

# Quantitative Literacy: An Imperative for America

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*Bernie Madison*  
*University of Arkansas*



Computers have made data easy to gather and analyze.  
Data and numbers occur in many areas of daily life.

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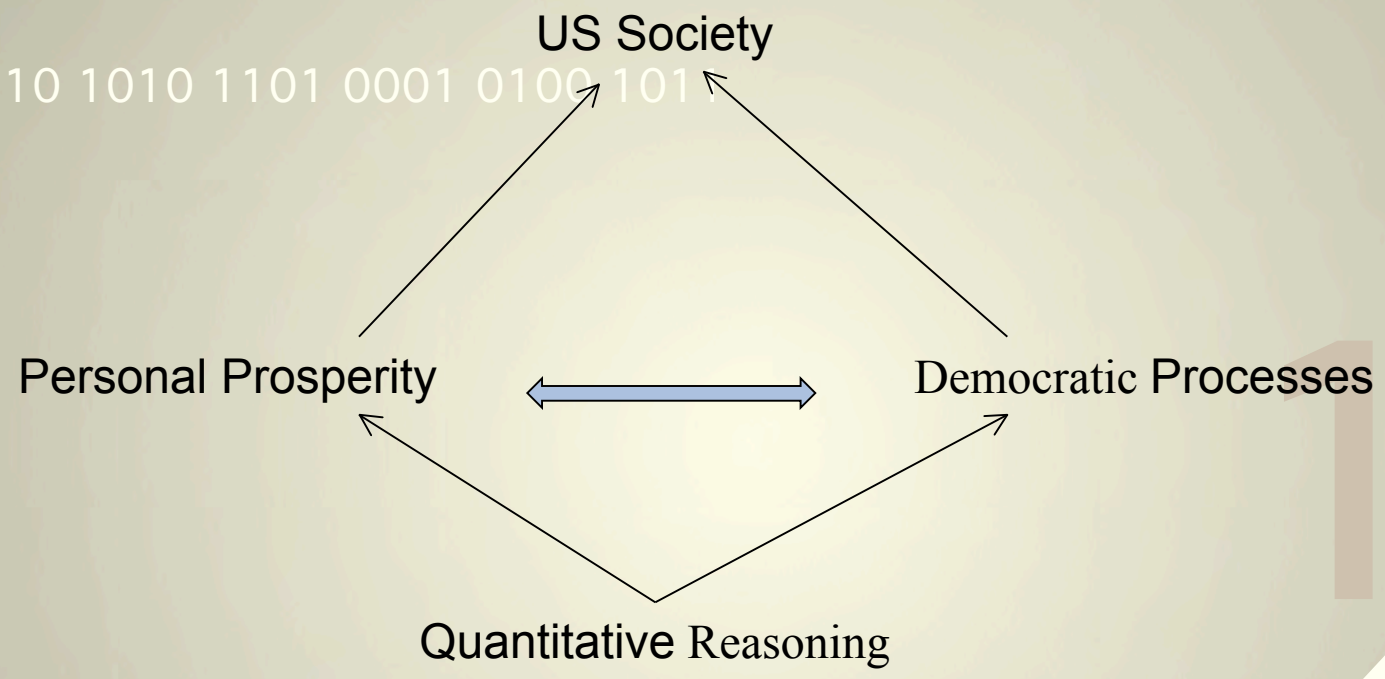
### Individual Decisions

- Health care
- Retirement plans
- Rents and mortgages
- Investing
- Credit rates and plans
- Insurance
- Wages and salaries
- Education results
- Consumer protection
- Sports results

### Decisions as Citizens

- Voting and polling
- Laws - regulation & de-regulation
- Court decisions
- Minority representations
- Taxes
- Federal & state budgets
- Economic policy
- Political debates
- Risk of terrorism
- Election procedures

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# Quantification of US Society

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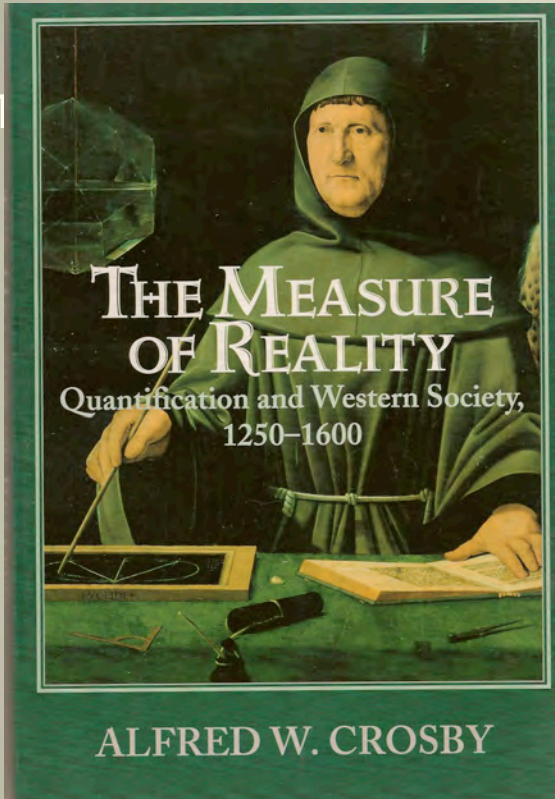
- 1250 – 1550
  - 1550 – 2009
  - 1700 – 1850
  - 1850 – 2009
  - 1950 – 2009
  - 1970 – 2009
- Qualitas to Quantitas  
Risk  
Calculating People  
Deregulation & Re-regulation  
Complete Market  
Computerization

1 2  
4 5

## Quantification of Western Society

*The Measure of Reality* by Alfred W. Crosby  
(1997)

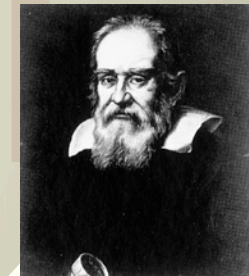
1250 – 1600



St. Thomas Aquinas  
(1225 or 1227 – 1274).

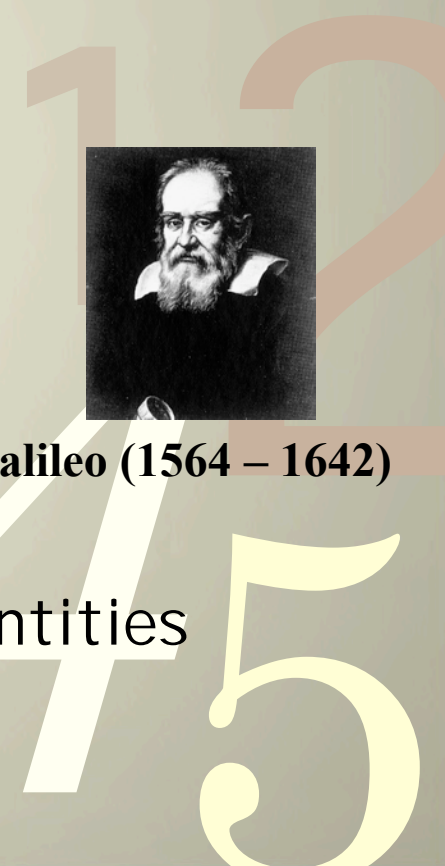
Venerable Model to  
the New Model

to



Galileo (1564 – 1642)

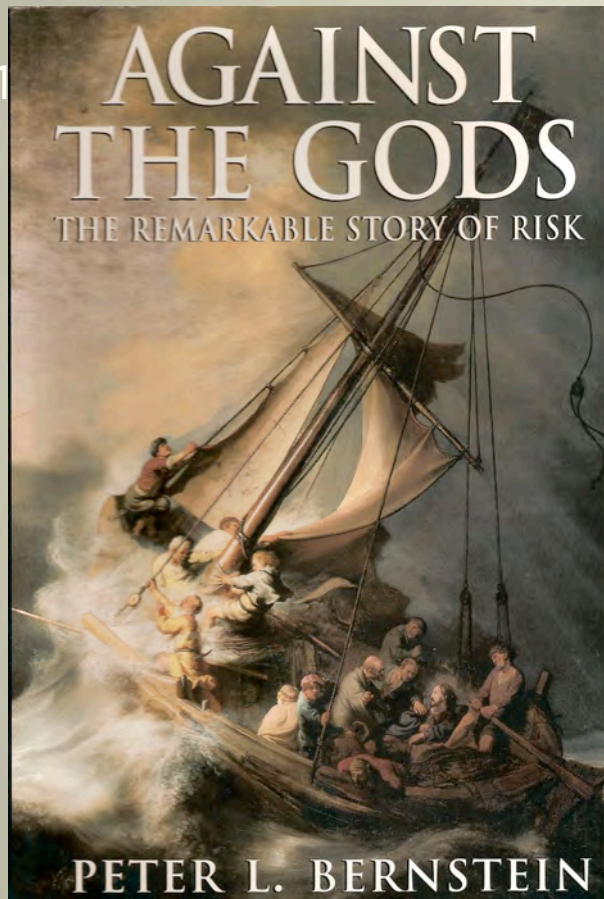
Qualities to Quantities



## Development of Probability

*Against the Gods: The Remarkable Story of Risk* by Peter Bernstein (1996)

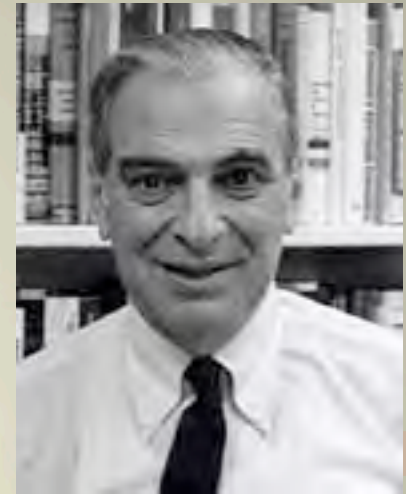
1600 – 2000



Why did humanity wait the many thousands of years leading up to the Renaissance before breaking down the barriers that stood in the way of measuring and controlling risk? ...

It was a game of chance that inspired Pascal and Fermat's revolutionary breakthrough into the laws of probability, not some profound question about the nature of capitalism or visions of the future

The ultimate extension of a seemingly  
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trivial pursuit



In 1953, economic Nobel laureate Kenneth Arrow used tools of quantification to articulate a world in which every potential outcome would have a predictable price tag. This idealized "complete market" is a direct albeit distant descendent of the nobleman's unfinished games of chance.



