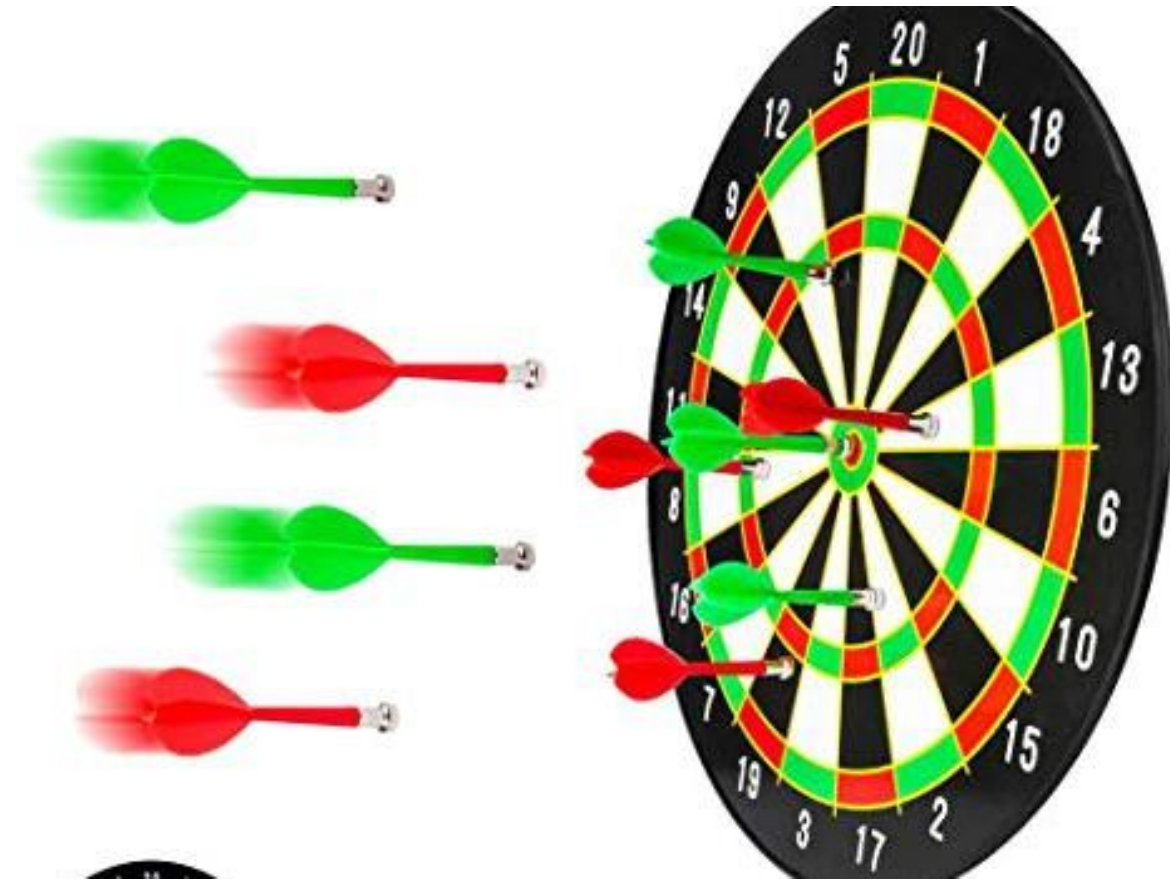


## Experimental Design



**Dart Madness**

## MENU

- 01 Design Introduction
- 02 Assumptions Checking
- 03 Data Analysis
- 04 Conclusion and Summary

