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Lexico-Syntactic Influences in Spoken-Word Recognition

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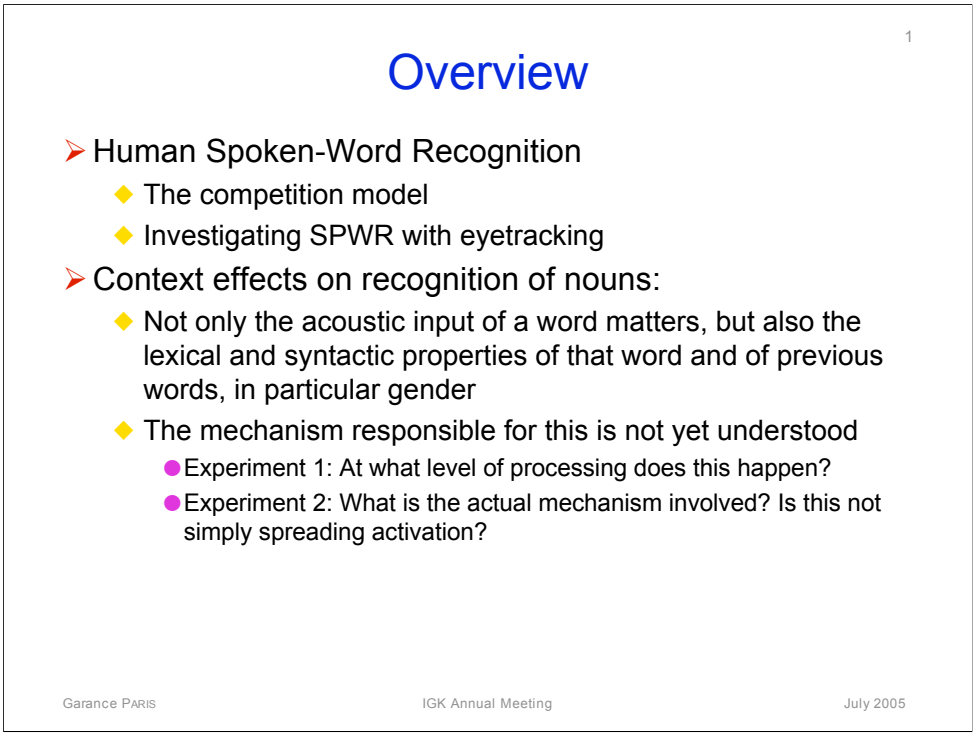

In this talk, I am going to present my current experimental work (2 experiments at various stages)

The domain of my work is spoken-word recognition, that is, investigating the way human beings recognize words, and how they access their lexical knowledge to do so

In particular, it has been shown that Spoken-Word Recognition is done in context, and that this context is drawn upon to achieve the high efficiency displayed by humans

We already know that … but …

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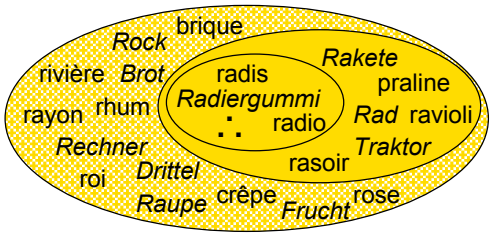
Human Spoken-Word Recognition

The competition model:

- Acoustic input activates all words that match partially
- These candidates compete for recognition
- As input unfolds, candidates which become inconsistent drop out of the competitor set
- Words from all known languages are considered

French:
/R/
/Ra/
/Rad/



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The commonly accepted model of spoken-word recognition is a competition model.

This means that first, acoustic input (1)... and then (2) ...

For example, in French, a French " r" sound would activate all nouns beginning with that phoneme, such as for example *radio*, *crèpe*, *rivière*, *rose*, *roi*, et cetera.

(3)...

So here, if the " r" sound were followed by an " a" , then among others *crèpe* and *rose* would fall out, and so on until the correct word is identified.

In the case of people who speak more than one language, (4)...

