom N Acc Vadn N Acc Vt" SR in matrix OBJ 0.03 "N Acc Vadn N Nom N Acc Vt" SR in matrix SBJ

Our modeling confirms the SR preference in Korean reported by Kwon et al. (2010) and further shows that this effect could emerge as early as the accusative/nominative marker. This reflects, among other factors, a greater entropy reduction brought by sentence-initial nominative noun phrases.

## Conclusion

Grammatical phenomena such as case-marking, head-omission, and object-drop create inferential problems that must be solved by any parsing mechanism. The Entropy Reductions brought about by "solving" these problems -- moving towards more concentrated distributions on derivations -- correspond with observed processing difficulty.

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**Minimalist** Grammar (Stabler, 1997) weighting constructions with corpus counts

## Chinese

#### **Experimental Observations:**

SBJ Relatives > OBJ Relatives (Lin & Bever, 2006; Wu, 2009; Chen et al., CUNY 2012) SBJ Relatives < OBJ Relatives (Hsiao & Gibson, 2003; Gibson & Wu, in press)

## **ER Modeling:**

#### Subject Relatives (SR)

W5 W6 邀请 富豪 的(官员)打了 记者 SBJ invite tycoon DE official hit reporter 'The official/Someone who invited the tycoon hit the reporter.'

#### **Object Relatives (OR)**

W1	W2		W3	W4	W5	W6
富豪	邀请	е	的	(官员)	打了	记者
tycoon	invite	OBJ	DE	official	hit	reporter
'The official/Someone who the tycoon invited hit the reporter.'						

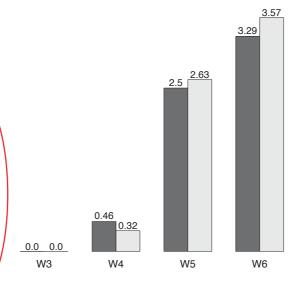
#### Analysis

naiy	W3 "Vt	N de"
	0.38 "Vt N de N"	pro in matrix SBJ & Poss-OBJ
	0.25 "Vt N de N Vt N"	SR in matrix SBJ
CD	0.19 "Vt N de N Vi"	SR in matrix SBJ
SR	0.06 "Vt N de Vt N"	headless SR in matrix SBJv
	0.05 "Vt N de Vi"	headless SR in matrix SBJ
	:	

#### W3 "N Vt de"

DR	0.35 "N Vt de N Vt N" 0.27 "N Vt de N Vi" 0.17 "N Vt de Vt N" 0.13 "N Vt de Vi"	OR in matrix SBJ OR in matrix SBJ headless OR in matrix SBJ headless OR in matrix SBJ OR in matrix SBJ	
	0.04 "N Vt de N Vt N de N"	OR in matrix SBJ & Poss-OBJ	
	:		

Our modeling derives an SR advantage at the head noun in line with structural frequencies (SR 55%/OR 45%). It also implicates headless RCs as a grammatical alternative whose existence makes processing easier at the head noun in SRs. A corpus study reveals that 14% of SRs have a null head whereas 31% of ORs are headless. This asymmetry suggests that an overt head is more predictable in SRs and less work needs to be done.



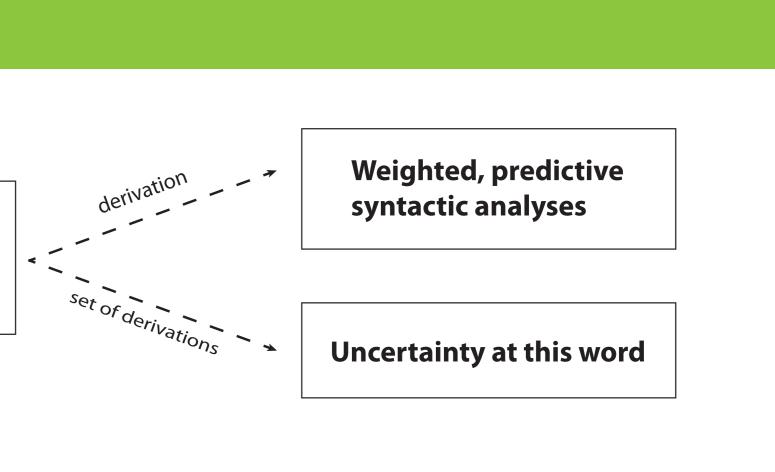
0.05 "N Nom N Acc Vadn N Acc Vt"

## **Modeling procedure**

Weighted **Context-Free Grammar** 

parse each prefix in the sentence  $\longrightarrow$ 

'Intersection' Grammar conditioned on prefixes (Nederhof & Satta, 2008)



## Japanese

#### **Experimental Observation:**

Subject Clefts < Object Clefts (Kahraman et al., 2011)

## **ER Modeling:**

## Subject Clefts (SC)

	W1	W2	W3	W4	W5	W6	W7
е	祖母	を	介抱した	$\mathcal{O}$	は	親戚	だ。
(SBJ)	grandma	ACC	nursed	NO	WA	relative	COP
'It was the relative who nursed the grandmother.'							