01

# Design Introduction

# Goal

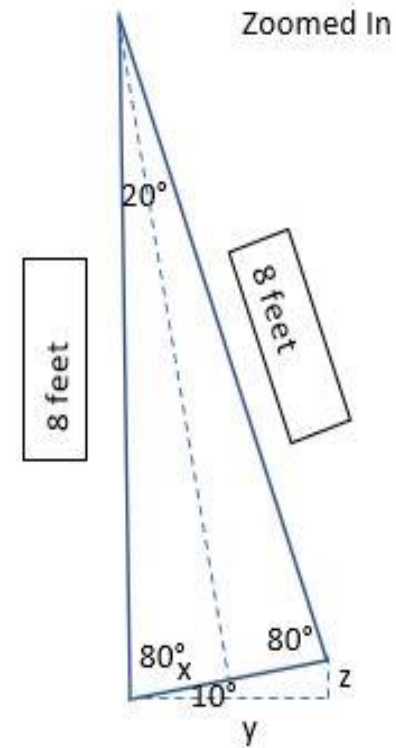
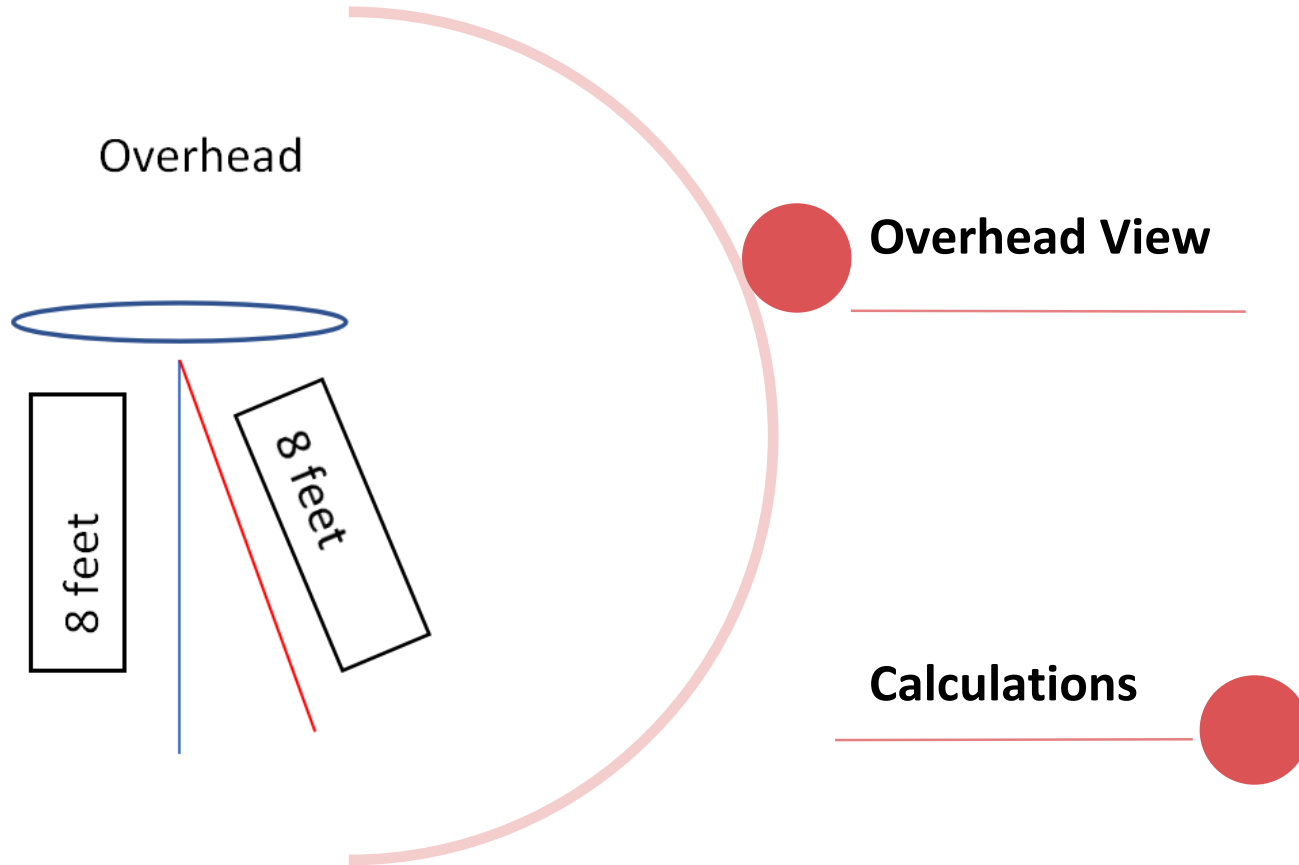
Our goal is to study four factors that could potentially impact our group's accuracy with respect to throwing darts. If all goes according to plan, we will find an optimal technique to wow all our friends.

# Response Variable and Controllable Factors



Factor	Levels
A = distance from dart board	3 (8 ft, 10 ft, 12 ft)
B = horizontal position	2 (straight on, to the right)
C = vertical position	2 (standing, on one knee)
D = specific hand throwing	2 (dominant, non dominant)

# More Details for “to the right” Position



$$\cos(80^\circ) = x/8$$
$$x = 1.389185421 \text{ ft}$$
$$2 * x = 2.778370843 \text{ ft}$$

$$\cos(10^\circ) = y/2.778370843$$
$$y = 2.736161147 \text{ ft}$$

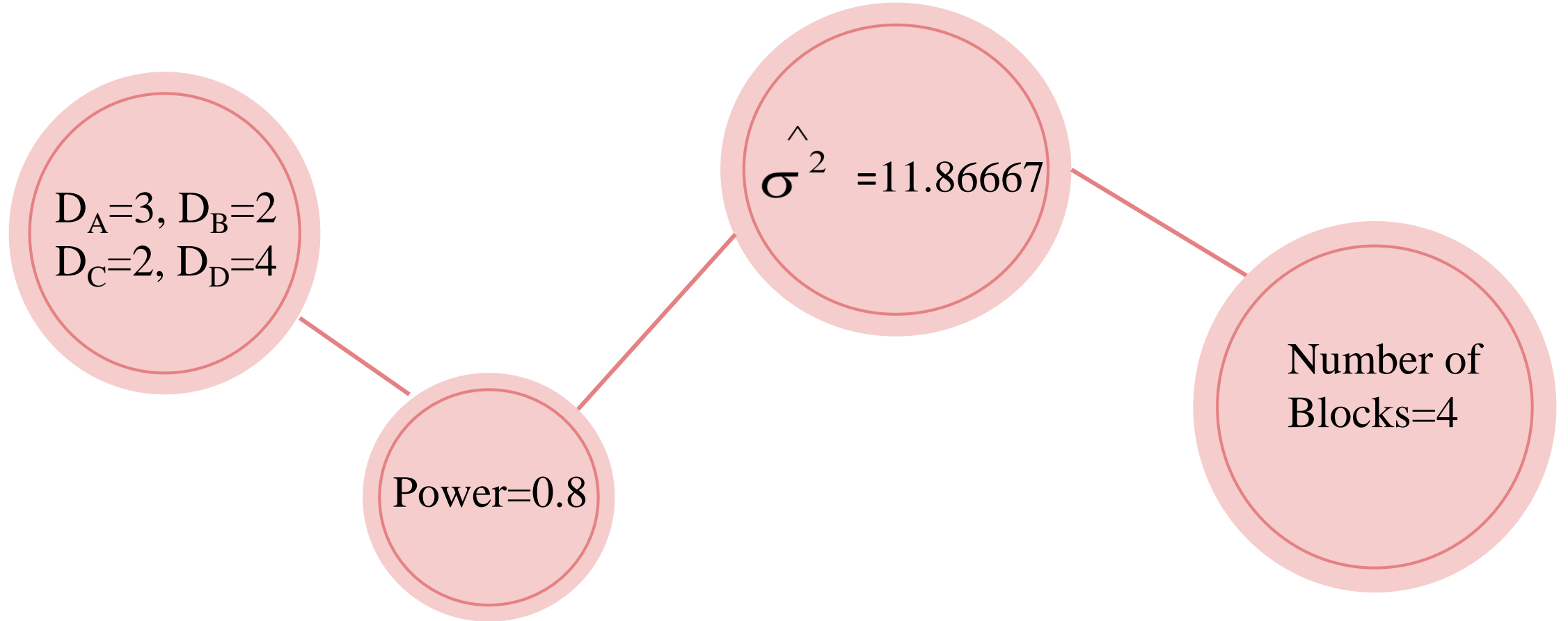
$$(2.778370843)^2 = (2.736161147)^2 + z^2$$
$$z = 0.4824590331 \text{ ft}$$