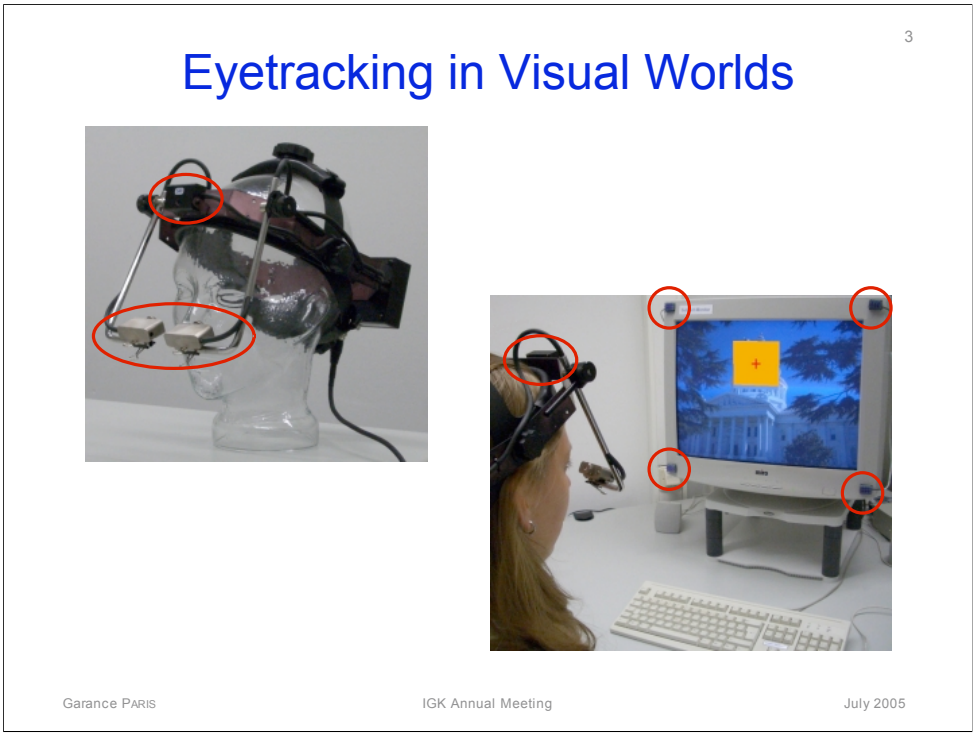
For example, a German native listening to French and hearing an " r" would also activate *Brot*, *Rechner*, etc.

This is a relatively simple model of lexical access which is called the "Cohort" model.

It was proposed at the end of 1970s by Marslen-Wilson.

But it has been confirmed and refined by a lot of recent work.

In particular, one modern way to further investigate lexical access is using a method called eyetracking…



Eyetracking means that we show people some objects in a display, and we give them some spoken instructions.

While they are listening to the instructions, we observe where they are looking at and what objects they are watching.

We use information about their eye movements to tell us something about the way they process the sentences they heard.

Here is the apparatus that I use… The headband carrying the cameras… The cameras filming the participants' eyes… The camera keeping track of movements of the head relative to the display… From this the software computes where the participant is looking on the screen.

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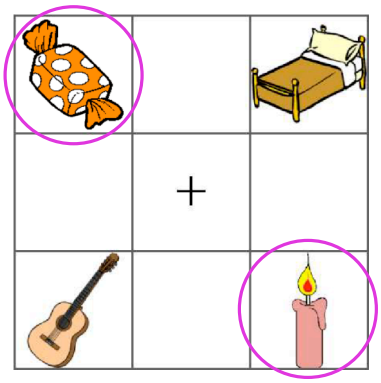
Lexical Competition in Eyetracking

Eyetracking is well-suited to observe competition:

"Pick up the can…"



When participants heard the noun onset *"can"*, they fixated both a *"candle"* and a *"candy"* in the display

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(1)..., as has been shown by Tanenhaus and colleagues

(2): In their experiment, there were 2 objects on the screen beginning with the same onset.

When participants heard the noun onset " *can*..." , they fixated...

As I have mentioned, however, the acoustic input of the word itself is not the only thing that matters.

