



# QS101: Introduction to Quantitative Methods in Social Science

Week 5: Levels of Measurement and Distributions

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30.10.2014



## Levels of Measurement

Nominal Scales

Ordinal Scales

Interval Scales

Ratio Scales

## Distributions

Tabular Display of Distributions

Graphical Display of Distributions



# Levels of Measurement



# Types of Variables

- ▶ Constant
  - ▶ Any characteristic that is observed only to take on one, single value
- ▶ Categorical
  - ▶ Qualitative in nature
  - ▶ Describes categories of a characteristic, e.g. party affiliation
  - ▶ Special case: DICHOTOMOUS variable
- ▶ Numerical
  - ▶ Quantitative variable
  - ▶ Further classification: continuous versus discrete (see next slide)



# Continuous versus Discrete Variables

## ▶ CONTINUOUS VARIABLE

- ▶ Can take any value in a specific range
- ▶ Varies between a smaller and a larger number
- ▶ Examples: GDP, time, length, age, weight, ...

## ▶ DISCRETE VARIABLE

- ▶ Can only take on certain values, many are not possible
- ▶ Arise from a counting process
- ▶ Examples: number of children in family, number of students per seminar, ...



# Levels of Measurement

## Nominal Scales



# Nominal Scales: Properties

- ▶ AKA categorical scales, or qualitative scales
- ▶ Assign people or objects into qualitatively different categories
- ▶ Assumption that all items in a category are equal with respect to that category
- ▶ NO intermittent categories
- ▶ Examples: accommodation, eye colour, gender, ...



# Nominal Scales: Descriptives

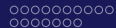
- ▶ Mean
  - ▶ No





# Nominal Scales: Descriptives

- ▶ Mean
  - ▶ No
- ▶ Median
  - ▶ No
  - ▶ Requires ordering



# Nominal Scales: Descriptives

- ▶ Mean
  - ▶ No
- ▶ Median
  - ▶ No
  - ▶ Requires ordering
- ▶ Mode
  - ▶ Yes
  - ▶ Measure the mode for a particular religion



# Levels of Measurement

## Ordinal Scales



# Ordinal Scales: Properties

- ▶ Rank people or objects on some variable
- ▶ Requires classification
  - ▶ How much of a value does an individual have?
- ▶ Requires ranking
  - ▶ Where does the individual stand relative to the others?
- ▶ Equal difference does not imply equal distance
- ▶ Examples: Order of finish in a race, military rank, ...



# Ordinal Scales: Descriptives

- ▶ Mean
  - ▶ No (understanding as categorical variable, most often the case) / Yes (understanding as numerical variable)



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# Levels of Measurement

## Interval Scales





# Interval Scales: Properties

- ▶ Most commonly used score in statistics
- ▶ Give information about ranking of people or objects
- ▶ Provide information on how far apart people or objects are on that variable
- ▶ Assumption: equal difference between all points on the score
  - ▶ E.g. difference between 7 and 8 is the same as between 20 and 21
- ▶ Examples: IQ test, temperature, year, ...



# Interval Scales: Descriptives

- ▶ Mean
  - ▶ Yes



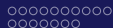
# Interval Scales: Descriptives

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  - ▶ Yes
- ▶ Median
  - ▶ Yes



# Interval Scales: Descriptives

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- ▶ Median
  - ▶ Yes
- ▶ Mode
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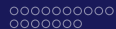
# Levels of Measurement

## Ratio Scales



# Ratio Scales: Properties

- ▶ See properties of interval scale



# Ratio Scales: Properties

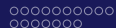
- ▶ See properties of interval scale
- ▶ PLUS: a natural zero point (ABSOLUTE zero) which indicates the total absence of a characteristic



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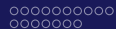
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- ▶ Less common in social sciences, frequently used for example in economics or sciences
- ▶ Examples: height, weight, age, blood pressure



# Ratio Scales: Descriptives

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  - ▶ Yes



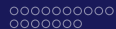
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# Distributions



# Distributions

## Tabular Display of Distributions





# Frequency

- ▶ Depicts the number of cases in a particular interval
- ▶ Note: Intervals are often grouped for convenience
- ▶ Grouping is a trade-off between loss of information and good communication of data



# Example

- ▶ Statistics Quiz
- ▶  $n = 25$
- ▶ 20 questions, 1 point each



# Frequency Distributions

x	f
9	1
10	1
11	2
12	1
13	2
14	1
15	3
16	1
17	5
18	3
19	4
20	1
	$n = 25$

**Table:** Frequency Distribution of Statistics Quiz Data (source: Lomax and Hahs-Vaughn (2012), p. 19)



# Cumulative Frequency

- ▶ Depicts the number of cases in that interval and all of the smaller intervals
- ▶ Shown in the column labelled *cf* on the next slide
- ▶ The number of the final interval is always the sample size.



