$$p(x_s|\cdot) = \frac{1}{Z_s} \exp\left\{-\frac{1}{T}\left(\alpha \sum_{\tilde{s}} \psi(x_s, x_{\tilde{s}}) + \beta \sum_r \psi(x_r, x_s)\right)\right\}$$

$$\log p(x_s|\cdot) = -\frac{1}{T}\left(\alpha \sum_{\tilde{s}} \psi(x_s, x_{\tilde{s}}) + \beta \sum_r \psi(x_r, x_s)\right) - \log Z_s$$

$$Z_s = \sum_{s \in \cdot\cdot} \exp\left\{-\frac{1}{T}\left(\alpha \sum_{\tilde{s}} \psi(x_s, x_{\tilde{s}}) + \beta \sum_r \psi(x_r, x_s)\right)\right\}$$

$$a = -\frac{1}{T}\sum_{\tilde{s}} \psi(x_s, x_{\tilde{s}}) \qquad b = -\frac{1}{T}\sum_r \psi(x_r, x_s)$$

$$\log p(x_s|\cdot) = a\alpha + b\beta - \log \sum_s e^{a\alpha + b\beta}$$

$$\frac{\partial \log p(x_s|\cdot)}{\partial \beta} = b - \frac{\sum_s e^{a\alpha+b\beta} \cdot b}{\sum_s e^{a\alpha+b\beta}}$$

$$\frac{\partial^2 \log p(x_s|\cdot)}{\partial \beta^2} = -\frac{\left(\sum_s e^{a\alpha+b\beta} \cdot b^2\right)\left(\sum_s e^{a\alpha+b\beta}\right) - \left(\sum_s e^{a\alpha+b\beta} \cdot b\right)^2}{\left(\sum_s e^{a\alpha+b\beta}\right)^2}$$

$$\frac{\partial \log p(x_s|\cdot)}{\partial \alpha} = a - \frac{\sum_s e^{a\alpha+b\beta} \cdot a}{\sum_s e^{a\alpha+b\beta}}$$

$$\frac{\partial^2 \log p(x_s|\cdot)}{\partial \alpha} = - \frac{\left(\sum_s e^{a\alpha+b\beta}\cdot a^2\right)\left(\sum_s e^{a\alpha+b\beta}\right) - \text{''}}{\left(\sum_s e^{a\alpha+b\beta}\right)^2}$$

$$\left(\sum_s e^{a\alpha+b\beta}\cdot a\right)^2$$

Let $M_0 = \sum_s e^{a\alpha+b\beta}$, $M_1 = \sum_s \left(e^{a\alpha+b\beta}\cdot b\right)$

$M_2 = \sum_s \left(e^{a\alpha+b\beta}\cdot b^2\right)$

$$\log p(x_s|\cdot) = a\alpha + b\beta - \log \sum M_0$$

$$\frac{\partial \log p(x_s|\cdot)}{\partial \beta} = b - \frac{M_1}{M_0}$$

$$\frac{\partial^2 \log p(x_s|\cdot)}{\partial \beta^2} = - \frac{M_2 M_0 - M_1^2}{M_0^2} = \frac{M_1}{M_0} - \frac{M_2}{M_0}$$