The context before the word is also important.

Lexical and syntactic properties of the preceding context can also influence what words are considered as possible continuations.

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Gender in French and German

- Nouns are arbitrarily divided in classes: Gender
- Article preceding a noun must agree with it in gender
  - French:

le	*radis*	*la*	*radio*
Art[masc]	*N[masc]*	*Art[fem]*	*N[fem]*
'the	*radish'*	*'the*	*radio'*

  - German:

der	*Radiergummi*	*die*	*Rakete*	*das*	*Rad*
Art[masc]	*N[masc]*	*Art[fem]*	*N[fem]*	*Art[neuter]*	*N[neuter]*
'the	*eraser'*	*'the*	*rocket'*	*'the*	*wheel'*

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In many languages, nouns are arbitrarily divided in several classes called " gender"

The article preceding a noun must agree with it in gender.

French:

- 2 classes, masculine and feminine

- *radish* being masculine, it must be preceded by the definite masculine article *le*, whereas *radio*, which is feminine, must be preceded by *la*

German:

- 3 classes: masculine, feminine, and neuter

- masculine nouns such as *eraser* are preceded by *der*, feminine nouns such as *rocket* by *die*, and neuter nouns by *das*

As I have said, gender can influence lexical access...

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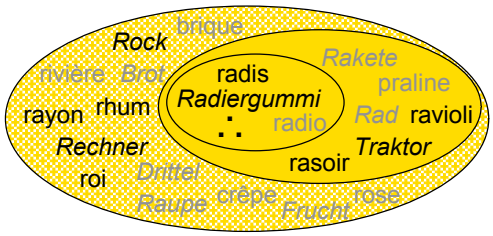
The Influence of Lexico-Syntactic Context

- Agreement information from the context preceding a word can speed up lexical access by reducing the search space
  - Gender: After hearing a gender-marked article, only gender-matching nouns are taken into account

    French: *le*$_{[masc]}$ *radis*, *la*$_{[fem]}$ *radio*

    German: *der*$_{[masc]}$ *Radiergummi*, *die*$_{[fem]}$ *Rakete*, *das*$_{[neuter]}$ *Rad*
  - Number, Case



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(1)...

In the case of gender, Dahan and colleagues have shown that (2)...

For example in French, after hearing the masculine article *le*, only...

Similarly, in German, a native-speaker hearing *der*... might activate... but not...

In principle, number and case could be used in a similar fashion

There are studies out there on role of number, but the findings show conflicting evidence.

I haven't until now encountered anything on case – but very little has been done in German in this respect anyway.

Now, coming back to gender, Dahan 2000 have shown that human listeners actually do make use of gender in this way to facilitate lexical access. However their work does not explain **how** this happens…

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Gender in WR: Surface or Deep?

- Form-based explanation (distributional regularities at surface level):

P(*Radiergummi* | /deɐ̯/)
>>
P(*Rakete* | /deɐ̯/),
P(*Rad* | /deɐ̯/)

- Grammar-based explanation (relying on gender categories):

P(*Radiergummi* | $Art_{[masc]}$)
>>
P(*Rakete* | $Art_{[masc]}$),
P(*Rad* | $Art_{[masc]}$)

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The 2 explanations they propose differ in the processing level at which gender comes into play.

On the one hand, it could be a simple frequency-based mechanism due to distributional regularities…

In this case it would be the surface form of the article */dea/* which has a higher frequency of co-occurrence with masculine nouns such as *Radiergummi*, but not with feminine or neuter nouns.

Thus *Radiergummi* is highly activated, but not *Rakete* or *Rad*.

On the other hand, it could be a deeper mechanism involving existing gender categories.

In this case, it is not the surface form of the article that matters, but rather the fact that it belongs to the masculine category.

