Psych 215: Language Sciences (Language Acquisition)

Lecture 11

Morphology II: Rules vs. Statistics, Continued

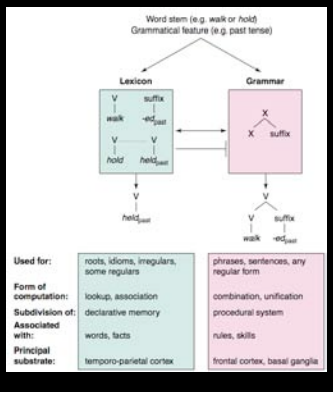
Words & Rules

Computational Problem: Identifying word *affixes* that signal meaning.
= Identify the rules for altering word forms in order to signal meaning.

Example: What do you have to change about the verb to signal the past tense in English? (There are both regular and irregular patterns.)

blink~blinked (+ed)	confide~confided (+ed)	drink~drank ("ih" --> "ey")
rub~rubbed (+ed)	hide~hid ("aye" --> "ih")	think~thought ("ink" --> "ought")

Words and Rules: Lexicon vs. Grammar

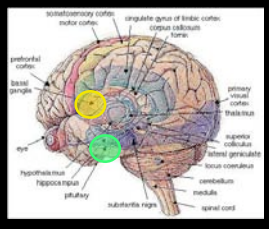


Words and Rules: Neurological Basis

Declarative/Procedural Hypothesis (Pinker & Ullman 2002):

lexical/irregular, hippocampus & medial lobe structures = declarative

grammatical/regular, basal ganglia & frontal cortex = procedural



Declarative/Procedural Hypothesis Predictions

1) Separable memory

Irregulars - psychological, linguistic, neuropsychological traces of lexical memory

Regulars - psychological, linguistic, neuropsychological traces of grammatical processing

2) "Elsewhere" rule for +ed

When memory fails for irregulars, use +ed rule for past tense.

Neurological Evidence: Declarative/Procedural Hypothesis

Studies on patients with brain lesions

agrammatism

anomia

Agrammatism: problems with grammar of language (rules)

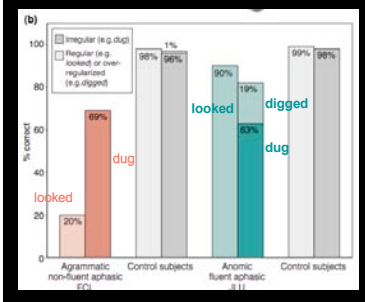
Prediction: These patients do worse on regular +ed rule than irregulars.

Anomia: problems with remembering words (lexical access)

Prediction: These patients do worse on irregulars than +ed rule.

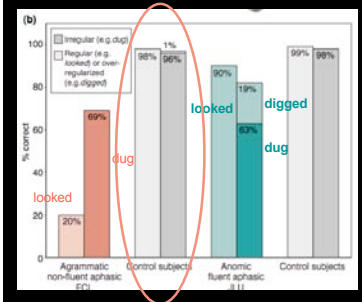
Neurological Evidence: Declarative/Procedural Hypothesis

Pinker & Ullman (2002)



Neurological Evidence: Declarative/Procedural Hypothesis

Pinker & Ullman (2002)

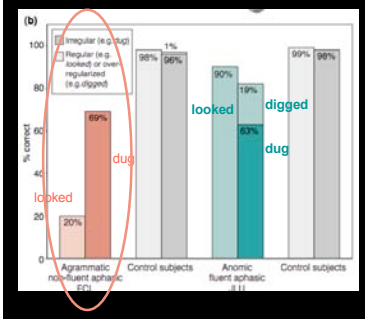


Control subjects:

At ceiling performance (near 100%) for producing the correct past tense for both irregular verbs (dig~dug) and regular verbs (look~looked).

Neurological Evidence: Declarative/Procedural Hypothesis

Pinker & Ullman (2002)



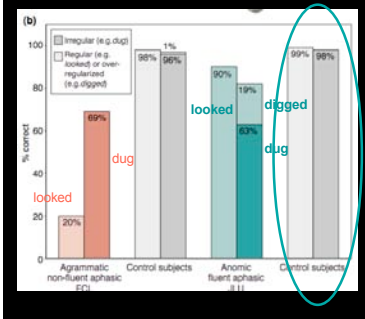
Agrammatic subject:

Poor performance comparatively, but much worse on producing the correct past tense form for regular verbs and no overregularizations for irregular verbs.

Worse at rules

Neurological Evidence: Declarative/Procedural Hypothesis

Pinker & Ullman (2002)

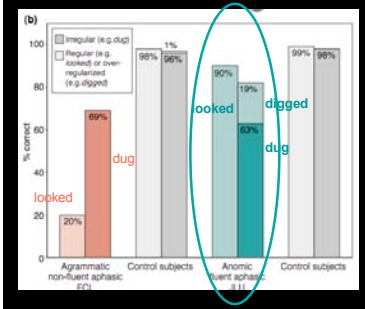


Control subjects:

At ceiling (near 100% performance) for producing both regular and irregular past tense forms.

