```
#----------------------------------------
# Atypicality index for compositional data
# Based on Aitchison(1986, 2003)
#
# January 25, 2006
# Developed by Hiroyoshi Arai
#----------------------------------------

atypicality <- function(x, z=NULL) {

  d <- ncol(x)-1
  x <- x/apply(x, 1, sum)
  Y <- data.frame(log(x[ ,1:d]/x[ ,d+1]))

  if (!is.null(z)) {
    if (is.vector(z)) {
      z <- matrix(z, nrow=1)
    }
    z <- data.frame(z)
    if (ncol(x) != ncol(z)) {
      stop("The number of columns is different between x and z.")
    }
    z <- z/apply(z, 1, sum)
    y <- data.frame(log(z[ ,1:d]/z[ ,d+1]))
    Ymu <- mean(Y)
    Ysigma <- var(Y)
    N <- nrow(x)
  } else {
    y <- Y
    N <- nrow(x)-1
  }

  result <- data.frame(matrix(NA, nrow=nrow(y), ncol=2))
  colnames(result) <- c("q(y)", "atypicality")
  n <- N-1

  for (i in 1:nrow(y)) {
    if (is.null(z)) {
      Ymu <- mean(Y[-i, ])
      Ysigma <- var(Y[-i, ])
    }
    qy <- 1/(1+1/N)*as.matrix(y[i, ]-Ymu)%*%solve(Ysigma)%*%t(y[i, ]-Ymu)
    result[i, ] <- c(qy, pbeta(qy/(qy+n), d/2, (n-d+1)/2))
  }

  return(result)
}
```