

## Presentation 9: Comprehension

Herbert H. Clark  
Stanford University

1

## Automatic processing

Intuition: *Parsing* utterances into constituents, and *resolution of ambiguities* is:

1. Fast  
2.5 words/sec  
How is this possible?
2. Automatic, or mandatory, no choice  
Stroop, Shor effects
3. Accomplished without awareness

2

## Verbal interference

### Stroop effect

What is the color of the ink?

blue	red	yellow	green
red	yellow	green	blue
red	blue	green	yellow
yellow	green	blue	red

### Shor effect

Which direction is the arrow pointing?

rig←ht	u↓p	rig←ht	u↓p
do↑wn	u↓p	rig←ht	le→ft
le→ft	rig←ht	le→ft	do↑wn

3

## Intrusive processes

True or false: Does the word on the left describe the location of the word in the rectangle?



4

## How many letters in each word

apple	three
dog	six
paper	eight
dine	nine
box	two
bird	five
apple	seven
were	four
key	one
heaven	twelve
cat	one

5

## Name the object



6

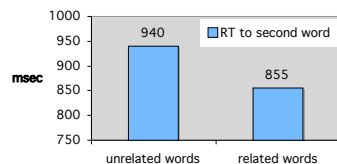
## Lexical priming

Lexical decision: Is this a word? plame

**Unrelated:** nurse butter

**Related:** bread butter

**Negative pairs:** plame wine, wine plame, plame reab



7

## Automaticity in parsing

## Two models of parsing

**Strictly bottom up:** Access information strictly in *this* order

1. Phonology
2. Syntax
3. Semantics
4. Pragmatics

**Constraint satisfaction:** Access information *as it becomes available* regardless of type

Phonological  
Syntactic  
Semantic  
Pragmatic  
Perceptual

8

9

## Listen for the word “guitar” and press button

Type of Anomaly	Utterance heard	RT	Extra
None	The crowd was waiting eagerly. The young man carried the <b>guitar</b> .	241	0
Pragmatic	The crowd was waiting eagerly. The young man buried the <b>guitar</b> .	262	+21
Semantic	The crowd was waiting eagerly. The young man drank the <b>guitar</b> .	290	+49
Syntactic	The crowd was waiting eagerly. The young man slept the <b>guitar</b> .	320	+79

10

## Parsing depends on pragmatic inferences

### Passage A

A burglar broke into a bank carrying some dynamite.  
He planned to blow open a safe. Once inside he saw that there was a safe with a new lock and a safe with an old lock.

1. The burglar blew open the safe **with the new lock**.

2. The burglar blew open the safe with the dynamite.

(Altmann and Steedman, 1988)

11

## Parsing depends on pragmatic inferences

### Passage B

A burglar broke into a bank carrying some dynamite.  
He planned to blow open a safe. Once inside he saw that there was a safe with a new lock and a strongbox with an old lock.

1. The burglar blew open the safe **with the new lock**.

2. The burglar blew open the safe with the dynamite.

(Altmann and Steedman, 1988)

12

## Eye tracking

(Tanenhaus & colleagues)

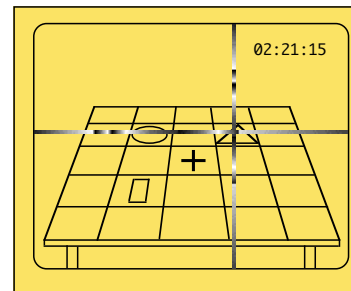


Eye movements are:

- Fast
- Frequent
- Ballistic
- Automatic

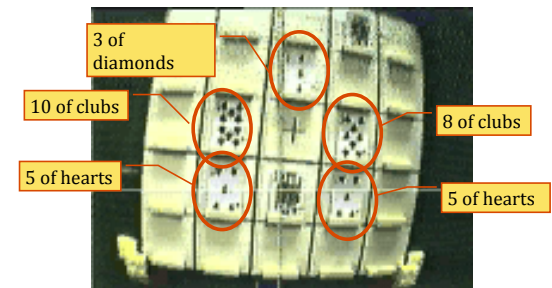
13

## Table with items on it



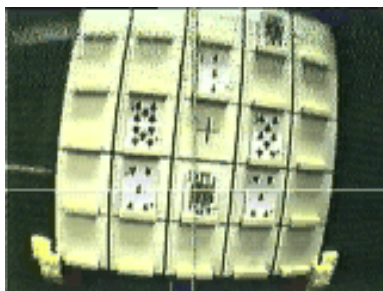
14

## What the experimenter records



15

## What the experimenter records

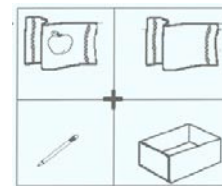


16

## Parsing depends on inferences from scene

(Tanenhaus et al., 1995)

Put the apple on the towel in the box



“one-referent context”

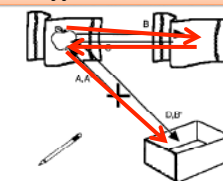
Put the apple **that's** on the towel in the box

17

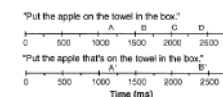
## Parsing depends on inferences from scene

(Tanenhaus et al., 1995)

Put the apple on the towel in the box



“one-referent context”



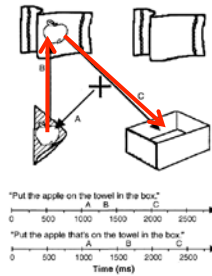
Put the apple **that's** on the towel in the box

18

## Parsing depends on inferences from scene

(Tanenhaus et al., 1995)

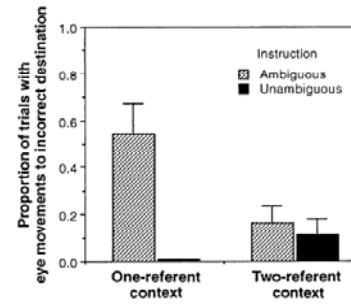
Put the apple on the towel in the box



"two-referent context"

Put the apple **that's** on the towel in the box

19

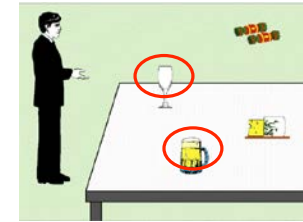


20

## Anticipatory eye movements

The man will drink all of the ... beer

The man has drunk all of the ... wine



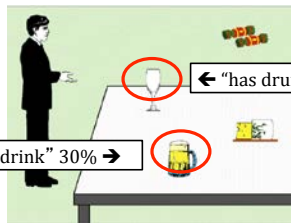
(Altmann & Kamide, 2007)

21

Table 2  
Experiment 2. Proportion of trials on which the eyes were fixating the wine glass or the beer in the future and past tense conditions

Object:	Beer		Wine glass	
Condition:	will drink	has drunk	will drink	has drunk
At onset of 'will/have'	.00	.10	.10	.00
At onset of 'the wine/beer'	.30	.21	.18	.25

Proportions are shown at two positions within the sentence: at the onset of the auxiliary verb and at the onset of the sentence-final referring expression.

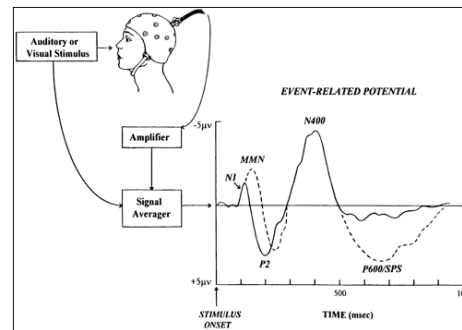


← "has drunk" 25%

"will drink" 30% →

22

## EEG and sentence anomalies



(Kutas & Hillyard, 1980)

23

## EEG and sentence anomalies

Spike in N400 with semantic anomalies

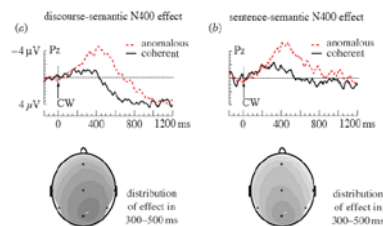
Normal: He spread his bread with *butter*