Neurological Evidence: Declarative/Procedural Hypothesis

Pinker & Ullman (2002)



Anomic subject:

Not so bad comparatively (over 80% production), but better at regular verbs (look~looked) than irregular verbs (dig~dug). Also, produced many overregularzations (dig~digged).

Good at rules, not so good at irregulars.

Neurological Evidence: Declarative/Procedural Hypothesis

There seems to be a double dissociation between performance on regular verbs and performance on irregular verbs. We can find patients who are good at regulars, but poor at irregulars. We can also find patients who are good at irregulars, but poor at regulars.

This lends support to the idea that the past tense of regular and irregular verbs may be generated differently. Regular verbs may be making use of more rule-like brain structures and irregular verbs may be making use of more associative-memory-like structures.

More Neurological Evidence: Declarative/Procedural Hypothesis

More results: Patients with Alzheimer's Disease, Parkinson's Disease, Huntington's Disease

1) Alzheimer's: impaired lexical knowledge (can't remember words) & impaired irregular verbs

2) Parkinson's: impaired grammatical knowledge (can't use rules of language) & impaired regular verbs

3) Huntington's: unsuppressed basal ganglion (~grammatical brain structure) & overuse of -ed rule (*dugged, walkeded*)

More Neurological Evidence: Declarative/Procedural Hypothesis

More results: Lexical Priming

1) Normal patients: regular & irregular forms prime stems (*walked~walk, found~find*)

2) Patients with left inferior frontal damage: priming only for irregulars & semantic priming (*goose~swan*)

3) Temporal-lobe damaged patient: priming only for regulars

More Neurological Evidence: Declarative/Procedural Hypothesis

More results: Electrophysiological Responses (ERPs)

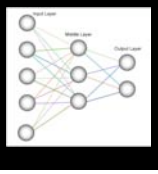
1) Regular suffix on irregular word (German *Muskels*) or left off of regular (Yesterday I *walk*): syntactic violation pattern (Left Anterior Negativity - LAN)

2) Irregular inflection illicitly applied (German *Karusellen*) or omitted (Yesterday I *dig*): semantic violation pattern (N400)

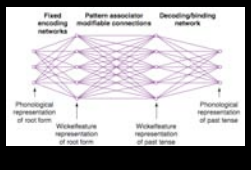
Words, No Rules

Rumelhart & McClelland (1986), McClelland & Patterson (2002)

Pattern associators learn via a gradual adjustment of simple processing units. They represent the mind's ability to retrieve the correct past tense form without ever using a rule. Also, they can easily capture the regularity in the irregular past tense forms (drink~drank, sink~sank, shrink~shrank), sometimes known as quasi-regularity. Quasi-regularity happens in many languages.



Note: wickelfeature = phonological feature like +/-stop



Words, No Rules

McClelland & Patterson (2002)

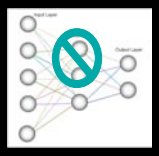
About rules:

rules = human cognition is symbolic, modular, innate, and domain-specific. The specific form of rule they're after here: rules as "discrete, categorical and symbolic objects used in a specialized, innate language module".

Pattern associators don't suppose any of this is necessary. Rules are about descriptions of language use, but there's no psychological reality to them.

Words, No Rules: What About the Neurological Evidence?

Because neural networks can be mapped to brains, networks can have "lesions" in them the same way that brains do, by selectively removing a section of a functional network.



Words, No Rules: What About the Neurological Evidence?

Because neural networks can be mapped to brains, networks can have "lesions" in them the same way that brains do, by selectively removing a section of a functional network.

However, it is hard to get the double dissociation pattern observed in human patients. No matter where a neural network is lesioned, the network's performance on irregulars (dig~dug) suffers more than its performance on regulars (look~looked). (It always behaves like an anomic patient, not like an agrammatic patient.)

Point from the rules camp: There must be something additional besides this kind of associative memory in human brains.

Rules Schmules

McClelland & Patterson (2002) say:

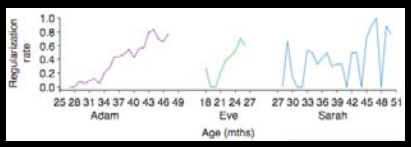
Predictions that symbolic rule models make

1) Acquisition of the symbolic rule is sudden
2) Rule is uniform in its applicability
3) Rule-based mechanism is separate from exceptions mechanism

Discussion: Are all these really true of the Words-And-Rules model? What about for any symbolic rule model?

Rules Schmules

Acquisition pattern for regular past tense rule +ed: probabilistic & noisy

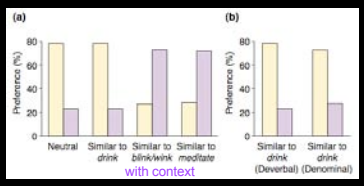


"There is always a considerable period…in which production-when-required is probabilistic. This is a fact that does not accord well with the notion that acquisition of grammar is a matter of the acquisition of rules, since the rules….either apply or do not apply. One would expect rule acquisition to be sudden."

