

# MMCT Mathematical background

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## 1 Introduction

This document describes the mathematical background of the MMCT python package, which can be used to do tests of multinomial data with monte carlo sampling. This document does not attempt to explain how to use the code. Instead look at the GitHub page for inspiration.

## 2 The multinomial distribution

The multinomial distribution is the natural extension of the binomial distribution, in which a random variable can fall in one of two cases with probability  $p$  and  $1 - p$ . In the multinomial distribution there are  $k$  different possibilities (bins) for the random variable, and accordingly each of the  $k$  bins are reached with probabilities  $p_1, p_2, \dots, p_k$ , such that

$$\sum_{i=1}^k p_i = 1. \quad (1)$$

We imagine drawing  $n$  times from probability distribution. We end up with  $x_1$  draws in bin 1,  $x_2$  draws in bin 2 and so on:

$$\sum_{i=1}^k x_i = n. \quad (2)$$

The probability density function (the probability of drawing exactly  $x_1, x_2, \dots, x_k$  given  $p_1, p_2, \dots, p_k$ ) is

$$f(x_1, \dots, x_k; n, p_1, \dots, p_k) = \frac{n!}{x_1! \dots x_k!} p_1^{x_1} \dots p_k^{x_k} \quad (3)$$

## Bibliography