# Treatment Combinations

		Dominant Hand			Non Dominant Hand		
	Distance	8 feet	10 feet	12 feet	8 feet	10 feet	12 feet
Posture	Horizontal						
Standing	Straight	1	2	3	4	5	6
Kneeling	Straight	7	8	9	10	11	12
Standing	Right	13	14	15	16	17	18
Kneeling	Right	19	20	21	22	23	24

Model: score~blocks+{(distance)\*(horizontal)\*(posture)\*(hand)}

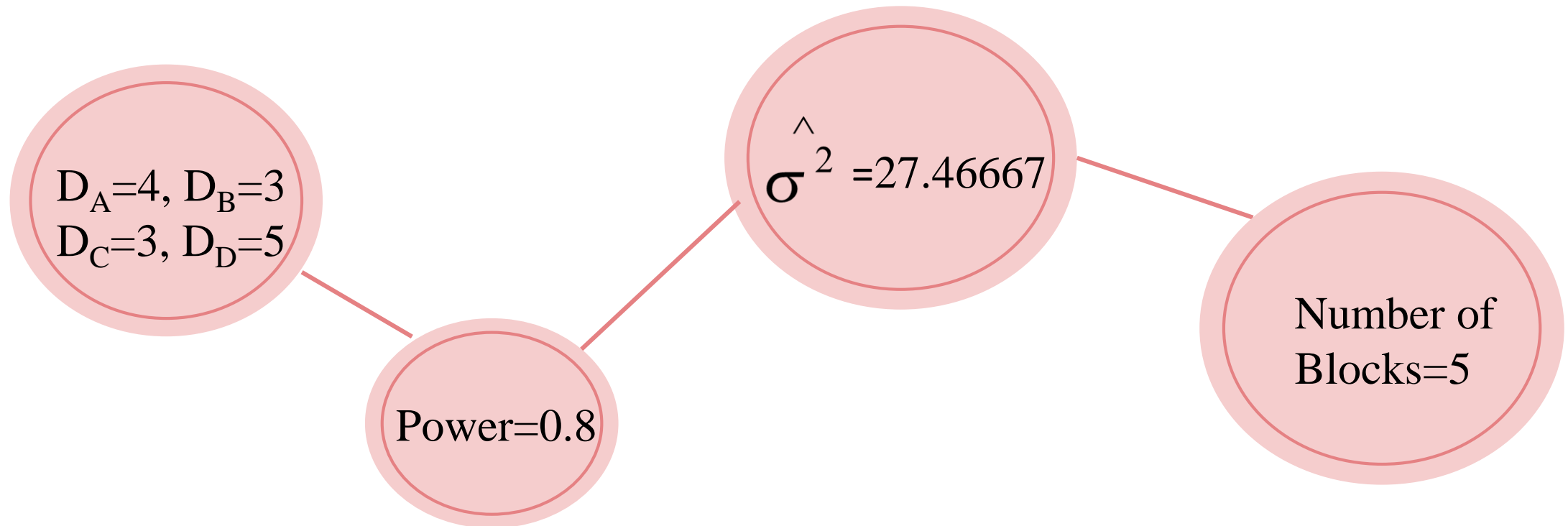
# Original Proposal Number of Blocks





# Changes from Original Proposal

- Few easily corrected mistakes (i.e. spelling, notation errors)
- Larger increments of distance (8/9/10 feet vs 8/10/12 feet)
- Clearly define the horizontal “to the right” position
- Obtain new pilot sample
- Recalculate number of blocks needed

