Form Sequence and the Strong Minimalist Thesis

Toward a middle-ground conception

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Overview

Introduction

Form Sequence (FSQ, also written FormSequence) was

- first proposed in Chomsky (2019, UCLA)
- officially named in Chomsky (2020, LSJ)
  (Chomsky 2021a, WCCFL 39, basically inherits Chomsky 2020)
- further discussed in Chomsky (2021b, “GK”)
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Song (2024): FSQ is indeed anti-SMT in Chomsky's original formulation. But the **idea** behind the operation could have **alternative, SMT-conforming** formulations.

This talk

Plan:

- Review FSQ as described in Chomsky's work.
- Introduce the alternative formulation in Song (2024).
- Demonstrate how the reformulated (and generalized) FSQ rule can be put to use.

Takeaway messages:

- FSQ is worth saving since sequence is a basic structure in human language and cognition.
- A reformulated and generalized FSQ rule can be a useful tool.

Overview

Extended Pair Merge

A sequence-generating operation was introduced in Chomsky (2019) as an extension of Pair Merge (Chomsky 2000). Recall that for two syntactic objects α and β,

$$\text{PairMerge}(\alpha, \beta) = \langle \alpha, \beta \rangle$$

To derive "unbounded unstructured coordination" like (1), Chomsky (2019) proposed (2).

(1) a. I met someone young, happy, eager to go to college, tired of wasting his time, …

b. The guy is young, tall, happy, young, eager to go to Harvard, …

(2) $\langle \text{CONJ}, \langle \text{S}_1, \text{L}_1 \rangle, \ldots, \langle \text{S}_n, \text{L}_n \rangle \rangle$
(each conjunct S_i is paired up with a link element L_i, and all such pairs are put in a sequence whose first slot is occupied by a conjunction)

All links in a sequence are assumed to be identical (*n*/*v* on Chomsky's conception).

Extended Pair Merge

Chomsky (2004) likens Pair Merge to higher-dimensional structure building. This is inherited in the pair-to-sequence extension:

> *… we need an operation Pair Merge, which will also apply to the simple adjunct case like "young man." "Young" will be adjoined to—will be attached to—"man," but you don't see it in the labeling, okay, 'cause it's* ***off in some other dimension****. And the unbounded unstructured cases show you in effect that there are* ***unboundedly many dimensions*** *to what's going on up there [in the mind]. It's not two-dimensional like a blackboard. You can add any number of adjuncts at any point.* *(10:09–10:47, Chomsky 2019)*

Naming the operation

In Chomsky (2020), the sequence-generating operation was verbally named

/ˌfɔrmˈsikwəns/

It got printed as FORMSEQUENCE (FSQ, Chomsky 2021b) and FormSequence (Chomsky 2023).

But spelling in the literature varies:

- "Form Sequence" in Ott (2021), Goto & Ishii (2021), and this talk
- "FORM SEQUENCE" in the conference presentation Ott (2021) is based on

It is unclear to what extent typography (e.g., [small] caps, spacing) is meant to be "lexicalized" in current Minimalist terminology (e.g., "Form Copy/Set"∼"FormCopy/Set"; "Merge"∼"MERGE").

Form Sequence: guises and gist

The sequence-generating procedure is given in a different guise in Chomsky (2020). Compare:

(3) a. $\langle \text{CONJ}, \langle S_1, L_1 \rangle, \ldots, \langle S_n, L_n \rangle \rangle$ (2019)

b. $\langle (\&), X_1, \ldots, X_n \rangle$ (& is an optional conjunction and each X_i is a conjunct) (2020)

Differences:

- "CONJ" vs. "&" (and its optionality)
- $\langle S_i, L_i \rangle$ vs. X_i (i.e., explicit linking vs. implicit matching)

But the gist remains the same: a family of conjunct items meeting certain sameness conditions are directly put in a sequence.

