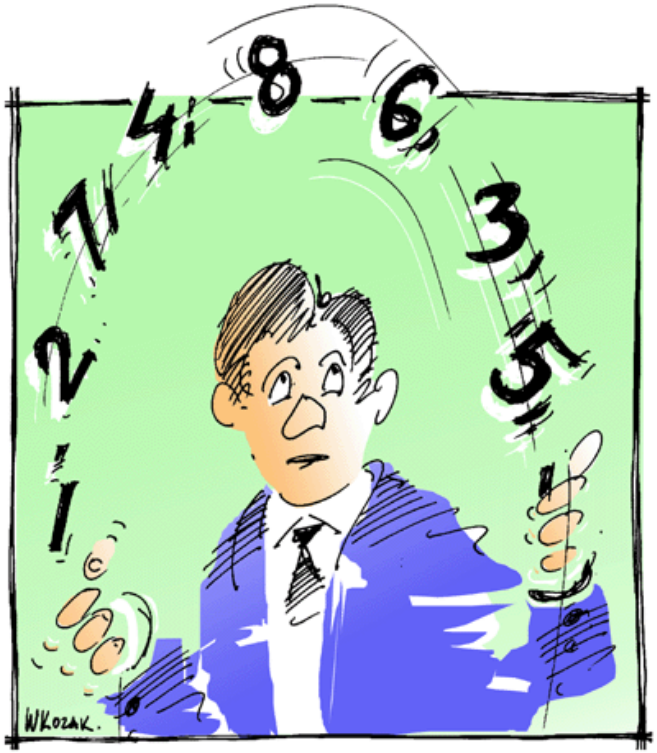
Stats 101 – Analyzing Your Data



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Disclaimer

- Dr. Lucker is a researcher and professor at Howard University and the University is not paying him for this presentation
- Dr. Lucker is in private practice and may receive referrals based on his presentation, but the presentation is not done for the referral sources
- Dr. Lucker will discuss his research as part of the evidence base of his presentation

Overview

- What is Normal and what is NOT normal
  - Values associated with the Bell Curve
- Comparing Test Findings from other Professionals
- What About Children with Cognitive Limitations?
- Measuring Improvements in Therapy
  - Post-Pre therapy comparisons incl. Cohen's d