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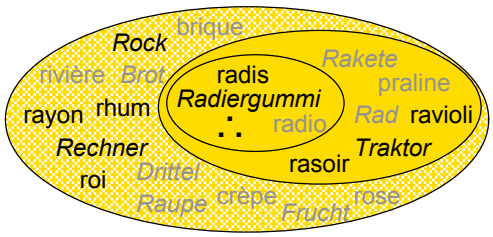
Bilinguals and Gender

- Both French and German have masculine and feminine nouns (+ neuter in German)
- Do German-speaking natives having learned French use German gender when listening to French?
- This would rather suggest a grammar-based explanation because $P(\ Rakete_{[German]} \mid /lə/_{[French]}\ ) = ???$



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I approached this question by testing German-French bilingual participants

As we have seen…

My question was: …

So: If we admit that when hearing the onset of French *radis*, German listeners also activate German words such as *Radiergummi, Rakete*, *Rad*, etc.

What happens when they hear *radis* preceded by its French definite masculine article *le*?

Will they consider *Rakete*, although its gender does not match in German, or not?

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Experiment 1: Setup

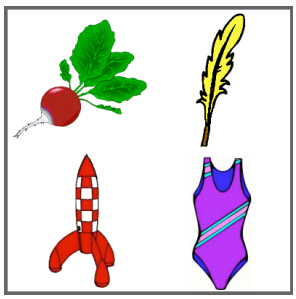
- *"Cliquez sur le*$_{[masc]}$*/la*$_{[fem]}$*…"* ('Click on the…')
- Participants:
  18 proficient German-French non-native listeners

French target: *table*$_{[fem]}$

German competitor: *Tanne*$_{[fem]}$

French target: *radis*$_{[masc]}$

German competitor: *Rakete*$_{[fem]}$



Same-Gender

Different-Gender

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The instructions were in French. There were 4 pictures in each display.

Participants were asked to click on one of the 4 pictures.

In the carrier sentences, the gender-marked definite article preceded the noun, thus providing gender information before the noun.

The participants were... At the end of the experiment, we gave them a vocabulary test to make sure they were good in French.

The picture that the participants were asked to click on is referred to as the target, for example here the table.

One of the other objects had a German name which overlapped in onset with the target, here *Rakete*. This is called the competitor.

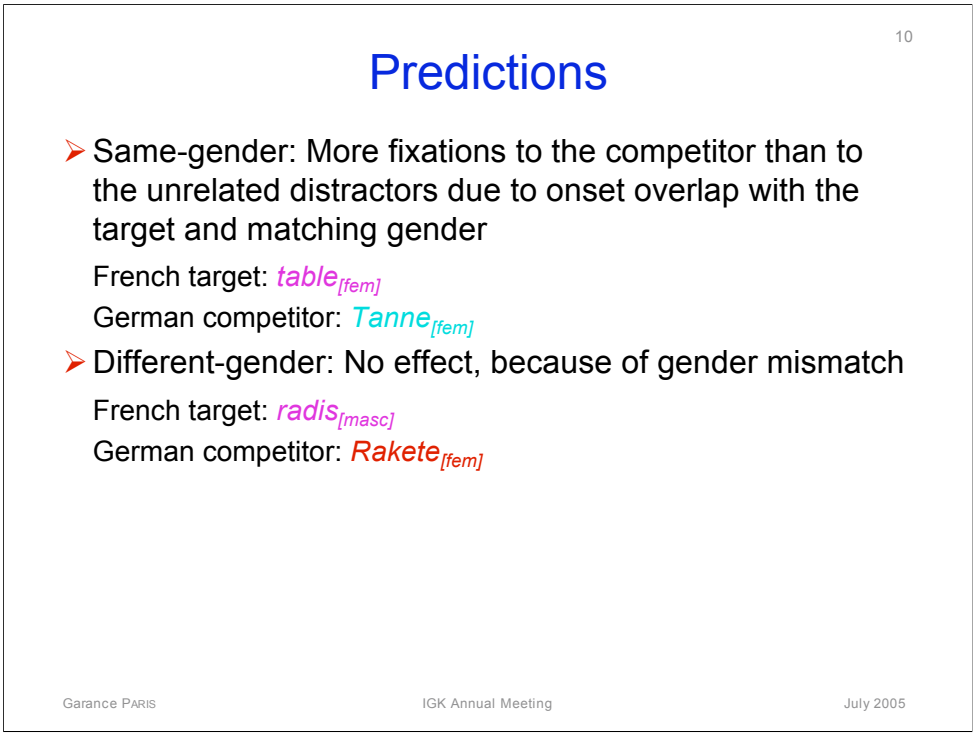
There were also 2 more unrelated objects on the screen: the distractors.