Anomaly: He spread his bread with *socks*

(Kutas & Hillyard, 1980)

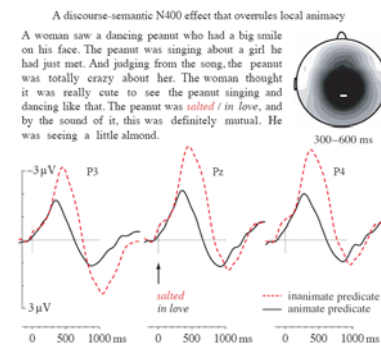
24

## Picture of N400



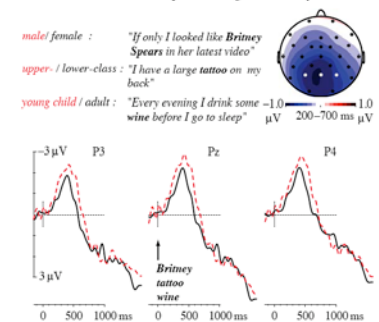
(Kutas & Hillyard, 1980)

25

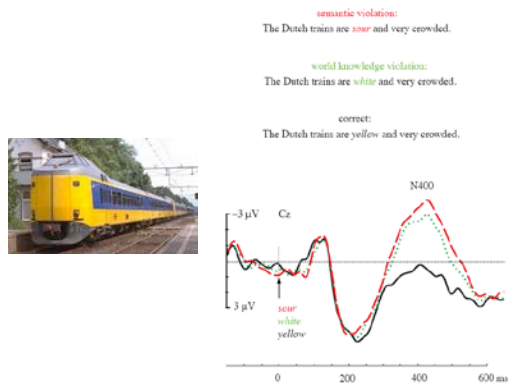


26

an N400 effect of speaker-message inconsistency



27



## Retaining conceptual pacts

(Brennan & Clark, 1996)



"the shoe" 77%  
"the penny-loafer" 23%

## Retaining conceptual pacts

(Brennan & Clark, 1996)



"the shoe" 77%  
"the penny-loafer" 23%



"the penny-loafer" 95%

## Retaining conceptual pacts

(Brennan & Clark, 1996)



"the shoe" 77%  
"the penny-loafer" 23%



"the penny-loafer" 95%



"the penny-loafer" 78%  
"the shoe" 22%

## Conceptual pacts in contrast

Trial 1-4



"the tree" 93%  
"the tree with leaves" 7%

Trial 5



"the tree" 38%  
"the tree without leaves" 62%

(Van Der Wege, 2000)

## Conceptual pacts rejected

[From British rape trial]

Attorney: An' you went to a-uh (0.9) ah you went to a *bar*? in Manchester (0.6) is that correct?

Victim: It's a *club*.

Attorney: An' during that evening (0.6) uh didn't Mistuh Jones come over tuh *sit with you* (0.8)

Victim: *Sat at our table*.

(Drew, 1992)

## Is word recognition constrained by conceptual pacts?

Task

- A tells B where to move objects in the pigeon holes.
- B is wearing eye-tracking goggles
- A is wearing sun glasses to hide his eyes

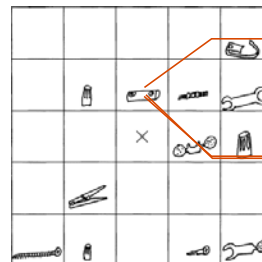
Manipulation

- A is or is not **replaced by new partner A'**
- A does or does not **violate a conceptual pact**



Brennan & Metzger, 2003

## Conceptual pact for one object



Original expression:  
"Now take the *shiny cylinder*"

New expression (violation):  
"Next is the *silver pipe*"

## What if you violate a conceptual pact?

Violation: same partner

...

A. Now take the *shiny cylinder*.

B. Okay.

...

A. Next is the *silver pipe*

B. Okay.

[Where does B look first?]

No violation: new partner

...