*A Calculating People: The Spread of Numeracy in Early America* by Patricia Cline Cohen (1982)

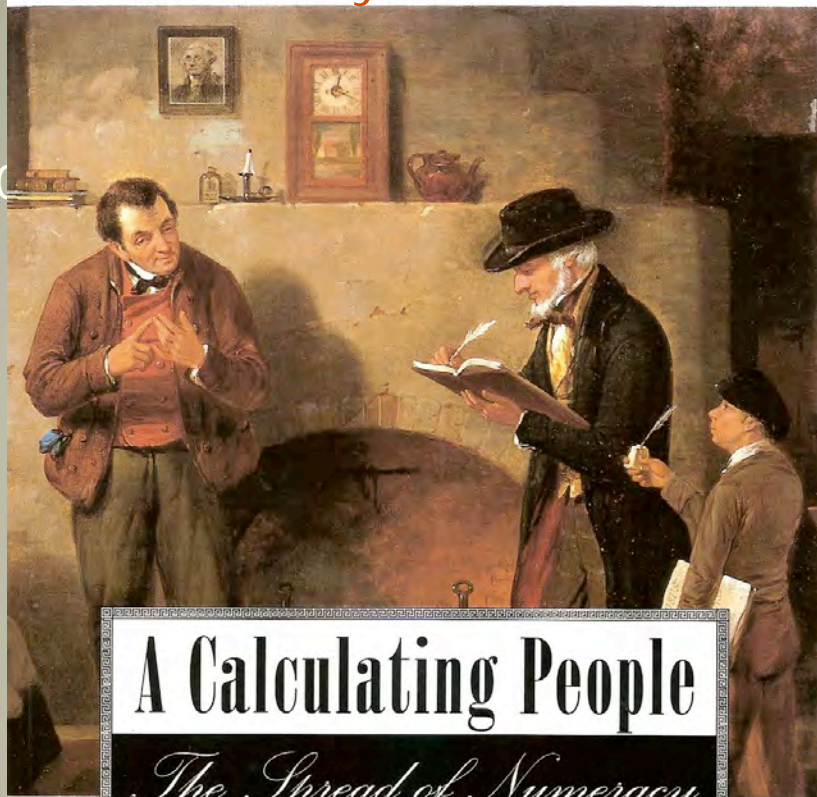
1600 - 1850

*Arithmetic, I presume, comes by instinct among this guessing, reckoning, expecting, and calculating people.*

Thomas Hamilton, 1830

*Unceasingly they weighed risks, computed advantages, and gauged the utility of any particular course of action ... Their minds were accustomed to definite calculations.*

Alexis de Tocqueville, 1830



**A Calculating People**

*The Spread of Numeracy  
in Early America*

BY THE AUTHOR OF THE MURDER OF HELEN JEWETT

*Patricia Cline Cohen*

45



# Fueling US demands for QL

- Apportionment

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- Census

- Competitive & comparative

- Individual freedoms

- Demands of a democracy

- Free markets

- Agile economy

- Minimal economic safety nets

- Deregulation

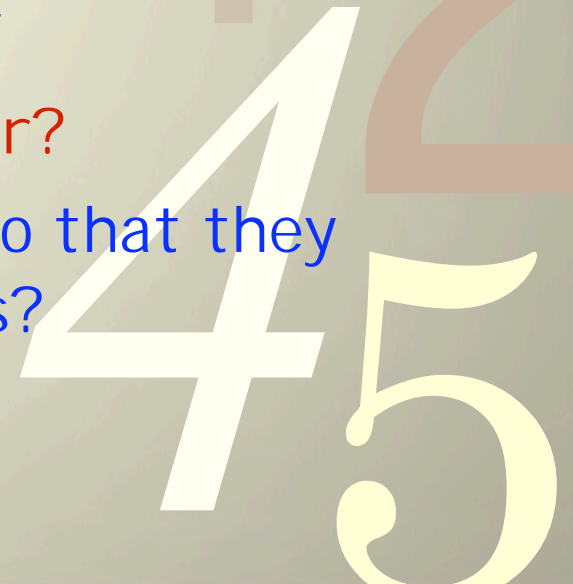
- Privatization



# Mismatch between a quantified society and an innumerate population...

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- Matthew Arnold, English poet and cultural critic, 1884 lament about America's more is better culture.
- As Bob Orrill put this in his Wingspread essay on QL, "In plain speech, Arnold means that all this talk of abundance is tiresome stuff."
- Has *qualitas* to *quantitas* gone too far?
- If not, can we educate our citizens so that they can understand these quantifications?



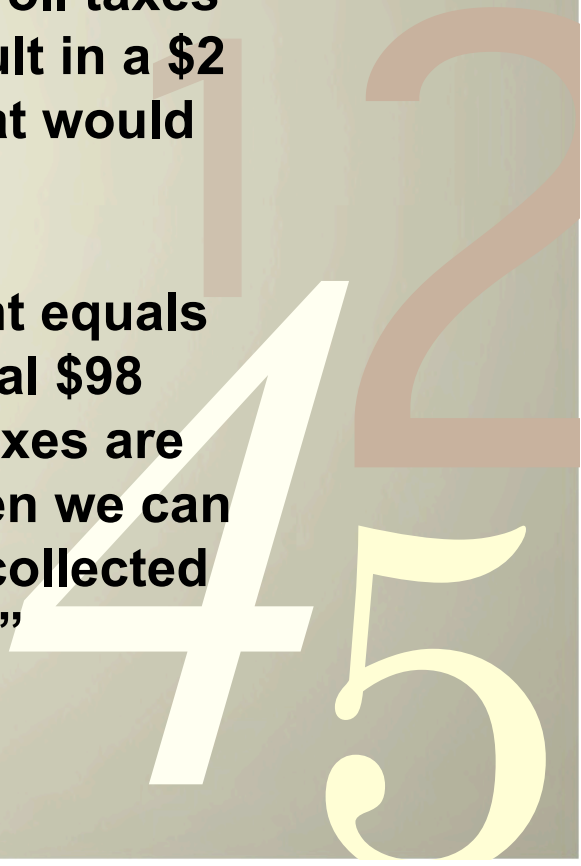
From a letter to the editor,  
*Arkansas Democrat Gazette* 18 March 2005

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...

**“The Democrats tell us that we cannot afford to allow younger workers to put 2 percent of their payroll taxes into private accounts because that would result in a \$2 trillion shortfall of the Social Security fund that would wreck the system.**

**Does anyone actually believe that? If 2 percent equals \$2 trillion, then the other 98 percent must equal \$98 trillion. And let’s see, since Social Security taxes are about 20 percent of a worker’s tax burden, then we can assume that 100 percent of the federal taxes collected each year must be around \$500 trillion. Wow!”**

...



# These are different

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- 40% to 60% is an increase of 20%
- 40% to 60% is an increase of 50%
- Percentage of women in the labor force with a child under 1 year of age
- Percentage of mothers of children under 1 year of age who are in the labor force

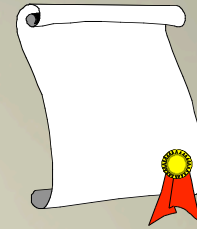
Literacy has two very different meanings  
and this difference creates problems for  
QL education.

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- 1) Literacy is often viewed as minimum competency as in “He is barely literate.”
- 2) Literacy is sometimes viewed as a high level of learning as in literati, or the educated class or intelligentsia.



## Two Kinds of Literacy

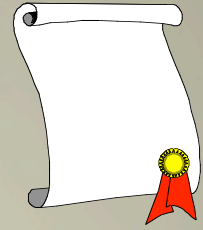


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- Inert - Level of verbal and numerate skills required to comprehend instructions, perform routine procedures, and complete tasks in a routine manner.
- Liberating - Command of both the enabling skills needed to search out information and power of mind necessary to critique it, reflect upon it, and apply it in making decisions.

Lawrence A. Cremins, *American Education: The Metropolitan Experience 1876-1980*. New York: Harper & Row, 1988. (as quoted by R. Orrill in M&D)

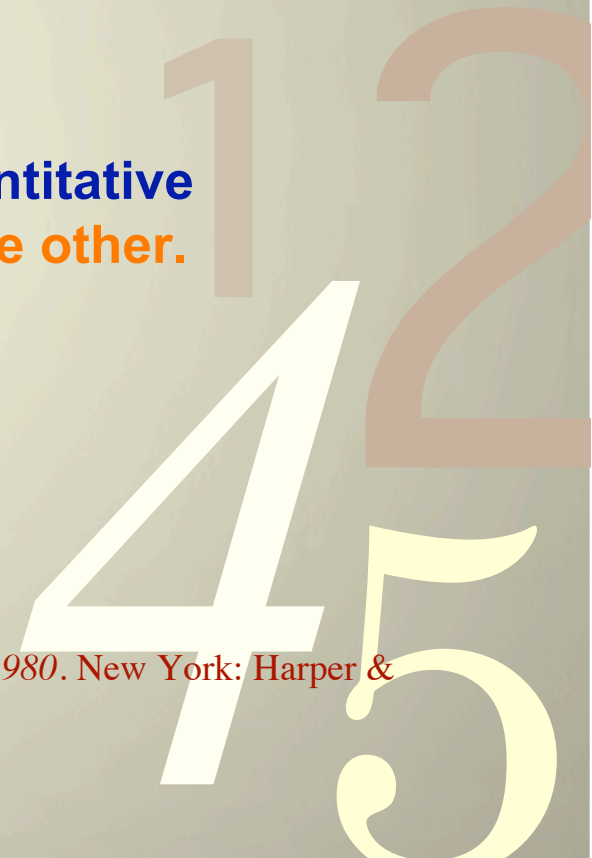
# QL or Numeracy



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- QL or numeracy is the power and habit of mind to search out quantitative information, critique it, reflect upon it, and apply it in their public, personal and professional lives. (NNN in Crimen's words)
- **QL is a cultural field where language and quantitative constructs merge and are no longer one or the other.** (Robert Orrill)

Lawrence A. Cremins, *American Education: The Metropolitan Experience 1876-1980*. New York: Harper & Row, 1988. (as quoted by R. Orrill in M&D)



## Evolution of QL (AKA Numeracy)

- 1959-1982: Formative phase

0011 0010-1 simple arithmetic skills normally acquired in childhood

- 1982- late 1990s: Mathematical phase

- ability to use mathematics in everyday life and to understand and appreciate information presented in mathematical terms

- 1990s to present: Integrative phase

- the power and habit of mind to search out quantitative information, critique it, reflect upon it, and apply it in public, personal and professional lives (NNN vision)
- cultural field where language and quantitative constructs merge and are no longer one or the other (Bob Orrill)

The three phase model is from Maguire, T. & O'Donoghue, J. (2002). A Grounded Approach to Practitioner Training in Ireland.



# Mathematics vs. QL

## 0011 0010 1010 1011 0001 0100 1011 Mathematics

- Power in abstraction
- Power in generality
- Some context dependency
- Society independent
- Apolitical
- Methods & algorithms
- Well-defined problems
- Approximation
- Heavily disciplinary
- Problem solutions
- Few opportunities to practice
- Predictable

## QL

- Real, metamorphic contexts
- Specific, particular
- Heavy context dependency
- Society dependent
- Political
- Ad hoc methods
- Ill-defined problems
- Estimation is critical
- Interdisciplinary
- Problem descriptions
- Many practice opportunities
- Unpredictable

# Relatives of QL

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- Mathematical literacy
- Numeracy
- Symbol literacy
- Document literacy
- Financial literacy
- Statistical literacy
- Quantitative reasoning
- Critical reasoning
- Analytical reasoning
- Scientific literacy
- Symbol literacy
- Technical literacy
- Ethnomathematics
- Functional mathematics

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## Has education responded?

