Application: Optimization

Why is any of this information useful?

- Optimization routines in R like `optim`, `nlm`, and `optimize` require you to pass a function whose argument is a vector of parameters (e.g. a log-likelihood)
- However, an object function might depend on a host of other things besides its parameters (like *data*)
- When writing software which does optimization, it may be desirable to allow the user to hold certain parameters fixed

Maximizing a Normal Likelihood

Write a “constructor” function

```
make.NegLogLik <- function(data, fixed=c(FALSE,FALSE)) {
        params <- fixed
        function(p) {
                params[!fixed] <- p
                mu <- params[1]
                sigma <- params[2]
                a <- -0.5*length(data)*log(2*pi*sigma^2)
                b <- -0.5*sum((data-mu)^2) / (sigma^2)
                -(a + b)
        }
}
```

Note: Optimization functions in R *minimize* functions, so you need to use the negative log-likelihood.

Maximizing a Normal Likelihood

```
> set.seed(1); normals <- rnorm(100, 1, 2)
> nLL <- make.NegLogLik(normals)
> nLL
function(p) {
                params[!fixed] <- p
                mu <- params[1]
                sigma <- params[2]
                a <- -0.5*length(data)*log(2*pi*sigma^2)
                b <- -0.5*sum((data-mu)^2) / (sigma^2)
                -(a + b)
        }
<environment: 0x165b1a4>
> ls(environment(nLL))
[1] "data"   "fixed"  "params"
```

Estimating Parameters

```
> optim(c(mu = 0, sigma = 1), nLL)$par
      mu    sigma
1.218239 1.787343
```

Fixing $\sigma = 2$

```
> nLL <- make.NegLogLik(normals, c(FALSE, 2))
> optimize(nLL, c(-1, 3))$minimum
[1] 1.217775
```

Fixing $\mu = 1$

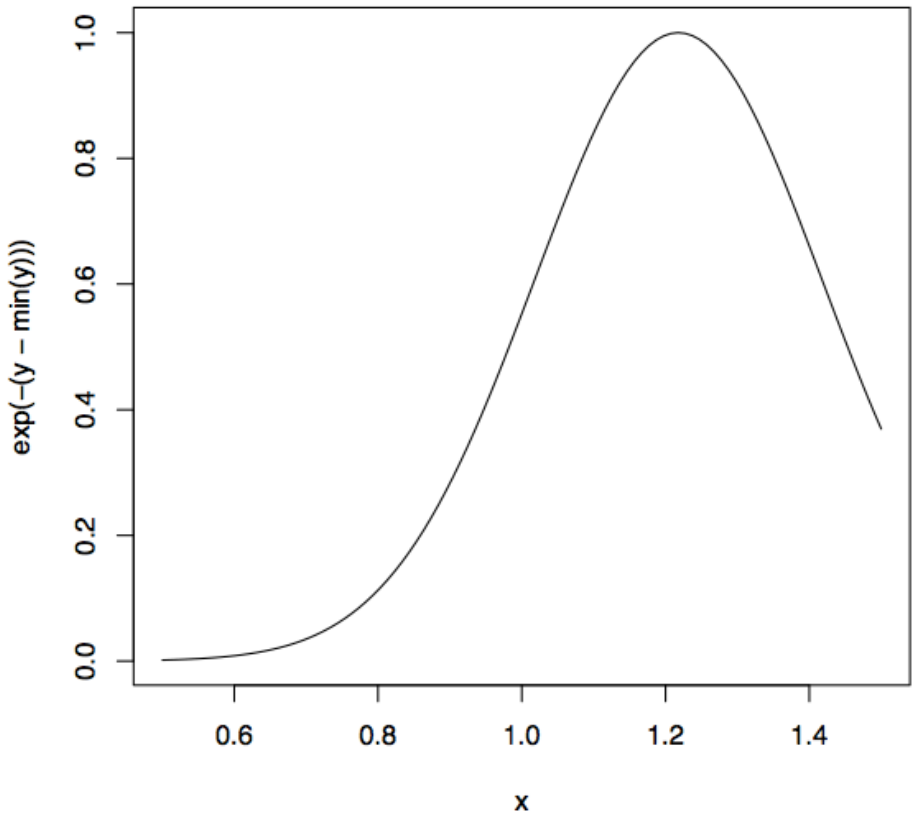
```
> nLL <- make.NegLogLik(normals, c(1, FALSE))
> optimize(nLL, c(1e-6, 10))$minimum
[1] 1.800596
```