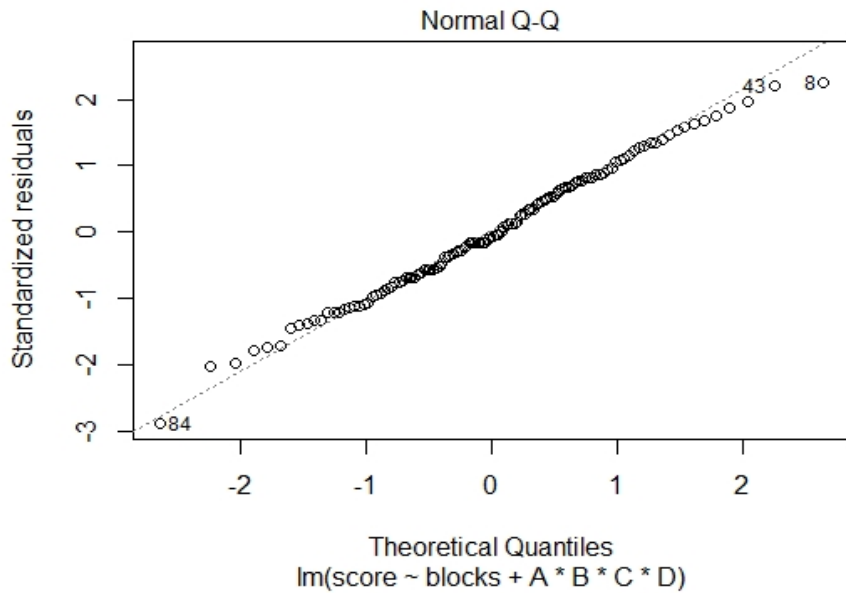


02

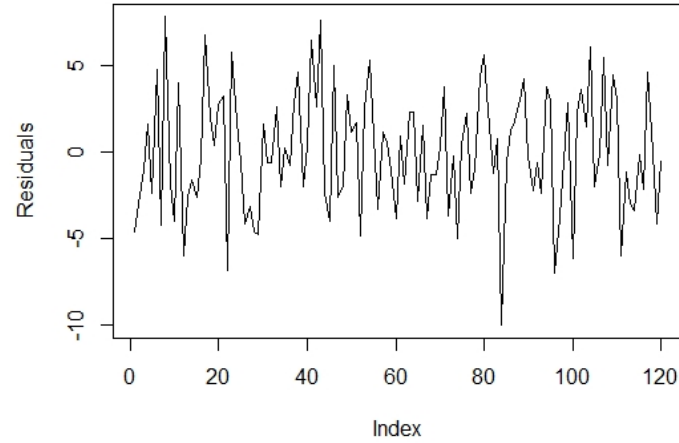
# Assumptions Checking

# Assumptions Checking

## Normality Assumption

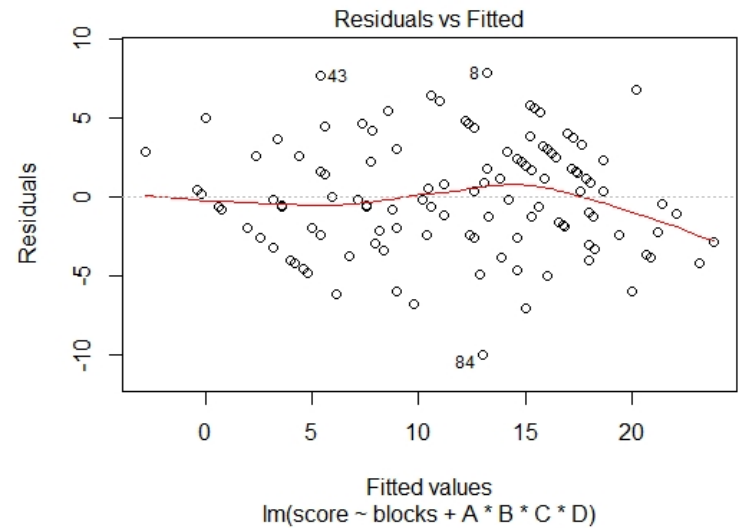


Residuals vs. Index

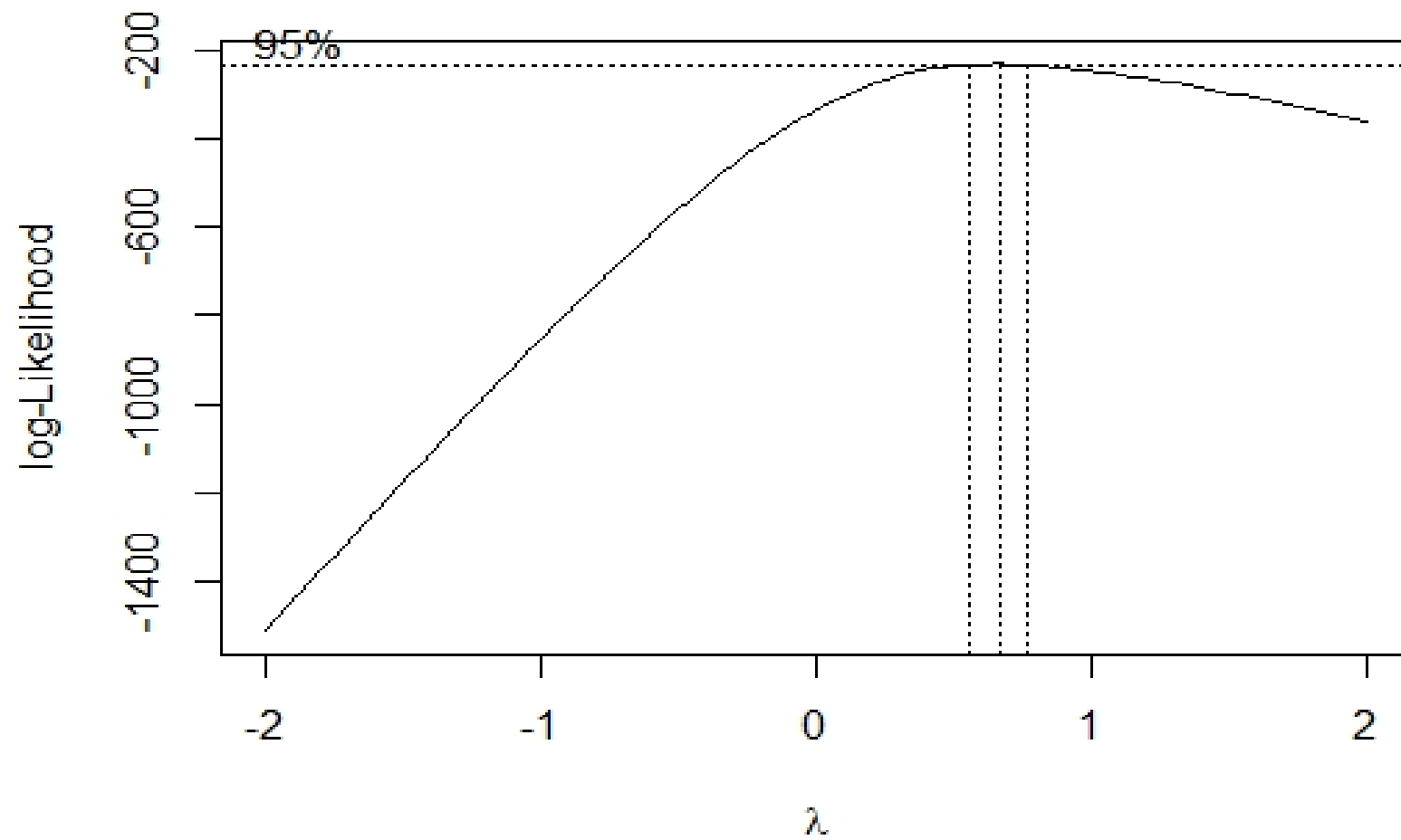


## Constant Variance

## Independence



# Box-Cox Transformation



# Breusch-Pagan Test



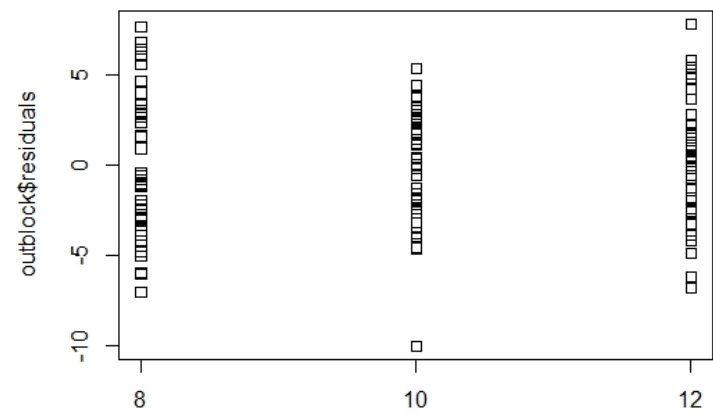
Non-constant Variance Score Test

Variance formula: `~ fitted.values`

Chisquare = 0.02546167, Df = 1, p = 0.87322

# Plot of Factors vs Residuals

Distance vs. Residuals



Horizontal vs. Residuals



Posture vs. Residuals




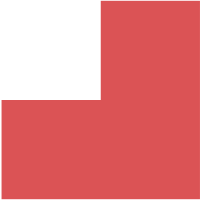
Hand vs. Residuals



03

# Data Analysis

# Data Collection on Experiment Day

- 
- Collected at a local bar, Campus Quarters
  - Measured and marked our physical locations to throw from (6 unique locations)
  - Not much difficulty running experiment; picked opportune time to run experiment