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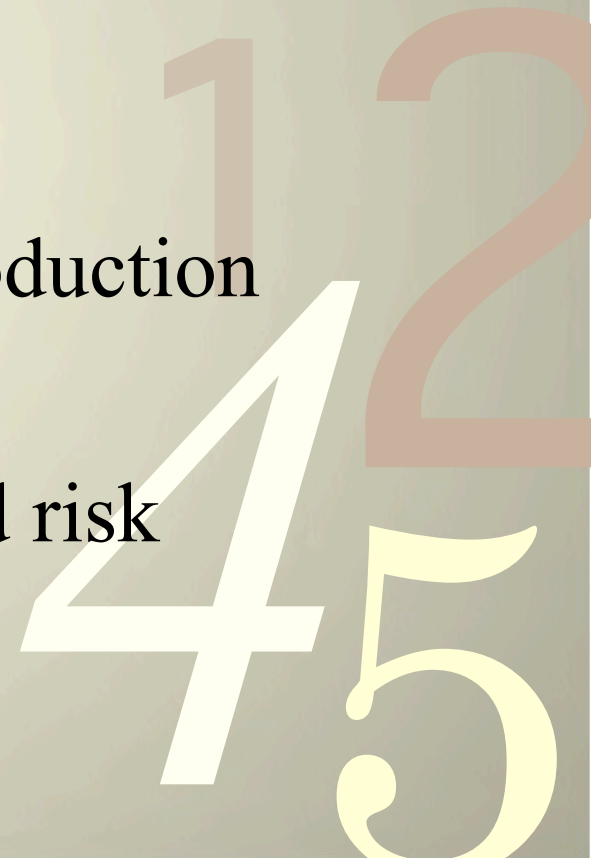
- Adapted to society that swims in information?
- Teach reasoning or facts and methods?
- Have synergism across our disciplines?
- Perform or guide?
- Teach our subjects the way they were developed?
- Do students know why they should learn?



# Mathematical reasoning

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- Numbers and quantities
- Percent and percent change
- Linear and exponential growth
- Graphical interpretation and production
- Measurement and indices
- Counting, probability, odds, and risk



# Learning Goals

- Recognize the importance of units

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- Recognize uses mis-uses of numbers and quantities
- Interpret large (or small) quantities in personally meaningful terms (Units)
- Compute on the fly - estimate and approximate
- Compare quantities

1 2  
4 5

More/less than

How much more/less  
than

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Ratios:

Percent

Percent more/less

Times

Times more/less ???

Comparing quantities  
should make sense ...



1 2  
4 5

# Canonical problem situation

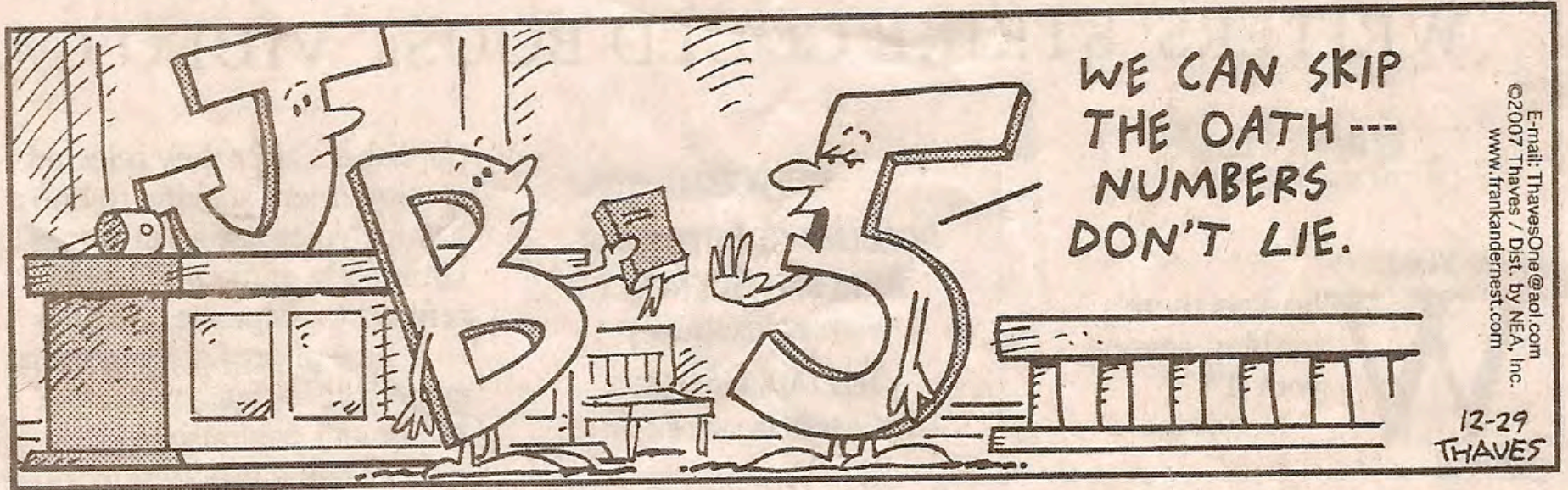
- Have confidence to take up the challenge.

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- Glean out the relevant information.
- Estimate to see if assertions are reasonable.
- Model with mathematics or statistics.
- Do the mathematics or statistics
- Reflect on the results.



Frank & Ernest



WE CAN SKIP  
THE OATH ---  
NUMBERS  
DON'T LIE.

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12-29  
THAVES

45



## NIGERIA

**\$5 million**

Estimated worth of the new President of Nigeria, Umaru Yar'Adua. Most of his wealth was inherited. He publicly declared his assets, an unusual move, in an effort to increase transparency

**70 million**

Estimated number of Nigerians who live on less than \$1 a day

Sources: BBC (2); *USA Today* (2); BBC; Portelligent; BBC; Reuters

TIME July 16, 2007

We are invited to compare a wealthy ruler with the poverty of the ruled...

# Context matters!

## HISTORY

### The Legacy of Little Rock. Even after 50 years, most U.S. schools are still racially separate and too often unequal

BY JUAN WILLIAMS

THE 50TH ANNIVERSARY OF THE LITTLE Rock school crisis is a powerful lesson in the complicated calculus of social change. People on all sides of the civil rights issues in 1957 were shocked by the sight of white mobs and the Arkansas National Guard, under orders from Governor Orval Faubus, blocking nine black children from entering the city's Central High School. When President Dwight Eisenhower sent in the 101st Airborne to protect the students, some feared this and other efforts to desegregate the nation's schools might signal the start of a second civil war. But the Governor backed down, and on Sept. 25 the nine became the first blacks to enroll at the high school.

Earlier this year the U.S. Mint issued a silver dollar commemorating the event, and throughout the anniversary week there will be other observations marking this turning point in U.S. history. But the joy will be somewhat muted, for American schools are still nearly as segregated as they were 50 years ago. Almost three-quarters of African-American students are currently in schools that are more than 50% black and Latino, while the average white student goes to a school that is 80% white, according to a 2001 study by the National Center for Education Statistics. Similarly, a 2003 study by the Civil Rights Project at Harvard found that 27 of the nation's largest urban school districts are "overwhelmingly" black and Latino, and segregated. The percentage of white students going to school with black students is "lower in 2000 than it was in 1970 before busing for racial balance began," the report said.

And public education in the U.S. is not only separate, it is often unequal. In 2005 the *New York Times* reported that the average black or Latino student graduating from high school "can read and do arithmetic only as well as the average eighth-grade white student." At the same time, on average, white elementary-school-age children go to schools in which about a third

of the students qualify for free or low-cost lunches, while the typical black or Latino grade-schooler attends one in which two-thirds of children are in the reduced-price lunch program.

The clear evil of racism explained the gaps in opportunities and achievement between black and white children back in 1957. But that kind of open malice is harder



Uncivil A mob taunted Elizabeth Eckford on her way to Central High in 1957

to find today, and the reasons for current discrepancies are more complicated and more challenging. At the time of Little Rock, no one could foresee that Hispanics would become the nation's largest minority and perhaps its most segregated group, but both are true today. It is also true that white flight and now the exodus of middle-class black families fleeing to the suburbs to escape crime have continued to take good students and active parents away from city

**89%**

Percentage of white students who attend schools that are more than 50% white

**72%**

Percentage of black students who attend schools that are more than 50% minority

Source: 2001 study by the National Center for Education Statistics

schools. But an even larger factor in early 21st century America is the declining number of school-age white children and increasing number of school-age minorities. Such demographic shifts are making it even more difficult to integrate American schools by race or class.

These realities have become an issue in recent court decisions. Judges point to high levels of residential segregation as the root cause of school segregation and question the wisdom of using children and schools to remedy adults' preferences for isolating themselves by income and race. This year the Supreme Court ruled that voluntary school-integration plans in Seattle and Louisville, Ky., violated the rights of students to

be judged on individual merit even if the ruling means that many schools remain segregated by race and class. It was a sad decision, acknowledging the defeat of the ideals and aspirations of Little Rock and the 1954 *Brown v. Board of Education* decision that made segregation illegal. But it should also be hailed for acknowledging new realities: first, even as we celebrate what happened 50 years ago in the glory days of the civil rights movement, the political will to integrate schools in this country is long gone. So, too, is the desire to fix every economic inequity before delivering quality education to all children.

But there is hope. Fifty years after critics charged one Republican President with risking civil war by sending federal troops into a Southern city to enforce integration, a Republican President is taking on the problem of underperforming big-city schools and what he calls the "bigotry of low expectations." George W. Bush is seeking renewal of the No Child Left Behind law, which holds schools accountable for teaching every student and narrowing the achievement gap regardless of a child's color, income or family background. Despite its shortcomings, like training students how to pass standardized tests instead of instructing them to think critically, the President's plan is worthy simply for insisting that all children can learn. Fifty years after U.S. troops had to escort nine black children to school in Little Rock, the issue is still how to take race out of the equation when it comes to educating every American child.