## **Object Clefts (OC)**

W1	W2		W3	W4	W5	W6	W7
祖母	が	е	介抱した	$\mathcal{O}$	は	親戚	だ。
grandma	NOM	(OBJ)	nursed	NO	WA	relative	COP
'It was the relative who the grandmother nursed.'							

## Analysis

## W4 "N Acc Vt no"

SC	0.08 "N Acc Vt no Nom N Acc Vt" 0.08 "N Acc Vt no wa N Acc Vt" 0.05 "N Acc Vt no Acc Vt" 0.05 "N Acc Vt no Acc Vt" 0.05 "N Acc Vt no Nom Vi"	SR in matrix SBJ SR in matrix Topic SR in matrix OBJ SBJ-pro in Comp C SR in matrix SBJ
	:	

## W4 "N Nom Vt no"

0.09 "N Nom Vt no Acc Vt" 0   0.09 "N Nom Vt no wa Vi" 0   0.09 "N Nom Vt no wa Vi" 0   0.08 "N Nom Vt no Nom N Acc Vt" 0	OR in matrix SBJ OR in matrix OBJ OR in matrix Topic OR in matrix SBJ OR in matrix SBJ
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Our modeling derives a pattern consistent with the empirical finding in Kahraman et al. (2011) that at the "-no-wa" marked embedded verb, subject clefts are read more slowly than object clefts. Upon reaching the topic marker "-wa", complement clauses with SBJ-pro are still in play in case of the SC prefix, which causes more amount of uncertainties reduced around that point. On the other hand, the OC prefix is less ambiguous because complement clauses with object-pro are extremely rare.

## **Selected References**

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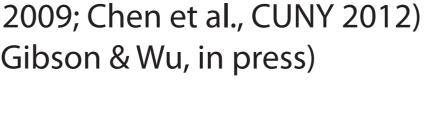
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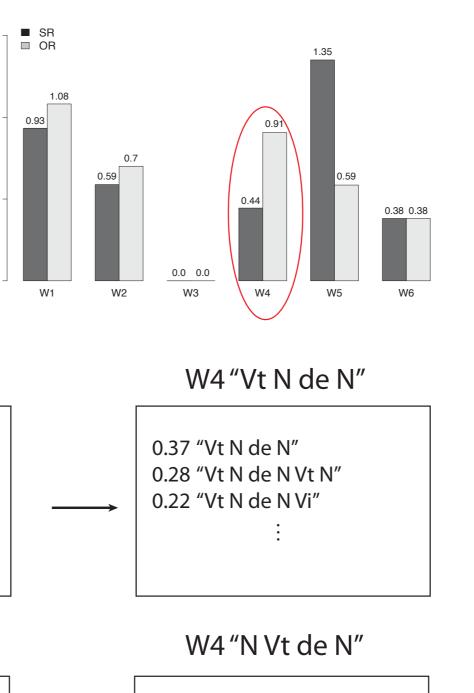
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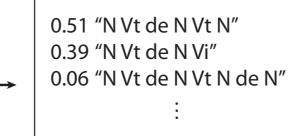
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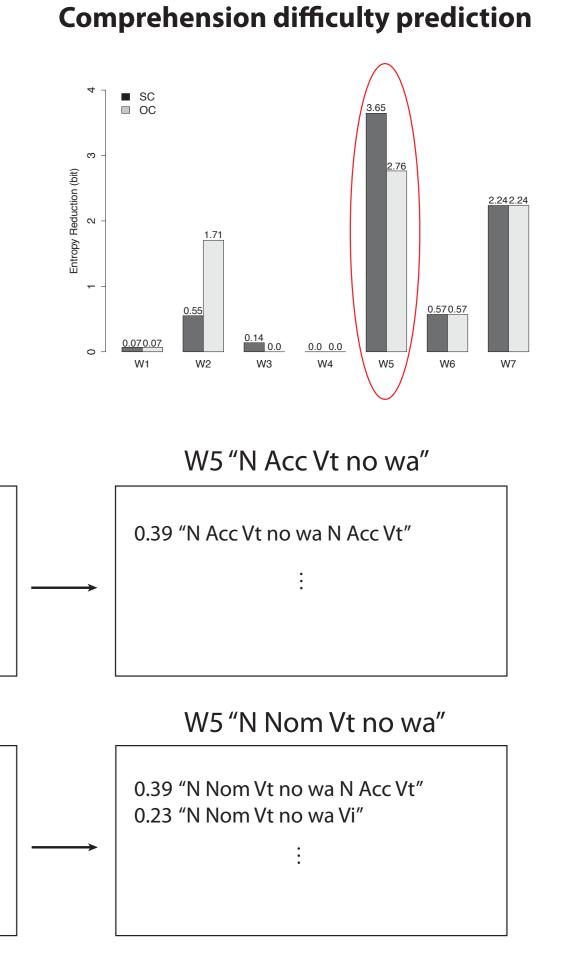




## **Comprehension difficulty prediction**







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