- 



## Table of Means

		Dominant Hand			Nondominant Hand		
	Distance	8 feet	10 feet	12 feet	8 feet	10 feet	12 feet
Posture	Horizontal						
Standing	Straight	16.8	11.2	12.2	18.6	11.6	7.6
Kneeling	Straight	13.4	10.4	13.0	15.4	10.0	10.6
Standing	Right	12.4	12.6	7.8	13.4	13.4	8.0
Kneeling	Right	12.8	12.0	8.6	15.6	10.0	5.2

# ANOVA Table

	<u>Df</u>	Sum Sq	Mean Sq	F value	Pr(>F)	
blocks	4	3355	838.7	53.978	< 2e-16	***
A	2	653	326.3	20.998	3.08e-08	***
B	1	75	75.2	4.840	0.0303	*
C	1	15	15.4	0.992	0.3220	
D	1	3	3.0	0.194	0.6610	
A:B	2	121	60.4	3.885	0.0240	*
A:C	2	22	11.1	0.715	0.4919	
B:C	1	1	0.7	0.043	0.8354	
A:D	2	99	49.5	3.186	0.0459	*
B:D	1	1	1.4	0.091	0.7640	
C:D	1	2	1.9	0.121	0.7291	
A:B:C	2	75	37.4	2.409	0.0956	.
A:B:D	2	9	4.3	0.274	0.7609	
A:C:D	2	10	5.0	0.320	0.7268	
B:C:D	1	8	8.0	0.515	0.4746	
A:B:C:D	2	17	8.6	0.551	0.5784	
Residuals	92	1430	15.5			

Significant variables:

