Psych 215:
Language Sciences
(Language Acquisition)

Lecture 14

Poverty of the Stimulus I

About Language

One way to think about how to classify the knowledge that you have when you know a language:

You know what items (sounds, words, sentences, questions, etc.) are part of the language. You can tell whether or not a given item is grammatical in the language.

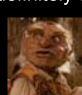
Hoggle is definitely an ornery dwarf. [grammatical]
* Hoggle an dwarf definitely ornery is. [ungrammatical]

About Language

One way to think about how to classify the knowledge that you have when you know a language:

You know what items (sounds, words, sentences, questions, etc.) are part of the language. You can tell whether or not a given item is grammatical in the language.

Hoggle is definitely an ornery dwarf. [part of English]
* Hoggle an dwarf definitely ornery is. [not part of English]



About Language

One way to think about how to classify the knowledge that you have when you know a language:

You know what items (sounds, words, sentences, questions, etc.) are part of the language. You can tell whether or not a given item is grammatical in the language.

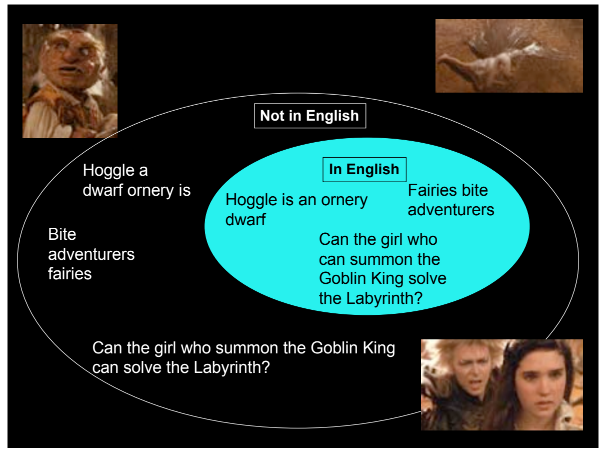
The reason you can do this is because you know the rules & patterns that generate the items that are part of the language. (mental grammar)

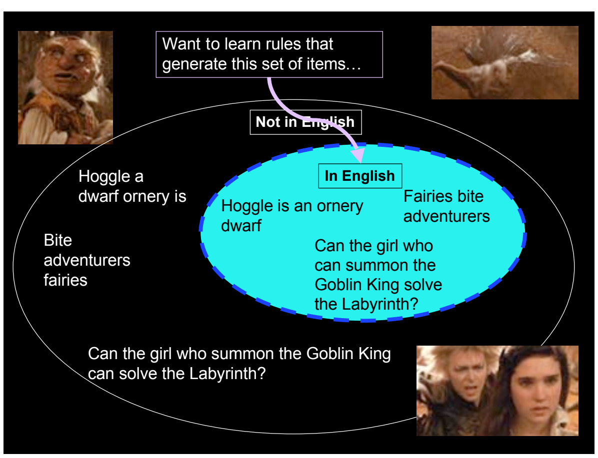
About Children Learning Language

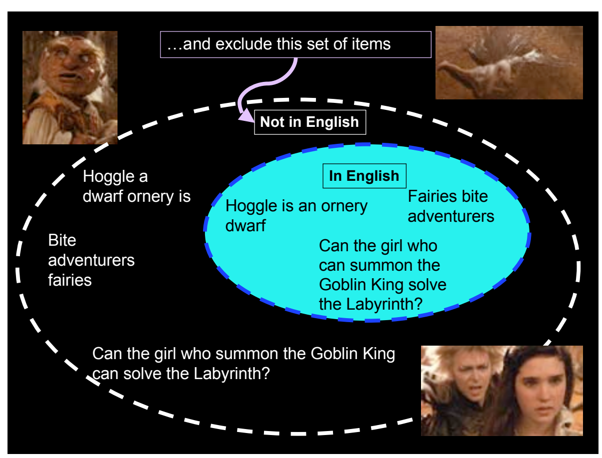
Adult knowledge: rules & patterns that generate the items that are part of the language. (mental grammar)

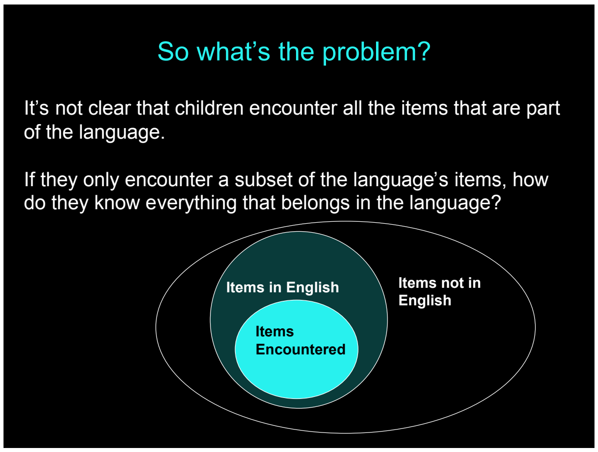
The child's job: figure out the rules that generate the items that belong in the language and that don't generate items that don't.

