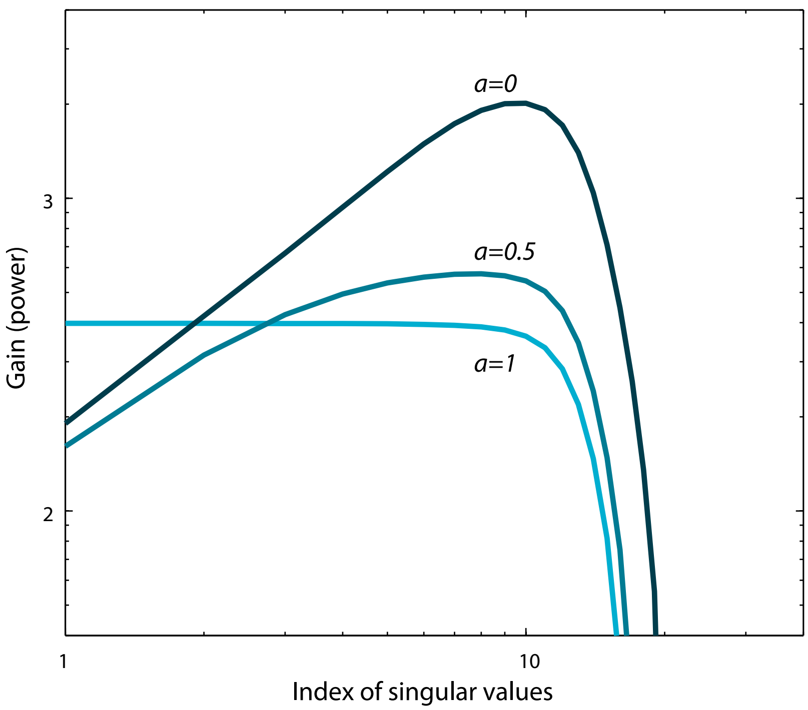
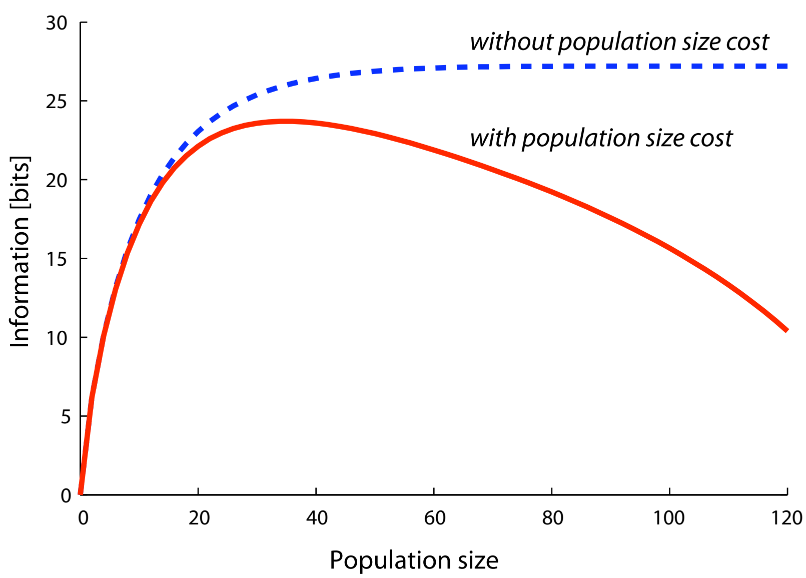


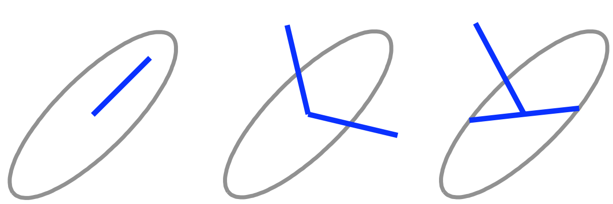
Optimal solution depends on the constraint function.