Discussion: Is it true that probabilistic performance does not accord well with the notion of acquisition of rules?

Rules Schmules

Application of rule: subject to phonological & semantic influences



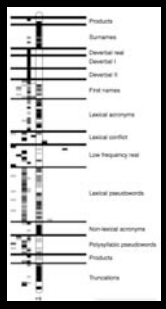
irregular
regular

Exocentric status didn't affect results

Point: regularization not just about the Elsewhere rule (which we would expect novel verbs to fall under)

Rules Schmules

Application of rule: against the Elsewhere application even for known words



German +s "default" plural usage - not so default

Fig. 3. Evidence that the German +s plural is not used uniformly across several situations supposedly calling for the use of a default as proposed by Marcus *et al.* [25]. Each row of the figure represents a different noun form, with the type of the form indicated; the horizontal bars separate the different types. Columns of the figure indicate alternative possible plural inflections, with the +s plural specifically highlighted. Grayscale darkness of the entry in each cell indicates the likelihood of using the particular plural for the given item, based on data from native German speaking adults. Reprinted with permission from Ref. [30].

Rules Schmules

McClelland & Patterson (2002): Neural basis for rules vs. words

1) Non-fluent aphasics (agrammatism): effects of regular vs. irregular difficulties disappear once test words are controlled more thoroughly for phonological properties

2) Parkinson's Disease (extra rule application - *dugged, walkeded*): could be due to phonological complexity of test words not being controlled

Well, maybe rules aren't so bad (M&P 2002)

Albright & Hayes (2003) is an example of a rule-based model that has good properties: graded rule activation, probabilistic outcomes, allow rules to strengthen gradually with experience, incorporate semantic and phonological constraints, and use rules within a mechanism that incorporates word-specific information.

But then is this empirically indistinguishable from a connectionist account? (M&P think not - "rules" are just higher-level descriptions of regularities in pattern associator.)

Pinker & Ullman (rebuttal) 2002: Combination and Structure!

Sure, there's quasi-regularity….but that's not the big deal

(which doesn't mean it's not important…)

Big deal: Does human cognition use mechanisms that are combinatorial and sensitive to grammatical structure and categories?

Rule = combinatorial operation (ex: +ed)

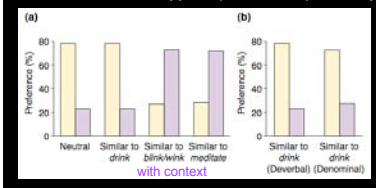
Of course they can be acquired and used probabilistically.

More important:

1) Do they apply when memory fails to retrieve exception?
2) Do they apply to heterogeneous situations with only grammatical category as the common denominator?
3) Does it disassociate neurophysiologically with memory lookup and associate with combinatorial processing?

Pinker & Ullman (rebuttal) 2002: Combination and Structure!

About when the rule applies (novel items): bad experiment

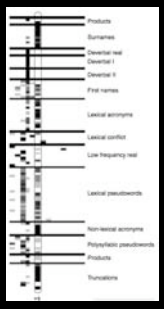


irregular
regular

Relationships aren't like any real verb, very short familiarization - how do we know subjects took restriction seriously?

Does experimenter want me to treat "frink" as a distorted form of "blink" or "drink"?

Pinker & Ullman (rebuttal) 2002: About German plurals



Even if the German situation is messy, the pattern associator story is no better - German speakers learn to connect +s with "each arbitrary property that must be associated with a specific use of an item in context", ex: surnames.

Coincidence in the pattern associator story: circumstances eliciting -s (names, unusual-sounding words, acronyms) have nothing in common except failure to access irregular root for grammatical category noun

Pinker & Ullman (rebuttal) 2002: About the double dissociation critique

Non-fluent aphasics (agrammatism): effects of regular vs. irregular difficulties disappear once test words are controlled more thoroughly for phonological properties

…but reappeared in other tasks that were also controlled!

Also, later manipulations included stems rhyming with irregulars, so not so perfectly controlled after all.

Words, No Rules: Pattern Associators & Issues with Novel Forms

Human Behavior (both adult and child): the ability to generate an appropriate past tense ending for a novel word (like "wug")

wug~wugged (regular past tense rule)

Neural network behavior: Unless the network has specifically built in a section that applies the past tense rule, it will not generate appropriate past tense forms for words it has never encountered before.

Example: Network is trained on English verbs, but never has seen "mail". When forced to generated a past tense form, it produces "membled" (something humans would never do).

Pinker & Ullman vs. McClelland & Patterson (2002): Caricatures

Pinker & Ullman:

Rules are what produce the regularities in human language. They are part of the human mind. Human cognition uses combinatorial processing that is more than simply a strong connection strength for certain regularities that appear.

McClelland & Patterson:

No, human cognition doesn't. You can get everything you need without recourse to a separate rule structure.