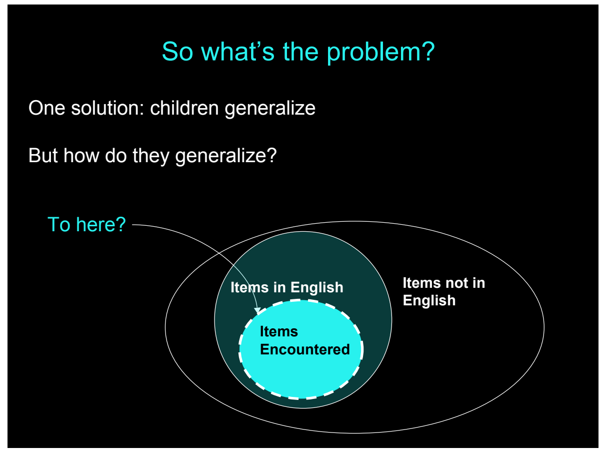
For example, the child wants rules to generate "Hoggle is definitely an ornery dwarf" but not "Hoggle an dwarf definitely ornery is".

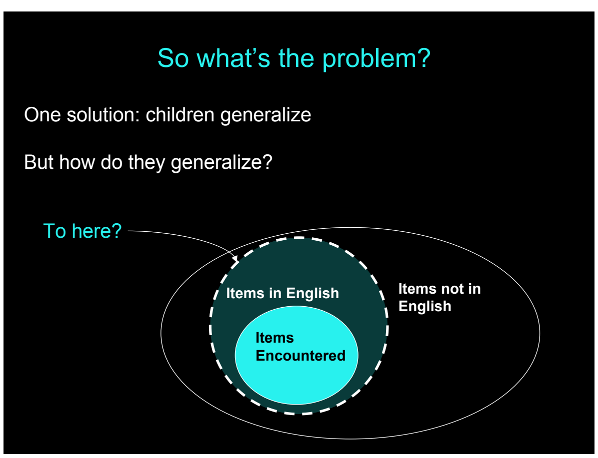


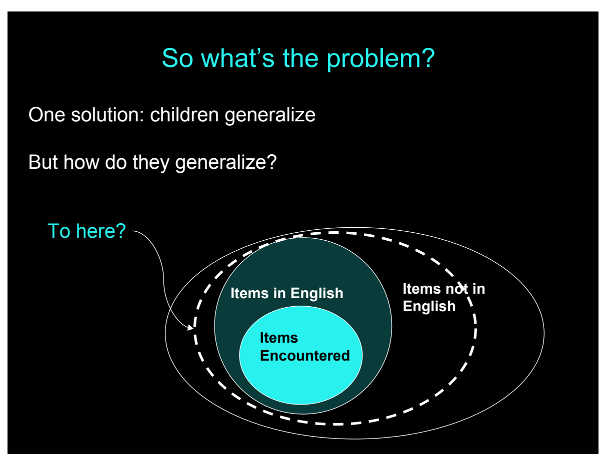





So what's the problem?
It's not clear that children encounter all the items that are part of the language.
If they only encounter a subset of the language's items, how do they know everything that belongs in the language?
Items in English
Items not in English
Items Encountered


So what's the problem?
One solution: children generalize
But how do they generalize?
To here?
Items in English
Items not in English
Items Encountered

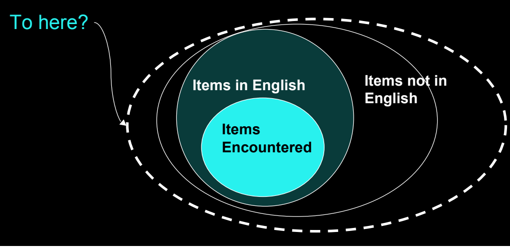

So what's the problem?
One solution: children generalize
But how do they generalize?
To here?
Items in English
Items not in English
Items Encountered


So what's the problem?
One solution: children generalize
But how do they generalize?
To here?
Items in English
Items not in English
Items Encountered

So what's the problem?

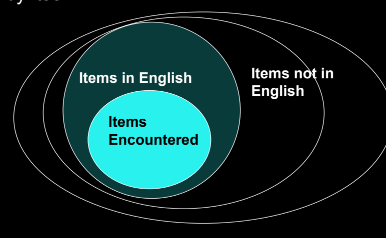
One solution: children generalize

But how do they generalize?



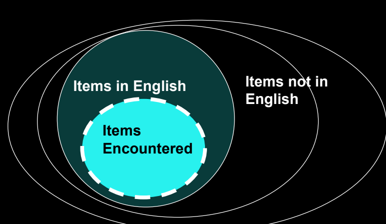
So what's the problem?

The problem is that children must make the right generalization from data that is compatible with multiple generalizations. In this sense, the data (stimulus) encountered is impoverished. It does not single out the correct generalization by itself.