Hilbert's epsilon operator

A noticeable (though perhaps nonreal) difference between Chomsky (2019) and Chomsky (2020, 2021ab) concerns **how exactly the sequence is fixed**. Chomsky (2019) fixes the sequence via Hilbert's epsilon (ϵ) operator. The issue is not touched on in Chomsky (2020, 2021ab).

The ϵ-operator was proposed in Hilbert & Bernays (1939) as a formal tool to create a term out of a formula.

(4) $\epsilon x.\mathrm{F}(x)$ (**an entity** x such that F is true for x)

Ex. if F is *apple*, then (4) denotes an apple. **NB** the choice is **indeterminate**.

Hilbert's epsilon operator

> *… in order to generate these objects, you* ***generate a set****—[a] finite set. You pick out of—you* ***form from that set a sequence****, and it could be any sequence of elements, and there's in fact infinitely many possible sequences. You pick one out of those, and that sequence—S, call it—is the thing that you are then going to merge into the construction to proceed with the interpretation. This operation of* ***picking a particular element out of the set of sequences*** *is—there's formal ways of doing it which are familiar. Those of you who know some logic will recognize that this is* ***David Hilbert's epsilon operator****, which picks a single thing out of a set. It was part of his work on foundations of mathematics—[a] basic operation. So, it's a straightforward operation, but it does have the property that it's indeterminate.* *(12:05–13:12, Chomsky 2019)*

⚠ The ϵ-operator is indeed indeterminate in mathematics, but it is at most semi-indeterminate (or even fully determinate) in linguistic applications (including FSQ).

A word on generality

The sequence-choosing scenario described by Chomsky is **much more general** than the case of coordination. Since each sequence has an underlying set, the generation of **any** sequence in any domain (linguistic or not) can be reduced to the same formal method, which is consistently definable via the ϵ-operator:

set of ingredients $\rightarrow$ set of all possible sequences $\rightarrow$ Choose one! (ϵ)

Form Sequence in different guises

Let's compare Chomsky's several descriptions of FSQ again:

(5) a. $\langle \text{CONJ}, \langle S_1, L_1 \rangle, \dots, \langle S_n, L_n \rangle \rangle$ (2019)

b. $\langle (\&), X_1, \dots, X_n \rangle$ (2020)

c. $\text{FormSet}(X_1, \dots, X_m) = \{X_1, \dots, X_m\}$ (2021b)
$\text{Merging-\&-and-FSQ}(\{X_1, \dots, X_m\}) = \langle \&, X_1, \dots, X_n \rangle$
(Chomsky does not clarify exactly how this Merge-plus-FSQ step works)

Form Sequence as a black box

Given the name of FSQ, we can say that the only place where it is actually defined is Chomsky (2019), albeit in casual terms. In Chomsky (2020, 2021ab), FSQ is invoked but not defined.

> *We therefore need an operation* FORMSEQUENCE *(FSQ) that selects m members X_i of WS and yields …* $\langle \&, X_1, \ldots, X_n \rangle$ *(Chomsky 2021b: 31)*

Chomsky (2021b) specifies the input/output of FSQ but leaves its inner workings in a black box.

The ϵ-based casual definition in Chomsky (2019) is the **only and most informative** peek into the black box given by Chomsky to date.

Dissection of Form Sequence

Combining Chomsky (2019) and Chomsky (2020, 2021ab), we can specify the following steps for FSQ. Take the coordinate phrase *young, tall, and happy* for example.

(6) a. {young, tall, happy} (a set of conjuncts)

b. {⟨young, tall, happy⟩, ⟨tall, young, happy⟩, …} (a set of possible sequences)

c. ⟨young, tall, happy⟩ (a particular sequence)

d. ⟨&, young, tall, happy⟩ (final output)

The process from (6a) to (6c) is beyond the power of Merge, which is why FSQ is a departure from the SMT.

