

# Optimal Experimental Design: Psychophysics of change point Detection.

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## Abstract

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## 1. Introduction

Experimental design First we need a research question, then the problem of design in the experiment arises, how many participants should we test, what are the values of the independent variable that we should use, how many times should we present each of those values, etc. The problem is when

### 1.1. Optimal experimental design

Elements:

Design space: what are the elements of the experimental design that we want to optimize Utility Function: function that maps points on the design space to the real numbers, this function should reflect the objective of the experiment, for example if we want to discriminate between two cognitive models, the utility function should assign a greater value to an experimental design for which the models give different predictions than to designs for which the predictions of the models are indistinguishable from one another.

## 15 2. Optimal Experimental Design: Example

16 Why is detecting changes important for an organism?

17 Change detection in probabilistic series.

18 Arising problems with experimental design.

19 Research question and its statistical interpretation

20 Assumption about the relationship between a subjects response the depen-  
21 dent variable under study

22 Design space for this problem and how to reduce the dimensionality of  
23 the space by assuming experimental constraints.

24 Utility function and its relationship with the objective of the experiment

25 Arising problems with utility function and the proposed response func-  
26 tion. Bayesian solution, assigning a prior distribution to the parameters, the  
27 less research in a field the more difficult it is to assign an informative prior,  
28 however, we could use other cognitive models in order to propose a prior  
29 distribution.

### 30 2.1. Using a model to generate prior distributions

31 Using the prior distribution, the utility function and the definition of  
32 a design space we can optimize the experimental design in this case we are  
33 looking for  $\delta\theta^*$  that maximizes the following equation:

$$U(\delta\theta^*) = \max_{\delta\theta} \int_{\beta} \log(\det(I(\beta|\delta\theta)))\pi(\beta)d\beta \quad (1)$$

34 The previous integral can be approximated via Monte Carlo sampling

### 35 **3. Results**

#### 36 *3.1. Construction of the prior distribution*

37 Prior over model parameters(Gallistel et al 2014) Results Constructing  
38 the prior: we take a multivariate normal distribution with mean and covari-  
39 ance equal to the unbiased estimators for both parameters.

#### 40 *3.2. Optimal design*

41 Aproximating the utility function (integral) throught Monte Carlo simu-  
42 lation Utility aproximation for 2 Design points  
43 the approximation returns a smooth curve over the 2 point design space.

### 44 **4. Discussion**

45 Optimal design for the example Properties of the most useful points (they  
46 land on the points of the curve where the steepness changes most dramati-  
47 cally)

48 Advantages of Optimal Design

49 Using models to generte prior distributions.