A. Now take the *shiny cylinder*.

B. Okay.

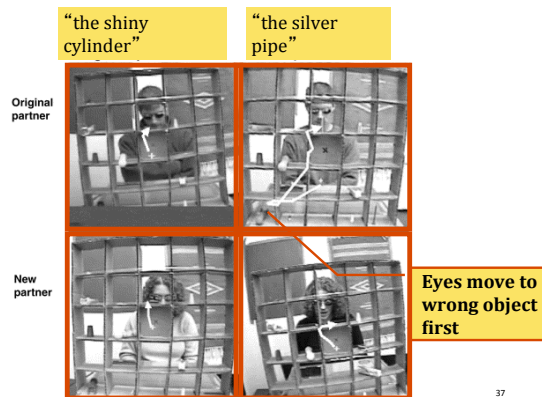
[Change of partner to A']

...

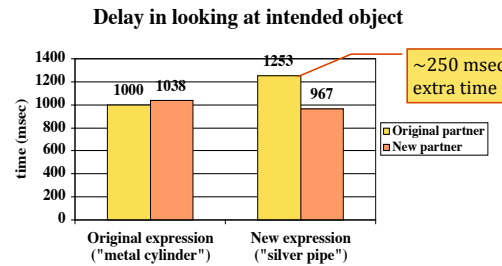
A'. Next is the *silver pipe*

B. Okay.

[Where does B look first?]



37



38

## Cautions about parsing: solecisms

No head injury is too trivial to ignore.

39

## Cautions about parsing: solecisms

### The Wason solecism

No head injury is too trivial to ignore.

Sign on London hospital wall for many years  
Problem:

"There is no head injury that is so small that it shouldn't be ignored."

Readers *cannot* have completely parsed sentence.

### Pragmatic shortcuts

We have pragmatic shortcuts

We may often *bypass a complete parsing* of a sentence.

40

## Listening is an *incremental process*

41

## Recognition of words

Raise your hand when you think you recognize the word



42

## Cohort model of word recognition

(Marslen-Wilson, 1987)

/e/	/el/	/ele/	/elef/	/elefe/
aesthetic	elbow	elegance	elephant	elephant
any	elder	elegant	Ella Fitzgerald	
ebony	eldest	elegy		
echelon	elegance	element		
ecstasy	elegy	elemental		
element	element	elephant		
elephant	elemental	elevate		
entry	elephant	elevator		
100's more	100's more	10's more		

Point of recognition:

When cohort is reduced to *one* word

43

## Word recognition

Recognizing a word is *incremental*

Cohort is reduced *segment by segment*

**Point of recognition:** when cohort is reduced to one word

Can listeners exploit the context in narrowing down choices?

Experiments using eye-tracking

44

## Word identification

(Marslen-Wilson & Tyler)

**People listened for the word *lead* and pressed a button**

**Normal prose:**

The church was broken into last night. Some thieves stole most of the lead off the roof.

**Syntactic prose:**

The power was located into great water. No buns puzzle some on the lead off the text.

**Random word order:**

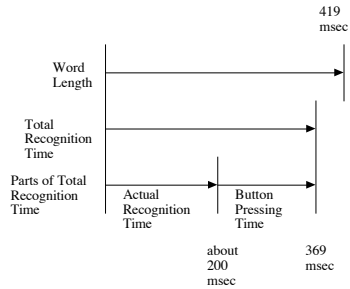
Into was power water the great located. Some the no puzzle buns in lead text the off.

**Word recognition time**

fastest in normal prose  
then syntactic prose

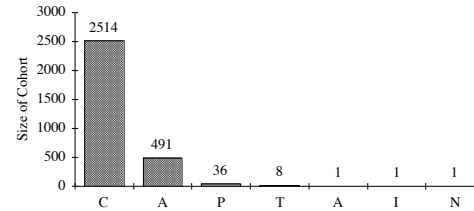
45

## Recognition Time of Average Word



46

## Cohort sizes for successive pieces of "captain"



47

## Spoken word is ambiguous before recognition point (Zwitserslood)

MW compared words presented in isolation:

capt|ain  
capt|ive

probes:

ship (primed by *captain*)  
guard (primed by *captive*)

two probe positions:

before separation (uniqueness) points (i.e., p)  
after separation (uniqueness) point

