A Drift Diffusion Model for Dual Task Response Times

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Objectives

- Define a diffusion model for reaction times and accuracy data from a dual task paradigm
- Model the reaction time specific distribution patterns
- Define a multinomial processing tree model for reaction times

Introduction

The specific distribution of reaction time data in speeded responses is well known and can be analysed with random walk models like the drift diffusion model proposed by Ratcliff [1].
In this project the accuracy and reaction time data from a dual task paradigm have been investigated. In previous analyses, a significant effect of a peripheral visual stimulus on reaction times has been shown. Participants had to respond to a visual task on a monitor and another visual task in the periphery simultaneously. The resulting distribution of response times has successfully been predicted by the model. A further aspect of this project was the definition of a multinomial processing tree (MPT) model which would explain different reaction time distributions in terms of parallel and serial processing. MPT models have been extensively used for accuracy data but rarely for reaction times [2].

The Drift Diffusion Model

The drift diffusion model is a random walk model which assumes that binary decision processes consist of random steps in their information accumulation [3]. Systematic and random influences drive the process to either one of two thresholds. The crossing initiates the corresponding response. Decisions are made by accumulating noisy evidence to one of two response criteria that represent the amounts of evidence needed to make each response. The process begins at starting point z and moves over time until it reaches the lower threshold at zero or the upper threshold at a [4].

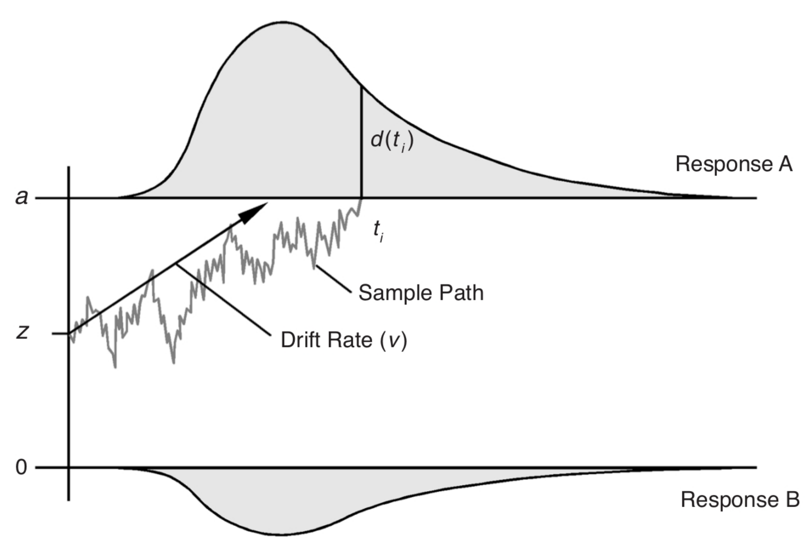

Figure 1: Drift Diffusion Model with Resulting Response Time Distributions

[1] R.Ratcliff.
A theory of memory retrieval.
Psychological Review, 85(2), 1978.

[2] X. Hu.
Extending general processing tree models to analyze reaction time experiments.
Journal of Mathematical Psychology, 45, 2001.

[3] K. Pearson.
The Problem of the Random Walk.
Nature, 72(1865), 1905.

[4] J.Voss A.Voss, K.Rothermund.
Interpreting the parameters of the diffusion model: An empirical validation.
Memory and Cognition, 32(7), 2004.

Results

A quantile probability function plot (QPF plot) for reaction times to the primary task. It shows the distribution of reaction times and accuracy under the different conditions for the model and the empirical data. The quantiles of the RT distribution for each condition are plotted vertically on the y-axis and the proportion of correct and error responses are plotted on the x-axis.