Williams is a senior correspondent for NPR, an analyst for Fox News and the author of *Enough*

**89%**

Percentage of white students who attend schools that are more than 50% white

**72%**

Percentage of black students who attend schools that are more than 50% minority

Source: 2001 study by the National Center for Education Statistics

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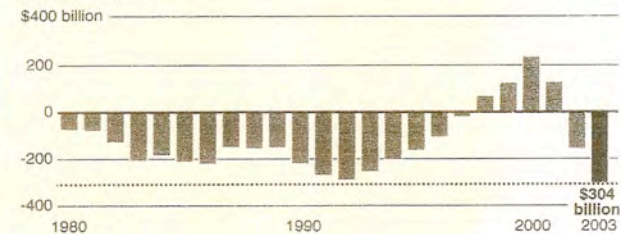
# GOP Disputes

## Vying To Set Deficit Record Straight

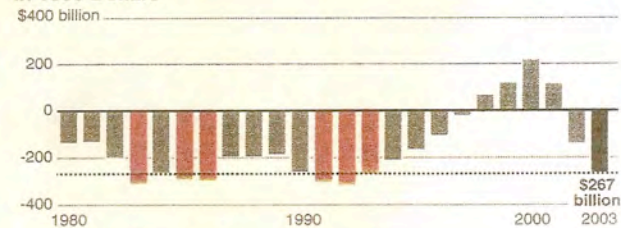
The \$304 trillion budget deficit projected by the Bush administration for 2003 would be the largest ever. But Republicans are quick to point out the deficit would not be a record when adjusted for inflation or represented as a percentage of the gross domestic product.

### Federal Budget Surpluses And Deficits

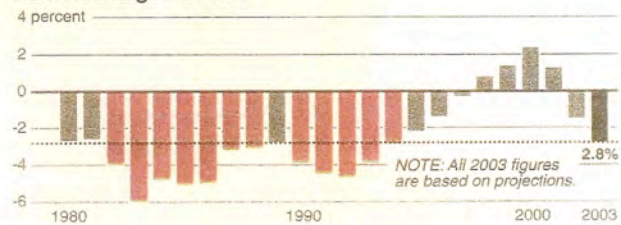
#### In Real Dollars



#### In 1996 Dollars



#### As Percentages Of GDP



NOTE: All 2003 figures are based on projections.

SOURCE: Office of Management and Budget

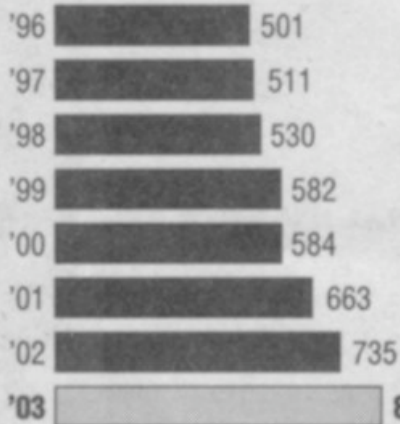
AP

## Is the glass half full . . .

Conservatives look at the federal government and see an alarming growth in discretionary spending — spending unrelated to mandatory programs such as Social Security and Medicare:

### Discretionary spending

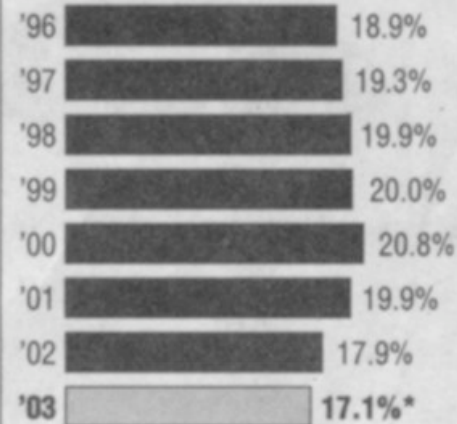
IN BILLIONS OF DOLLARS



Liberals look at the federal government and see an alarming decline in government revenues as a share of gross domestic product — the total value of the goods and services produced in the country.

### Government revenues as a share of GDP

PERCENT CHANGE



\*projected

SOURCES: Heritage Foundation, Center on Budget and Policy Priorities

Are these two views compatible?

Can one determine how much the tax cut is?

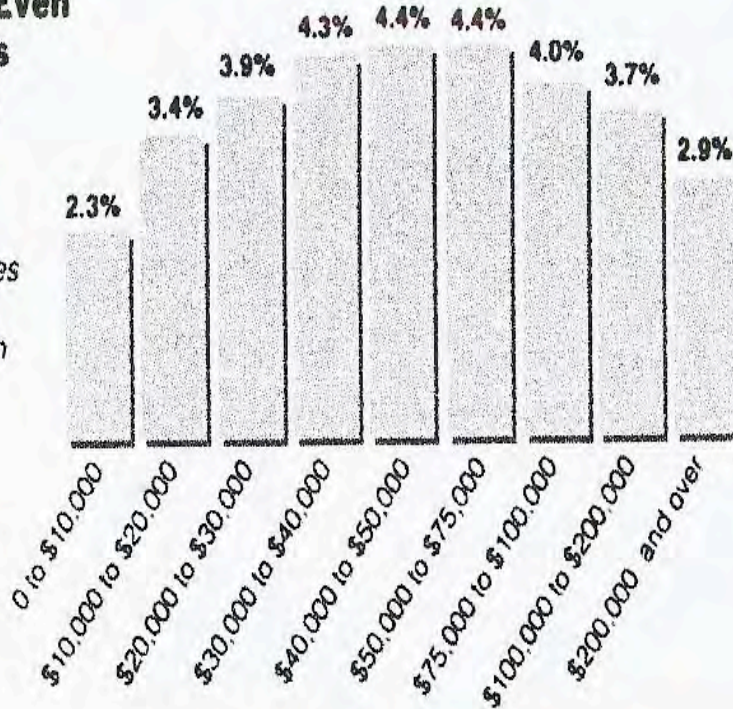
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ON THE OTHER HAND . . .

## Two Views of a Tax Cut

### Republican Math: An Even Cut Across the Board

How much taxes would fall for families in each group

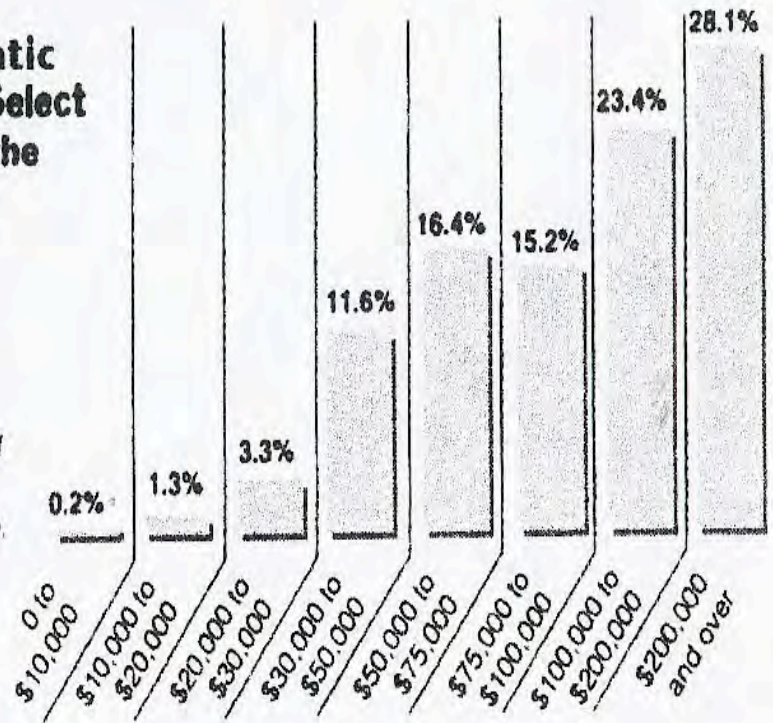


Source House Ways and Means Committee

### Democratic Math: A Select Few Get the Benefits

#### SHARE OF TAX CUTS

Share of tax cuts assigned to each income group



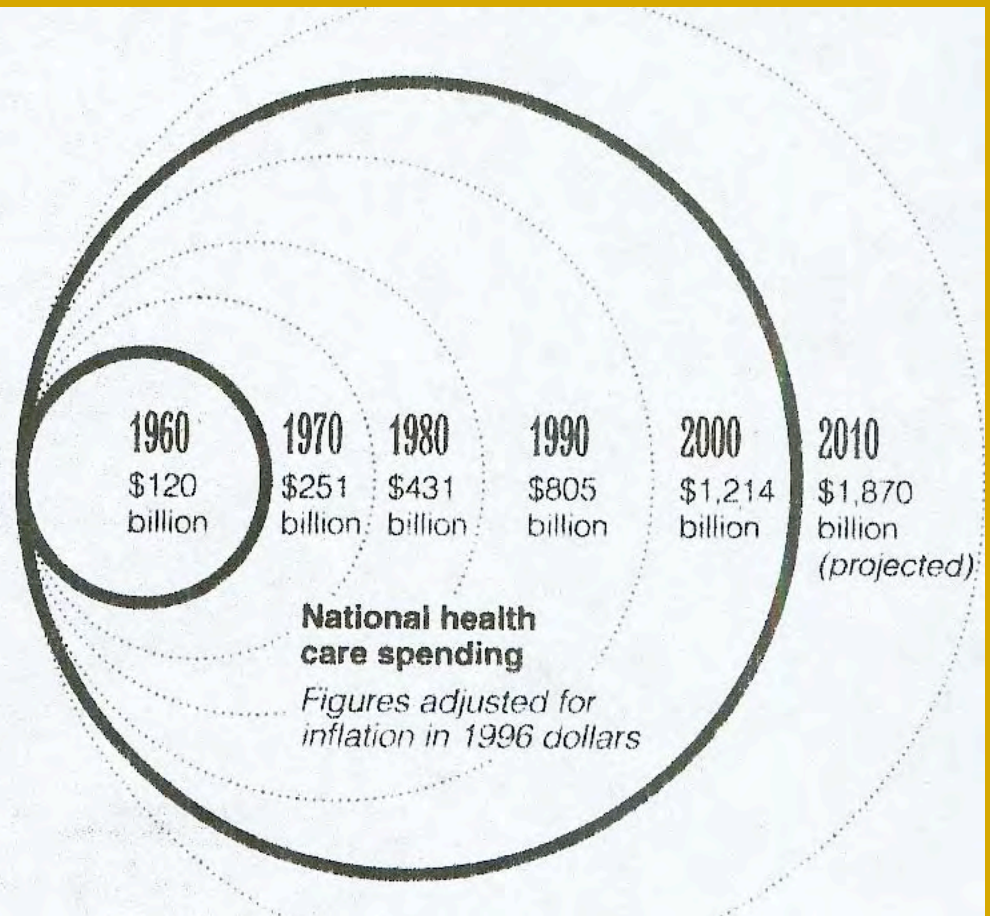
Source: Treasury Dept.