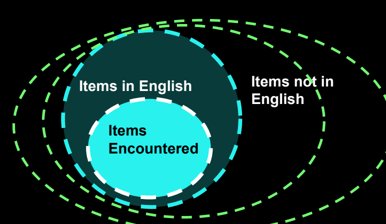
Poverty of the Stimulus: Logic

Children encounter data that is compatible with many hypotheses about the correct rules and patterns of the language.



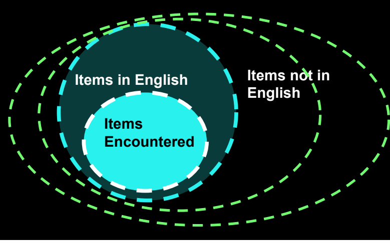
Poverty of the Stimulus: Logic

Specifically, the data encountered is compatible with both the correct hypothesis and other, incorrect hypotheses about the rules and patterns of the language.



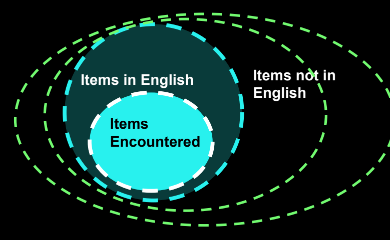
Poverty of the Stimulus: Logic

A rational learner would consider all compatible hypotheses, and perhaps make errors before choosing the correct hypothesis. Maybe some rational learners would choose the incorrect hypotheses in the end.



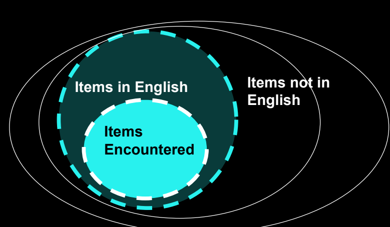
Poverty of the Stimulus: Logic

Expectation for rational learners: errors in performance. Children will behave as if they think ungrammatical items are part of the language.



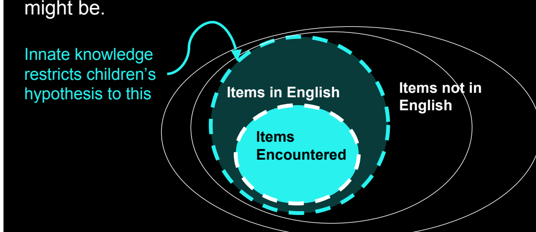
Argument about Innate Knowledge

But what if children never behave as if they consider the incorrect hypotheses? That is, they never produce errors compatible with the incorrect hypotheses. They only seem to produce items that are compatible with the correct hypothesis.



Argument about Innate Knowledge

Nativist conclusion: children have some prior knowledge (possibly innate) that causes them never to consider the incorrect hypotheses. Instead, they only consider the correct hypothesis for what the rules and patterns of the language might be.



Specific Example: Yes/No Question Formation

Jareth can alter time.

Can Jareth alter time?

To turn the sentence into a yes/no question, move the auxiliary verb (“can”) to the front.

The child’s task: figure out a rule that will form yes/no questions from their corresponding sentences.

Specific Example: Yes/No Question Formation

Jareth can alter time.
Can Jareth alter time?

Rule?

Specific Example: Yes/No Question Formation

Jareth can alter time.
Can Jareth alter time?

Rule: Move first auxiliary?

Specific Example: Yes/No Question Formation

Jareth can alter time.
Can Jareth alter time?

Rule: Move first auxiliary?

Anyone who <u>can</u> wish away their brother would be tempted to do it.
Would anyone who <u>can</u> wish away their brother be tempted to do it?

Specific Example: Yes/No Question Formation

Jareth can alter time.
Can Jareth alter time?

Rule: Move first auxiliary?

Rule?

Anyone who can wish away their brother would be tempted to do it.
Would anyone who can wish away their brother be tempted to do it?

Specific Example: Yes/No Question Formation

Jareth can alter time.
Can Jareth alter time?

Rule: Move first auxiliary?

Rule: Move last auxiliary?

Anyone who can wish away their brother would be tempted to do it.
Would anyone who can wish away their brother be tempted to do it?

Specific Example: Yes/No Question Formation

Jareth can alter time.
Can Jareth alter time?

Rule: Move first auxiliary?

Rule: Move last auxiliary?

Anyone who can wish away their brother would be tempted to do it.
Would anyone who can wish away their brother be tempted to do it?

Someone who can solve the labyrinth can show someone else who can't how.
Can someone who can solve the labyrinth show someone else who can't how?

Specific Example: Yes/No Question Formation

Jareth can alter time.
Can Jareth alter time?

Rule: Move first auxiliary?

Rule: Move last auxiliary?

Anyone who can wish away their brother would be tempted to do it.
Would anyone who can wish away their brother be tempted to do it?

Rule???

Someone who can solve the labyrinth can show someone else who can't how.
Can someone who can solve the labyrinth show someone else who can't how?

Specific Example: Yes/No Question Formation

Jareth can alter time.
Can Jareth alter time?

Rule: Move first auxiliary?

Rule: Move last auxiliary?

Anyone who can wish away their brother would be tempted to do it.
Would anyone who can wish away their brother be tempted to do it?

Rule???

Someone who can solve the labyrinth can show someone else who can't how.
Can someone who can solve the labyrinth show someone else who can't how?