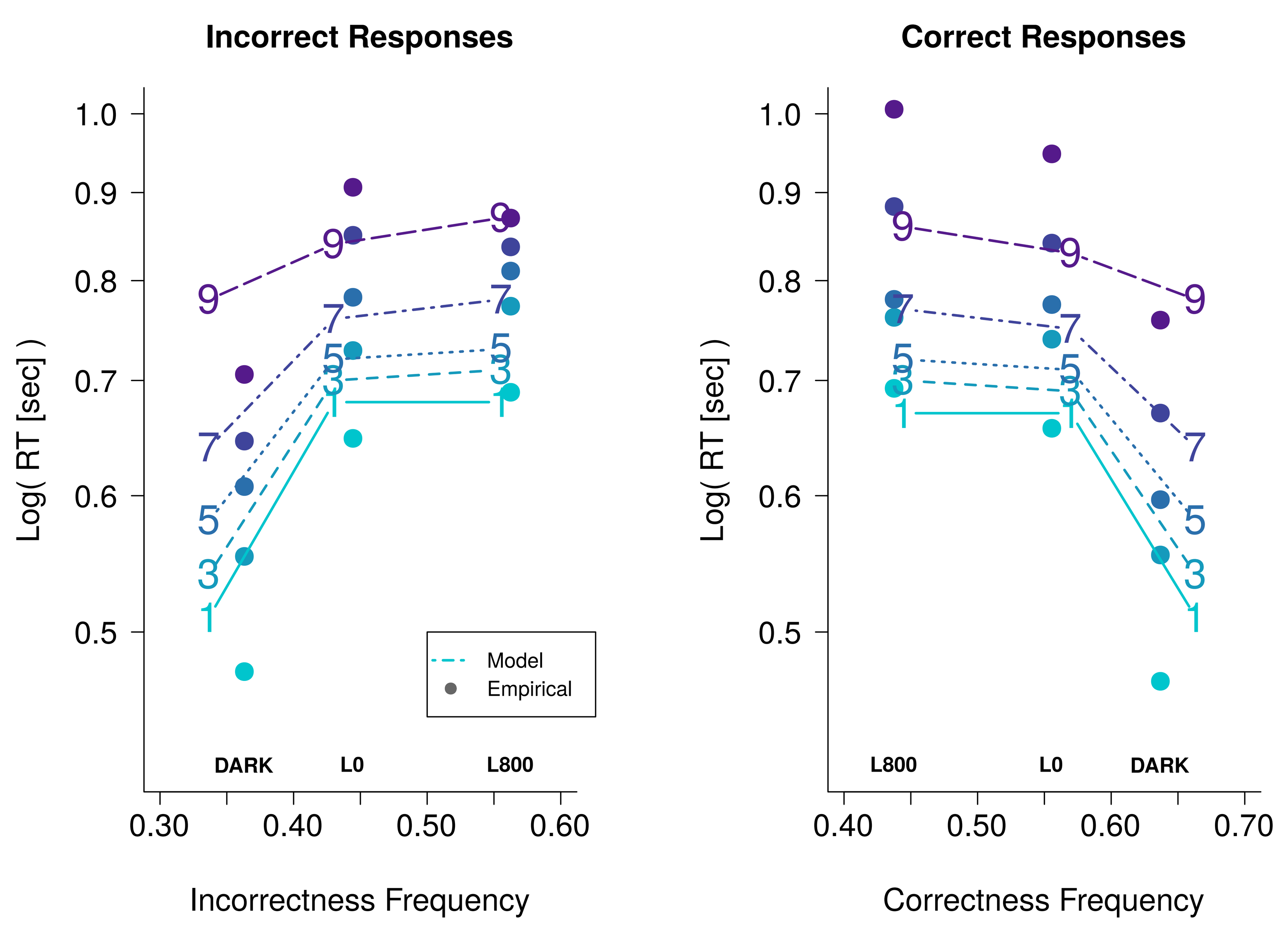

Figure 2: Quantile Probability Function Plot for Reaction Times

Predicted and empirical cumulative distribution functions (CDF) for reaction times to the primary task. The given graph visualizes a data set of reaction times under the two condensed conditions darkness and light. The ascending blue line is the accumulated probability function computed according to the diffusion model. The purple line shows the cumulative probability of empirical response times.