In the simplest case, target and competitor had the same gender in French and German, so the French article in the instruction also agreed with the German competitor, for example...

In the more interesting condition though, the German competitor's gender was different from the target: *rocket* in German is feminine while *radish* in French is masculine.

Thus here the article did not agree with the German noun.

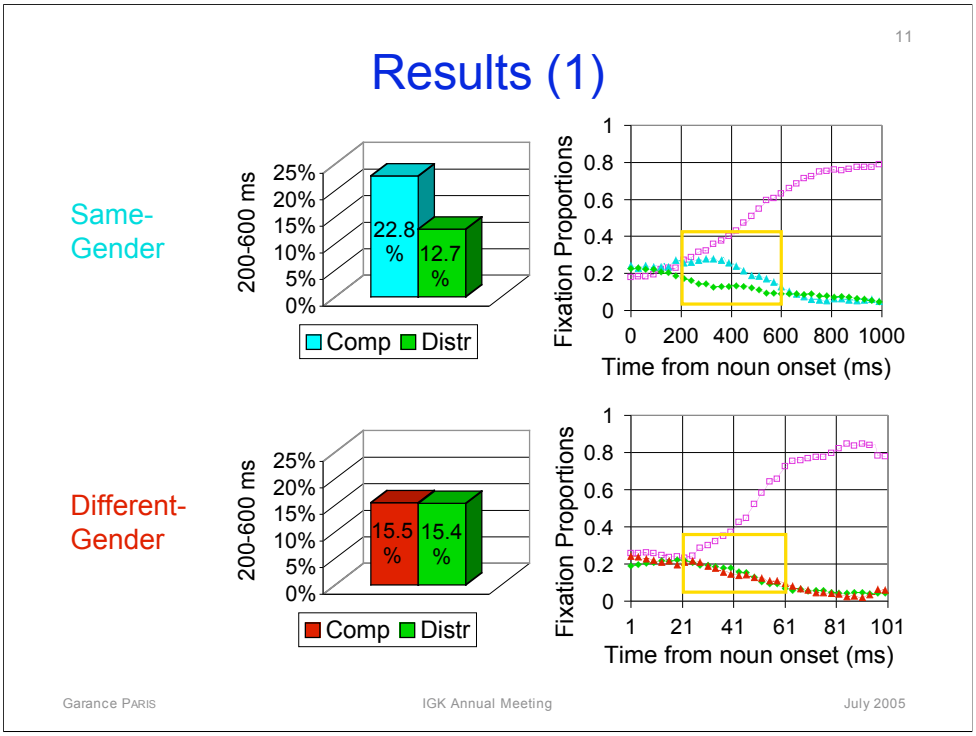
Same-gender and Different-gender pairs



In both conditions, if you do not take gender information into consideration you would actually expect the competitor to be activated alongside the target, due to the onset overlap, and to receive more attention than the unrelated words used as distractors.

In the same-gender pairs, gender should not interfere, since gender is the same for the French target and the German competitor.

In the different-gender pairs, however, ...



It has been shown that after an eye-movement is planned, it takes approx. 150 to 200 ms to actually launch it, so we expect that participants' fixations will start being influenced by the acoustic input at about 200 ms after noun onset.

Moreover, we know that people will look at the target when they hear the instruction. But since the names of the distractors do not overlap acoustically with the target, the distractor is a good baseline against which to compare the competitor to judge whether it is being activated or not.

On the left, the bar diagram shows percentages of fixations to the competitor and to the average of both distractors for the time-window from 200 to 600 ms after noun onset (both distractors were averaged).

For the same-gender pairs, those in which French target & German competitor shared gender, there is a significant difference between the fixations to both types of pictures.

On the right, the line graph shows the time-course of fixations during word-recognition.