New York Times - August 11, 2002 - page 1  
*Decade After Health Care Crisis,  
Soaring Costs Bring New Strains*

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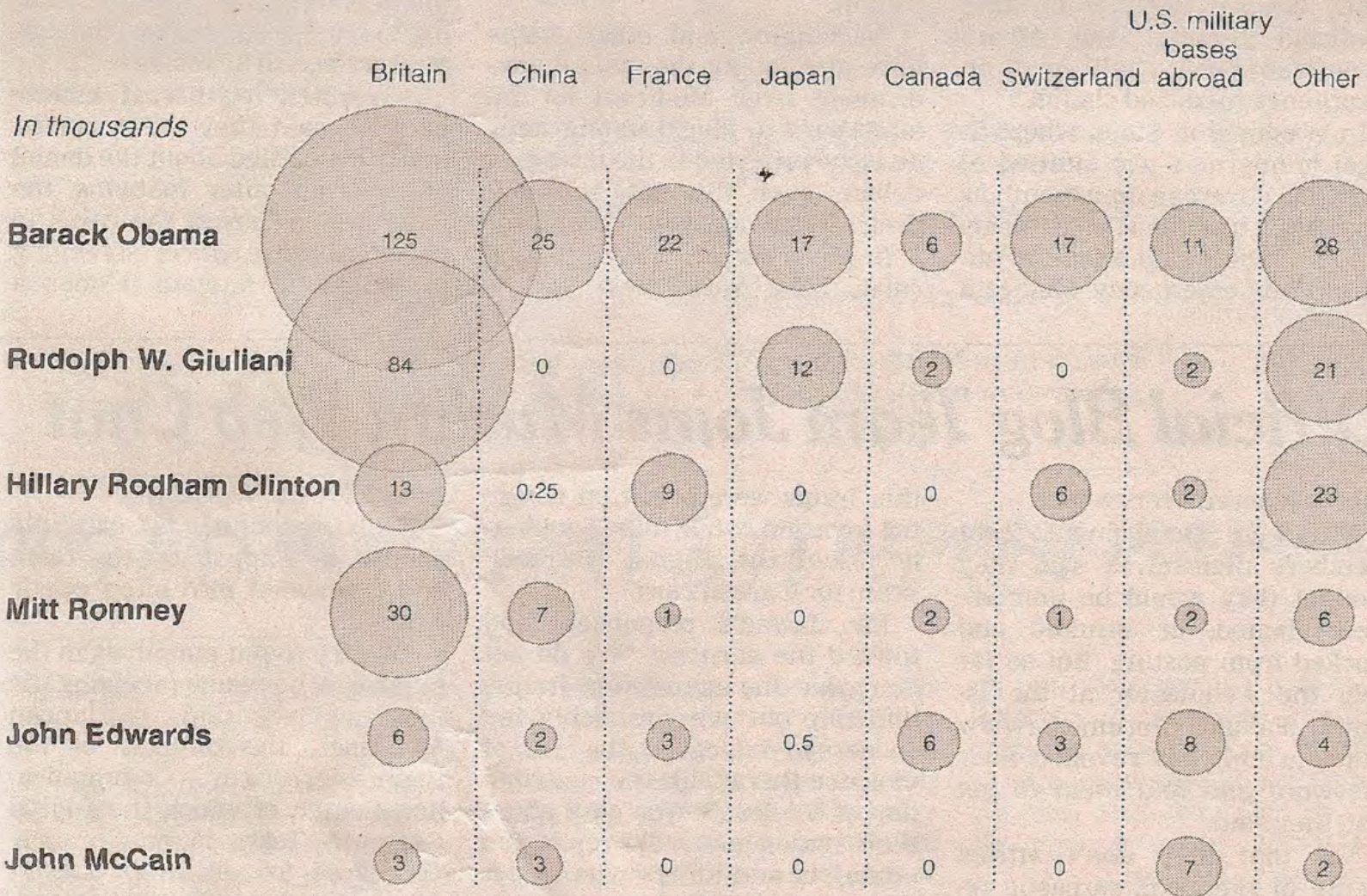
## The Costs Of Health Care, And the Shifts In Coverage

From 1960 to 2000, the United States population increased **57%**. Over the same period, national health care spending increased **909%**.



### Contributions From Abroad

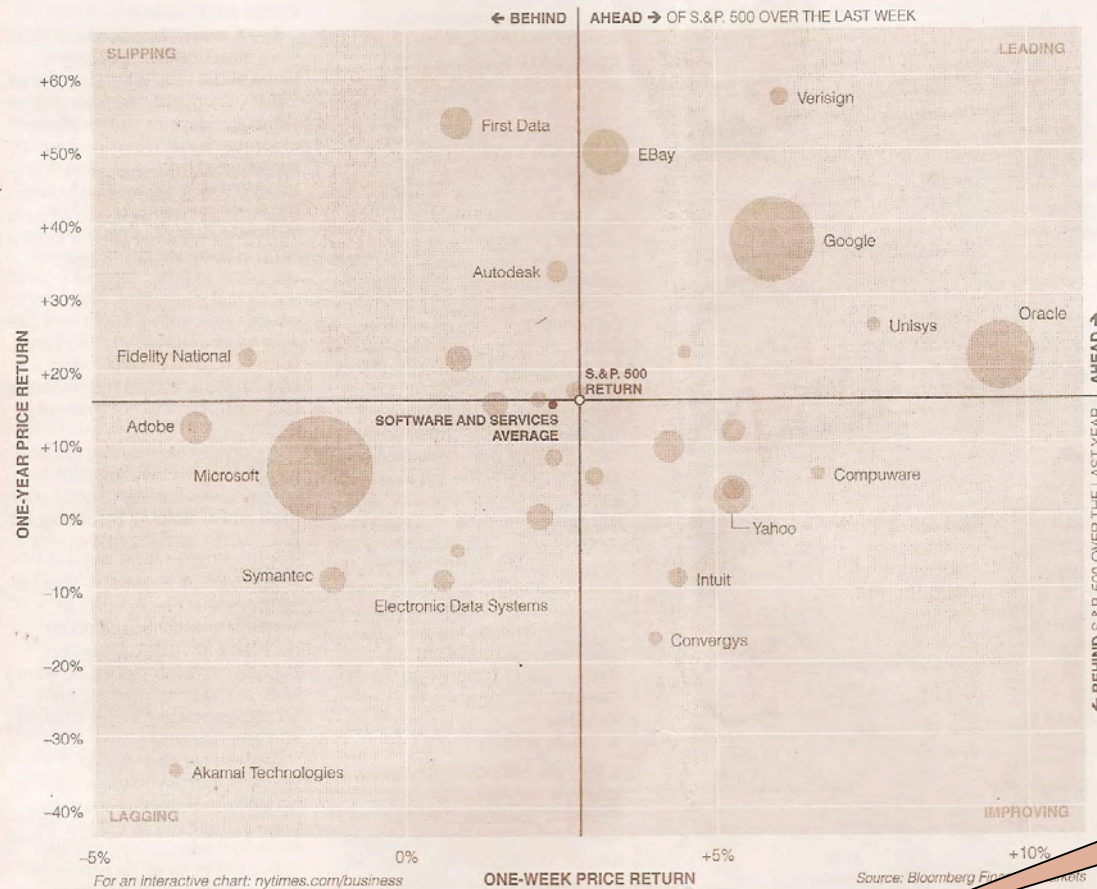
Candidates running in the presidential campaign are increasingly drawing contributions from Americans living overseas.



Source: Federal Election Commission

## MARKET GAUGES

DOW **13,820.19** **+53.49** NASDAQ **2,671.22** **+16.93** 10-YEAR **4.62%** **-0.08** CRUDE **\$81.62** **-\$0.16**  
 TRIALS COMPOSITE TREASURY YIELD OIL



### Category versus the S.&P. 500 over the last year



### How to read the chart

The chart shows how companies in a category performed versus the S.&P. 500 over the last week and year.

Circles are sized according to their current market capitalization in the category index.

Slipping		Leading	
↓ Week	↑ Year	↑ Week	↑ Year
Lagging		Improving	
↓ Week	↓ Year	↑ Week	↓ Year

S.&P. 500 RETURN

Directions

45

## 0 How to read the chart

The chart shows how companies in a category performed versus the S.&P. 500 over the last week and year.

● Circles are sized according to their current market capitalization in the category index.

## PERFORMANCE VS. S.&P. 500





USA Today July 6, 2004

Who says USA Today is written at the 6<sup>th</sup> grade level?

**How to use this chart**

**1 Weekly change (W)**

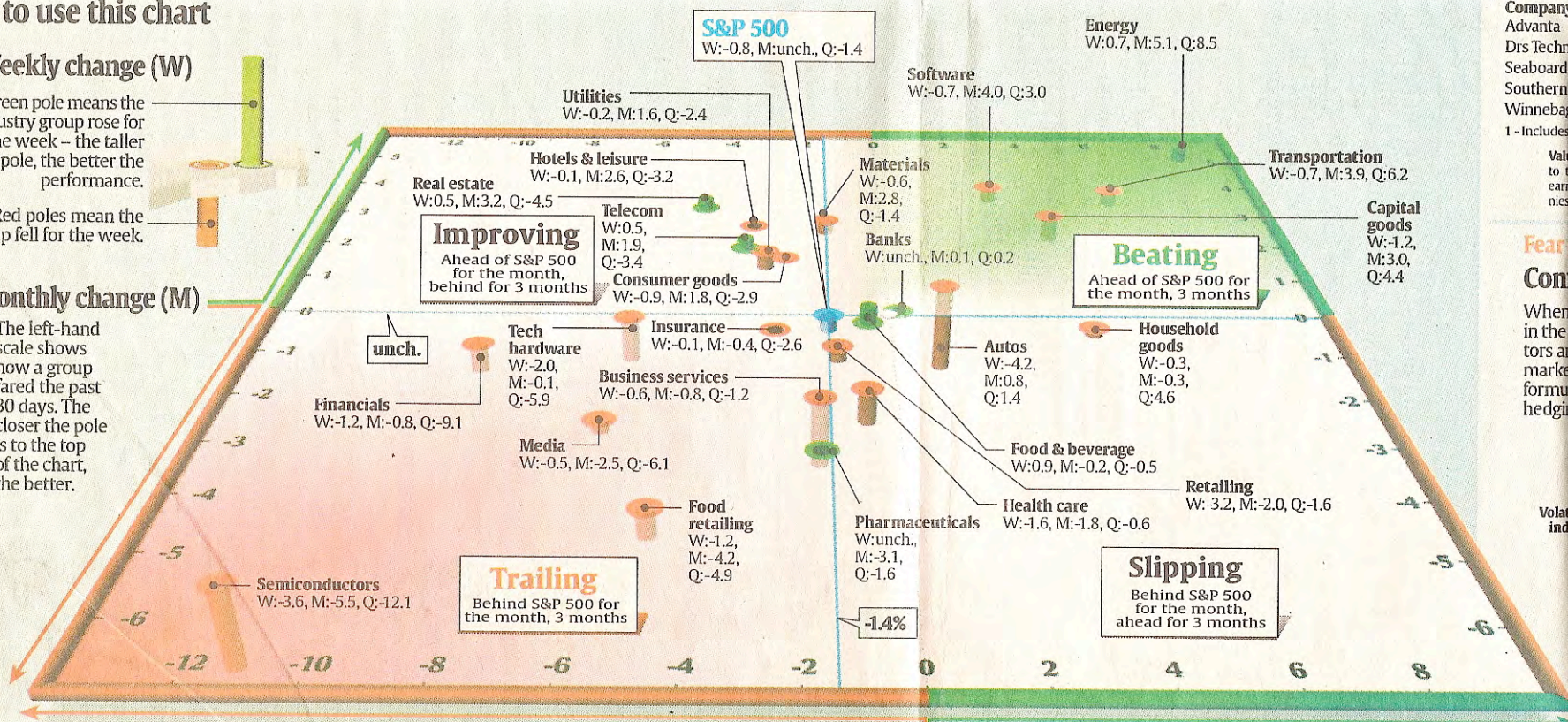
A green pole means the industry group rose for the week – the taller the pole, the better the performance.  
Red poles mean the group fell for the week.