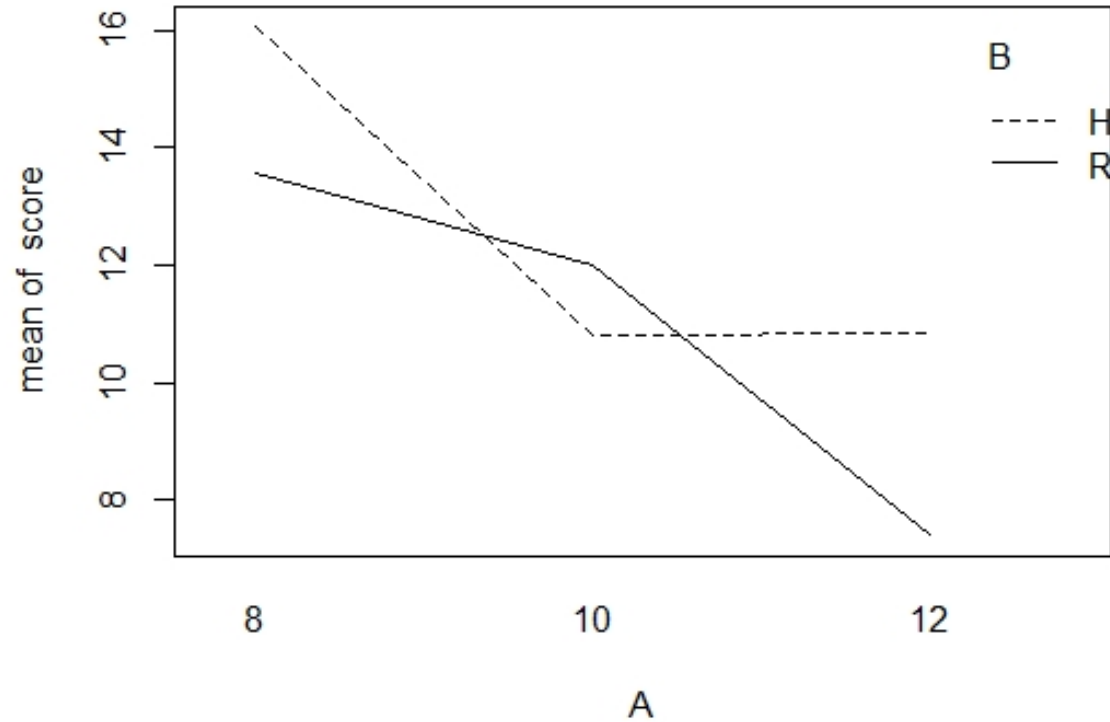
- Blocks
- A (Distance)
- B (Horizontal)
- A:B (Distance and Horizontal Interaction)
- A:D (Distance and Hand Interaction)

# Relative Efficiency

- CRD vs RCBD~ The RCBD's p-value from ANOVA is  $2e-16$  which is highly significant to our “dart madness” model.
- Relative efficiency obtained is 3.21 which states that “Blocking” effect is worthwhile to control unnecessary noise.

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
blocks	4	3355	838.7	53.978	< 2e-16 ***
Residuals	92	1430	15.5		

