Supplementary Material: Analysis of switch-rate distribution

Fitting switch-time distributions

One of the classical approaches to analysing perceptual switching data is to follow Levelt’s lead and fit a gamma function to the distribution of an individual’s time-normalized switching period histogram and report the two fitting parameters. One consistent finding is that the two parameters which define the gamma distribution are strongly correlated (Borsellino et al., 1972; De Marco et al., 1977; Levelt, 1968) and often identical (Note they used a different formulation of the gamma function than used here). The reason for this correlation is still not known, but it suggests that even two parameters may be more than is required to fit the distributions after scaling by the mean switch period. Despite its widespread use, some researchers have reported that the function fails to fit all subjects’ data well, leading to the use of other fitting functions which have been found to fit as well, if not better. According to one exhaustive survey, the log-normal distribution produces the best fits (Zhou, et al. 2004). Brascamp et al. (2005) took a different approach, fitting a gamma distribution to switch rates and reported better fitting results.

As Levelt (1968) and Blake, Fox and McIntyre (1971) point out, fitting gamma functions, or indeed any other function, is only really interesting if it can tell us something about the underlying mechanisms of perceptual switching. It is surprising then, that as Mamassian and Goutcher (2005) succinctly put it: “...these parameters are often left completely uninterpreted”. One of the most notable exceptions was Levelt himself, who argued that the best fitting parameters revealed how one should link the incidence of a perceptual switch to the triggering event. He went on to argue that a saccade might prompt a reevaluation of the stimulus and that based on the fitting parameters it could be the case that on average four saccades are required before a perceptual switch occurs. In practice this theory has been discredited. Modern eye-tracking studies suggest that if a causal link exists at all, it is in the opposite direction and is one of suppression, i.e. perceptual switches reduce the likelihood of eye movements, but eye movements do not of themselves provoke switches (van Dam and van Ee, 2005). However, it was a worthy attempt to attach meaning to the fitting parameters.

A more mundane explanation for the skewed distributions of dominance durations seen in all studies is that subjects generally switch at a fairly consistent rate, but occasionally take much longer. Because switch (or response) time cannot shorten ad infinitum towards zero seconds, but is effectively unbounded in the other direction, the resulting distribution is necessarily skewed to longer times. If that is the case, then a reasonable approach might be to do as Zhou et al. (2004) suggest and use a log-normal fit. Some comparisons of log-normal and gamma distribution fits to our data are given in Error! Reference source not found. and Error! Reference source not found.. The fit parameters were obtained using the maximum-likelihood methods implemented by the MATLAB fitting functions lognfit and gamfit. In general the lognormal captured the peaks in the probability density function more closely than the gamma function (see Error! Reference source not found.), but overall the gamma function yielded better fits in terms of a chi-squared test: One third of the duration distributions (across subjects and stimulus type) could be fit significantly well by the gamma function (p<0.05), and only a quarter by the lognormal function. Following the lead of Brascamp et al. (2005), we also fitted switch rates, but found no evidence of significantly better fitting with either the lognormal or gamma function.
Figure 16 Lognormal fitting parameters for dominance duration in all 24 subjects and all four stimuli under investigation. Data are broken down into periods of dominance during bistable (ABA), tristable (ABC) and both switch types. Parameters are seen to be stable across the majority of subjects irrespective of switch type analysed.
$P_t(t) = \frac{1}{t \sqrt{2\pi \sigma^2}} e^{-\frac{(ln(t) - \mu)^2}{2\sigma^2}}$
Figure 17 Gamma function fitting parameters for dominance duration for all 24 subjects and all four stimuli under investigation. Data are broken down into periods of dominance during bistable (ABA), tristable (ABC) and both switch types. Parameters are seen to be relatively stable across the majority of subjects although more variable than when using the Lognormal function.
\[ P_c(i) = \frac{e^{-t/b}}{\beta^a \Gamma(a)} t^{a-1} \]
**Figure 18** Fitting Gamma and Lognormal distributions to the switch durations in one of the 24 subjects. On the left the raw data is compared to the best fitting cumulative distributions of the two functions and on the right the probability density functions are compared to the individual’s data. In general the Lognormal distribution appeared less sensitive to small numbers of very long dominance durations and so captured the form of the data better than the Gamma function.
References