Basic Statistical Analyses

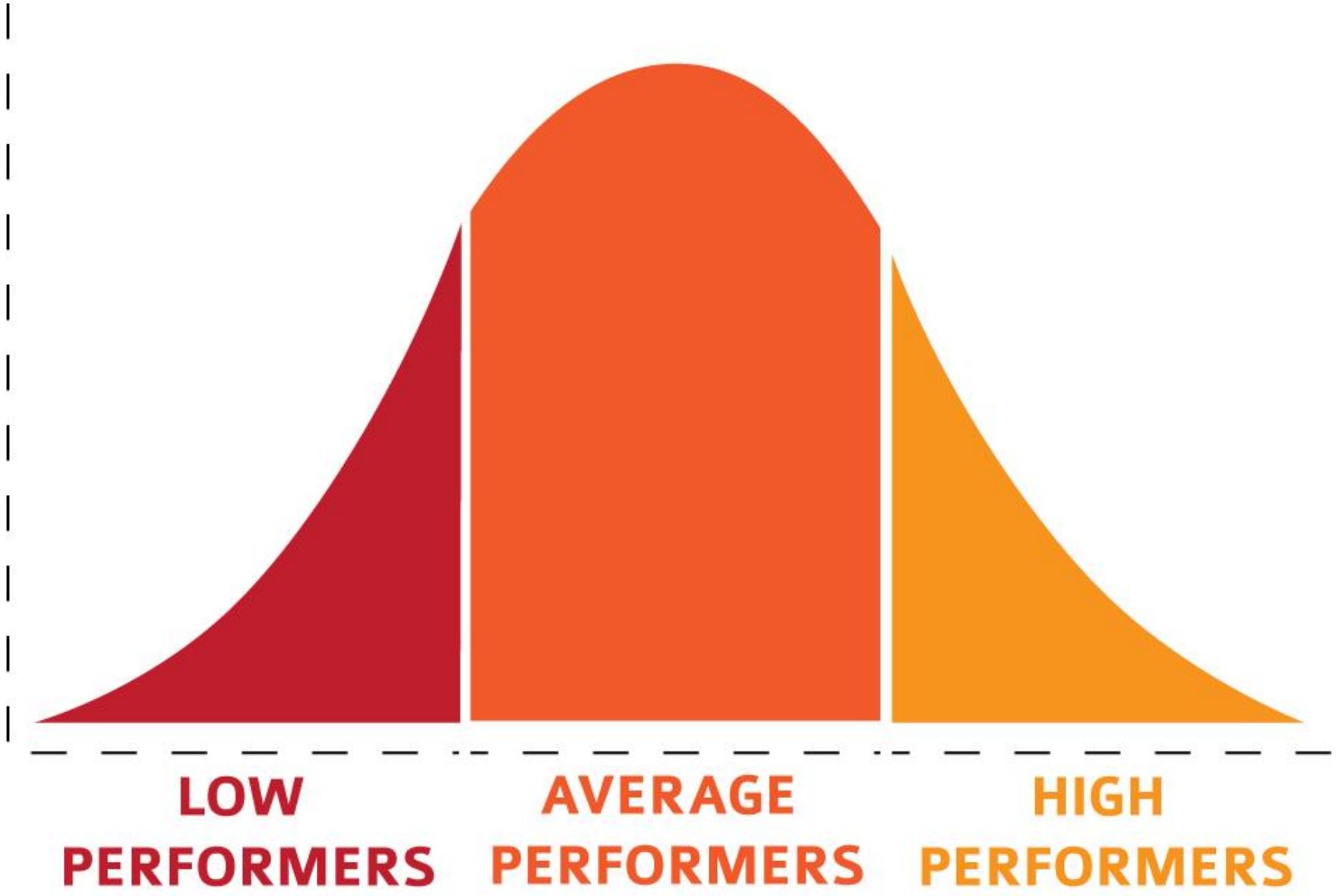
- In any profession, there are two aspects of statistical analyses
  - One is to compare test results with some **normative data** based on some statistical analyses/comparisons
  - Second is to consider doing statistical analyses to look at changes/differences
- We are generally aware of the first factor: comparisons, but what if the scales differ?

Using Norms

- When we test, we compare our client's performance with some set of norms
  - One set is normative data based on **standard scores, scaled scores, percentiles**
  - The other set is **criterion referenced data** which merely identifies a CRITERION level for normal
    - Scores at or above this criterion level are normal
    - Scores below this criterion level at not normal
- Normal is based on the Normal Bell Curve

What Does Normal Mean?

- Scores are typically based on statistics
- People choose different **scales** for different reasons
- The scales DO relate to each other as seen in the next slides
- These norms are based on what is called the **BELL CURVE**


LOW PERFORMERS
AVERAGE PERFORMERS
HIGH PERFORMERS

Statistical Analyses and the Bell Curve

- Researchers (mostly mathematicians) have identified that if we take a group of people, some will be average (normal), some below average (below normal), and some above average (above normal)
- A very small number will be very abnormal while a very small number will be very superior
- Most are average (in the middle) = normal

The Bell Curve and Normal

- Mathematicians identified that “normal” is based on the middle score (called the median score)
- Half the people are above this level and half the people are below this level
- Thus, the mid-point or median is the 50th percentile
- This was identified as the 0 level (Z=0)