Need a rule that is compatible with *all* of these, since they're all grammatical English questions.

Specific Example: Yes/No Question Formation

Jareth can alter time.
Can Jareth alter time?

Anyone who can wish away their brother would be tempted to do it.
Would anyone who can wish away their brother be tempted to do it?

Someone who can solve the labyrinth can show someone else who can't how.
Can someone who can solve the labyrinth show someone else who can't how?

Idea: Try looking at the sentence structure, not just the linear order of the words in the sentences.

Specific Example: Yes/No Question Formation

Jareth can alter time.
Can Jareth alter time?

embedded clauses = additional descriptive sentences that are not part of the main clause

Anyone [who can wish away their brother] would be tempted to do it.
Would anyone [who can wish away their brother] be tempted to do it?

Someone [who can solve the labyrinth] can show someone else [who can't] how.
Can someone [who can solve the labyrinth] show someone else [who can't] how?

Idea: Try looking at the sentence structure, not just the linear order of the words in the sentences.

Specific Example: Yes/No Question Formation

Jareth can alter time.
Can Jareth alter time?

embedded clauses = additional descriptive sentences that are not part of the main clause

Anyone [who can wish away their brother] would be tempted to do it.
Would anyone [who can wish away their brother] be tempted to do it?

Someone [who can solve the labyrinth] can show someone else [who can't] how.
Can someone [who can solve the labyrinth] show someone else [who can't] how?

Let's look just at the main clauses in these examples

Specific Example: Yes/No Question Formation

Jareth can alter time.
Can Jareth alter time?

Anyone would be tempted to do it.
Would anyone be tempted to do it?

Someone can show someone else how.
Can someone show someone else how?

Let's look just at the main clauses in these examples

Specific Example: Yes/No Question Formation

Jareth can alter time.
Can Jareth alter time?

Anyone would be tempted to do it.
Would anyone be tempted to do it?

Someone can show someone else how.
Can someone show someone else how?

Rule that works for all of these examples (and all English examples): Move the auxiliary verb in the main clause to make a yes/no question.

This is a rule dependent on the structure of the sentences.

Children's Knowledge

Children seem to know this rule by the age of 3. (Crain & Nakayama 1987)

Learning problem: Children don't encounter all the examples we saw. They encounter a subset of the possible yes/no questions in English.

Most of the data they encounter (particularly before the age of 3) consists of simple yes/no questions.

Jareth can alter time.
Can Jareth alter time?

Learning Difficulties: Yes/No Questions

The problem is that these simple yes/no questions are compatible with a lot of different rules.

Jareth can alter time.
Can Jareth alter time?

Rule: Move first auxiliary?

Rule: Move last auxiliary?

Rule: Move main clause auxiliary?

Rule: Move auxiliary in even-numbered position in sentence?

Rule: Move auxiliary closest to a noun?

Learning Difficulties: Yes/No Questions

Rational learner prediction: if children considered all these hypotheses, they should make mistakes on more complex yes/no questions. Let's look at two hypotheses in detail.

Rule: Move first auxiliary?

Rule: Move main clause auxiliary?

Learning Difficulties: Yes/No Questions

The girl who can solve the labyrinth is happy.

Predictions of questions generated

Rule: Move first auxiliary?

* Can the girl who solve the labyrinth is happy?

Learning Difficulties: Yes/No Questions

The girl who can solve the labyrinth is happy.

Predictions of questions generated

Rule: Move first auxiliary?

* Can the girl who solve the labyrinth is happy?

Rule: Move main clause auxiliary?

Correct rule = grammatical question

Is the girl who can solve the labyrinth happy?

Learning Difficulties: Yes/No Questions

Crain & Nakayama (1987) showed that children as young as 3 years old don't make these mistakes. They use the right rule for this complex yes/no question.

Predictions of questions generated

Rule: Move first auxiliary?

* Can the girl who solve the labyrinth is happy?

Rule: Move main clause auxiliary?

Is the girl who can solve the labyrinth happy?

Learning Difficulties: Yes/No Questions

But the simple questions they see are compatible with both of these hypotheses (along with many others). How do children choose the right rule from all the possible rules that are compatible? That is, how do they generalize the right way from the subset of the data they encounter?

Rule: Move main clause auxiliary?

Is the girl who can solve the labyrinth happy?

Learning Difficulties: Yes/No Questions

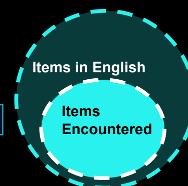
Nativist position: Children have an innate bias to look for rules that make use of sentence structure. Specifically, they only consider rules that are structure-dependent.

~~Rule: Move first auxiliary?~~

~~Rule: Move last auxiliary?~~

~~Rule: Move auxiliary in even-numbered position in sentence?~~

~~Rule: Move auxiliary closest to a noun?~~



Rule: Move main clause auxiliary?

Is the girl who can solve the labyrinth happy?

Learning Difficulties: Yes/No Questions

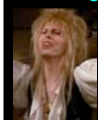
It is this structure-dependent learning bias that allows children to generalize the correct way from "impoverished" data.