# A:B Interaction Plot and Polynomial Contrasts



**Factor B Fixed at H (Straight On)**

P-value for  $B_{lin}$  = 0.003989327

P-value for  $B_{quad}$  = 0.08556764



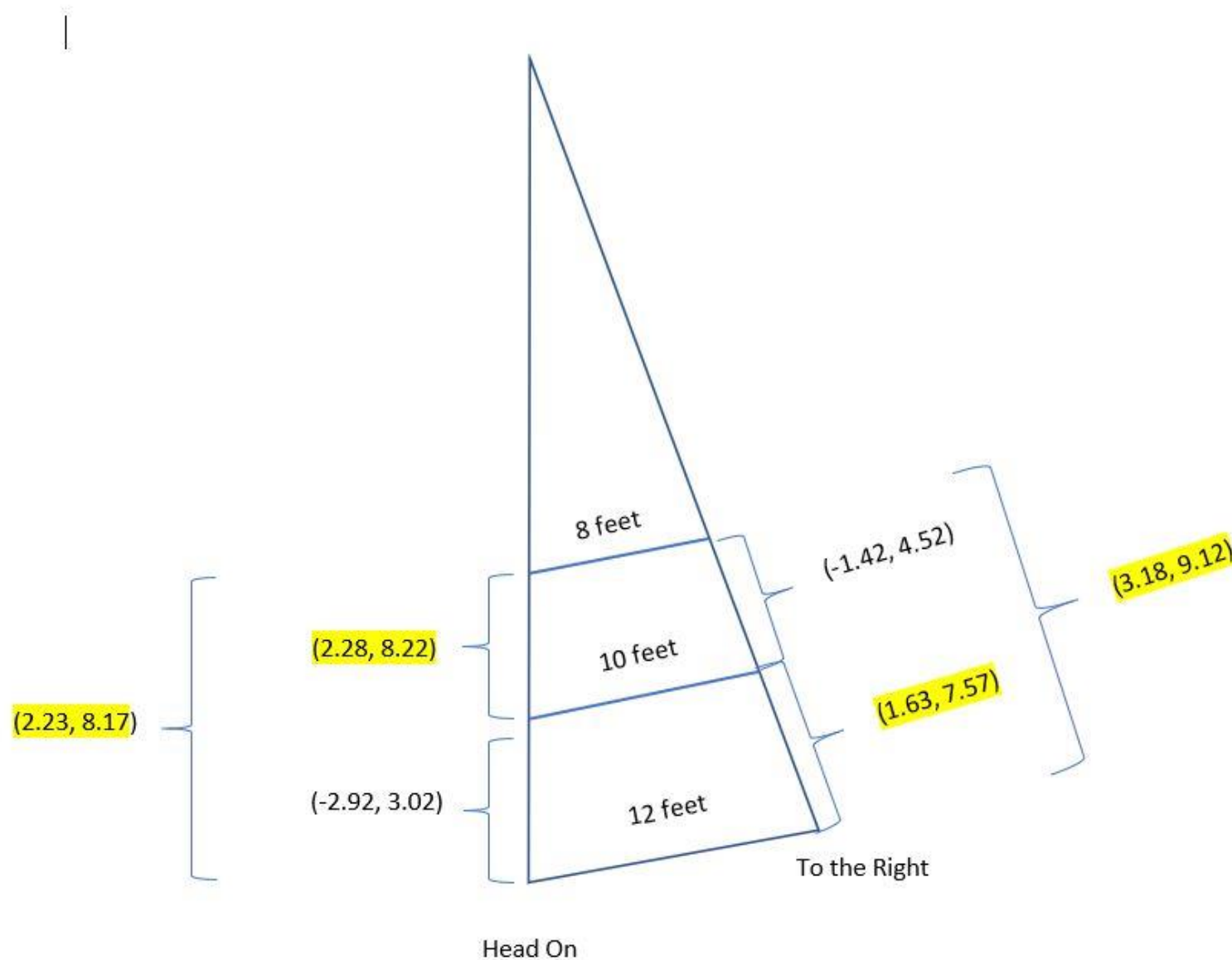
**Factor B Fixed at R (To The Right)**

P-value for  $B_{lin}$  = 0.0007362503

P-value for  $B_{quad}$  = 0.2608425



# Confidence Intervals



## Factor B fixed at H (Straight On)

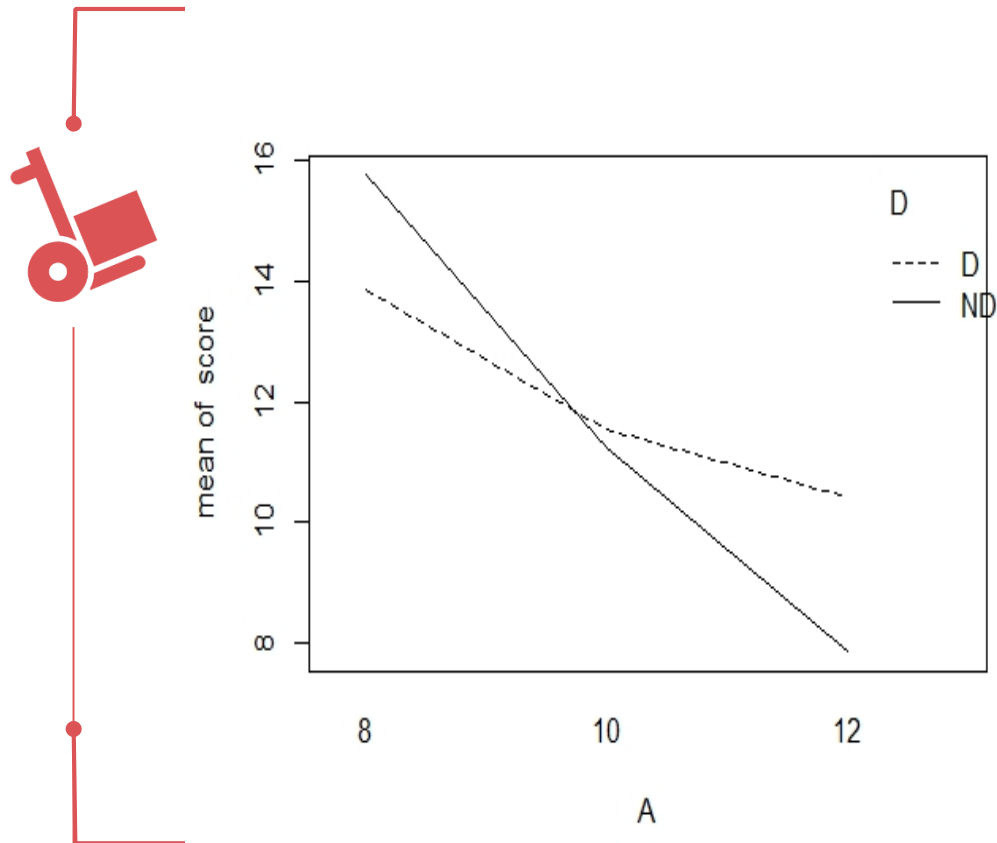
- 8 feet-10 feet:  $(2.28, 8.22)$
- 8 feet-12 feet:  $(2.23, 8.17)$
- 10 feet-12 feet:  $(-2.92, 3.02)$

