The Imposed Disorder: Syntax resistance in a task of free sentence distortion

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ON THE PSYCHOLOGICAL REALITY OF PHRASES

Theoretical syntax shows that words are assembled into complex hierarchical recursive structures, i.e. phrases.

- **Psycholinguistic studies** [1, 2] confirmed this view, proving the psychological reality of formal representations.
- **Neuroimaging studies** have begun to reveal the neurobiological correlates of phrase structure processing [3, 4]

In all these studies, subjects were passively exposed to either **artificial non-recursive structures** [5, 6, 7] or to **systematic violations** [8, 9, 10] **designed by the experimenters** [11].

A NEW EXPERIMENTAL PARADIGM

In our study we inverted the common strategy by **asking subjects themselves to produce syntactic chaos** and tested whether:

- **Experiment 1**: Subjects randomly rearrange **words** constituting well-formed sequences or rather they unconsciously obey to the phrase structure underlying them.
- **Experiment 2**: The regularities observed in Experiment 1 are due to lexical-semantic properties or frequency of co-occurrence, by testing **pseudo-words (pw)**.

METHODS

- **Subjects**:
  Exp.1: 58 volunteers (30 F, m.a. 23.12±1.77 yrs, Italian native speakers)
  Exp.2: 50 volunteers (24 F, m.a.22.52±2.19 yrs, Italian native speakers)

- **Stimuli**: Different well-formed types of phrases in Italian, further subdivided in a variety of structural types, all containing 6 words, including:
  Noun Phrases
  Simple Clauses

16 stimuli for each structural variety were created.
Each subject was given 2 stimuli for each structural variety.

- **Task**: Participants read aloud one stimulus at a time. Immediately after reading it, the stimulus was hidden and the subjects had to repeat the same words in a different arbitrary order. No constraints on the execution of the task, nor any hints on phrase structure or prosodical clues were provided. For example (translation of the actual Italian sentence): ***a thief has stolen the purses***, became ***purses the a thief stolen has.***

Original	Un_1	$ladro_2$	ha_3	$rubato_4$	le_5	$borse_6$
Answer	3	4	6	5	2	1

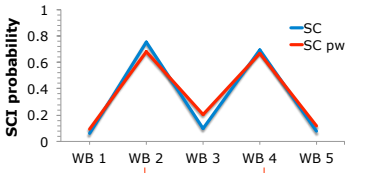
Answers were associated to numerical strings: the number under each word indicates the position of that word in the sequence produced by the speaker.

Boundaries between consecutive words (WB) were numbered from 1 to 5. Boundaries between phrases (vs. those within) are in highlighted in red.

To measure the amount of disorder, a **Sequence Change Index (SCI)** is assigned to words boundaries: 1 when two adjacent words in the stimulus get a non-adjacent positions in the answers, 0 otherwise. Our example, gets:

Word Boundary	WB 1	WB 2	WB 3	WB4	WB 5
SCI	0	1	0	1	0

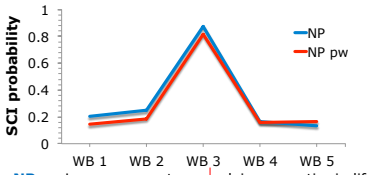
Simple Clauses



SC	Un	ladro	ha	rubato	le	borse
	(A	*thief*	*has*	*stolen*	*the*	*purses)*
SC pw	Un	lerro	ha	duccato	le	diste

- Answers containing all words as in the stimuli:
  Exp.1 89,29%; Exp.2 78%
- Equality of SCI probability between WB
  Exp.1: $F_{r(4)}$= 52.696 p<0.001
  Exp.2: $F_{r(4)}$ = 44.474 p<0.001
  Post-hoc: TR2 & TR4 > TR1, TR3 & TR5 with p<0,005

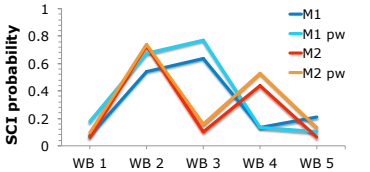
Noun Phrases (with two phrases)



NP	Le	cure	materne	dei	neonati	indifesi
	(The	*care*	*motherly*	*of-the*	*babies*	*vulnerable)*
NP pw	Le	mirle	poviche	dei	cumi	tervosi

- Answers containing all words as in the stimuli:
  Exp.1 76.79%; Exp.2 54%
- Equality of SCI probability between WB
  Exp.1: $F_{r(4)}$= 36.879 p<0.001
  Exp.2: $F_{r(4)}$ = 31.330 p<0.001
  Post-hoc: TR3 > TR1, TR2, TR4 & TR5 with p≤0,001

(Simple Clauses with) "Mirror" Noun phrases [12]



M1	Ha	letto	saggi	di	questo	tipo
	(Has	*read*	*essays*	*of*	*this*	*type)*
M2	Ha	letto	questo	tipo	di	saggi
	(Has	*read*	*this*	*type*	*of*	*essays)*

- Answers containing all words as in the stimuli:
  M1 89.36%; M1 pw 59.62%
  M2 84%; M2 pw 81.25%
- Equality of SCI probability between WB
  M1: Exp.1 $F_{r(4)}$= 30.749 p<0.001
  Exp.2 $F_{r(4)}$= 36.208 p<0.001
  M2: Exp.1 $F_{r(4)}$= 38.623 p<0.001
  Exp.2 $F_{r(4)}$= 26.472 p<0.001

Stimuli containing the same words but disposed in a different order elicited different answer patterns

Some empirical Generalizations

- The SCI probability is higher in correspondence of phrase boundaries
- The answer pattern is independent from lexical-semantic factors
- Simple clauses and noun phrases contrasted with respect to whether the answers contain all words as in the stimuli

CONCLUSIONS

When asked to recombine the words of a sequence in a random order, subjects showed a statistically significant **persistence of phrase structure syntax**. The same was also found by using pseudo-words, demonstrating the irrelevance of lexical-semantics or frequency of cooccurrence.

This new methodology allows to directly access some aspects of the **phrase structure analysis that is spontaneously produced** by naïve untrained subjects, possibly constrained by memory load reduction requirement. Such a spontaneous and unbiased analysis confirms the psychological reality of phrases in a novel manner and may lead to a deeper comprehension of the neural basis of syntactic processing.

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