The Normal Distribution

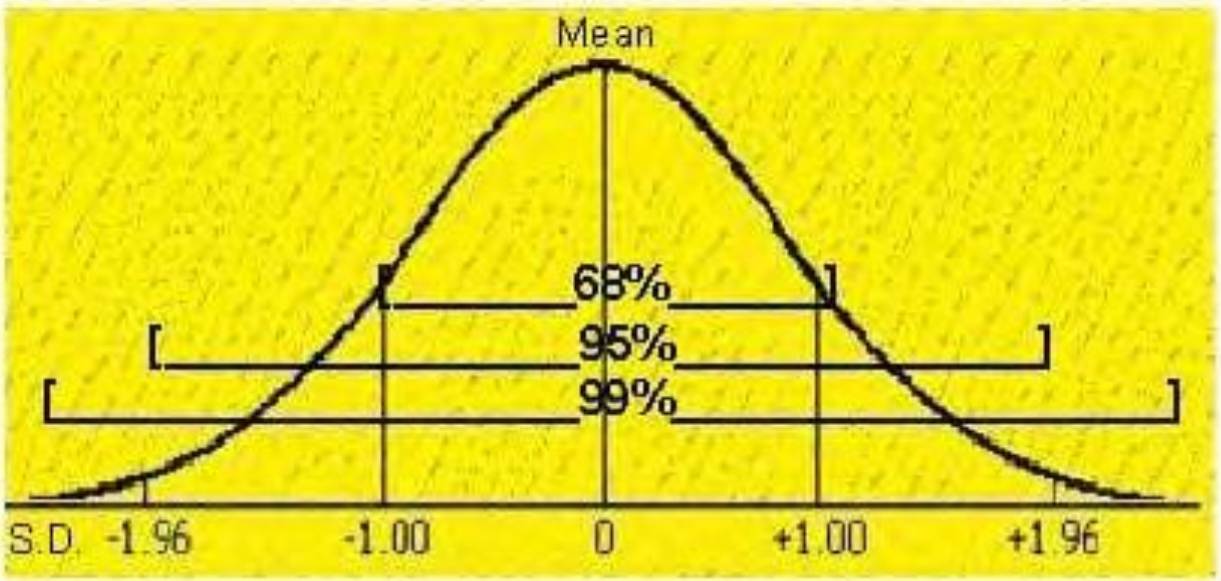
- To be normal you do not have to be at the 50th percentile
- We all vary from day to day, hour to hour, activity to activity
- Thus, a **standard deviation** from the 50th percentile (or middle) was calculated
- This standard deviation was initially labeled -1 (below) and +1 (above) the 50th percentile

The Original Normal Distribution

- The original normal distribution was developed as the middle (50^{th} percentile or median) being the mean or average **if** the distribution is perfectly normal
- It was calculated that the middle was 0 (50^{th} percentile), and the two ends (lower -1 and upper +1) would be the 16^{th} percentile to the 84^{th} percentile
- Thus, the normal range is 68% of the total