Another example of children's constrained generalization

Crain & McKee (1985): pronoun interpretation

While he danced around the throne room, Jareth smiled.
(Adults: he = Jareth)
(Children: he = Jareth)

Another example of children's constrained generalization



Crain & McKee (1985): pronoun interpretation

While he danced around the throne room, Jareth smiled.
(he = Jareth)

Jareth smiled while he danced around the throne room.

Another example of children's constrained generalization

Crain & McKee (1985): pronoun interpretation

While he danced around the throne room, Jareth smiled.
(he = Jareth)

Jareth smiled while he danced around the throne room.
(Adults: he = Jareth)
(Children: he = Jareth)

Possible generalization: Can put pronoun before name or name before pronoun

Another example of children's constrained generalization

Crain & McKee (1985): pronoun interpretation

While Jareth danced around the throne room, he smiled.
(Adults: he = Jareth)
(Children: he = Jareth)

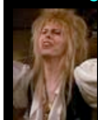
Another example of children's constrained generalization

Crain & McKee (1985): pronoun interpretation

While Jareth danced around the throne room, he smiled.
(he = Jareth)

He smiled while Jareth danced around the throne room.

Another example of children's constrained generalization



Crain & McKee (1985): pronoun interpretation

While Jareth danced around the throne room, he smiled.
(he = Jareth)

He smiled while Jareth danced around the throne room.
(Adults: he cannot be Jareth)

Another example of children's constrained generalization

Crain & McKee (1985): pronoun interpretation

While Jareth danced around the throne room, he smiled.
(he = Jareth)

He smiled while Jareth danced around the throne room.
(Adults: he cannot be Jareth)
(Children: he cannot be Jareth)

Possible generalization fails: Order of pronoun and name matters. Why?

Another example of children's constrained generalization

Crain & McKee (1985): pronoun interpretation

While Jareth danced around the throne room, he smiled.
(he = Jareth)

He smiled while Jareth danced around the throne room.
(Adults: he cannot be Jareth)
(Children: he cannot be Jareth)

Answer: Constraint on pronoun interpretation. This constraint is structure-dependent, it turns out.

Another example of children's constrained generalization

Crain & McKee (1985): Summary

While he danced around the throne room, Jareth smiled.
(he = Jareth)

Jareth smiled while he danced around the throne room.
(he = Jareth)

While Jareth danced around the throne room, he smiled.
(he = Jareth)

He smiled while Jareth danced around the throne room.
(he ≠ Jareth)

Another example of children’s constrained generalization

Crain & McKee (1985): Summary

The point: Children generalize only in a very specific way. In particular, they don’t just generalize everything that they can. Their generalizations appear to be constrained.

Nativist idea for how their generalizations/hypotheses are constrained: prior (possibly innate) knowledge about language.

Poverty of the Stimulus leads to Innate Knowledge about Language: Summary of Logic

1) Suppose there is some data.

2) Suppose there is an incorrect hypothesis compatible with the data.

3) Suppose children behave as if they never entertain the incorrect hypothesis.

Conclusion: Children possess prior (innate) knowledge ruling out the incorrect hypothesis from the hypotheses they do actually consider.

Hypothesis = Generalization

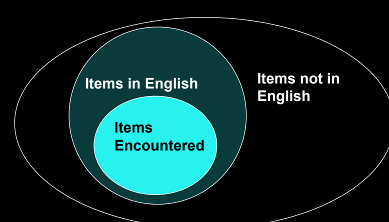
1) Suppose there is some data.

2) Suppose there is are multiple generalizations compatible with the data.

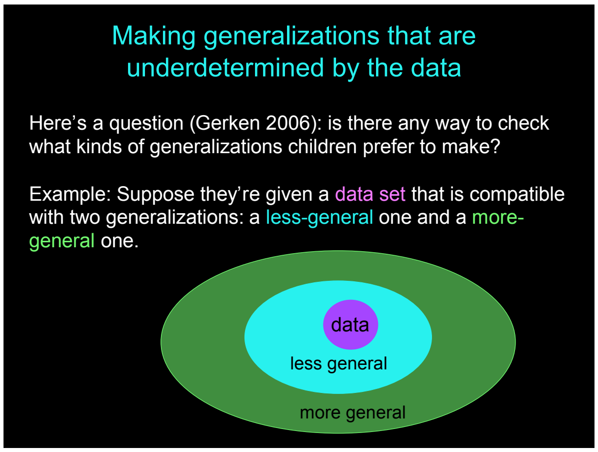
3) Suppose children behave as if they only make one generalization.