On the X-axis, we have time after the onset of the noun, in milliseconds.

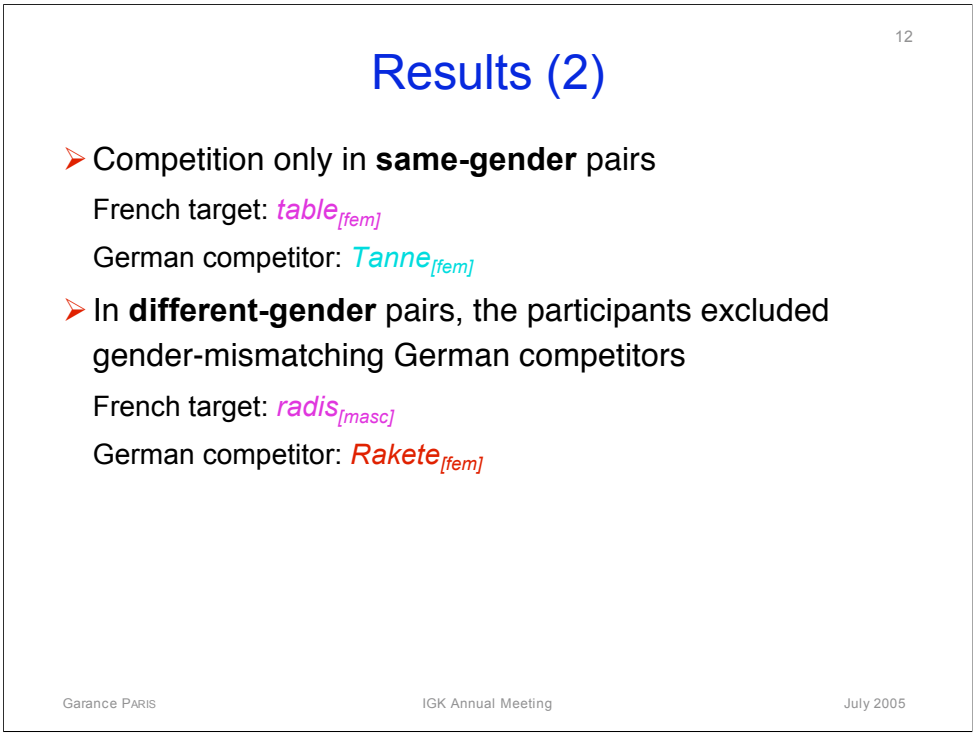
On the Y-axis, fixation proportions to the target (purple), competitor (turquoise), and distractor (green).

We can see that at first, the competitor is activated together with the target before dropping.

In the case of the different-gender pairs - that's the case in which the gender of the German competitor was different the target…

Here, the competitor is marked in red.

There was no difference between the amount of fixations to competitors and distractors, as can be seen from the bar graphs and from the time-course graph.



As we have seen, when German native listeners listen to French instructions, they also activate German competitors which have the same onset as the target.

But **only** if their German gender is the same as the gender of French target.

If the gender of the German competitor is different from that of the French article preceding the noun, then the noun isn't activated.

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Cognates & Non-Cognates

- Cognate: French *canon*, German *Kanone*, English *canon*
- Presentation language: German
- Participants: French learners of German
- Different-gender pairs:
  - German target: *Kassette*$_{[fem]}$ (‘cassette)
  - French competitor: *canon*$_{[masc]}$, in German *Kanone*$_{[fem]}$
- Results:
  - Participants do not use foreign gender
  - They do make use of gender - but of their mother-tongue’s gender!
  - Native German listeners behaved differently
- Currently, the non-cognate experiment is also being run with a French monolingual control group

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Last year, I did a similar experiment with cognate nouns, of which this is actually a follow-up.

Cognate...

However, the experiment was the other way around: The presentation language was German and the participants...