The Bell Curve

The Normal Curve

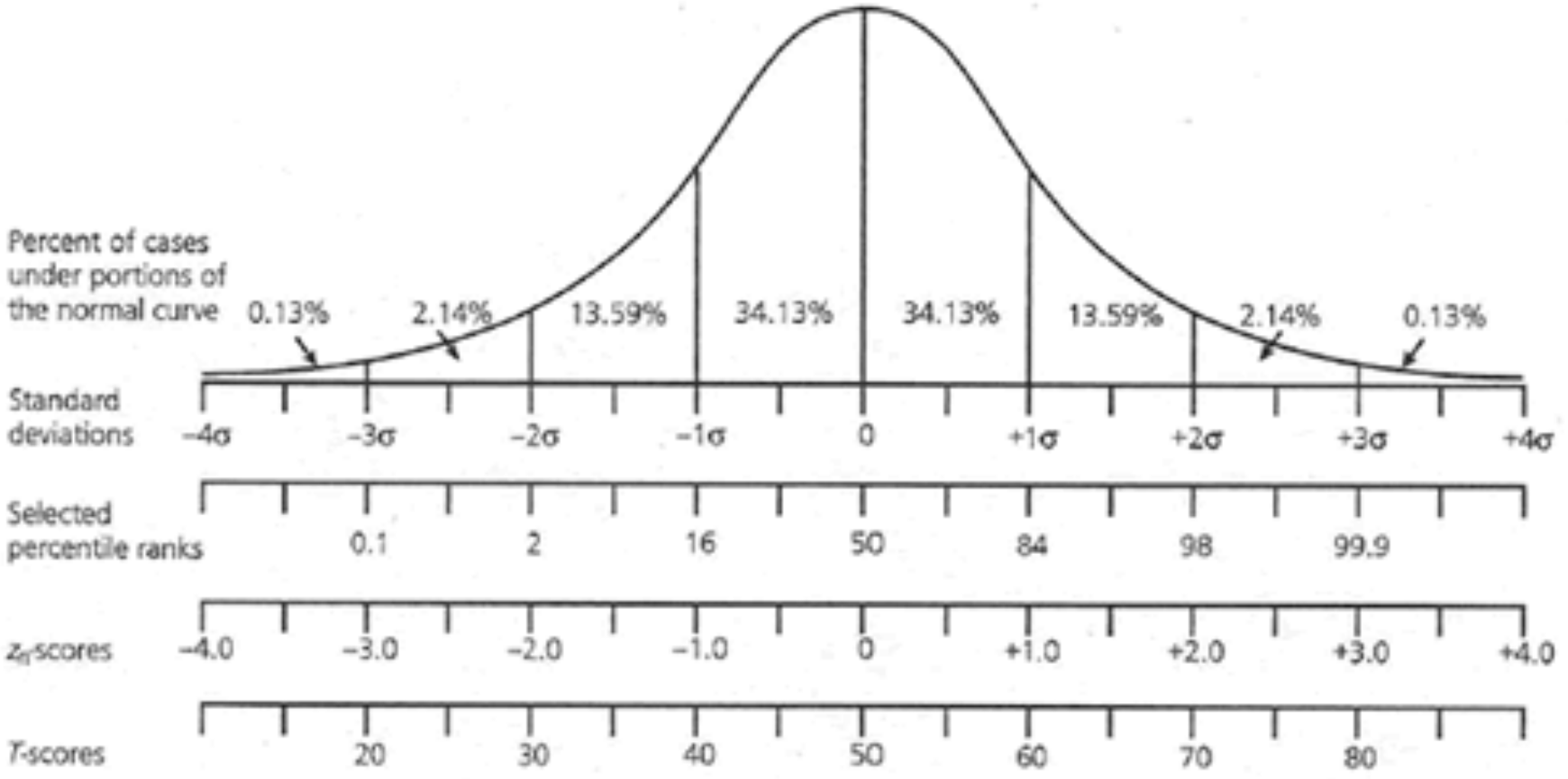


Sigma	-3.00	-2.00		-1.00		0		+1.00		+2.00		+3.00
T-Score	20	30		40		50		60		70		80
College Board	200	300		400		500		600		700		800
Percentile	1	5	10	20	30	50	70	80	90	95	99	
Stanines	1	2	3	4	5	6	7	8	9			

What is NOT normal?

- Anything below the 16th percentile is below normal or not normal or abnormal
- Anything above the 84th percentile is above normal or superior or gifted
- Thus, we use one standard deviation (-1 or +1) as the range of normal
- We can also have 2 standard deviations (SD), 3 SD, we usually end with 3SD