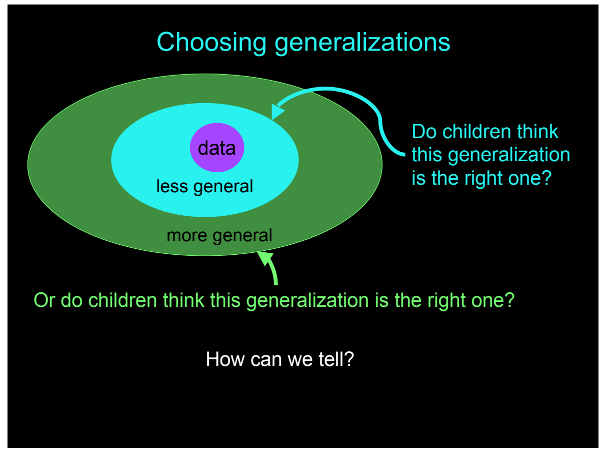
Conclusion: Children possess prior (innate) knowledge biasing them away from the incorrect generalizations.

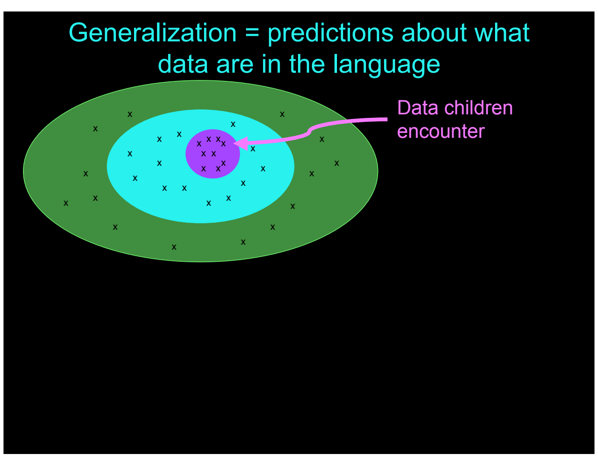
Making generalizations that are underdetermined by the data

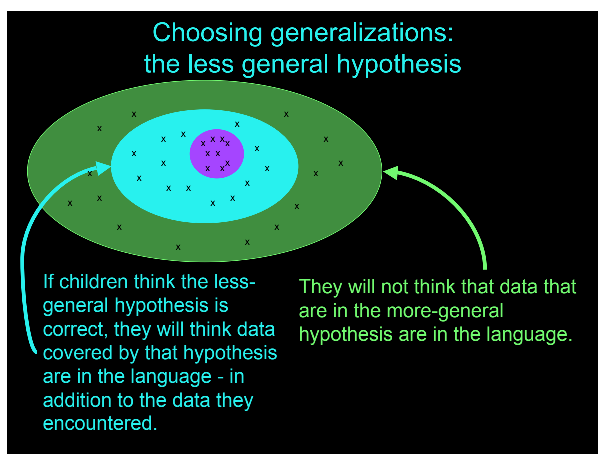


Children encounter a subset of the language’s data, and have to decide how to generalize from that data

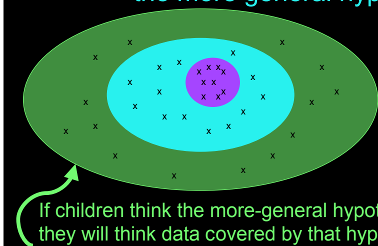

Making generalizations that are underdetermined by the data
Here's a question (Gerken 2006): is there any way to check what kinds of generalizations children prefer to make?
Example: Suppose they're given a data set that is compatible with two generalizations: a less-general one and a more-general one.
data
less general
more general


Choosing generalizations
data
less general
more general
Do children think this generalization is the right one?
Or do children think this generalization is the right one?
How can we tell?


Generalization = predictions about what data are in the language
Data children encounter

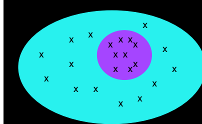

Choosing generalizations: the less general hypothesis
If children think the less-general hypothesis is correct, they will think data covered by that hypothesis are in the language - in addition to the data they encountered.
They will not think that data that are in the more-general hypothesis are in the language.

Choosing generalizations: the more general hypothesis

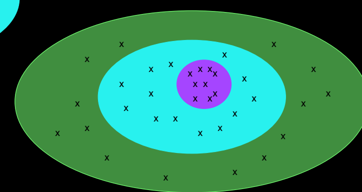


If children think the more-general hypothesis is correct, they will think data covered by that hypothesis are in the language - in addition to the data they encountered and the data in the less-general hypothesis.

Potential child responses when multiple generalizations are possible



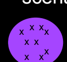
less-general



more-general

Reality check

What do these correspond to in a real language learning scenario?



Data: Simple yes/no questions in English

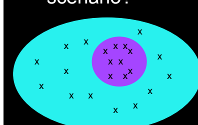
"Is the dwarf laughing?"

"Can the goblin king sing?"

"Will Sarah solve the Labyrinth?"

Reality check

What do these correspond to in a real language learning scenario?



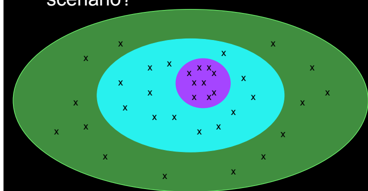
less-general hypothesis: Some complex grammatical yes-no questions

"Is the dwarf laughing about the fairies he sprayed?"

"Can the goblin king sing whenever he wants?"