## Factor B fixed at R (To The Right)

- 8 feet-10 feet:  $(-1.42, 4.52)$
- 8 feet-12 feet:  $(3.18, 9.12)$

# A:D Interaction Plot and Polynomial Contrasts

## A:D Interaction Plot



## Polynomial Contrasts

### Factor D Fixed at D (Dominant)

P-value for  $D_{lin}$  = 0.053085

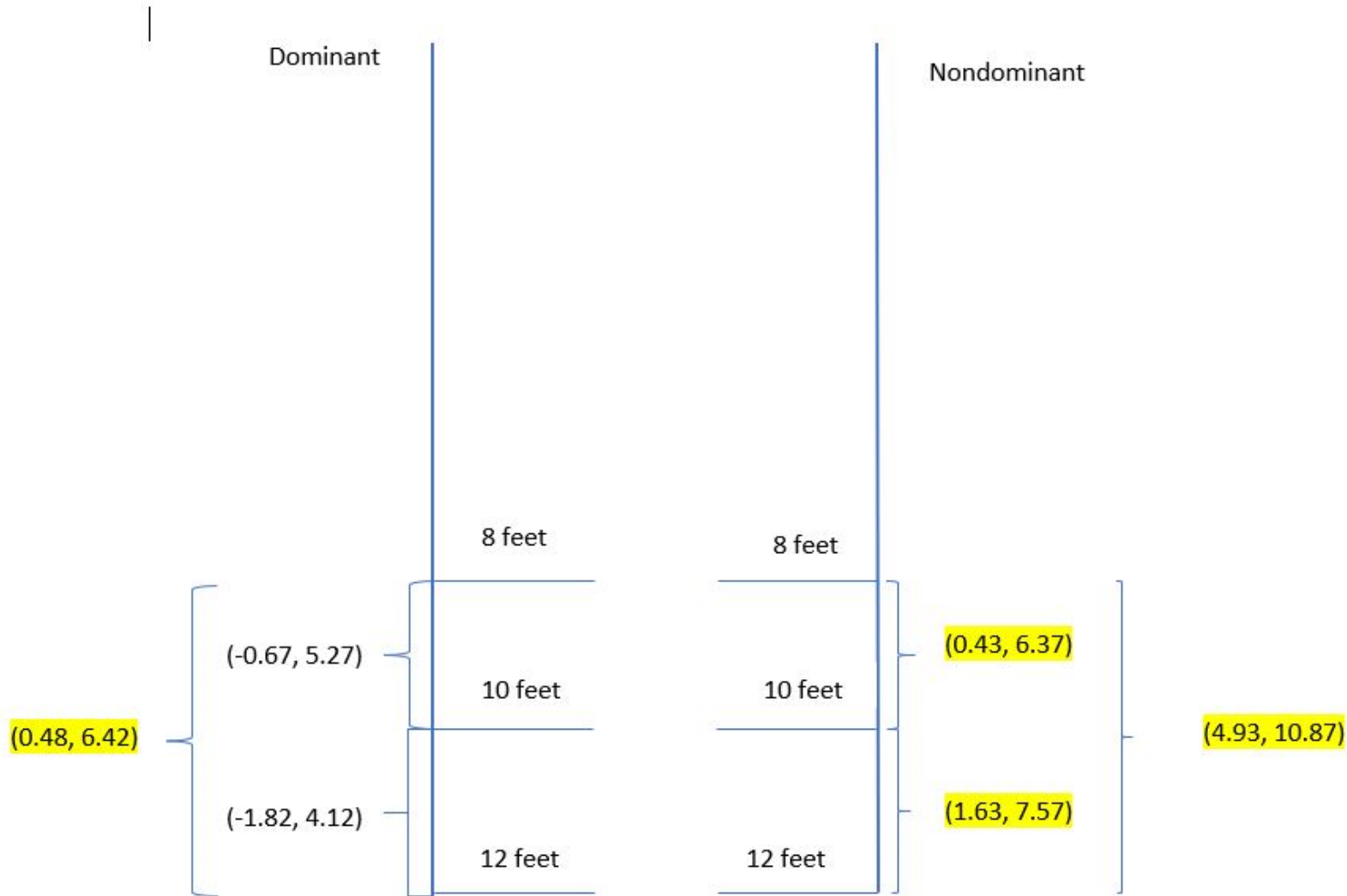
P-value for  $D_{quad}$  = 0.7069678

### Factor D Fixed at ND (Nondominant)

P-value for  $D_{lin}$  = 1.675551e-05

P-value for  $D_{quad}$  = 0.7437226

# Confidence Intervals



## Factor D fixed at D (Dominant)

- 8 feet-10 feet:  $(-0.67, 5.27)$
- 8 feet-12 feet:  $(0.48, 6.42)$
- 10 feet-12 feet:  $(-1.82, 4.12)$

## Factor D fixed at ND (Nondominant)

- 8 feet-10 feet:  $(0.43, 6.37)$
- 8 feet-12 feet:  $(4.93, 10.87)$
- 10 feet-12 feet:  $(1.63, 7.57)$

04

# Conclusion and Summary




# Conclusion

- Blocking was highly significant
- Factor D (hand): individually insignificant but significant through A:D interaction
- Factor B (horizontal position): individually significant and significant through A:B interaction
- Nondominant hand prevails?

		Dominant Hand			Nondominant Hand		
	Distance	8 feet	10 feet	12 feet	8 feet	10 feet	12 feet
Posture	Horizontal						
Standing	Straight	16.8	11.2	12.2	18.6	11.6	7.6
Kneeling	Straight	13.4	10.4	13.0	15.4	10.0	10.6
Standing	Right	12.4	12.6	7.8	13.4	13.4	8.0
Kneeling	Right	12.8	12.0	8.6	15.6	10.0	5.2

# Difficulties

- 
- Keeping a fixed angle for our horizontal position “to the right” provided its challenges
  - Uncertainty with specious Box-Cox test
  - Difficulties in analysis
- 