SAN and Movement?







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The Sustained Anterior Negativity King and Kutas 1995

The reporter [who the senator harshly attacked __] admitted the error.

The reporter [who ____ harshly attacked the senator] admitted the error.



The SAN looks like a grammatical operation (move) that triggers a specific set of processes (working memory).

King and Kutas 1995 proposed that the SAN reflects maintenance of the filler in working memory until the gap location.

What are the **constructions** that yield SANs?

The previous literature looks like A'-constructions with sufficient unpredictability in the gap location. Object relative clauses (but not subject) Object wh-questions (but not subject) NP-scrambling (not-previously-mentioned)

construction	move	A' or A	
WH through islands	yes	Α'	
WH-adjuncts	yes	Α′	
NP and WH Scrambling	yes	Α′	
WH-the-hell	yes	?	
How-come	no	no	
Backward binding	no/yes	А	
Raising	yes	А	
Control	no/yes	А	
Negative Concord	no	no	

For me, this is a grammarlevel question. I want to know to what extent we can use something like the SAN to diagnose (subtypes of) movement (of course, relying on a predictable mapping between the construction and a specific parsing process).

What are the **processes** that yield SANs?

The space of possible theories is very large, so here I will just focus on a few that would be the most interesting for syntacticians. The goal is to identify processes that link the head and tail of the dependency:

What did the advertisement for the show interrupt ____?

King and Kutas 1995: Maintenance of a filler in working memory.

Retrieval theories of WM: Presence of a retrieval feature in working memory.

Active filling: The search for a gap location (to some extent suggested by Fiebach et al. 2002).

Active searching more generally: The search for a required element (e.g., the antecedent backward binding).

Syntactic dependencies more generally: The search for any unsatisfied syntactic feature (active or not).

The constructions and processes

construction	move	A' or A	WM filler	Active filling	Active search	Syntax	SAN
WH through islands	yes	Α′	✓	_		✓	
WH-adjuncts	yes	Α′	?	?	?	?	
NP and WH Scrambling	yes	Α′	✓	✓	✓	✓	
WH-the-hell	yes	?	?	—	?	✓	
How-come	no	no		—		_	
Backward binding	no/yes	А	?	—	✓	✓	
Raising	yes	А	?	—	?	✓	
Control	no/yes	А	?	_	?	✓	
Negative Concord	no	no	_	_	_	✓	

Some experimental details (roughly the same for all experiments)

The items:

Each subject saw **300 items plus 10 practice items** in their session.

10 conditions, with 30 items per sentence type (=300 items).

4 SAN dependencies: WH, backward binding, and two not discussed here (backward sluicing, which showed nothing, and embedded wh-questions, which showed the N400-like effect seen in Phillips et al. 2005)

2 conditions forming a classic N400 paradigm as an extra sanity check.

Sentences were presented word-by-word using the **Rapid Serial Visual Presentation** (RSVP) paradigm.

The presentation rate: 300ms on, 200ms off (500ms SOA, 200ms ISI)

Participants: 32 self-reported native speakers of English from the University of Connecticut. 2 removed for too many artifacts (>30% of trials).

The task: Yes/No comprehension questions after 25% of items.

WH-through-islands (subject islands) (tests active filling)

What did the advertisement for the show interrupt ___ ?

Did the advertisement for the show interrupt the game?



This looks like a SAN that is not suppressed through the island.

WH-through-islands (appositive adjuncts) (tests active filling)

What did the advertisement, due to the show's budget, interrupt ___?

Did the advertisement, due to the show's budget, interrupt the game?



This looks like a SAN that is not suppressed through the island.

Backward binding (tests active searches)

I don't know its age, but Mary said that she found a coin in the park. I didn't find anything, but Mary said that she found a coin in the park.



This does not look like a SAN. There may be an anterior negativity around the antecedent. There also may be a repetition N400 at the verb.

Raising vs Control vs Bridge (no detrending) (tests A-movement)

The queen seemed, due to the prince's speech, _____ to be a kind ruler.

The queen tried, due to the prince's speech, PRO to be a kind ruler.

The queen thought, due to the prince's speech, that the king is a kind ruler.



Raising vs Control vs Bridge (no detrending) (tests A-movement)

The queen seemed, due to the prince's speech, _____ to be a kind ruler.

The queen tried, due to the prince's speech, PRO to be a kind ruler.