**2 Monthly change (M)**

The left-hand scale shows how a group fared the past 30 days. The closer the pole is to the top of the chart, the better.

**3 Quarterly (3-month) change (Q)**

Use the bottom scale to see how a group did the past 3 months. Poles closest to the chart's right edge have fared best.



Questions about the stock market? Ask USA TODAY's Matt Krantz today at 1 p.m. ET at talk.usatoday.com.

07/06/04

By Jim Sergent and Robert W. Ahrens, USA TODAY

April 23: 14.01  
52-week low

Company  
Advanta  
Drs Techn  
Seaboard  
Southern  
Winnebago  
1 - Includes

Value to the  
earnings

Fear  
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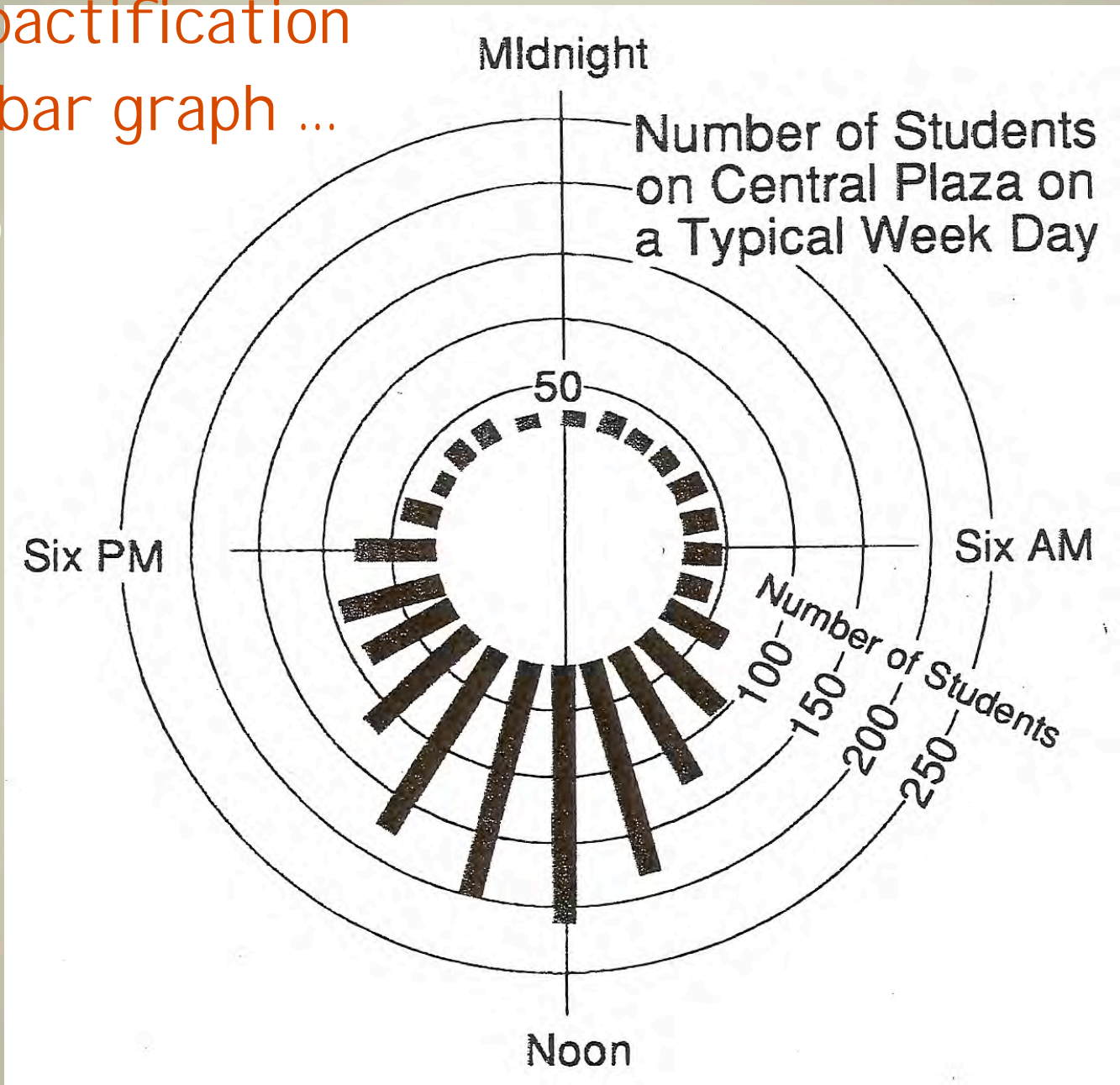
When in the  
gators are  
market  
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hedging

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inde



# Compactification of a bar graph ...

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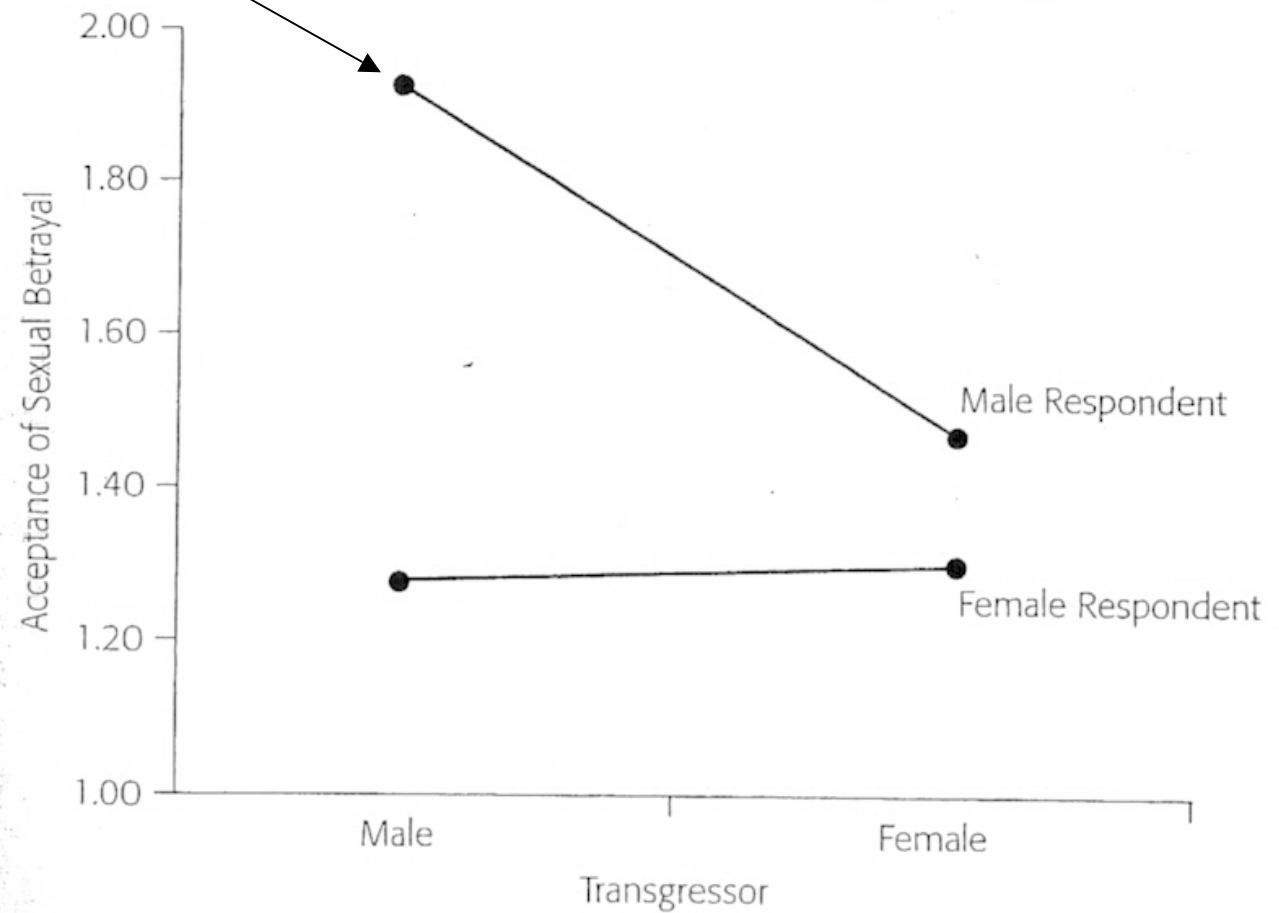


1 - highly unacceptable

2 - unacceptable

3 - acceptable

4 - highly acceptable



**FIGURE 1.4** The Interaction of Sex of Respondent and Sex of Transgressor on the Acceptance of Sexual Betrayal

LOOK AT THIS! MY HOMEWORK PILE IS 21 INCHES HIGH! THAT'S 7 INCHES MORE THAN LAST YEAR - A 50% INCREASE!

WHY DO 100% OF MY TEACHERS GIVE 100% HOMEWORK 100% OF THE TIME? 5 SUBJECTS, AN HOUR EACH = 5 HOURS OF HOMEWORK!

IF I COULD ELIMINATE JUST ONE SUBJECT, I'D HAVE AN EXTRA HOUR

WHAT SUBJECT WOULD YOU ELIMINATE?