The Strong Minimalist Thesis

In Chomsky's (2020) words, the SMT "holds that I-language, the system that generates thought, keeps to Merge and language-independent principles, such as computational efficiency." Chomsky et al. (2023: 12) add: "The innate system should be reduced to a minimum, and appeal to the third factor should be concomitantly maximized."

FSQ, in Chomsky's original formulation, is indeed anti-SMT, as it cannot be reduced to Merge. Chomsky (2021b: 35) remarks that FSQ "may not be a departure at all" if it "can be regarded as part of the 'third factor' toolkit."

However, FSQ clearly cannot be entirely reduced to the "third factor" toolkit either, as it still serves to **manipulate syntactic objects** and **build structures** after all. Only *bona fide* syntactic operations can do such things!

Overview

A middle-ground conception

Idea: We still want a sequence-generating operation like FSQ at our disposal, but do not want the sequence to be entirely generated in Narrow Syntax. Instead, we just let NS **pave the way** for the eventual generation of such a structure at the interfaces.

A middle-ground conception

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The reformulation of FSQ in Song (2024) implements its syntactic part as **multidimensional Pair Merge** based on the description in Chomsky (2019).

Recall that in Chomsky's (2019) description of FSQ, each conjunct item is adjoined from a different dimension to the same point. Let's call this point the **pivot** of coordination. It is what structurally holds the multiple conjunct items together.

The pivot of coordination

What do we know about the pivot?

- Since the pivot structurally holds the conjuncts together, it must lie at the **intersection** of all the dimensions involved in a coordination.
- Since there can be an unbounded number of conjuncts, the pivot must have **flexible arity** (i.e., accept any number of arguments).

The pivot of coordination

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An obvious candidate for the pivot is the (potentially abstract) **conjunction**, henceforth **Co**.

👉What about the link elements?

They may reflect an **interface condition** on well-formedness—perhaps as part of Chomsky's (2020, 2021ab) "matching conditions."

Matching conditions vs. link elements

Caveat: link elements and matching conditions are similar but **nonidentical** notions.

The matching conditions are a **broader** notion, because they may be syntactic, semantic, or pragmatic (Chomsky 2021: 32).

(7) a. John arrived at the hospital [in an ambulance] and [in a coma].

b. *John arrived at the hospital in [an ambulance and a coma]. (Chomsky 2021b: 31)

Since both conjunct pairs in (7) match in syntactic categories, the difference in acceptability must be due to semantic/pragmatic mismatches. By comparison,

(8) $\langle \text{CONJ}, \langle S_1, L_1 \rangle, \ldots, \langle S_n, L_n \rangle \rangle$

The link elements L_i in (8), especially on Chomsky's *v*/*n* conception, are unambiguously formal syntactic in nature. We may take them to be the **syntactic part** of the matching conditions.

Link-assigning function

Specifically, we may think of

(9) $\langle \text{CONJ}, \langle S_1, L_1 \rangle, \ldots, \langle S_n, L_n \rangle \rangle$

as a **high-level declaration** rather than an actual syntactic object. This notation declares that a link element can be identified for each conjunct.

Formally, this amounts to a (metatheoretical) function $\lambda S_i.\, L_i$ assigning to each conjunct term one of its subterms, which in set talk is exactly a set of pairs $\{\langle S_1, L_1 \rangle, \langle S_2, L_2 \rangle, \ldots, \langle S_n, L_n \rangle\}$.

On this view, the pairs $\langle S_i, L_i \rangle$ are not products of Pair Merge but just a **metatheoretical notation**. The alternative notation $S_i^{L\text{-}i}$ (or S_i^{L} since all link elements are identified) is less ambiguous.

