Cue combination lecture notes

<u>the maximum likelihood cue combination model</u>

- two depth cues; r.v.'s D1, D2 with known standard deviations sigma1, sigma2
- assume cues are unbiased, with means mu1, mu2 (= mu)
- one sample from each cue, d1, d2
    - capitals for r.v.'s, lower case for samples
- what is the the true depth? try an ML estimate
    - give formulas
    - d = w1*d1 + w2*d2, with w1 = ..., w2 = ...
    - so our ML depth estimates are a new r.v., D = w1*D1 + w2*D2; w1 + w2 = 1

- what are the properties of this ML estimate?
- if mu1=mu2=mu, then E[D] = mu; also unbiased
- if mu1≠mu2, then E[D] = w1*mu1 + w2*mu2
    - so the results of a cue conflict experiment can be predicted from sigma1, sigma2
- var[D] = sigma12^2, where 1/sigma12^2 = 1/sigma1^2 + 1/sigma2^2
    - smaller variance than either cue
    - note that this doesn't depend on mu1, mu2, or mu1-mu2

<u>testing the ML cue combination model</u>

- how can we test the ML model? we need to measure sigma1, sigma2, mu12, sigma12
- we will use a model of the psychometric function in a 2afc task
    - task: shown two stimuli in random order; say which has a greater depth
    - difference rule: choose stimulus that has a greater decision variable
        R = A if DA>=DB, B if DB>DA
- P(R=B) = P(DB>DA) = P(DA-DB<0) = pnorm(0, muA-muB, sqrt(sigmaA^2+sigmaB^2))
    - if sigmaA=sigmaB=sigma, then
    = pnorm(0, muA-muB, sqrt(2)*sigma)
    = pnorm(muB, muA, sqrt(2)*sigma)
    - so if we hold muA fixed and vary muB, P(R=B) is a normal cdf
        - P(R=B)=0.5 where muA=muB; this is the PSE
            - useful, because we may not be controlling muA and muB directly
            - we may be controlling stimulus properties xA and xB, giving muA(xA), muB(xB), e.g., depth from disparity and depth from motion
            - it may be interesting to know the x for which muA(xA) = muB(xB)
        - standard deviation of normcdf is sqrt(2)*sigma
            - so sigmaA=sigmaB=sigma can be estimated as sigma_fit/sqrt(2)

- test 1: see whether sigma12 is as predicted
    - prediction: 1/sigma12^2 = 1/sigma1^2 + 1/sigma2^2
    - measure sigma1
        - let A be a fixed depth stimulus with cue 1; muA1
        - let B be a varying depth stimulus with cue 1; muB1
        - note that sigmaA=sigmaB (=sigma1)
        - measure psychometric function; then sigma1=sigma_fit/sqrt(2)
    - measure sigma2 (same method as for sigma1)
        - let A be a fixed depth stimulus with cue 2; muA2
        - let B be a varying depth stimulus with cue 2; muB2
        - note that sigmaA=sigmaB (=sigma2)
        - measure psychometric function; then sigma2=sigma_fit/sqrt(2)
    - measure sigma12 (same method as for sigma1)
        - let A be a fixed depth stimulus with cues 1 and 2; muA1, muA2
            - note that it doesn't matter here whether muA1=muA2; sigmaA is the same
        - let B be a varying depth stimulus with cues 1 and 2; muB1, muB2
            - let this be a consistent stimulus, muB1=muB2
        - note that sigmaA=sigmaB (=sigma12)
        - measure psychometric function; then sigma12=sigma_fit/sqrt(2)

- test 2: see whether w1 and w2 are as predicted
    - prediction: w1 = ..., w2 = ...
    - use measurements of sigma1, sigma2 from test 1 to calculate w1, w2
    - measure a PSE between consistent and inconsistent stimuli
        - let A be a cue conflict stimulus of fixed depth; muA1≠muA2
        - let B be a consistent stimulus of varying depth; muB1=muB2=muB
        - measure a psychometric function and PSE
            - PSE should be at muB = w1*muA1 + w2*muA2