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Comparison of k Distributions Using the Example of an Anchoring Effect Experiment

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Overview

Methods

Applications

Methods

Experimental Design and Data Preparation

Design Overview

- 2x2 between-subjects factorial design
- Factors: a. Anchor Precision (round vs. precise) and b. Motivation to underestimate (weak vs. strong)
- 9 estimation tasks per participant
- DV: standardized mean deviation (Z-score) from anchor

Data Preparation

- Compute deviation from anchor for each item
- Standardize using z-scores across different scales
- Exclude responses where `DROP == 1`

	Weak (0)	Strong (1)
Round (0)	Group 1	Group 2
Precise (1)	Group 3	Group 4

Table 1: 2x2 Between-Subjects Design (Binary Encoding)

Standard Normalization

- **Z-score (Standardized Residuals)**: Computes z-scores per item, then averages per person.
- Formula:

$$z = \frac{X - \mu}{\sigma} \quad \text{where } X = \text{Estimate}, \mu = \text{Mean}, \sigma = \text{SD}$$

- Removes units: values become comparable across different scales
- Centers data at 0: Mean-centered
- Sets variance = 1: Same spread across variables
- Reduces scale-driven noise: Better for ANOVA, regression

Hypotheses

Let μ_{ij} be the mean response for anchor type $i \in \{0,1\}$ and motivation level $j \in \{0,1\}$.

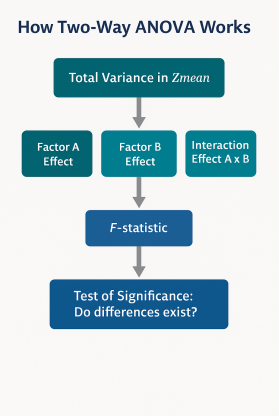
- **H_1: Main Effect of Anchor Precision**
  $H_0^{(1)} : \mu_{0\cdot} = \mu_{1\cdot} \quad \text{vs.} \quad H_A^{(1)} : \mu_{0\cdot} \neq \mu_{1\cdot}$
- **H_2: Main Effect of Motivation**
  $H_0^{(2)} : \mu_{\cdot 0} = \mu_{\cdot 1} \quad \text{vs.} \quad H_A^{(2)} : \mu_{\cdot 0} \neq \mu_{\cdot 1}$
- **H_3: Interaction Effect**
  $H_0^{(3)} : (\mu_{11} - \mu_{10}) = (\mu_{01} - \mu_{00}) \quad \text{vs.} \quad H_A^{(3)} : (\mu_{11} - \mu_{10}) \neq (\mu_{01} - \mu_{00})$

Why Two-Way ANOVA?

- **Purpose:** To examine the effect of two independent variables (factors) and their interaction on a continuous dependent variable.
- **Factors in our study:**
  - Anchor Precision: round vs. precise
  - Motivation: strong vs. weak
- **Advantages:**
  - Tests each main effect separately
  - Tests whether one factor modifies the effect of the other (interaction)
  - More efficient than two separate one-way ANOVAs

How Two-Way ANOVA Works

- Divides total variability in the data into components:
  - Variance explained by Factor A (e.g. Precision)
  - Variance explained by Factor B (e.g. Motivation)
  - Variance explained by Interaction (A × B)
  - Residual (within-group) variance
- Calculates an **F-statistic** for each component:
  - F = (Mean Square of Effect) / (Mean Square of Error)
  - Compares observed variance to expected variance under null
- **Significant F** means the factor or interaction has a real effect



ANOVA Assumptions

- **Assumption 1: Independence of Observations**
  Responses are independent across participants (between-subjects design).
- **Assumption 2: Normality**
  The dependent variable (Z-scores) is approximately normally distributed within each group.
- **Assumption 3: Homogeneity of Variances (Homoscedasticity)**
  The variance of the dependent variable is equal across the four experimental groups.
- **Assumption 4: Dependent Variable Is Continuous**
  The outcome (standardized deviation from anchor) is measured on an interval/ratio scale.