Multidimensional Pair Merge

Now we let each conjunct item S_i^L pair-merge with the pivot Co from a separate dimension, obtaining the following syntactic object:

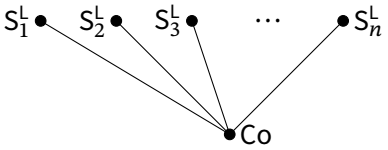
(10) $\langle Co, S_1^L \rangle, \langle Co, S_2^L \rangle, \ldots, \langle Co, S_n^L \rangle$ 👈 **NB** no c-command relation between conjuncts

The pivot Co is what holds the multidimensional structure together. Formally, this structure is a (strict) **partially ordered set** (=**poset**) with one element ranked against all other elements, while these other elements are all incomparable. Let's put this in a **Hasse diagram** ($Co < S_i^L$).

Order-theoretically, (10) is equivalent to (11).

(11) $\langle Co, \{S_1^L, S_2^L, S_3^L, \ldots, S_n^L\} \rangle$

This is in a sense pair-merging Co "with a set."



The place of &

The order-theoretic interpretation of multidimensional Pair Merge incidentally helps us solve a mystery in Chomsky's formulation of FSQ.

> *… first selects $X_1, \dots, X_m$ from WS, forming $Y = \{X_1, \dots, X_m\}$, freely using the core operation of set-formation already discussed.* ***Merging of & and FSQ*** *yields $\langle \&, X_1, \dots, X_n \rangle$, where the X_i's exhaust the elements of Y.* *(Chomsky 2021b: 31–32)*

As we have discussed, it is unclear how "&" (i.e., our Co) eventually becomes part of the sequence. Now we can tentatively flesh out the "merging of & and FSQ" process as follows:

(12)

a. $\text{FormSet}(X_1, \dots, X_m) = \{X_1, \dots, X_m\}$

FSQ effectively sequences all the extra **dimensions**.

b. $\text{PairMerge}(\&, \{X_1, \dots, X_m\}) = \langle \&, \{X_1, \dots, X_m\} \rangle \equiv \langle \&, X_1 \rangle, \dots, \langle \&, X_n \rangle$ 👈 Narrow Syntax

c. $\text{FormSequence}(\langle \&, \{X_1, \dots, X_m\} \rangle) = \langle {}^{\&}X_1, \dots, {}^{\&}X_n \rangle$ ➔ each X_i is still connected to &

d. $\text{Pronounce}(\langle {}^{\&}X_1, \dots, {}^{\&}X_n \rangle) = X_1, \dots,$ and X_n ➔ & is normally only pronounced once

Multidimensional structures cannot be linearized by c-command-based algorithms. FSQ helps!

The computational context

In sum, on our middle-ground conception, the narrow-syntactic part of Form Sequence is just (repeated) **Pair Merge**. It does not yield a sequence as output but yields a **poset** that can be subsequently converted into a sequence. Syntactic structure is kept purely **hierarchical**.

👉 This means that FSQ, in its entirety, happens in an environment $\mathbb{E}$ larger than Narrow Syntax.

Keeping strictly to the SMT, let's assume that NS is just Merge. If so, then $\mathbb{E}$ includes also

- a prederivational preparatory stage $\mathbf{P}$ ➔ where lexical (sub)arrays / workspaces are formed
- the interfaces $\mathbf{I}$ ➔ PF, LF (including the discourse)

Let's call the larger environment minus NS ($\mathbb{E} - \text{NS}$) the **computational context**.

$$\mathbb{E} = \mathbf{P} + \text{NS} + \mathbf{I} + \cdots$$

Semideterministic epsilon choice

The ϵ-choice in FSQ is not necessarily indeterminate (pace Chomsky 2019). Consider:

(13) a. [John and Bill] saw [Tom and Mary] respectively. (Chomsky 2019)

b. As for fruit, I like [apples, bananas, oranges, and strawberries], in that order.

c. The rainbow colors are [red, orange, yellow, green, blue, indigo, and violet].