# Frequency Distributions

x	f	cf
9	1	1
10	1	2
11	2	4
12	1	5
13	2	7
14	1	8
15	3	11
16	1	12
17	5	17
18	3	20
19	4	24
20	1	25

$n = 25$

**Table:** Frequency Distribution of Statistics Quiz Data (source: Lomax and Hahs-Vaughn (2012), p. 19)



# Relative Frequency

- ▶ Depicts the percentage of cases in a particular
- ▶ Shown in the column labelled *rf* on the next slide
- ▶ Can be used with *any* measurement scale



# Frequency Distributions

x	f	cf	rf
9	1	1	$f/n = 1/25 = 0.04$
10	1	2	0.04
11	2	4	0.08
12	1	5	0.04
13	2	7	0.08
14	1	8	0.04
15	3	11	0.12
16	1	12	0.04
17	5	17	0.20
18	3	20	0.12
19	4	24	0.16
20	1	25	0.04
	$n = 25$		$\Sigma = 1.00$

**Table:** Frequency Distribution of Statistics Quiz Data (source: Lomax and Hahs-Vaughn (2012), p. 19)



# Cumulative Relative Frequency

- ▶ Depicts the percentage of cases in that interval or smaller
- ▶ The *crf* in the largest interval is equal to 1
- ▶ Cannot be used with nominal data





# Frequency Distributions

x	f	cf	rf	crf
9	1	1	$f/n = 1/25 = 0.04$	0.04
10	1	2	0.04	0.08
11	2	4	0.08	0.16
12	1	5	0.04	0.20
13	2	7	0.08	0.28
14	1	8	0.04	0.32
15	3	11	0.12	0.44
16	1	12	0.04	0.48
17	5	17	0.20	0.68
18	3	20	0.12	0.80
19	4	24	0.16	0.96
20	1	25	0.04	1.00
	$n = 25$		$\Sigma = 1.00$	

**Table:** Frequency Distribution of Statistics Quiz Data (source: Lomax and Hahs-Vaughn (2012), p. 19)



# Distributions

## Graphical Display of Distributions

# Bar Graph

- ▶ Popular for displaying nominally scaled data

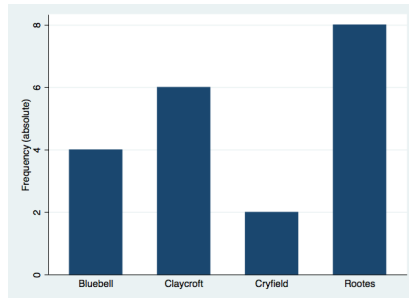


Figure: Bar Graph for Accommodation Type



# Histograms

- ▶ Appropriate for data that are at least ordinal
- ▶ x-axis: values of the variable  $x$
- ▶ y-axis: frequency for each interval
- ▶ Midpoint of the interval is also the midpoint of the bar (!)

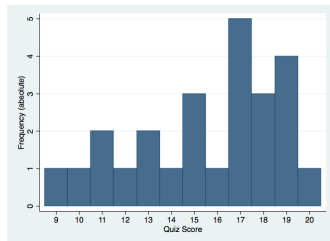


Figure: Histogram of statistics quiz data





# Cumulative Frequency Polygon

- ▶ Appropriate for data that are at least ordinal
- ▶ y-axis: cumulative frequencies
- ▶ Polygon cannot be closed on the right hand-side

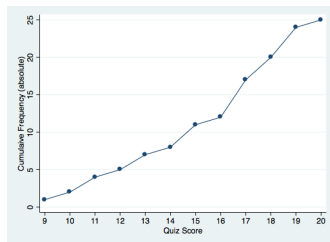
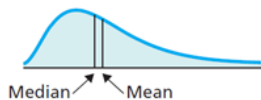


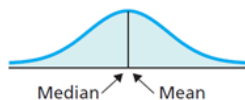
Figure: Cumulative frequency polygon of statistics quiz data



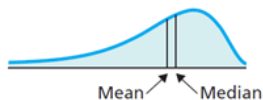
# Shapes of Frequency Distributions



Positively skewed



Normal Distribution



Negatively skewed



# Box-and-Whisker Plot

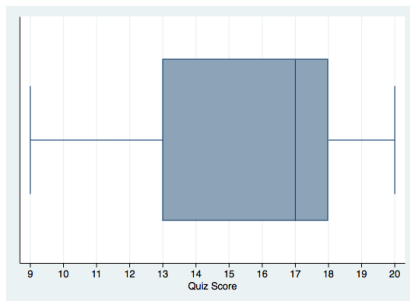


Figure: Box-and-Whisker plot of statistics quiz data



## Graphical Display of Distributions