Various Scores from the Normal Distribution

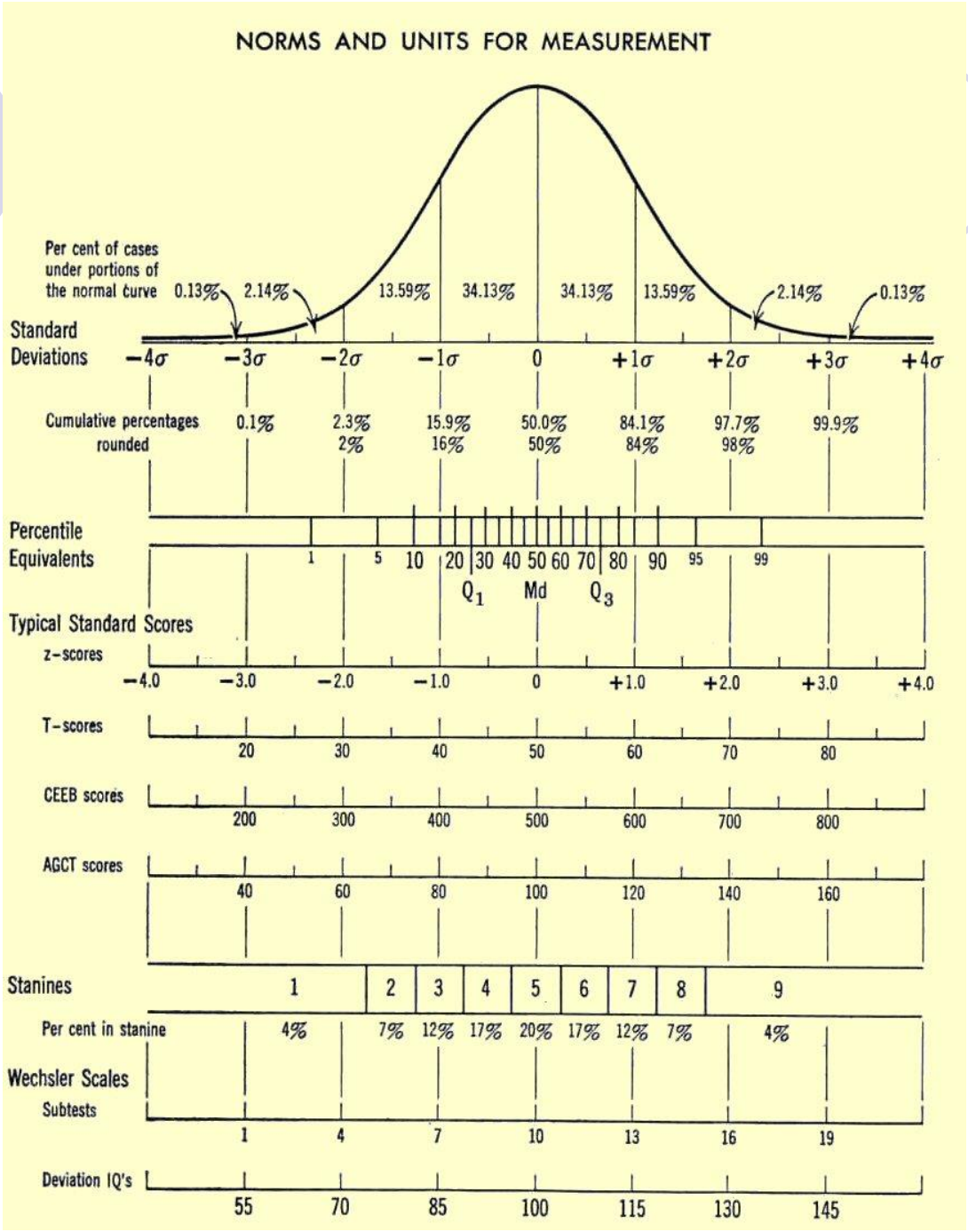


SD and Percentiles

- In the previous slide, you may have noticed that SD is written as sigma (Greek letter) and the slide shows the percentiles
- 0 is the center = 50^{th} percentile
- -1SD = 16^{th} & +1SD = 84^{th}
- -2SD = 2^{nd} & +2SD = 98th
- -3SD = 0.1^{st} & +3SD = 99.9^{th}
- These values (number of SD) = **Z scores**

Wouldn't It Be Nice If Everyone Used Z Scores?