The queen thought, due to the prince's speech, that the king is a kind ruler.



How-come (tests A' semantics without movement)

How come the advertisement for the show interrupted the game?

Did the advertisement for the show interrupt the game?



This looks like a SAN, plus some sort of posterior positivity.

Why, when, how, what, and how-come again (semantically parallel to how-come)

All three wh-adjuncts show a SAN, and the SAN for how-come replicates!



Dependencies in Korean

kangdo-lul ku yongkamhan kyengchal-i unhayng-eyse tanpeney ____ cheyphohayss-supni-kka?
 robber-ACC the brave police-NOM bank-at immediately arrested-HON-Q
 `Did the brave police immediately catch the robber at the bank?'

nwuku-lul ku yongkamhan kyengchal-i unhayng-eyse tanpeney ___ cheyphohayss-supni-kka?
 who-ACC the brave police-NOM bank-at immediately arrested-HON-Q
 `Who did the brave police immediately catch at the bank?'

amwuto ku phyenghwalowun kongwen-eyse maykcwu-lul masici-anh-ass-ta.nobody the peacefulpark-atbeer-ACCdrink-NEG-PST-DECL`No one drank beer at the peaceful park.'

VCI

cotaychey

totaycheyku yongkamhan kyengchal-i unhayng-eyse tanpeney nwuku-lul cheyphohayss-supni-kka?the-hellthe bravepolice-NOMbank-atimmediately who-ACCarrested-HON-Q`Who the hell did the brave police immediately catch at the bank?'

Experiment 3: Details

The items:

Each subject saw **270 items plus 10 practice items** in their session.

9 conditions, with 30 items per sentence type (=270 items).

4 types of dependencies, 3 control conditions (NP-in-situ, Wh-in-situ, and NIC control), and 2 conditions forming a classic N400 paradigm as an extra sanity check.

Sentences were presented word-by-word using the **Rapid Serial Visual Presentation** (RSVP) paradigm.

The presentation rate: 500ms on, 250ms off (750ms SOA, 250ms ISI)

Participants: 21 self-reported native speakers of Korean from the University of Connecticut.

The task: Yes/No comprehension questions after 25% of items.

Two analyses of totaychey/the-hell

It is not clear how *totaychey* gets to the left edge of the sentence. There are at least two theories in the literature (Huang and Ochi 2004).



A SAN could be driven by either the (non-movement) dependency between totaychey and the wh-word, or by covert movement of the wh-word.

 Overt movement:
 [CP totaychey
 [IP NP ...
 [VP Adv ___ who/what ... V]] Q]

A SAN could be driven by either the overt movement of totaychey, or by covert movement of the wh-word.

Grand average waveforms at electrode F3



Baselined to 300-500ms after the first word in the plot, bandpass filtered at 0.1 and 30hz, with gray boxes indicating when each word was visible.

There is a SAN for NP-scrambling, Wh-scrambling, and *totaychey*, but <u>not NCI</u>.

Scalp distributions of the SANs



Mass univariate (cluster-based) permutation tests (Groppe et al. 2011)



What is the distribution of the SAN?

Except for how-come, so far it seems to track A'-constructions, and something like the WM requirements for fillers (but not active filling or active search).

construction	move	A' or A	WM filler	Active filling	Active search	Syntax	SAN
WH through islands	yes	Α′	✓		_	✓	yes
WH-adjuncts	yes	Α′	?	?	?	?	yes
NP and WH Scrambling	yes	Α′	✓	✓	✓	✓	yes
WH-the-hell	yes	?	?		?	✓	yes
How-come	no	no			—	_	yes
Backward binding	no/yes	А	?		✓	✓	no
Raising	yes	А	?	_	?	✓	no
Control	no/yes	А	?	_	?	✓	no
Negative Concord	no	no	_	_	_	✓	no

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PS - backward sluicing shows no SAN

I don't know what, but Mary said that she found something in the park. I didn't find anything, but Mary said that she found something in the park.



This is either not good for me, or not good for Masaya, or these backward sluicing sentences are not the right kind to test. We will drink some beers and figure this out!



Thank you!



I'd like to thank my generous collaborators for their time and intellectual energy, the NSF for its support over the years, and you for the opportunity to share some of this research today.

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Additional slides that may or may not be useful.

Is the SAN just the offset in words between the two conditions?

Note: Not in the general case. King and Kutas 1995 and Fiebach et al. 2002 did not involve word offsets. But our conditions did.

