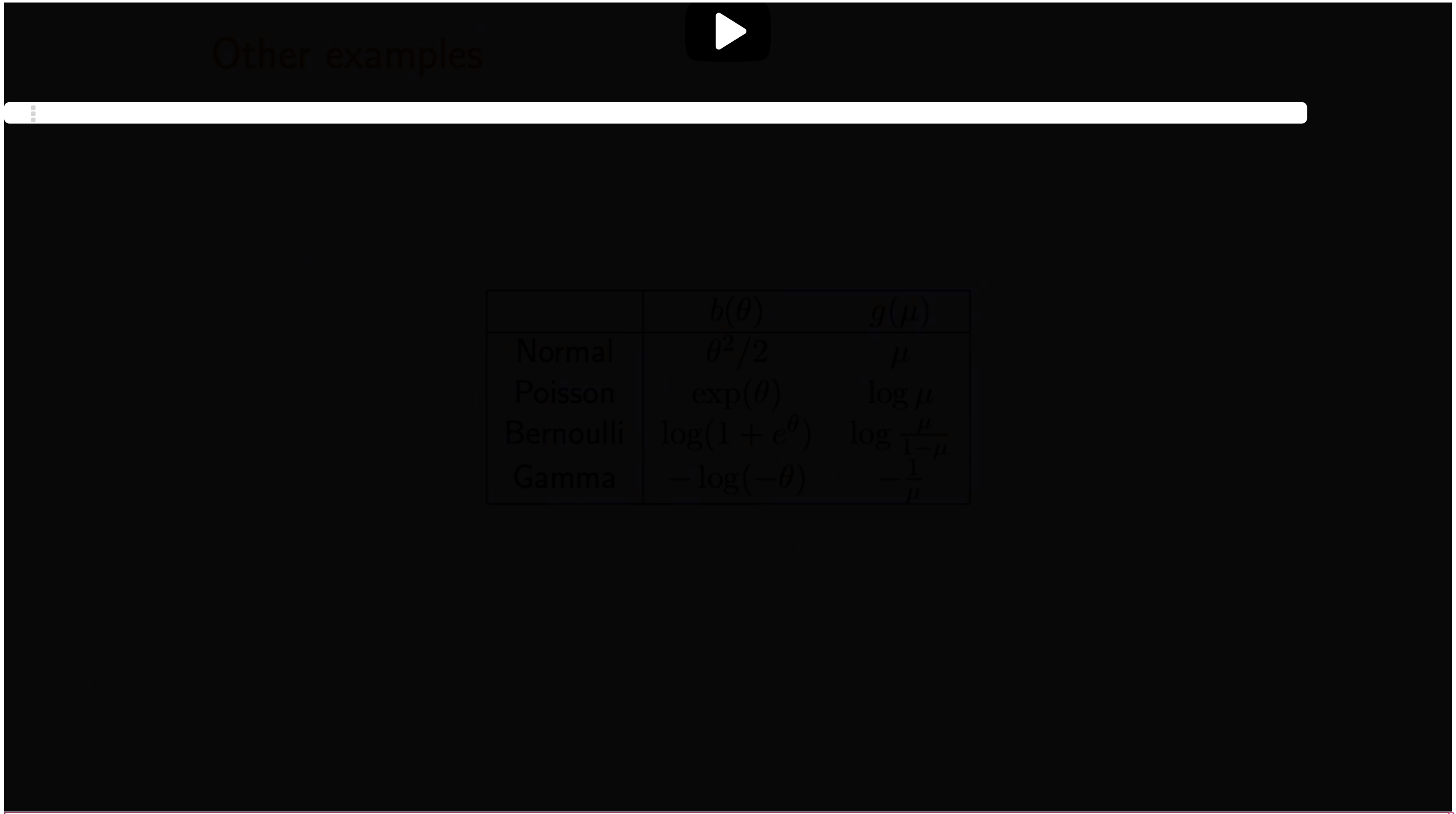
3. The Canonical Link Function

The Canonical Link Function and Bernoulli Example



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Canonical Link function for the Binomial Distribution

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The binomial distribution, with distribution function

$$f_p(x) = \binom{n}{x} p^x (1-p)^{n-x}$$

can be written as a canonical exponential family, as long as n is a fixed number. **For this problem, plug in $n = 1000$.**

What is the canonical link function $g(\mu)$? (With the understanding that $\mu = np$)

ln(mu/(1000-mu))

✔ **Answer:** ln(mu/(1000-mu))

$\ln\left(\frac{\mu}{1000-\mu}\right)$

STANDARD NOTATION

Solution:

For the binomial distribution, $b(\theta) = n\ln(e^\theta + 1)$ if we use the canonical parameter $\theta = \log\left(\frac{p}{1-p}\right)$. Therefore, the canonical link is $g(\mu) = (b')^{-1}(\mu)$. A direct computation yields $b'(\theta) = \frac{ne^\theta}{e^\theta+1}$, and so $g(\mu) = \ln\left(\frac{\mu}{n-\mu}\right)$.

Remark: In some texts, you might see $g(\mu) = \ln\left(\frac{\mu}{1-\mu}\right)$, the logit of μ instead of what we derived. This is due to a re-normalization convention where we think of the likelihood of $\overline{x} = x/n$, so that the mean of $\overline{x}$ is p instead of np. Notice that if you plug in $\mu = np$ into our expression, the n's cancel and we end up with the logit of p, which gives the alternate convention.

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Answers are displayed within the problem

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