Gain function (the singular values, diag(Ω), of the RF matrix W=PΩQ'), optimized for different values of parameter a, that controls the relative significance of power and weights costs: a tr(WW') + (1–a) tr(WΣW'). For the high input SNR condition (20 dB), the solution is band-pass for a=0 (power cost only) as in (Atick & Redlich, 1990; Atick, Li, & Redlich, 1990; van Hateren, 1992), and low-pass for a=1 (weights cost only) as in (Campa et al., 1995).



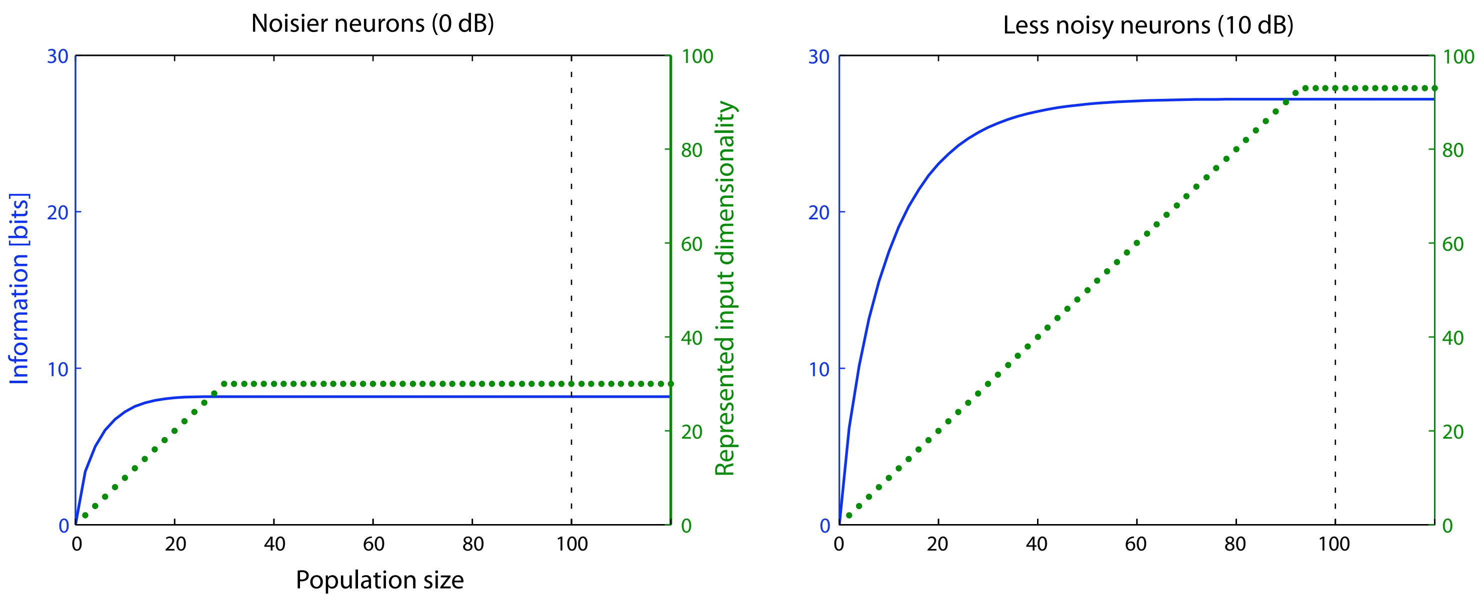
Including a cost for population size allows determination of an optimal population size.

Information grows monotonically with population size when population size is selected manually (blue dashed line). But when the cost function includes a term for population size, there is a unique maximum (red line).