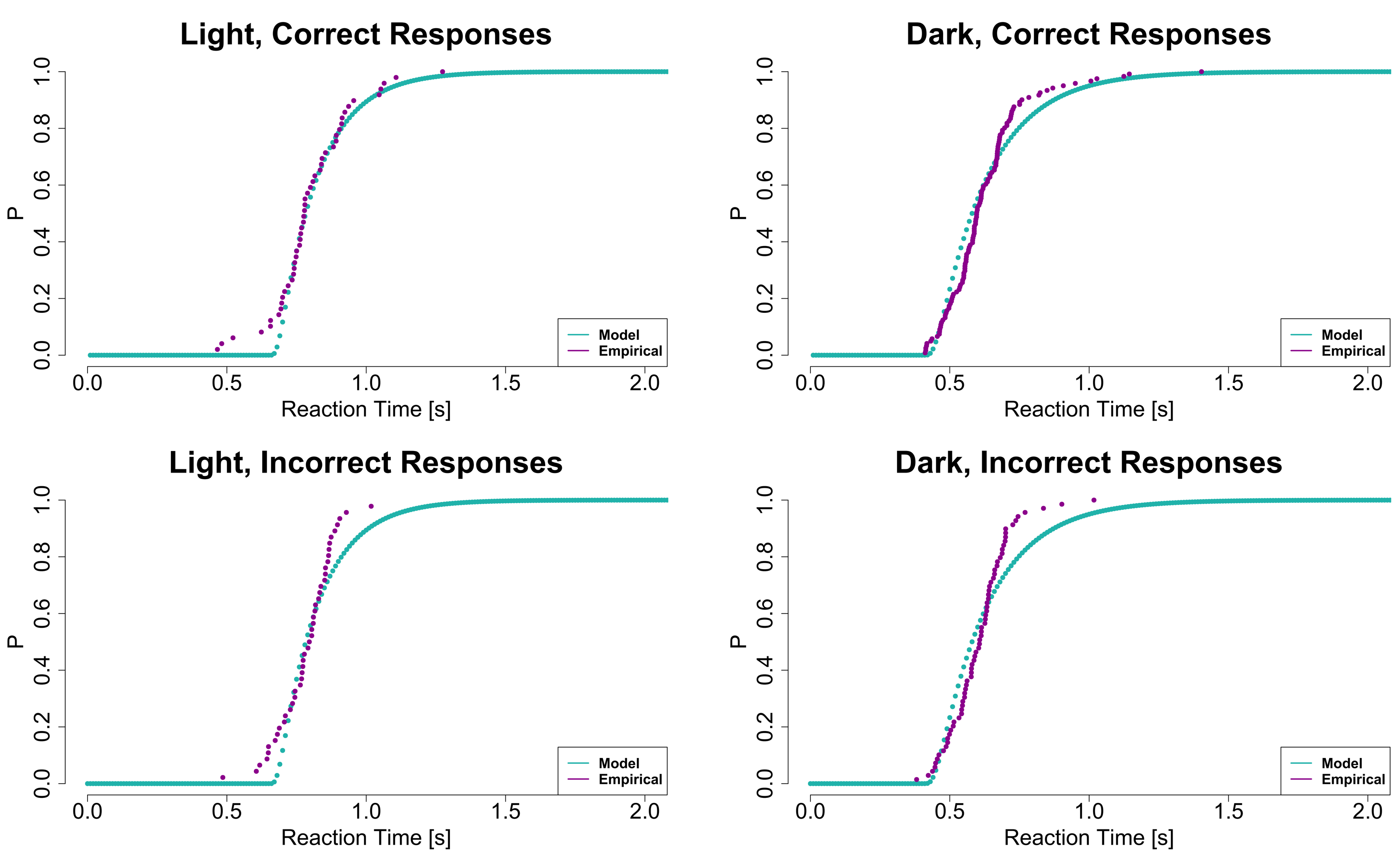

Figure 3: Cumulative Density Function of Model Values and Empirical Values

A Multinomial Processing Tree Model for Reaction Times

MPT models make the basic assumption that certain cognitive processes are serial in nature. These models represent the processes in terms of branching trees, with parameters being the conditional link probabilities from one stage to another. The graph shows an MPT model for reaction times instead of probabilities. With the presentation of the stimulus, two possible paths for the composition of the final reaction time emerge. In one path the subject responded to the primary task first, in the other path, the subject responded to the LED first.