Words presented in isolation, or in context

Early probes: no difference between "ship" and "guard"

Late probes: only appropriate probe activated

48

## "Pick up the candy" (Spivey et al., 2002)

No candle  
Cohort unique at c\*andy



Candle present  
Cohort unique at candy\*

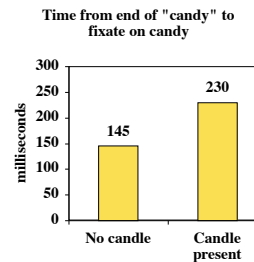


49

## "Pick up the candy."

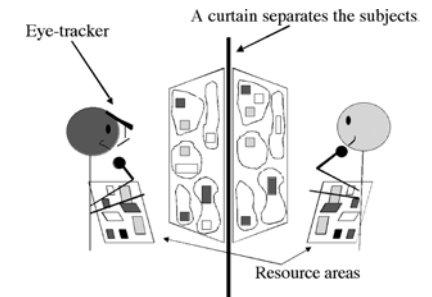
Recognition point with no candle  
c\*andy

Recognition point with candle present  
candy\*



50

## Cohort reduced by structure of discourse



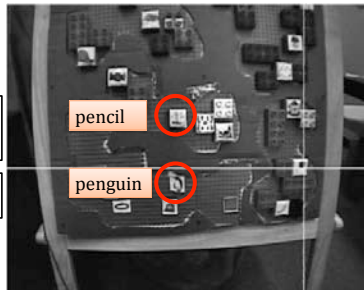
Brown-Schmidt & Tanenhaus (2008)

51

"Do you see the penguin?"

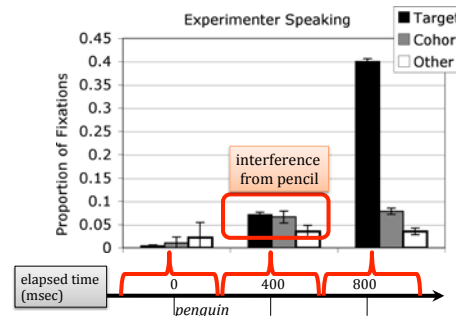
[asked by *experimenter* in calibrating eye-tracker]

[asked by *partner* as part of task]



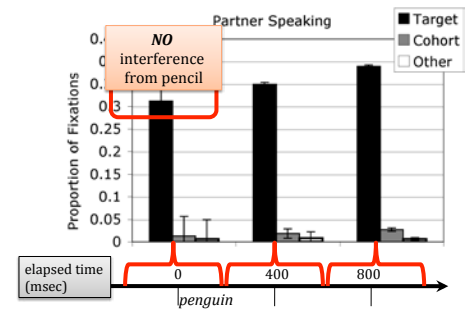
52

## Experimenter: "Do you see the penguin?"



53

## Partner: "Do you see the penguin?"



54

## Cautions about ambiguity: innovations

Erma  
Bombeck

*Steam irons* never have any trouble finding  
roommates.

*Stereos* are a dime a dozen.

*Our electric typewriter* got married and split.

411  
telephone  
operator

You'll have to ask a zero.

55

## Cautions about ambiguity: innovations

Presuppositions of all models of ambiguity

1. **Enumeration:** short list of word senses

"zero" has three senses:  
naught  
freezing temperature  
nonentity

2. **Selectivity:** understanding word = selecting right sense

It's zero out.

Problem: word innovations

You'll have to ask a zero.

Caller to 411 on telephone wanting toll information

"I don't know. You'll have to ask a zero."

Meaning of "zero"

"someone you get by dialing 'naught'"

Meaning of innovation is created around chosen sense

Do we merely "select the intended sense of a word"?

56

## Conclusions

1. We hear sentences and words **incrementally**
2. We **narrow down** options (the cohort of possibilities) incrementally
3. In narrowing down, we draw on **information from all available sources**  
sounds heard, previous words in sentence  
situational model, anything in common ground
4. We even **project**, or predict, words that are about to come
5. We also rely on **pragmatic shortcuts**

57