Plotting the Likelihood

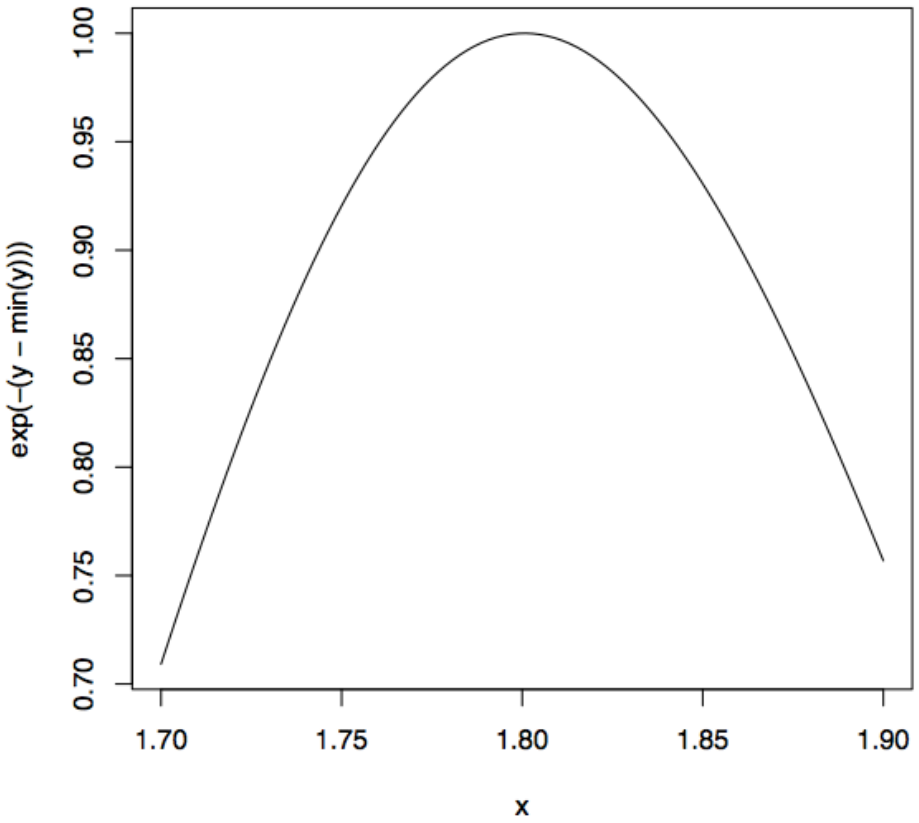
```
nLL <- make.NegLogLik(normals, c(1, FALSE))
x <- seq(1.7, 1.9, len = 100)
y <- sapply(x, nLL)
plot(x, exp(-(y - min(y))), type = "l")

nLL <- make.NegLogLik(normals, c(FALSE, 2))
x <- seq(0.5, 1.5, len = 100)
y <- sapply(x, nLL)
plot(x, exp(-(y - min(y))), type = "l")
```

Plotting the Likelihood



Plotting the Likelihood



Lexical Scoping Summary

- Objective functions can be "built" which contain all of the necessary data for evaluating the function
- No need to carry around long argument lists — useful for interactive and exploratory work.
- Code can be simplified and cleand up
- Reference: Robert Gentleman and Ross Ihaka (2000). "Lexical Scope and Statistical Computing," *JCGS*, 9, 491–508.