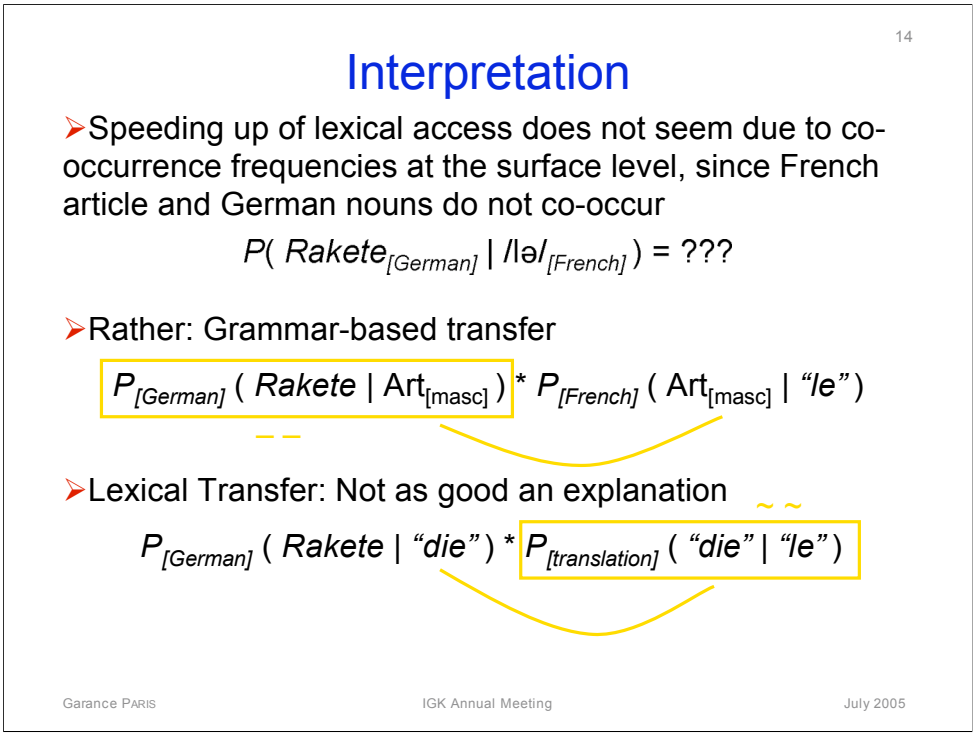
Different-gender pairs...

If the participants had been able to use the gender of their foreign language, which they knew well, the should not have excluded the *canon* from consideration, since in German, both *cassette* and *canon* are feminine.

What we saw though, is that the non-native participants did make use of gender, but not gender of presentation language...

They excluded the *canon* from consideration, showing that they were using the gender of their mother-tongue!

Native listeners however **did** look at the *canon*, which means that the observed effect cannot be due to the pictures, the frequency of the words, or anything else, but must be due to the fact that the French-German participants were performing in a foreign language.



As a consequence, it seems that we cannot explain the speeding up of lexical access with co-occurrence frequencies at the surface level, since...

It rather seems that the explanation should rely on transfer grammatical categories.

The probability of looking at the rocket (German *Rakete*) after hearing the French article *le* would be mediated by the fact that *le* is a masculine article.

Since *Rakete* however is not masculine in German, the first factor has a low probability, and the rocket will not be highly activated.

There is another alternative, which is lexical transfer: The French article *le* would first be translated on the fly to the corresponding German article, and the mediation between both languages then takes place via the German article.

However, this explanation does not explain the experimental data as well as grammatical transfer, because there is no correspondence between French and German gender (words which are masculine in one language can very well be feminine in the other and vice-versa),.

Thus the probability of *le* being translated as *die* is **as high** as the probability of its being translated as another German article.

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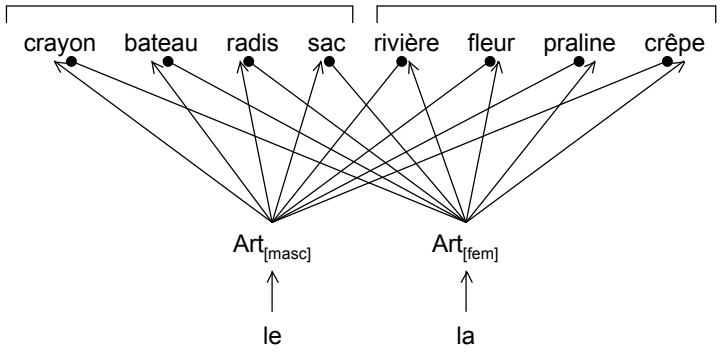
Is this spreading activation?