- Most researchers/statisticians do not agree on the same score values
- Thus, we have
- Z scores
- T Scores
- Standard Scores
- Scaled Scores
- Percentiles


NORMS AND UNITS FOR MEASUREMENT
Per cent of cases under portions of the normal curve
0.13%
2.14%
13.59%
34.13%
34.13%
13.59%
2.14%
0.13%
Standard Deviations
−4σ
−3σ
−2σ
−1σ
0
+1σ
+2σ
+3σ
+4σ
Cumulative percentages rounded
0.1%
2.3%
2%
15.9%
16%
50.0%
50%
84.1%
84%
97.7%
98%
99.9%
Percentile Equivalents
1
5
10
20
30
40
50
60
70
80
90
95
99
Q1
Md
Q3
Typical Standard Scores
z-scores
−4.0
−3.0
−2.0
−1.0
0
+1.0
+2.0
+3.0
+4.0
T-scores
20
30
40
50
60
70
80
CEEB scores
200
300
400
500
600
700
800
AGCT scores
40
60
80
100
120
140
160
Stanines
1
2
3
4
5
6
7
8
9
Per cent in stanine
4%
7%
12%
17%
20%
17%
12%
7%
4%
Wechsler Scales
Subtests
1
4
7
10
13
16
19
Deviation IQ's
55
70
85
100
115
130
145

Comparison of Scales – Mid-Value

- Z = 0
- Percentile 50^{th}
- T = 50
- Standard Score = 100
- Scaled Score = 10
- College Boards = 500
- Stanine = 5

Comparisons of Scores Using Different Scales

Scale	- 3 SD	- 2 SD	- 1 SD	Mean	+ 1 SD	+ 2 SD	+ 3 SD
Z Scores	-3	-2	-1	0	+1	+2	+3
Percentile	0.1st	5th	16th	50th	84th	94th	99.9th
Scaled Score (100)	55	70	85	100	115	130	145
Standard Score (10)	1	4	7	10	13	16	19
T Score	20	30	40	50	60	70	80
College Boards	200	300	400	500	600	700	800
Stanines	1	2 - 3	3 - 4	5	6 - 7	8 - 9	9

On-Line Conversion Table

http://faculty.pepperdine.edu/shimels/Courses/Files/ConvTable.pdf

Go to this URL and you will see a much, much more iin-depth conversion table

How to Use These Scores

- In Auditory Processing Testing, we have both standard scores, scaled scores, percentiles, and criterion referenced scores
- SCAN-3 uses scaled scores for subtests and standard scores for overall measure
  - Both scaled and standard scores are converted to percentiles

How to Use These Scores

- SSW, SIN, and PST use criterion referenced scores
  - Number of errors are normed at -2SD and at -1 SD
  - PST uses normal cut-off based on number correct (which I believe is -1SD)
  - SIN uses percent correct (which I also believe is -1SD)

Other Tests in the AP Test Battery

- All tests using **percent correct** or **number correct** or **number of errors** are using criterion referencing with the lowest end of normal (usually -1 SD) and below -1SD being failure (not normal) or at or above criterion (-1SD) being normal no problem
- Problem is we cannot judge how far from normal or values that are exceptional

Comparing Scores from Other Professionals

- Psychologists and SLPs and educational tests (I will focus on these)
- Standard scores = mean of 100 with SD of 15:normal range = 85 to 115 (-1SD)
- Scaled scores = mean of 10 with SD of 3: normal range = 7 to 13
- Percentiles = mean of 50^{th} with SD of 34: normal range = 16^{th} to 84^{th}
- T scores = mean of 50 with SD of 10: normal range = 40 to 60

Comparing Test Performance

- Imagine a child with the following scores
  - IQ test (standard score) 92
  - Educational testing of 45th percentile
  - Executive functioning scale T = 47
  - SLP test standard score of 95
  - SCAN-3 scaled scores of 9
- Does this child have ANY problems?
- What is the strongest and weakest areas?

Comparisons of Scores Using Different Scales

Scale	**- 3 SD**	**- 2 SD**	**- 1 SD**	**Mean**	**+ 1 SD**	**+ 2 SD**	**+ 3 SD**
Z Scores	-3	-2	-1	0	+1	+2	+3
Percentile	0.1st	5th	16th	50th	84th	94th	99.9th
Scaled Score (100)	55	70	85	100	115	130	145
Standard Score (10)	1	4	7	10	13	16	19
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Case Study Quiz

- This is a client/patient who has been given a battery of tests
- They could be ANY tests
- Your task is to determine if the client/patient is normal or not normal on each of the tests