Learning from Mistake

- **Z-score ANOVA**:
  - Removes item-level scale noise
  - Reveals significant effects for Precision and Motivation
  - Better controls error variance
- **Relative Scaled ANOVA**:
  - **Formula:** Deviation $= \frac{\text{Anchor} - \text{Estimate}}{\text{Anchor}}$
  - Effects diluted by unstandardized scale variation
  - More noise → higher residuals → non-significant F-tests

Applications

Applications: Precision Framing

- **Negotiation**: Precise offers anchor the final outcome closer
- **Retail Pricing**: €9.95 feels more intentional than €10.00
- **Consumer Perception**: Enhances trust and perceived expertise

Applications: Real Life Context of Precision Framing

Anchor Precision: Aldi Pricing

- Aldi commonly uses precise prices like **1,99** or **4,95**.
- Creates a perception of savings and thoughtfulness.
- Consumers tend to underestimate due to left-digit bias.

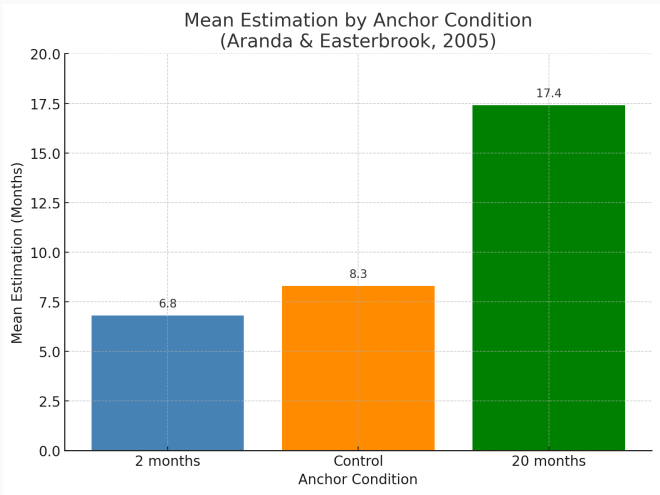
Influence of Anchors on Software Time Estimation

- **Study:** Aranda & Easterbrook conducted an experiment on the anchoring effect in software time estimation.
- **Design:** Participants received a software project brief and either a low (2 months), high (20 months), or no anchor.
- **Finding:** Estimates were significantly biased by anchors:
  - Low anchor group mean = 6.8 months
  - High anchor group mean = 17.4 months
  - Control group mean = 8.3 months
- **Insight:** Even clearly implausible anchors (e.g., “2 months” for a complex project) biased estimations.
- *Aranda & Easterbrook, 2005*

Empirical Results and Key Implications

Key Implications:

- Anchors distort software estimates—even for experienced developers.
- Anchoring effect occurs even when anchors are disclaimed or downplayed.
- *Aranda & Easterbrook, 2005*



Estimates grouped by anchor condition *(Aranda & Easterbrook, 2005)*

Application of Anchoring in Non-Numerical Contexts

Motivational Framing: Cyclist Performance Study

- Cyclists received either a **supportive** (“Do your best!”) or **controlling** (“You must continue until failure”) message.
- These messages acted like **non-numeric anchors**, setting different expectations.
- **Controlling framing** = high-pressure anchor → reduced perceived competence.
- **Supportive framing** = low-pressure anchor → preserved autonomy and confidence.
- Similar to our study: **framing strength (magnitude)** shaped response behavior.
- *Source: Fasczewski et al., The Sport Journal (2023)*

Real Life Applications in Other Areas

- **Legal Judgments**: Judges' sentencing decisions can be influenced by sentencing demands *(Englich et al., 2005)*.
- **Forecasting**: Initial value bias predictions in domains like sales, performance
- **Valuations**: Anchors affect how people value products such as used cars and groceries *(Ariely et al., 2003)*.
- **Reference Pricing**: Consumers compare prices to initial anchor values when deciding what seems reasonable.
- **Online Auctions**: Early bids serve as anchors, strongly guiding final bidding behavior *(Wolk & Spann, 2008)*.
- **Consumer Anchoring**: Even irrelevant cues like product model numbers or packaging details can anchor judgments.

Our Study: Is It Practically Relevant?

- Two-Way ANOVA confirms practical relevance:
  - Precision has a statistically significant effect on deviation ($p = 0.0039$)
  - Motivation shows a strong effect ($p < 0.0001$)
  - No interaction suggests additive influence, not conditional
- Anchoring influences high-stakes decisions and is resistant to warnings or expertise
- Recognize effects to better design communication, avoid bias and make informed decisions

Thank You