- Spreading activation: Activation of the determiner leads to the gradual activation of same-gender nouns and/or inhibition of different-gender nouns



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Now I come to the 2nd topic I am going to address, namely what the actual mechanism is behind the effect of gender in spoken-word recognition.

Here my question is: Isn't this simply spreading activation?

By spreading activation, I mean...

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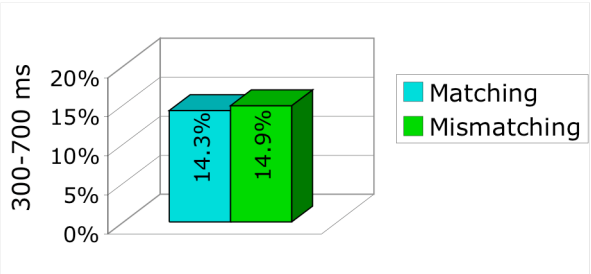
Problem...

- When the nouns do not overlap in onset, no activation of gender-matching nouns after article only:

  In French, when hearing *le*$_{[masc]}$ *balai* ('broom'), participants do not look more often to *zèbre*$_{[masc]}$ ('zebra') than to *louche*$_{[fem]}$ ('laddle')



- But: This is a null-effect; maybe the delay between article and noun was just too short

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Actually this might seem a relatively natural way to think about the gender effect if the lexicon is considered as a network.

But: There is experimental evidence against this, so I'd like to take a look at it more closely.

Problem: There is an experiment by Dahan and colleagues in which they find no activation of gender-matching nouns when no other noun overlaps with the target.

For example, when French native listeners heard the French masculine article followed by the word for *broom*, they did not look to another masculine noun such as *zebra* any more than to a feminine noun such as *ladle*.

However, this is a null-effect, and in statistics you always have to be careful when interpreting this kind of effect: It could be that the delay between the article and the noun was just too short for an effect to show up.

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Potential Test

- German adjectives preceded by a definite article are not marked for gender:

  der alte Fernseher, die alte Mütze, das alte Telefon

  (the old television set/cap/telephone)
- Plan: Introduce an adjective between article and noun
  - Monosyllabic adjectives
  - Adjectives should fit all comparison-relevant objects equally well
  - Pretests:
    - Adjective-noun pairs: How likely is it for television set to be old?
    - Pictures: Is this a good picture of an old television set?

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When a German adjective is preceded by a definite article, the adjective is not marked for gender.

For example, in the 3 noun phrases here, the ending of the adjective is the same whatever the gender of the word.

...

Adjectives should be monosyllabic because longer adjectives might give participants enough time to induce strategies.

Adjectives should fit all comparison-relevant objects equally well because we do not want the adjective to influence fixations to particular objects.

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Experiment 2: Setup

- *"Wo befindet sich der$_{[masc]}$/die$_{[fem]}$/das$_{[neuter]}$…" ('Where is the...')*
- 2 objects of one gender and 2 objects of another gender in display (6 conditions: m-n, m-f, f-n + symmetrics)

target:
der$_{[masc]}$ alte Fernseher
'television set'

target:
die$_{[masc]}$ alte Mütze
'cap'

matching competitor:
Koffer$_{[masc]}$
'suitcase'

mismatching competitor:
Lokomotive$_{[fem]}$
'engine'

- Counterbalanced for pictures

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This time the whole experiment will be in German with German participants performing in their mother-tongue.

The instructions will be..., thus also providing gender-information before the noun.

Conclusion

- Two experiments on gender and its positive effect in spoken-word recognition
- Level of processing:
  - Speeding up of lexical access does not seem due to co-occurrence frequencies at the surface level
  - Instead: Seems to rely on existing gender categories
- Mechanism: Is this spreading activation?