Case #1

- Test #1 St Sc = 90
- Test #2 St Sc = 70
- Test #3 Sc Sc = 8
- Test #4 Sc Sc = 4
- Test #5 T score = 35
- Test #6 Criterion Reference scored 40 correct / -1SD is 50 correct

Case #2

- Test #1 = 25th percentile
- Test #2 = Criterion Reference -2SD = 15 errors child made 13 errors
- Test #3 = St Sc = 90
- Test #4 = Sc Sc = 9
- Test #5 = T score of 65

Case #1 vs. #2

- Compare performance on these five tests
- Who has greater problems and on which tests are the problems greater?

What About People with Cognitive Limitations?

- Many professionals state you cannot do APD assessments and dx people with APD if they have cognitive limitations
- Review of ASHA (2005; 2011) and AAA (2010) indicate care should be taken when evaluating people with have cognitive limitations
- But, can we appropriately evaluate people with low cognitive functioning for APD?

APD and People with Cognitive Limitations

- A question arises whether the cognitive limitations (esp. verbal abilities) are limited partially by APD problems
  - This can be the case
- But, how can we assess APD issues in people with cognitive impairments?
- Well, some say just do the APD tests and see if they fail

Failure on APD Tests for People with Cognitive Limitations

- If a person (say) with an IQ score of 50 is given APD tests, what would you expect to find?
- In my experiences, typically they fail ALL or almost ALL measures of auditory processing
- So, could they have a general auditory processing deficit (APD) in all areas?

Looking at Measures of APD

- Although the traditional way (ASHA, AAA, EAA, almost everyone) is to say that auditory processing is an auditory system issue, I do not agree
- ALL measures of auditory processing involve cognitive processing as well
- If my cognitive functioning is very impaired (my example IQ of 50) then my very poor cognitive functioning can cause me to fail

How Can I CONTROL for the Cognitive Limitations?

- The first step is to understand what is meant by an IQ score
  - Note that cognitive problems are diagnosed based on IQ measures
- IQ represents the **percent of chronological age (CA) at which the person is functioning**
- Thus, an IQ of 50 means the person is functioning at 50% the person's CA

Mental Age Equivalent

- Calculating the percent of the CA based on the IQ score, you obtain a mental age equivalent or MA equivalent
- Lucker (published in SSW Reports and in many professional presentations) suggests: Compare performance on APD tests with the person's MA equivalent
  - This controls for or eliminates the cognitive factor as a contributing factor

What IQ Score Should I use?

- Since APD is verbal, use the VERBAL IQ score
  - WISC, WAIS Verbal Comprehension score
  - S-B and some other IQ measures = Verbal IQ
- You can also compare with CA to see the difference
- You can also compare with the highest IQ (often non-verbal or Perceptual Reasoning) to see the difference

Sample Case with an IQ of 50

- Let's say we have a child of 10 years old who has an IQ of 50
- 50% of 10 (CA) is 5 years old (MA equivalent)
- Compare results of APD testing with the 5 year old norms
- I will present some real cases

Case #1 Male, Down Syndrome

- This is a 14 year old male with DS with a verbal and overall IQ (relatively even) around 50 (Verbal IQ was 50 and non-verbal was 55)
- MA equivalence is 7 years old
- Failed ALL measures of APD based on 14 year old age level norms
- Passed all measures of APD based on 7 year old age norms

Case #2 Male with DS, 15 years old

- This male has an overall IQ of 40
- His MA equivalence is 6 years old
- Fails ALL measures of APD at the 15 year old norm level
- Passes all BUT fails the following based on 6 year old age norms
  - SSW (RC, LC); SCAN-3-C CW (Free Recall and Directed Recall), CS, shows sig. ear difference; fails SIN tests and AFG +8 on SCAN

End Result

- Child #1 does NOT have APD problems
  - Failure is likely cognitively based
- Child #2 DOES have specific APD problems especially in integration, overloading, auditory distractibility (not attention passes the ACPT and psych. results showed no significant attention problems)