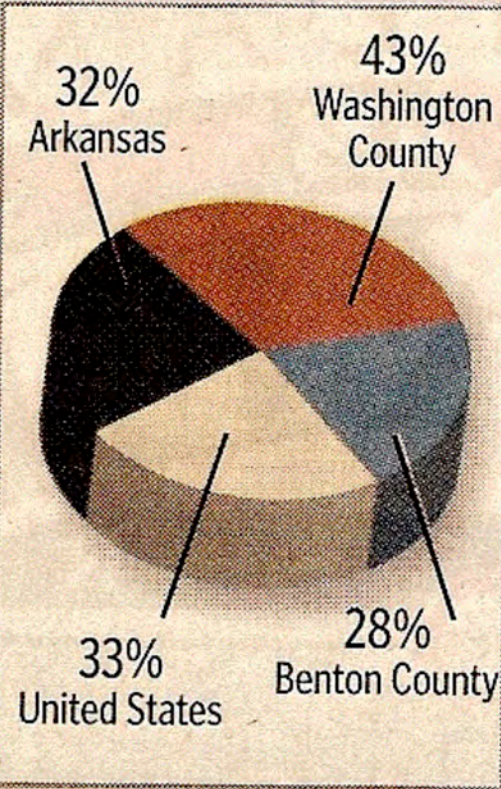
I DUNNO. PROBABLY MATH. WHEN DO I EVER USE THAT?



01/25/09

## Where The Renters Are

More folks rent in Washington County than the state or national average.



Source: U.S. Census Bureau  
MICHELLE OBANA THE MORNING NEWS

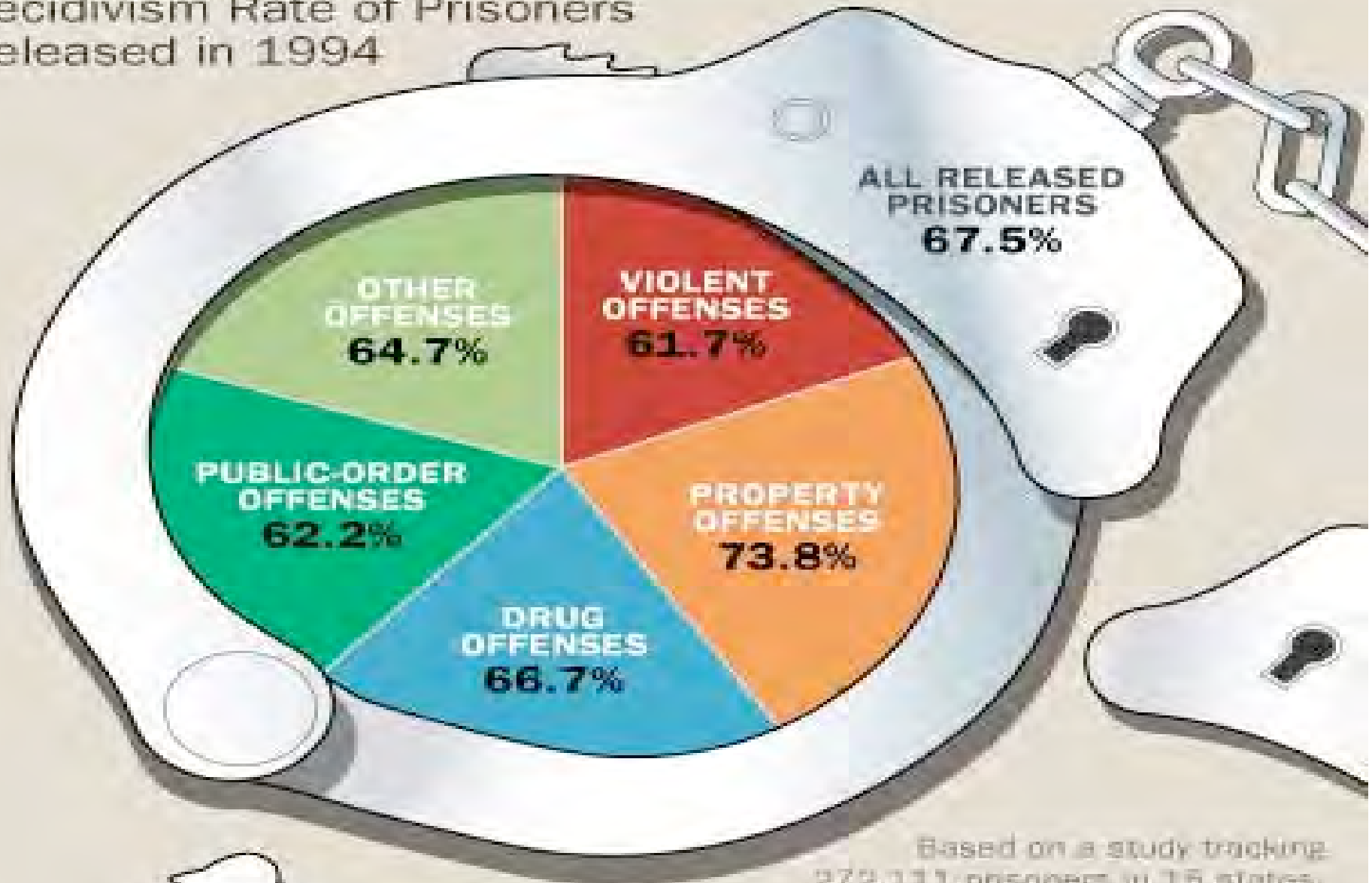
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1 2  
4 5

# How Prison Works

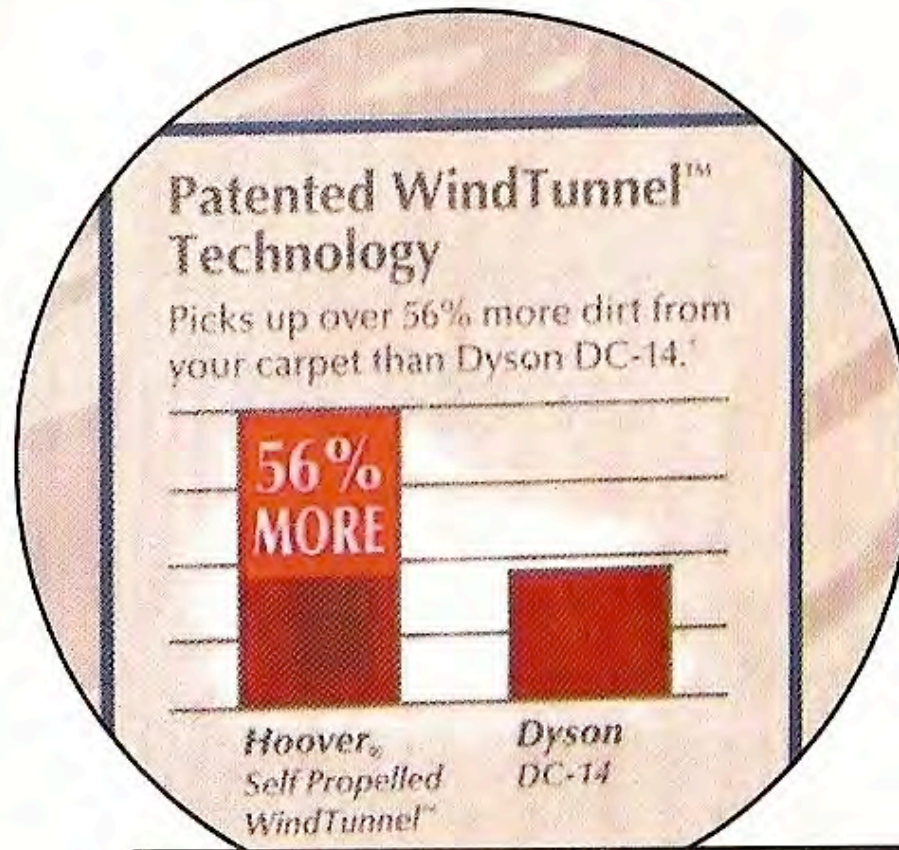
©2007 HowStuffWorks

Recidivism Rate of Prisoners Released in 1994



Based on a study tracking 272,111 prisoners in 16 states.  
Source: U.S. Department of Justice Statistics  
Reentry Trends in the United States

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## Never mind!

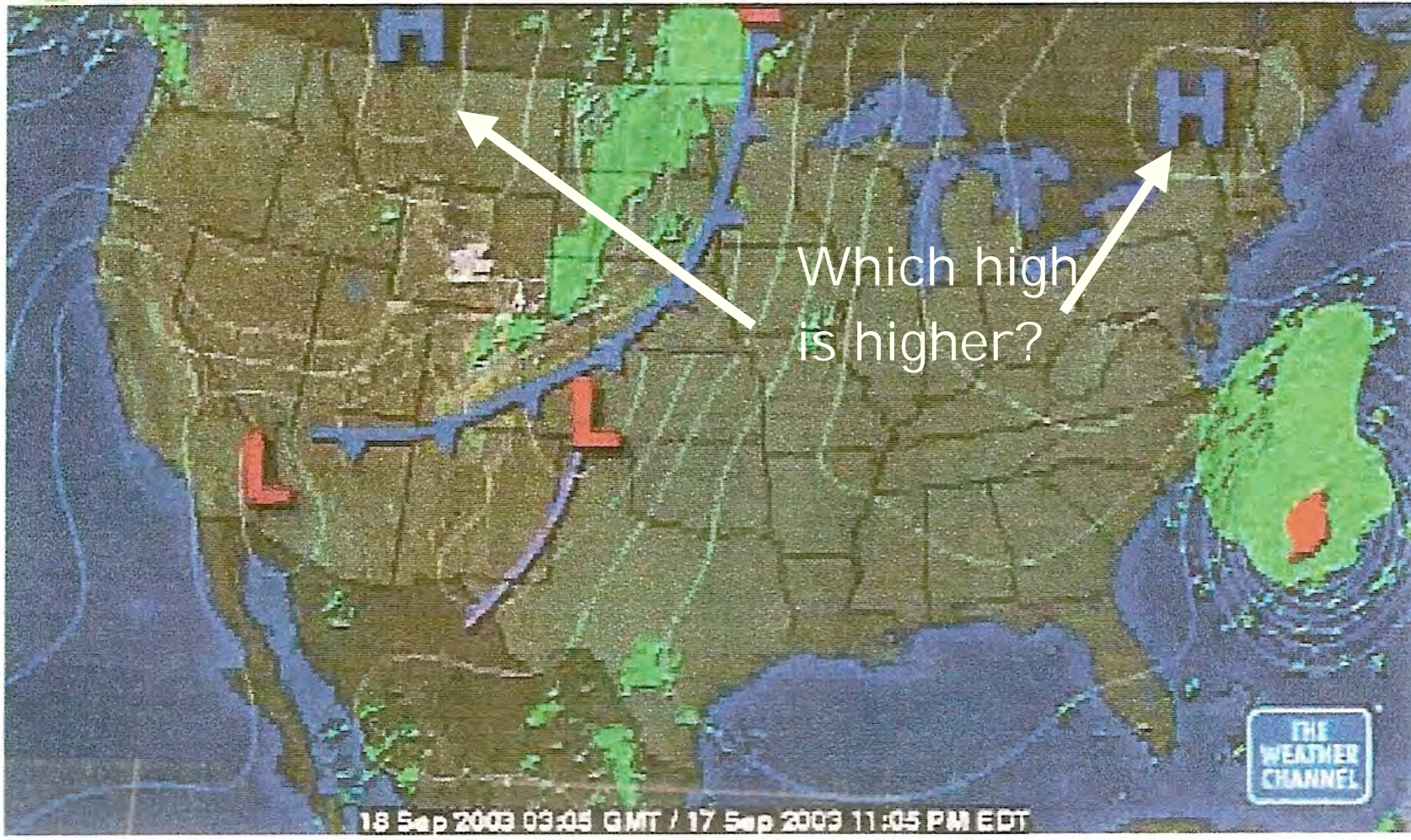
Hoover's claim (including the "56% more" that resembles 100 percent more) is undermined by the message revealed when you follow the asterisk. It says: "The Hoover Cleaning Performance System is for comparing the relative progressive performance of Hoover uprights only and not for comparison with any other brands."