Reality check

What do these correspond to in a real language learning scenario?



more-general hypothesis:
Full range of complex grammatical yes-no questions

"Can the girl who ate the peach and forgot everything save her brother?"

"Will the dwarf who deserted Sarah help her reach the castle that's beyond the goblin city?"

Experimental Study: Gerken (2006)

How can we tell what generalizations children actually make? Let's try an artificial language learning study.

Children will be trained on data from an artificial language. This language will consist of words that follow a certain pattern.

The child's job: determine what the pattern is that allows a word to be part of the artificial language.

Artificial language: AAB/ABA pattern

Marcus et al. (1999) found that very young infants will notice that words made up of 3 syllables follow a pattern that can be represented as AAB or ABA.

Example: A syllables = le, wi B syllables = di, je

AAB language words: leledi, leleje, wiwidi, wiwije

ABA laguage words: ledile, lejele, widiwi, wijewi

Artificial language: AAB/ABA pattern

Gerken (2006) decided to test what kind of generalization children would make if they were given particular kinds of data from this same artificial language.

Words in the AAB pattern artificial language.

	di	je	li	we
le	leledi	leleje	leleli	lelewe
wi	wiwidi	wiwije	wiwili	wiwiwe
ji	jijidi	jijije	jijili	jijiwe
de	dededi	dedeje	dedeli	dedewe

What if children were only trained on a certain subset of the words in the language?

Words in the AAB pattern artificial language.

	di	je	li	we
le	leledi	leleje	leleli	lelewe
wi	wiwidi	wiwije	wiwili	wiwiwe
ji	jijidi	jijije	jijili	jijiwe
de	dededi	dedeje	dedeli	dedewe

(Experimental Condition) Training on four word types: leledi, wiwidi, jijidi, dededi

This data is consistent with a less-general pattern (AAdi) as well as the more-general pattern of the language (AAB)

Question: If children are given this subset of the data that is compatible with both generalizations, which generalization will they make (AAdi or AAB)?

(Experimental Condition) Training on four word types: leledi, wiwidi, jijidi, dededi

This data is consistent with a less-general pattern (AAdi) as well as the more-general pattern of the language (AAB)

Words in the AAB pattern artificial language.

	di	je	li	we
le	leledi	leleje	leleli	lelewe
wi	wiwidi	wiwije	wiwili	wiwiwe
ji	jijidi	jijije	jijili	jijiwe
de	dededi	dedeje	dedeli	dedewe

(Control Condition) Training on four word types: leledi, wiwije, jijili, dedewe

This data is only consistent with the more-general pattern of the language (AAB)

This control condition is used to see what children's behavior is when the data are only consistent with one of the generalizations (the more general AAB one).

If children fail to make the generalization in the control condition, then the results in the experimental condition will not be informative. (Perhaps the task was too hard for children.)

(Control Condition) Training on four word types: leledi, wiwije, jijili, dedewe

This data is only consistent with the more-general pattern of the language (AAB)

Experiment 1

Task type: Head Turn Preference Procedure

Experimental: leledi…wiwidi…jijidi…dededi

Control: leledi…wiwije…jijili…dedewe

Children:
9-month-olds

Stimuli: 2 minutes of artificial language words.

Test condition words: AAB pattern words using syllables the children had never encountered before in the language. Ex: kokoba (novel syllables: ko, ba)

Experiment 1 Predictions

Control: leledi…wiwije…jijili…dedewe

If children learn the more-general pattern (AAB), they will prefer to listen to an AAB pattern word - even if it doesn't end in di - like kokoba, over a word that does not follow the AAB pattern, like kobako.

Experiment 1 Predictions

Experimental: leledi…wiwidi…jijidi…dededi

If children learn the less-general pattern (AAdi), they will not prefer to listen to an AAB pattern word that does not end in di, like kokoba, over a word that does not follow the AAB pattern, like kobako.

If children learn the more-general pattern (AAB), they will prefer to listen to an AAB pattern word - even if it doesn't end in di - like kokoba, over a word that does not follow the AAB pattern, like kobako.

Experiment 1 Results

Control: leledi…wiwije…jijili…dedewe

Children listened longer on average to test items consistent with the AAB pattern (like kokoba) [13.51 sec], as opposed to items inconsistent with it (like kobako) [10.14].

Implication: They can notice the AAB pattern and make the generalization from this artificial language data.

Experimental: leledi…wiwidi…jijidi…dededi

Experiment 1 Results

Control: leledi…wiwije…jijili…dedewe

They can notice the AAB pattern and make the generalization from this artificial language data.

Experimental: leledi…wiwidi…jijidi…dededi

Children did not listen longer on average to test items consistent with the AAB pattern (like kokoba) [10.74 sec], as opposed to items inconsistent with it (like kobako) [10.18].

Implication: They do not make the more-general generalization (AAB).

Experiment 1 Results

Control: leledi…wiwije…jijili…dedewe

They can notice the AAB pattern and make the generalization from this artificial language data.

Experimental: leledi…wiwidi…jijidi…dededi

They do not make the more-general generalization (AAB) from this data.

