Perception example of EZBHDDM

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Introduction

Data from Ratcliff and Rouder (1998), experiment 1, participant N.H.:

> "...subjects were asked to decide **whether the overall brightness of pixel arrays displayed on a computer monitor was "high" or "low"** (Fig. 3a). The brightness of a display was controlled by the proportion of the pixels that were white. For each trial, the proportion of white pixels was chosen from one of two distributions, a high distribution or a low distribution, each with fixed mean and standard deviation (Fig. 3b). Feedback was given after each trial to tell the subject whether his or her decision had correctly indicated the distribution..."

There are 66 cells in the design with two main factors:

- **Accuracy vs Speed instructions**: Conditions 1-33 had an accuracy instruction, 34-66 a speed instruction.
- **More black vs More white pixels**: Conditions 1-16 and 34-49 had more black pixels; conditions 18-33 and 51-66 had more white, and conditions 17 and 50 were ambiguous and will not be used here because they can't provide accuracy measures.

```r
# Load necessary libraries/packages
library(R2jags)
```

Loading and cleaning the data

Load the data

```r
# Load the data from one participant
data_raw <- read.csv("./nh.tsv", sep = "")
colnames(data_raw) <- c("index","cond","response","RT")
head(data_raw)
```

```
##   index cond response  RT
## 1     1    1        1 457
## 2     1    1        1 569
## 3     1    1        1 390
## 4     1    1        1 534
## 5     1    1        1 501
## 6     1    1        1 488
```

```r
# Data set dimensions
dim(data_raw)
```

```
## [1] 7889    4
```

Clean the data

```r
# Create a copy of the raw data file
data <- data_raw

# Get 'accuracy' binary coding based on the condition and response in raw data file
accuracy <- as.integer(data_raw$cond > 0  & data_raw$cond < 17 & data_raw$response==1|
                       data_raw$cond > 17 & data_raw$cond < 34 & data_raw$response==2|
                       data_raw$cond > 33 & data_raw$cond < 50 & data_raw$response==1|
                       data_raw$cond > 50 & data_raw$cond < 67 & data_raw$response==2)

# Update the 'response' column of the data copied so it reflects accuracy
data$response <- accuracy

# Remove rows where RT > 3000ms
data <- data[which(data$RT<=3000),]
```

Get summary statistics

Write custom function `ez_summaries`

```r
# Define a function to compute the summary statistics used by EZ-DDM
ez_summaries <- function(subset){
  # Identify condition ID
  cond <- unique(subset$cond)
  # Return relevant summary statistics
  return(data.frame("nTrials" = nrow(subset),
                    "score" = sum(subset$response),
                    "meanRT"  = mean(subset$RT[which(subset$response==1)]/1000),
                    "varRT"   = var(subset$RT[which(subset$response==1)]/1000),
                # Index variable: Accuracy (-0.5) vs Speed (0.5) condition
                    "Xi"  = as.integer(cond>33)-0.5,
                # Arbitrary scale of stimulus configuration | 0 is 50/50 black and white
                    "Xs"  = ((cond-1) %% 33 - 16)/5))
}
```

Compute summary statistics from data

```r
# Initialize an empty output data frame (df)
tmp <- matrix(0,nrow = max(data$cond),ncol = 6)
df <- as.data.frame(tmp)
colnames(df) <- c("nTrials", "sum_accuracy", "mean_rt_correct",
```

```
                  "variance_rt_correct", "Xi", "Xs")

# Populate the df output using the ez_summaries function
for(i in 1:max(data$cond)){
  df[i,] <- ez_summaries(data[which(data$cond==i),])
}

# Remove the two ambiguous conditions (17 and 50, with 50/50 black and white)
df <- df[-which(df$Xs==0),]
head(df,3)
```

```
##   nTrials sum_accuracy mean_rt_correct variance_rt_correct   Xi   Xs
## 1      30           30       0.4917333          0.03115648 -0.5 -3.2
## 2      24           24       0.4888750          0.03118168 -0.5 -3.0
## 3      36           36       0.4994722          0.02872146 -0.5 -2.8
```

The model

The model incorporates an effect (β) of instruction (i.e., x_i, Xi) on the *bound parameter (α)*.

$$\alpha \sim \text{Normal}(\mu_\alpha + \beta X_i, \sigma_\alpha)$$

We also include a nonlinear regression on the drift rate δ using instruction (i.e., x_i, Xi) and stimulus configuration (i.e., x_s, Xs) as predictors. For the later, we used the absolute value (i.e., $|x_s|$, abs(Xs)) to represent the task difficulty getting easier as the black/white balance departs from 50%.

$$Y = \Phi(\beta_1 + \beta_2|X_s| + \beta_3 X_i|X_s|)$$
$$\delta_{\text{pred}} = \mu_\delta + \beta_0 Y + \beta_4 X_i$$
$$\delta \sim \text{Normal}(\delta_{\text{pred}}, \sigma_\delta)$$