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Grammar:
The Heart of Numeracy

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2017
National Numeracy Network Conference
www.StatLit.org/pdf/2017-Schield-NNN2-Slides.pdf

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What is Numeracy?

As a discipline:
• Intersection of math, statistics & critical thinking
• Critical thinking about numbers in context

As a numerate person, what can one do?
• Use mathematical & logical thinking in context
• Make and evaluate quantitative claims

As a language:
• Use English to describe quantitative relations.

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Numeracy:
Numerically-based grammar

Four distinct parts of the grammar of numeracy:

1. Comparison grammar
2. Ordered-Relation grammar
3. Named-Ratio grammar
4. Association-Causation grammar

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1. Comparison Grammar
True / False / Ambiguous

A1   Eight is four times as much as two
A2   Eight is four times two
A3   Eight is three times more than two
A4   Eight is three times two

B1   Four times less than eight is minus two
B2   Four times less than eight is two
B3   Drug deaths: two times less in 2017 than '16
B4   Profits: two times less in 2017 than in 2016

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1. Comparison Grammar

Women's Health provides this difference:

The average woman is two times less likely to enjoy a restful night's sleep during vacation than a man...

But she is twice as likely to enjoy ordering from room service and the minibar.

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1. Comparison Grammar

Candidate A has 55% of the vote; B has 45%.

True / False / Ambiguous or I don't know

1. Candidate A has 10% more than candidate B

2. Candidate A has 10% more **of the vote** than B

3. Candidate A has 10% more **votes** than B.

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2. Grammar of Ordered Operations

Addition and multiplication are order-independent
Subtraction and division are order-dependent

From and *to* can be either.
- Distance *from* LA to NY same as *from* NY to LA.
- Take away 3 *from* 5 ≠ Take away 5 *from* 3.

Participant survey:
Q. How much is two into four?
    a. two   b. one-half   c. I don't know

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2. Ordered Operations Survey 28 Augsburg Students

Distance grammar
Q1. The distance from Saint Paul to Minneapolis is 12 miles (downtown to downtown). What is the distance from Minneapolis to St. Paul?
The same (24)   Something different (2)   Don't know (2)

Subtraction grammar:
Q2. How much is two from five?
    Minus three (2)   Three (25)   I don't know (1)
Q3. How much is five from two?
    Minus three (21)   Three (6)   I don't know (1)

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2. Ordered Operations Division grammar: by vs. into

Study of 28 Augsburg undergrad business students

Division grammar:
Q4. Divide four **by** two gives
    Two (25)   One-half (2)   Don't know (1)

Q5. Divide two **into** four gives
    Two (5)   One-half (21)   Don't know (2)

Division 'into' is a real problem!!!

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2. Division using "Into": Two Explanations

1. it comes from the early schooling context of learning long division, where the operation is invariably described as answering the question *"How many times does X go into Y?"*.
2. there are two [ways] for performing division, and two common prepositions. So if we know what *"divide 4 by 2"* means, we're happy to accept *"divide 4 into 2"* to designate the "opposite or inverse" operation. E.g., The ball went by (into) the pocket.

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2. Division Grammar: Ratio Grammar Survey

Q10. *"The ratio of men to women is three"*.
What does that mean?
a) Three times as many women as men (3)
b) Three times as many men as women (22)
c) Something else (1)
d) I don't know (2)

22 correct; six other. 79% correct

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2. Division Grammar: Ratio Grammar Survey

Q11. *"The male-female ratio is two"*.
What does this mean?

a) Two times as many men as women (21)
b) Two times as many women as men (1)
c) Something else (4)
d) I don't know (2)

21 correct; 7 other.   75% correct

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2. Division Grammar: Ratio Grammar Survey

Q12. *Jan likes small classes.* Which does Jan like?
a) A small teacher-student ratio (3)
b) A large teacher-student ratio (12)   71%
c) I don't know (2)

Q13. *Amy likes small classes.* Which does Amy like?
a) A small student-teacher ratio (10) 91%
b) A larger student-teacher ratio (1)
c) I can't tell (0)

Different students: Q12 young FT; Q13 older working.

3. Named Ratio Grammar

Ordinary grammar ratios use just *per*, *of* or *out of*

Named ratios include

• Percent
• Percentage (fraction and share)
• Rate (incidence and prevalence)
• Chance (odds, risk, likelihood and probability

Schield (2000). www.statlit.org/pdf/2000SchieldASA.pdf

3. Named Ratio Grammar Percent vs. percentage

% is preceded by a number or adjective.
Percentage is preceded by *the* or *what*.

1. *20% [per cent] of men are smokers*
2. *The percentage of men who are smokers is 20%*
3. *A small percent of men are smokers*
4. *What is the percentage of men who are smokers?*
5. *What percentage of men are smokers?*

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4. Association vs. Causation

Association is a mathematical idea;
Causation is not a mathematical idea.

Mathematics describes associations in many ways:
   comparisons, correlation (total and partial)
There is no mathematical operator for 'causes'.

Philosophically,
• mathematics deals with the form (association);
• statistics deals with form and matter (causation)

4. Association vs. Causation: A-B-C Grammar

A: Association grammar (associate, correlate)
   Comparisons: Whites more likely to suicide…
   Internal change: As kids age, height increases.

C: Causation grammar (Cause, effect, result of)
   Sufficiency: Lightning *resulted in* a fire.
   Contra-fact: Those who do X *get more* Y
                  than if they hadn't done X.

B: Between grammar:
   Implies – but does not assert – causation

4. Association vs. Causation: A-B-C Grammar: 20-60%-10

B: Between grammar: states an association.
   'Implies' – but does not assert – causation

• Action verbs: *cuts, ups, raises, increases*.
   Red wine cuts cancer risk.   TV ups kids' risk of flunking. Smoking raises asthma risk.
• Action nouns: Spinach is an *asthma protector*.
• Combinations: Smoking is a *causal factor*.
• Connectors: Nuts *linked* to cancer.

Source: www.statlit.org/pdf/2008RaymondSchieldASA.pdf

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1. Association vs. Causation: A-B-C Grammar

B: **Between grammar: states an association. 'Implies' – but does not assert – causation**

- Change-in-subject comparisons: *As teacher pay increases, student scores increase*
- Time: Autism develops *right after vaccination*
- Modals: *Smoking may cause cancer.*
- Logical: *Anxiety increases due to (because of) high stakes testing.*

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4. Association vs. Causation: News Headlines: Same Story

*Lack of insurance **associated with** 45,000 deaths*

*Study: 45,000 **Uninsured Die** a Year*
*Lack of insurance **linked to** 45,000 deaths*
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Association vs. Causation News Headlines: Same Story

*Lack of Health Insurance **Kills** 45,000 a Year*

*One [death] every 12 minutes **due to** no insurance*
*45,000 die ... **because of** lack of health insurance*

*Lack of Health Insurance **cause** 44,789 deaths*
*Lack of insurance to **blame for** 45,000 deaths*

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Conclusions

Students need help in using ordinary English

- to describe quantitative relationships
- to distinguish association from causation
- to distinguish part from whole in percentages
1. Take survey: www.statlit.org/pdf/2017-Schield-Association-Causation-Survey.pdf

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References

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