These sequences are determined by discourse information, the speaker's knowledge about themself, and the speaker's general world knowledge. Both types of knowledge are stored in the speaker's memory $\mathbf{M}$, which should thus be considered part of the computational context.

$$\mathbb{E} = \mathbf{P} + \mathsf{NS} + \mathbf{I} + \mathbf{M}$$

Summary

On the middle-ground conception we have just seen, Form Sequence is reformulated as a hybrid operation with a syntactic and a postsyntactic part:

- Syntactic: repeated Pair Merge ➔ SMT-conforming
- Postsyntactic: ϵ-choice ➔ third factor

Such a sequence-generating operation is more useful at PF, but it can be useful at LF too. Consider:

(14) I went to [the post office, the market, and the bookstore], in reverse order.

In this case, two different sequences are chosen at PF/LF. This further confirms that the sequence output of FSQ cannot be generated in Narrow Syntax.

Overview

Application demonstration

Next, I demonstrate how the reformulated and generalized FSQ can be put to use.

Examples:

1. Adjective ordering (Larson 2021)
2. Chinese coordinate compounds (Song 2021)
3. Definite NPs and salience ranking (von Heusinger 2013)

Example 1: Adjective ordering

The ordering of attributive adjectives is often nonrigid:

(15) a. big red barn ∼ *red big barn

b. beautiful big house ∼ ?big beautiful house

c. circular red patch ∼ red circular patch (Truswell 2009, via Larson 2021)

Dissatisfied with the cartographic approach, Larson (2021) proposes an alternative approach based on **preordered feature sets** (=**prosets**), ordered by **subjectivity** (Scontras et al. 2017).

Larson lets each modified N bear a proset of adjectival class features, the ordering in which determines the order in which As merge with N (i.e., less subjective As are closer to N).

(16) a. small furry gray mouse ∼ small gray furry mouse

b. mouse: [COLOR]$\approx_{SUBJ}$[MATERIAL]<[SIZE] (Larson 2021: 257)

Example 1: Adjective ordering

Two problems in Larson's theory:

- It explains nonrigidity but not gradient acceptability (as Larson acknowledges).
- It still relies on many **syntacticized semantic features**, as in Cartography.

With FSQ, we can implement Larson's idea in a different way, where adjective ordering is still determined by subjectivity, but **not** in a syntactically hard-coded way. We leave it to ϵ instead.

(17) a. Syntax: $\text{PairMerge}(\text{Co}, \text{FS}(\textit{small}, \textit{furry}, \textit{gray})) = \langle \text{Co}, \{\textit{small}, \textit{furry}, \textit{gray}\}\rangle$

b. PF: $\text{Pronounce}(\text{FSQ}(\langle \text{Co}, \{\textit{small}, \textit{furry}, \textit{gray}\}\rangle)) = \textit{small, furry, gray}$ ($\text{Co} \rightarrow \varnothing$)

c. ϵ-choice: semi-determinate (*small* fully determined, *furry*/*gray* arbitrary)

No formal features like [COLOR], [MATERIAL], [SIZE] need to be postulated. The relevant notions remain conceptual and are accessible to ϵ in the computational context. Gradient acceptability may arise because there may still be **other factors** influencing the ϵ-choice.

Example 2: Chinese coordinate compounds

Chinese has a large number of coordinate compounds (with 2–7 roots).

(18) a. ***dà-xiǎo*** 'big-small; size', ***gāo-fù-shuài*** 'tall-rich-handsome; a perfect guy'

b. ***yī-shí-zhù-xíng*** 'clothes-food-residence-travel; everyday activities', ***fēng-shuāng-yǔ-xuě*** 'wind-frost-rain-snow; hardships of journey of life'

c. ***wēn-liáng-gōng-jiǎn-ràng*** 'temperate-kind-courteous-restrained-magnanimous; civilized', ***chái-mǐ-yóu-yán-jiàng-cù-chá*** 'firewood-rice-oil-salt-sauce-vinegar-tea; daily necessities'

The inter-root ordering is sometimes (but not always) flexible.