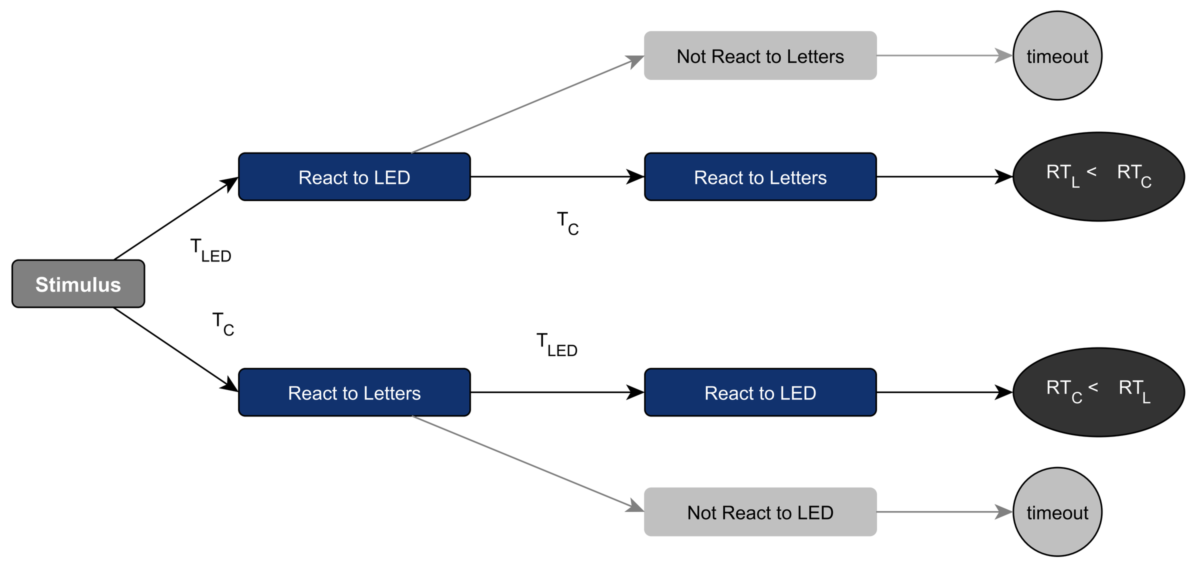

Figure 4: Multinomial Processing Tree Model for Reaction Times

The Experiment

The experiment had a dual task setup during which the subjects had to react to a task on a monitor and to an LED in the periphery. With the presentation of the stimuli the measurement of the response time was initiated. Participants were instructed to respond as quickly and as accurately as possible whether they saw the target letter "N" or the target letter "X" on the screen. There were three conditions. In the first condition the light appeared immediately. In the second condition, the LEDs were presented with a fading of 800 ms and in the third condition, no light in the periphery was presented at all. All conditions were presented in four iterations per subject, thus each subject responded to 288 trials in total.

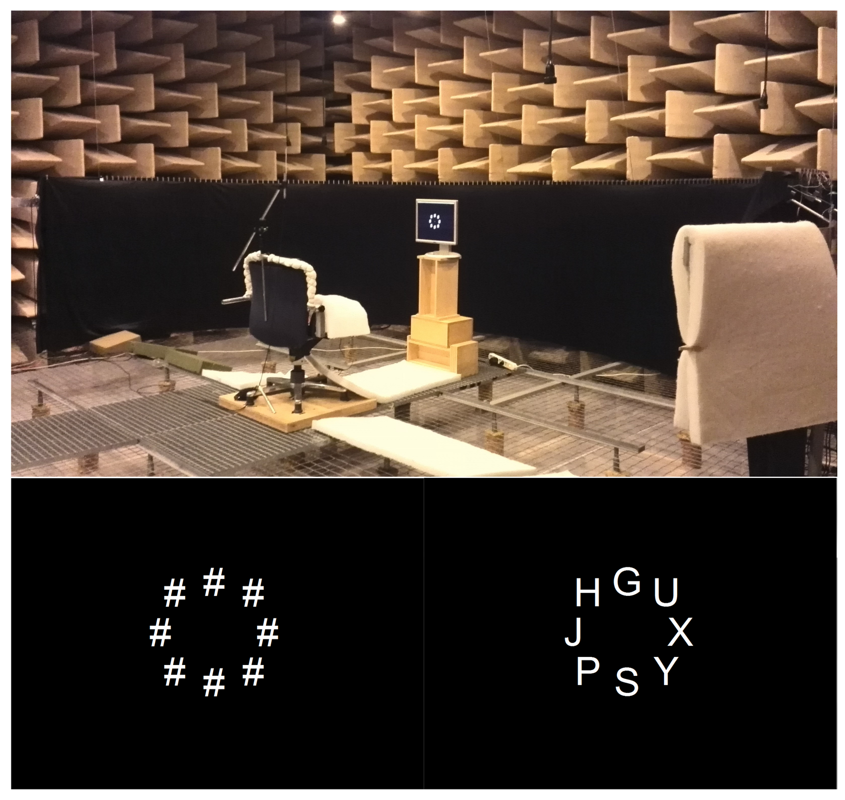

Figure 5: Anechoic Chamber an Primary Task Stimuli

The FastDMPlot R-Package

Software written by A.Voss and collegues was used for the analysis (`www.uni-heidelberg.de/ae/meth/fast-dm/`). R functions have been implemented to pre-process data for the model, compose the input and compile various plots and outputs. The functions have been composed together into an **R-package** which can be found on github.

Future Work

The definition of an MPT model for parallel processing has not been done yet. Assuming that the cognitive processes in a dual task paradigm are not strictly serial, but involve parallel processing, the previously defined MPT model is not yet sufficient but outlines only a possible abstraction.

Acknowledgements

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