Question: Do they make the less-general generalization (AAdi), or do they just fail completely to make a generalization?

Experiment 2

Task type: Head Turn Preference Procedure

Experimental: leledi…wiwidi…jijidi…dededi

Children: 9-month-olds

Stimuli: 2 minutes of artificial language words.

Test condition words: novel AAdi pattern words using syllables the children had never encountered before in the language. Ex: kokodi (novel syllable: ko)

Experiment 2 Predictions

Experimental: leledi…wiwidi…jijidi…dededi

If children learn the less-general pattern (AAdi), they will prefer to listen to an AAdi pattern word, like kokodi, over a word that does not follow the AAdi pattern, like kodiko.

If children don't learn any pattern, they will not prefer to listen to an AAdi pattern word, like kokodi, over a word that does not follow the AAdi pattern, like kodiko.

Experiment 2 Results

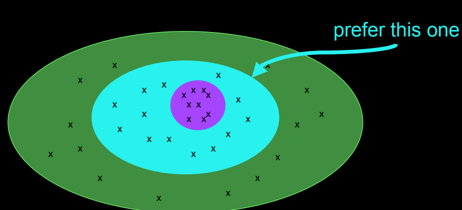
Experimental: leledi…wiwidi…jijidi…dededi

Children prefer to listen to novel words that follow the less-general AAdi pattern, like kokodi [9.33 sec] over novel words that do not follow the AAdi pattern, like kodiko [6.25 sec].

Implication: They make the less-general generalization (AAdi) from this data. It is not the case that they fail to make any generalization at all.

Gerken (2006) Results

When children are given data that is compatible with a less-general and a more-general generalization, they prefer to be conservative and make the less-general generalization.



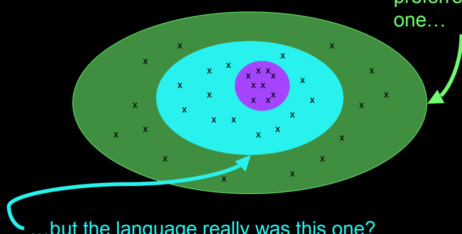
Gerken (2006) Results

When children are given data that is compatible with a less-general and a more-general generalization, they prefer to be conservative and make the less-general generalization.

Specifically for the artificial language study conducted, children prefer not to make unnecessary abstractions about the data. They prefer the AAdi pattern over a more abstract AAB pattern when the AAdi pattern fits the data they have encountered.

Why would a preference for the less-general generalization be a sensible preference to have?

What if children preferred this one…

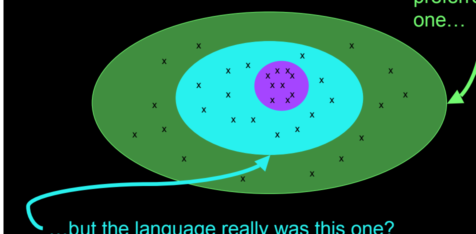


…but the language really was this one?

Problem: There is no data the child could receive that would clue them in that they less-general generalization is right. All data compatible with the less-general one are compatible with the more-general one.

Why would a preference for the less-general generalization be a sensible preference to have?

What if children preferred this one…



…but the language really was this one?

This is known as the Subset Problem for language learning.

Solutions to the Subset Problem

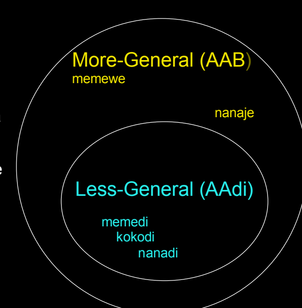
Subset Principle (Wexler & Manzini 1987): In order to learn correctly in this scenario where one generalization covers a subset of the data another generalization covers, children should prefer the less-general generalization.

This is a learning strategy that can result very naturally from a type of probabilistic learner known as a Bayesian learner, which uses the Size Principle (Tenenbaum & Griffiths 2001).

Size Principle Logic

Has to do with children's expectation of the data points that they should encounter in the input

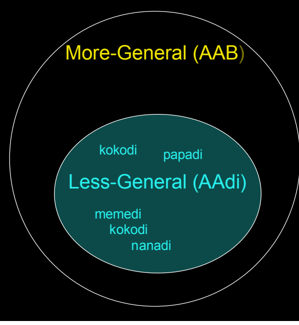
If more-general generalization (AAB) is correct, the child should encounter some data that can only be accounted for by the more-general generalization (like memewe or nanaje). This data would be incompatible with the less-general generalization (AAdi),



Size Principle Logic

Has to do with children's expectation of the data points that they should encounter in the input

If the child keeps *not* encountering data compatible only with the more-general generalization, the less-general generalization becomes more and more likely to be the generalization responsible for the language data encountered.



Size Principle Logic

Another way to think about it: probability of generating data point

The likelihood that a given data point (like memedi) was generated if the subset is doing the generating is, by definition, higher than the likelihood that data point would be generated if the superset was doing the generating. So, the subset has a higher probability of having produced this data point - it gets favored (+some probability) when this data point is encountered.