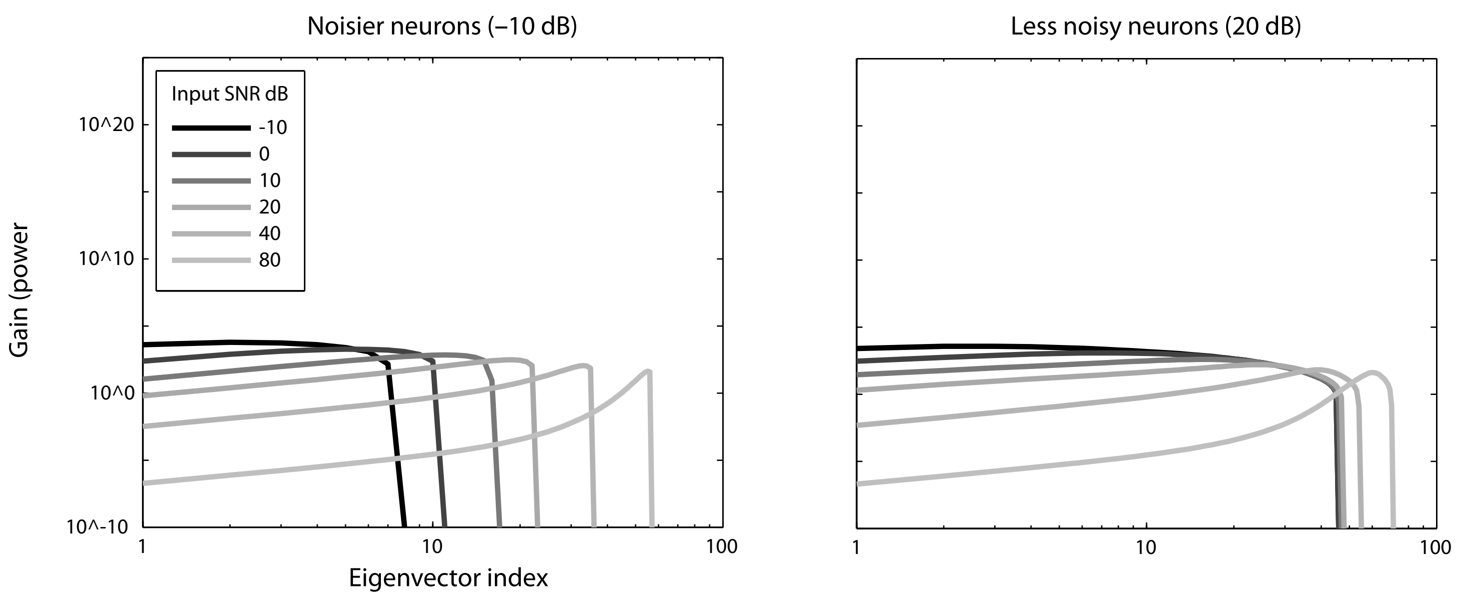


Optimally efficient solutions can be found for undercomplete and overcomplete cases.

Two-dimensional signal covariance ellipse, with 1, 2, or 3 neurons (rows of optimal W, shown as blue lines). In the overcomplete case, the solution is redundant, but still well-defined.



Optimally efficient solutions can be redundant, even in the undercomplete case.
Depending on noise levels and cost function, additional neurons may be utilized to represent additional input dimensions (known as *diversity gain*), but also may be utilized to increase the redundancy in the representation (to cope with neural noise). The plots show the transmitted information as a function of population size (blue line), along with the number of input dimensions that the neural population represents (green dots). Neural population is noisier for the left panel than the right, leading to an increase in redundancy. All other conditions such as input noise and total cost are exactly the same: population size cost is set to zero (and population size is adjusted manually), input dimensionality is 100 (so a population size of 100, indicated by dashed vertical line, corresponds to a complete representation).



Redundancy in the optimal representation depends on output noise level.
Previous literature (Atick & Redlich, 1992; Atick, Li, & Redlich 1992; Li 1996) provides an approximate solution for efficient coding: a sequential cascade of low-pass filtering (to reduce the effects of input noise) and whitening (to defend against corruption by output noise). Although it is intuitive and appealing, it fails to account for the behavior of the optimal solution (as found in Atick & Redlich 1990; Atick, Li, & Redlich 1990; van Hateren, 1992). The problem is that whitening does not depend on the output noise level, and hence, the solution of the approximate model is identical at different output noise levels. Here we show efficient coding solutions at two output noise levels (left: more noisy neurons, right: less noisy neurons) for a variety of input noise levels. The solution critically depends on the output noise level (if the approximate model were correct, the left and right should be identical).