$$l_{\gamma_k}(\gamma) = \frac{\partial l(\gamma)}{\partial \gamma_k} = \sum_{x_i \in R} y_{ik} - \sum_{x_i \in R} \frac{e^{\beta_k(x_i)+\gamma_k}}{\sum_{m=1}^{K} e^{\beta_m(x_i)+\gamma_m}}$$

$$l_{\gamma_k\gamma_k}(\gamma) = \frac{\partial^2 l(\gamma)}{\partial \gamma_k^2} = -\sum_{x_i \in R} \frac{e^{\beta_k(x_i)+\gamma_k}\left(\sum_{m=1}^{K} e^{\beta_m(x_i)+\gamma_m}\right) - \left(e^{\beta_k(x_i)+\gamma_k}\right)^2}{\left(\sum_{m=1}^{K} e^{\beta_m(x_i)+\gamma_m}\right)^2}$$

b) $$\gamma_k^1 = \gamma_k^0 - l_{\gamma_k\gamma_k}(\gamma_k^0)^{-1} \, l_{\gamma_k}(\gamma_k^0)$$

$$l_{\gamma_k}(0) = \sum_{x_i \in R} y_{ik} - \sum_{x_i \in R} \overbrace{\frac{e^{\beta_k(x_i)}}{\sum_{m=1}^{K} e^{\beta_m(x_i)}}}^{p_k(x_i)} = \sum_{x_i \in R} (y_{ik} - p_k(x_i))$$

$$l_{\gamma_k\gamma_k}(0) = -\sum_{x_i \in R} \left(p_k(x_i) - p_k^2(x_i)\right)$$

$$\gamma_k^1 = 0 - \left(-\sum_{x_i \in R} \left(p_k(x_i) - p_k^2(x_i)\right)\right)^{-1} \sum_{x_i \in R} (y_{ik} - p_k(x_i))$$

$$\overset{!}{=} \frac{\sum_{x_i \in R} (y_{ik} - p_k(x_i))}{\sum_{x_i \in R} p_k(x_i)(1 - p_k(x_i))}$$

c) subtract the mean