SANs only appear with word offsets

What did the advertisement for the show interrupt ___ ? Did the advertisement for the show interrupt the game?

What did the advertisement, due to the show's budget, interrupt __? Did the advertisement, due to the show's budget, interrupt the game?

How come the advertisement for the show interrupted the game? Did the advertisement for the show interrupt the game?

One possibility is that there is a general negative-going trend for sentences, such that comparing a target condition that is one word further along in the sentence would yield an increase in negativity.

We don't have a direct test of this, but we could create artificial offsets to test it. (This also mimics the K&K95 design where non-matched words are compared.)

It seems like it is not just the offset

What did the advertisement for the show interrupt ___ ? Did the advertisement for the show interrupt the game?

What did the advertisement, due to the show's budget, interrupt __? Did the advertisement, due to the show's budget, interrupt the game?

How come the advertisement for the show interrupted the game? Did the advertisement for the show interrupt the game?

First, the effects created by the word offset test have a distinctive stepfunction shape, unlike SANs, which are relatively linear.

Second, the offset conditions are not impacted by detrending, but SANs are impacted (they get smaller), suggesting that there is something different about dependency conditions (as expected if SANs are real).

Experiment 1 - word offset test



Experiment 2 - word offset test



Experiment 2 - word offset for sluicing



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Experiment 3 - word offset



Experiment 3 - adjunct word offset



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What about a "pragmatic" theory of the SAN?

Yano and Koizumi 2019: previously mentioned scrambled objects show no SAN



Y&K19 find that previously mentioned scrambled NPs in Japanese show no SANs. Newly mentioned scrambled NPs do show a SAN. This suggests some involvement of pragmatics.

There is also something going on with newly mentioned subjects.

Yano and Koizumi 2019: previously mentioned scrambled objects show no SAN

The Y&K19 results are difficult to interpret, something that Y&K19 discuss.

At the very least, it looks like there are two <u>necessary</u> conditions for a SAN: a long-distance dependency and not-previously-mentionedness.



But it is tempting to ask if there is an overarching pragmatic theory of the SAN that can capture all of the facts. This would be one that subsumes the dependency requirement completely as an artifact of the pragmatic requirement.

I am not yet sold on this because of the collection of dependencies that show SANs. They do not form an obvious pragmatic class. But I am a syntactician, so what do I know!

[Relative clauses, matrix questions, embedded questions, scrambling, scrambled the-hell]

Parse trees for a subject island sentence







Fiebach et al. 2002: maybe hyperactive gap filling?

Fiebach et al. 2002 - wh-questions

... [who-acc on Tuesday afternoon after the accident the doctor ____ called has]

... [who-nom ____ on Tuesday afternoon after the accident the doctor called has]



These results suggest that distance between the wh-word and verb (and therefore WM) is not quite enough to explain SANs. It seems as though the location of the gap is also critical, perhaps related to hyperactive gap-filling.

Backward sluicing and embedded wh-movement

Why sluicing? A'-movement but no gap(?)

sluicing

I don't know what, but Mary said that she found something in the park. I didn't find anything, but Mary said that she found something in the park.

I don't think we have a great theory of how backward sluicing is processed.

There is likely some sort of interesting processing when the antecedent is encountered.

But, crucially, it is unlikely to be identical to typical A'-dependency processing.

It also makes for a potentially interesting comparison to backward binding, given how similar the two constructions can be in form.

binding

I don't know its age, but Mary said that she found a coin in the park. I didn't find anything, but Mary said that she found a coin in the park.

Backward sluicing - no detrending





Backward sluicing - with detrending



Why embedded wh? Phillips et al. 2005

Phillips et al. manipulated the length of the embedded dependency, and found strange results:

- ... which accomplice the detective hoped that the shrewd witness would recognize ____.
- two ... that the detective hoped that the shrewd witness would recognize the accomplice.
- ... which accomplice the shrewd witness would recognize ____ ... one
 - ... that the shrewd witness would recognize the accomplice ...



There is no existing theory about this effect. It may have something to do with the content of Phillips' et al. design (systematically manipulating 1 and 2 clause sentences, perhaps noticeable through the +wh/-wh predicates). So we wanted to look at it within our design (matrix versus one-clause embedded, but with other constructions too) to see what happens.

Embedded wh-movement - no detrending



Embedded wh-movement - with detrending