(19) a. ***dài-tì*** ∼ ***tì-dài*** 'replace', ***xún-zhǎo*** ∼ ***zhǎo-xún*** 'search'

b. ***dà-xiǎo*** ∼ **xiǎo-dà* 'big-small; size', ***chén-zhòng*** ∼ **zhòng-chén* 'heavy'

c. ***gāo-fù-shuài*** ∼ ***gāo-shuài-fù*** ∼ **shuài-gāo-fù* 'tall-rich-handsome; a perfect guy'

d. ***fēng-shuāng-yǔ-xuě*** ∼ ***yǔ-xuě-fēng-shuāng*** ∼ **fēng-yǔ-shuāng-xuě* 'wind-frost-rain-snow; hardships of journey or life'

Example 2: Chinese coordinate compounds

Song (2021) proposes an FSQ-based approach to coordinate compound linearization, using root coordination before categorization. (The technical details below are updated.)

(20) *gāo-fù-shuài* 'tall-rich-handsome; a perfect guy'

a. Syntax: $\text{PairMerge}(\text{Co}, \text{FS}(\sqrt{\text{GĀO}}, \sqrt{\text{FÙ}}, \sqrt{\text{SHUÀI}})) = \langle \text{Co}, \{\sqrt{\text{GĀO}}, \sqrt{\text{FÙ}}, \sqrt{\text{SHUÀI}}\}\rangle$
(this coordinate "root phrase" is categorized as a whole, with the root sounds and meanings being retrieved upon Spell-Out)

b. PF: $\text{Pronounce}(\text{FSQ}(\langle \text{Co}, \{\sqrt{\text{GĀO}}, \sqrt{\text{FÙ}}, \sqrt{\text{SHUÀI}}\}\rangle)) = \textit{gāo-fù-shuài}$ (Co $\rightarrow \varnothing$)

c. ϵ-choice: semi-determinate (*gāo* fully determined, *fù*/*shuài* arbitrary)

The ϵ-choice here is determined by multiple factors (Chen 2008, Xu 2016, Hsieh 2021), with **prosody** being a key factor (e.g., level $\prec$ oblique tone). Other factors include meaning, style, etc.

Example 3: Definite NPs and salience ranking

Konstanz School scholars developed a semantic theory of definite NPs based on **contextually indexed** ϵs and the notion **salience** (see von Heusinger 2013 and references therein).

(21) a. Classical ϵ-term: $\epsilon x.\mathrm{F}(x)$ ➔ $[\![\epsilon x.\mathrm{apple}(x)]\!]$ = an arbitrary apple

b. Indexed ϵ-term: $\epsilon_c x.\mathrm{F}(x)$ ➔ $[\![\epsilon_c x.\mathrm{apple}(x)]\!]$ = the most salient apple in context c

The context-indexed ϵ does two jobs at once (Egli & von Heusinger 1995: 134):

i. It ranks $[\![\mathrm{F}]\!]$ based on its members' salience levels in the discourse. ➔ choose a sequence

ii. It chooses the most salient element out of $[\![\mathrm{F}]\!]$. ➔ choose an element

Konstanz School scholars do not specify how exactly the salience ranking is formed, but since it is a sequence, we can use FSQ.

(22) $\mathrm{FSQ}(\mathrm{FS}(🍎_1, 🍎_2, \ldots))$ ➔ no Co since NS is irrelevant

Here the ϵ-choice is fully determinate due to the contextually fixed salience ranking.

Factors influencing the epsilon choice

In the three examples we have seen, the following choice-influencing factors are involved:

Example	Factors	Determinacy
Adjective ordering	semantic/conceptual	semi-determinate
Chinese coordinate compounds	mainly prosodic	semi-determinate
Definite NPs and salience ranking	discourse	fully determinate

Overview

Conclusion

In this talk, I have

- reviewed FSQ as described in Chomsky's work
- introduced an SMT-conforming alternative formulation
- demonstrated how the reformulated FSQ rule can be put to use

Takeaway messages:

- FSQ is worth saving since sequence is a basic structure in human language and cognition.
- A reformulated and generalized FSQ rule can be a useful tool.

Thank you!

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