# Current Surface

LT RAIN/DRIZZLE MOD/HVY RAIN RAIN/ICE/SNOW LT SNOW/FLUR MOD/HVY SNOW FOG

0011



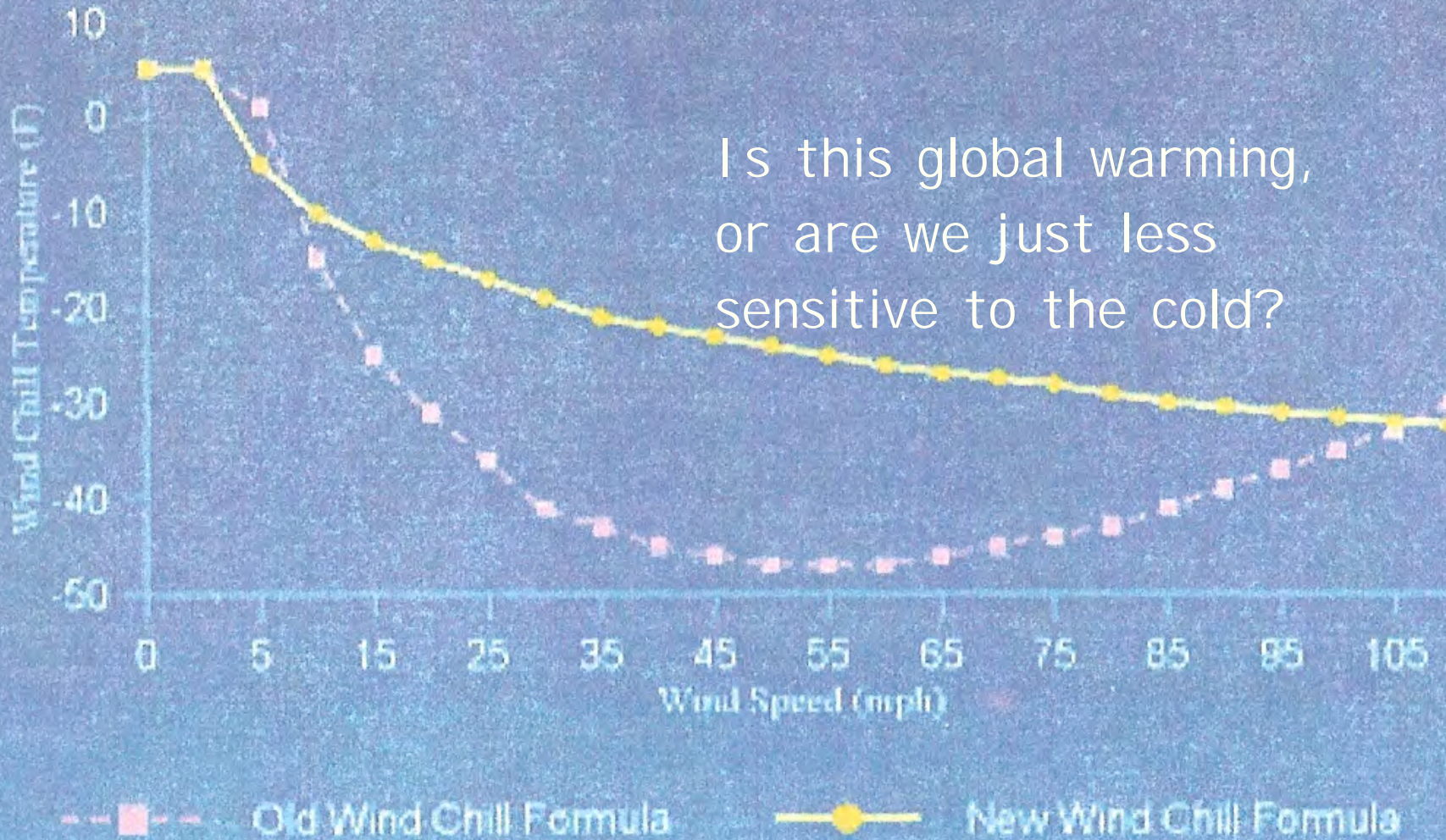
Which high is higher?





# Wind Chill Temperature Comparison (Old vs. New)

Air Temperature of 5°F



# St. Petersburg Times

stpetertimes.com

FLORIDA'S MOST READ PAPER

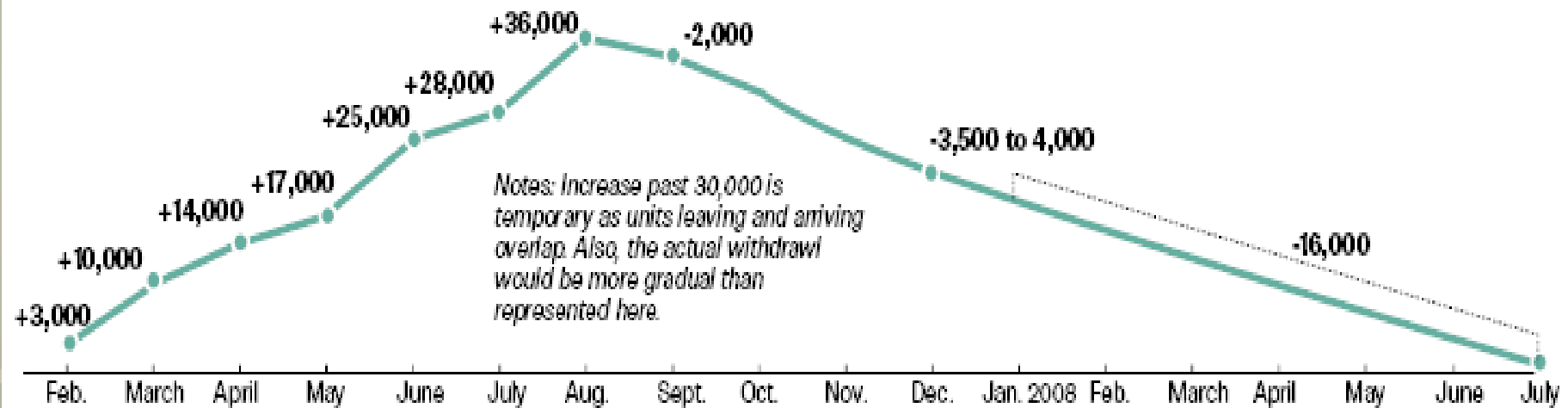
Tuesday, December 9, 2007

0011 0010 1010 1101 0001 01

## General: Same role with fewer troops

### The surge and the draw down

At the end of January, the United States had about 132,000 troops in Iraq. By next July, Gen. David Petraeus said, the extra 30,000 troops sent as part of President Bush's revised strategy would be withdrawn. The combat portion of that force includes five Army brigades, two Marine infantry battalions and the 13th Marine Expeditionary Unit. The buildup also included 8,000 support troops.



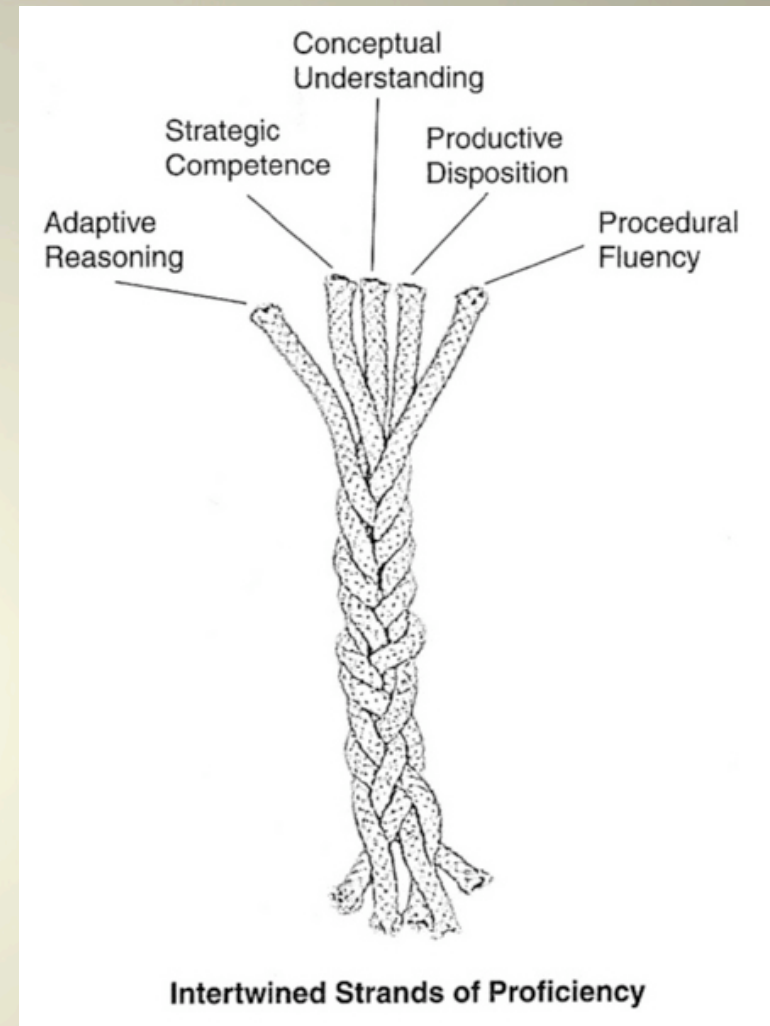
Notes: Increase past 30,000 is temporary as units leaving and arriving overlap. Also, the actual withdrawal would be more gradual than represented here.

Sources: Washington Post; Associated Press

RON BRACKETT | Times

# Mathematical Proficiency from *Adding It Up*

- *conceptual understanding* – comprehension of mathematical concepts, operations and relations
- *procedural fluency* – skill in carrying out procedures flexibly, accurately, efficiently, and appropriately
- *strategic competence* – ability to formulate, represent, and solve mathematical problems
- *adaptive reasoning* – capacity for logical thought, reflection, explanation, and justification
- *productive disposition* – habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one's own efficacy.



Probably most important one for QL

45