## 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 | $\mathbf{A}^{\prime}$ or $\mathbf{A}$ |
| :---: | :---: | :---: |
| WH through islands | yes | $\mathbf{A}^{\prime}$ |
| WH-adjuncts | yes | $\mathbf{A}^{\prime}$ |
| NP and WH Scrambling | yes | $\mathbf{A}^{\prime}$ |
| WH-the-hell | yes | $?$ |
| How-come | no | no |
| Backward binding | no/yes | A |
| Raising | yes | A |
| Control | no/yes | A |
| 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 $\qquad$ ?

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 $^{\prime}$ or A | WM <br> filler | Active <br> filling | Active <br> search | Syntax | SAN |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| WH through islands | yes | $\mathbf{A}^{\prime}$ | $\checkmark$ | - | - | $\checkmark$ |  |
| WH-adjuncts | yes | $\mathbf{A}^{\prime}$ | $?$ | $?$ | $?$ | $?$ |  |
| NP and WH <br> Scrambling | yes | $\mathbf{A}^{\prime}$ | $\checkmark$ | $\checkmark$ | $\checkmark$ | $\checkmark$ |  |
| WH-the-hell | yes | $?$ | $?$ | - | $?$ | $\checkmark$ |  |
| How-come | no | no | - | - | - | - |  |
| Backward binding | no/yes | A | $?$ | - | $\checkmark$ | $\checkmark$ |  |
| Raising | yes | A | $?$ | - | $?$ | $\checkmark$ |  |
| Control | no/yes | A | $?$ | - | $?$ | $\checkmark$ |  |
| Negative Concord | no | no | - | - | - | $\checkmark$ |  |

## 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: 300 ms on, 200 ms off ( $500 \mathrm{~ms} \mathrm{SOA}, 200 \mathrm{~ms}$ 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 $\qquad$ ? Did the advertisement for the show interrupt the game?

No detrending


## With detrending




## 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?

No detrending



## With detrending




# 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.

## No detrending



## With detrending




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 <br> (tests $A^{\prime}$ semantics without movement)

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

## No detrending





## With detrending



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!


[^0]
## Dependencies in Korean

kangdo-lul ku yongkamhan kyengchal-i unhayng-eyse tanpeney $\qquad$ 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 peaceful park-at beer-ACC drink-NEG-PST-DECL 'No one drank beer at the peaceful park.'
totaychey ku yongkamhan kyengchal-i unhayng-eyse tanpeney nwuku-lul cheyphohayss-supni-kka? the-hell the brave police-NOM bank-at immediately who-ACC arrested-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: 500 ms on, 250 ms off (750ms SOA, 250 ms 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).

Base generation: [cp totaychey [ip NP ... [vp Adv who/what ... V ]] Q]


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

(a) NP-in-situ vs. NP-scrambling


- NP in-situ - NP scrambling
(c) Wh-in-situ vs. Wh-the-hell

(b) Wh-in-situ vs. Wh-scrambling

(d) NCl -control vs. NCl


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

There is a SAN for NP-scrambling, Wh-scrambling, and totaychey, but not NCI.

## Scalp distributions of the SANs



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


NCI-licensing


## What is the distribution of the SAN?

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

| construction | move | A $^{\prime}$ or A | WM <br> filler | Active <br> filling | Active <br> search | Syntax | SAN |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| WH through islands | yes | A $^{\prime}$ | $\checkmark$ | - | - | $\checkmark$ | yes |
| WH-adjuncts | yes | A $^{\prime}$ | $?$ | $?$ | $?$ | $?$ | yes |
| NP and WH <br> Scrambling | yes | A $^{\prime}$ | $\checkmark$ | $\checkmark$ | $\checkmark$ | $\checkmark$ | yes |
| WH-the-hell | yes | $?$ | $?$ | - | $?$ | $\checkmark$ | yes |
| How-come | no | no | - | - | - | - | yes |
| Backward binding | no/yes | A | $?$ | - | $\checkmark$ | $\checkmark$ | no |
| Raising | yes | A | $?$ | - | $?$ | $\checkmark$ | no |
| Control | no/yes | A | $?$ | - | $?$ | $\checkmark$ | no |
| Negative Concord | no | no | - | - | - | $\checkmark$ | no |

## 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.

No detrending


## With detrending





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 $\qquad$ ?

Did the advertisement for the show interrupt the game?

What did the advertisement, due to the show's budget, interrupt $\qquad$ ?
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 $\qquad$ ?
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



## Experiment 3 - word offset



## Experiment 3 - adjunct word offset



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 necessary conditions for a SAN: a long-distance dependency and not-previously-mentionedness.

$\mathrm{S}_{\text {NEW }} \mathrm{O}_{\text {GIVEN }} \mathrm{VD}$ Mr.Yoshida-NOM yesterday-GEN night Mr.Kimura-ACC
$\mathrm{S}_{\text {GIVEN }} \mathrm{O}_{\text {NEW }} \mathrm{VD}$ Mr.Yoshida-NOM yesterday-GEN night Mr.Kimura-ACC
$\mathrm{O}_{\text {NEW }} \mathrm{S}_{\text {GIVEN }} \mathrm{VI}$ Mr.Kimura-ACC yesterday-GEN night Mr.Yoshida-NOM

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
(C)

## Islands: Maintenance of the filler


(C)

## Presence of active retrieval features

Stowe (1986), a.o., showed that gaps are predicted at gap-selecting items like V or P , and also that they are suppressed within islands.
(D -wh)
what

| read-in | predict |
| :---: | :---: |
| D-wh $+w h C_{1}$ <br>   <br>   |  |

## Presence of a MOVE retrieval feature



Fiebach et al. 2002: maybe hyperactive gap filling?

## Fiebach et al. 2002-wh-questions

... [who-acc on Tuesday afternoon after the accident the doctor $\qquad$ 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? $A^{\prime}-$ 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 $\mathrm{A}^{\prime}$-dependency processing.

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

## 

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



but Mary $\quad$ said $\quad$ that $\quad$ she


## Backward sluicing - with detrending





When there is nothing significant, the plot is completely blank, including the scale (because 0 is the range of the data).

## Why embedded wh? Phillips et al. 2005

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

O ... which accomplice the detective hoped that the shrewd witness would recognize $\qquad$ .
... that the detective hoped that the shrewd witness would recognize the accomplice.
$\stackrel{0}{0}$
. which accomplice the shrewd witness would recognize $\qquad$ ...
... 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 $+\mathrm{wh} /-\mathrm{wh}$ 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




[^0]:    - how come - how - argument
    - why - when - yes $/ \mathrm{no}$