Analyzing Improvements in Therapy

- When we do therapy, we want to insure that the clients are improving
- One way is called qualitative analysis
- In qualitative analysis, you describe changes
- Another is to look at test scores and see if there are changes (improvements hopefully) in the findings

Analyzing Test Scores

- Simplest is merely to present the scores
  - Often what we say is qualitative
  - The client's scores are better
  - Higher scores
  - Lower number of errors
- Other is to compare results relative to the normal distribution
  - Example: Scores below -1SD change to within normal range after therapy

Analyzing Test Scores

- The best way is to do a statistical analysis
- Simplest is comparing how far from the mean or the normal cut-off were the pre-tx scores compared with the post-tx scores
- As scores come closer to the mean (middle or 50^{th} percentile) we can see improvements
- But, this does not really measure if the changes are significant

Doing a Statistical Analysis

- We can use a statistical analysis to measure the **EFFECT SIZE** of change
- Effect size is measured as the number of standard deviations change
- Thus, you don't have to worry if a change is coming closer to normal or not normal, but how much change has been made after therapy is provided

Cohen's d

- One statistical analysis is Cohen's d
- Cohen's d requires four values
- Mean score pre
- SD pre
- Mean score post
- SD post
- Then, go to the following website and calculate Cohen's d

Cohen's d website

- http://www.uccs.edu/~lbecker/
- From Dr. Lee A. Becker
- College of Letters, Arts, and Sciences
- University of Colorado
  - Colorado Springs, CO

How to Use Cohen's d

- Imagine your scores are APD test data
- You need a group of similar scores and find the means and SD pre and post therapy
- Put the POST data in the website's first group and the PRE data in the website's second group
- Then hit the "calculate" button

Example: SSW Test Condition Scores

- **Pre-Therapy**
- RNC = 5, RC = 8, LC = 11, LNC = 4
- Values are 5, 8, 11, 4 = total of 28
- Mean = 7
- SD = 3.162
- **Post-Therapy**
- RNC = 2, RC = 6, LC = 8, LNC = 3 = total of 19
- Mean = 4.75
- SD = 2.754

Calculating Cohen's d

- Post-Therapy
  - Mean = 4.75
  - 2.754
- Pre-Therapy
- Mean = 7
- SD = 3.162
- Cohen's d = -0.7588465
- What does this mean?

Cohen's d = -0.7588465

- Rounded off, this is -0.79
- The negative value means the score went down
  - Since we are looking at the number of errors, that is a good thing because negative means fewer errors
- The value 0.79 can be converted to a percent = 79%
  - This means there was an improvement of 79% of ONE standard deviation (less than 1 SD change)

Qualitative Rating of Cohen's d

- Look for changes
- Values equal:
  - 0 to 0.19 no significant change
  - 0.20 to 0.49 small change
  - 0.50 to 0.79 medium change
  - 0.80 to 1.00 large change
  - 1.00 or greater very large change
- Each value relates to percent of SD

Value of Cohen's d

- Cohen's d provides evidence based practice
- It is an acceptable statistical analysis that measures how much change occurred, the direction of the change (more + & less -)
- Convert values to percent and it is that percent of a standard deviation change
- 0.50=½ SD; 1.00=one SD; 2.00=2SD

For Therapy

- Obtain values for some therapy activity for at least three separate measures (three days, three weeks)
- Do this at the beginning and end of therapy
- Calculate the mean and SD for these pre and post therapy scores
- Calculate Cohen's d

Example: Therapy using percent correct

- Pre therapy or first three sessions
  - Do some sample task (no therapy, just test)
  - 40% - 30% - 40% (mean = 36.7; SD = 5.77
- Post therapy last three sessions
  - Do same as above
  - 80% - 90% - 90% (mean = 86.7; SD = 5.77)
- Obtain means and SD and calculate Cohen's d

Conclusion

- We can use statistical knowledge to be better able to report test findings and improvements in therapy to our clients, parents, schools, etc.
- There are other statistical analyses for research purposes which are not discussed here
  - These are more for research than clinical practice

Keep In Touch

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