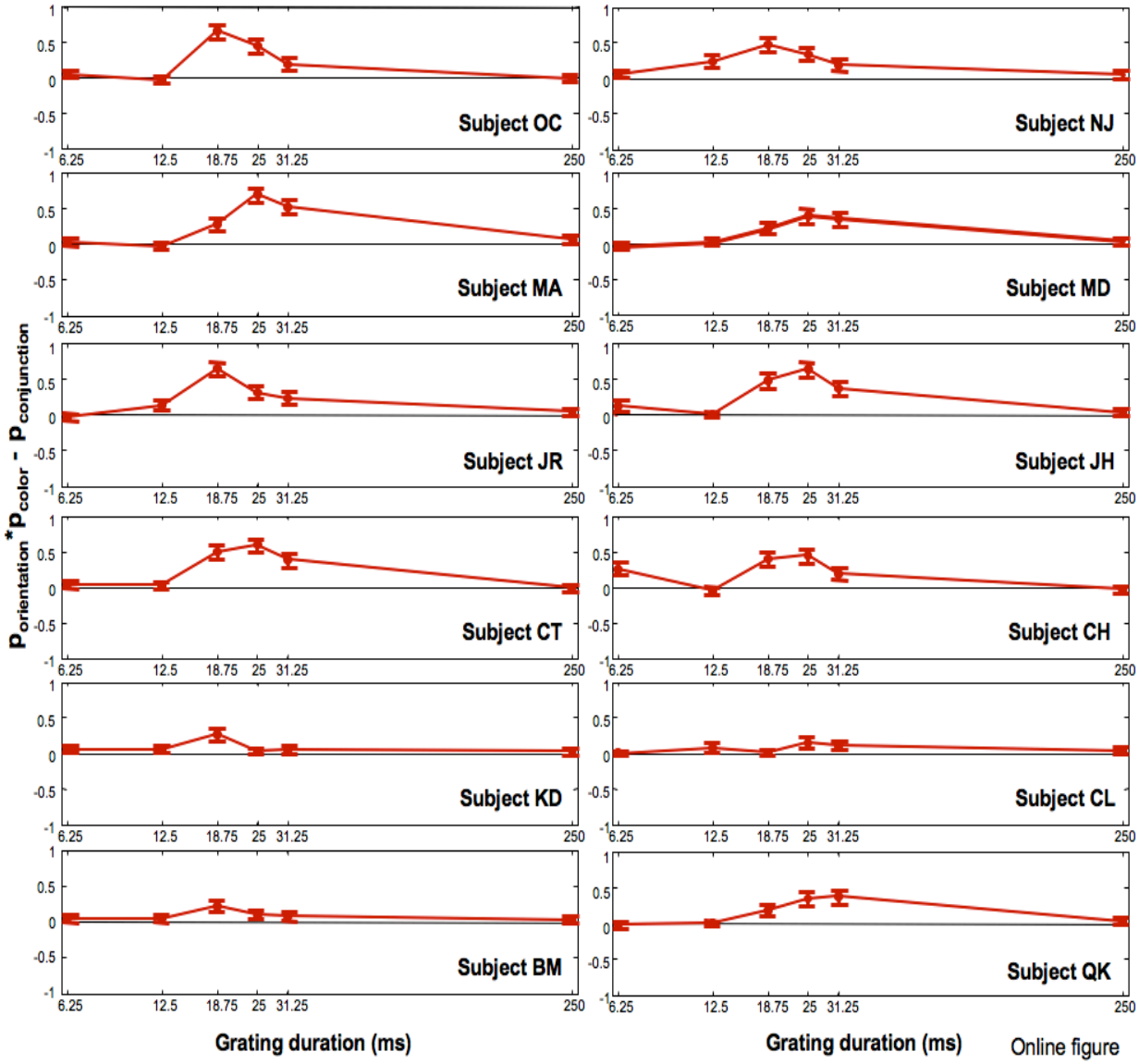
Supplemental material



Supplemental Figure legend

Each panel corresponds to an individual subject. Each point is the product of $p_{orientation}$ and p_{color} minus $p_{conjunction}$. Positive values thus indicate poorer performance in identifying

conjunctions than would be expected if each feature were identified independently and were instantaneously integrated to form a conjunction. Error bars indicate 95% confidence intervals based on the McNemar test, as applied to differences of proportions (Newcombe 1998). For each subject there was at least one intermediate frequency for which the difference was significantly greater than zero, reflecting the cost of integration. In no observer is there any frequency at which the difference is significantly less than zero.

Test for temporal resolution of orientation

Color and conjunctions both merge over successive gratings to be indistinguishable across sequences. Thus, our estimates of temporal resolution for color and conjunction are strictly comparable in this sense. However, orientation information is abolished because counter phase gratings cancel one another. In our experiment, counter phase gratings appear on every other frame. This could, potentially, cause us to overestimate temporal resolution for orientation. To test this, we undertook two separate control experiments. In the first, we interdigitated trials of two types: (1) the standard sequences used in the main experiment (Figure 1 in the paper) and (2) sequences of gratings in which only one orientation was present and each grating was the counter phased version of the preceding grating, so that any pair of successive gratings would abolish the orientation information. To equate the two conditions as closely as possible, successive gratings also varied in color, just as in the main experiment. So, in this condition the subject might be presented with a 135° blue grating, followed by a counter-phased 135° yellow grating. Eight subjects were tested with at least 48 stimulus sequences at each frequency (on average 69 repetitions, SEM 7). At the end of each control condition trial, we asked subjects to make a two alternative, forced choice orientation judgment, and

analyzed it using the multinomial model that was used in the main experiment adapted for a two alternative forced choice task. Our estimates of temporal resolution for orientation were comparable across the two types of trials, and were comparable to the estimates derived in the main experiment. For trials that duplicated the conditions of the main experiment, the threshold for orientation was, on average, 8.5 ±1.6 ms, closely reproducing the estimate derived in the main experiment, 8.4 ±1.0 ms. For control trials, the threshold was in close agreement with both estimates, on average 9.9 ±0.6 ms.

To further validate our measure of temporal resolution for orientation, we ran a second control experiment. In this control, we randomly interdigitated trials of two types: (1) the standard sequences used in the main experiment (see Figure 1 in the manuscript) and (2) sequences in which we altered the order of the four stroke sequence used in the main experiment to place counter phase versions of each grating adjacent to one another. For example, we might present a red 45° grating followed by the counter phase version of that grating followed by a green 135° grating followed by its counter phase partner. Eight subjects were tested with at least 48 stimulus sequences at each frequency (on average 69 repetitions, SEM 7). As before, at the end of each control condition trial, we asked subjects to make a two alternative, forced choice orientation judgment. The mean and SEM of the orientation thresholds across subjects tested in this control experiment, for trials matching the original condition was 8.9 ± 1.9 ms, as compared to 10.5 ±1.4 ms in the control condition. On the basis of these two control experiments, we conclude that our original method provides an accurate measure of temporal resolution for orientation that can safely be compared to our measures of temporal resolution for color and for conjunctions.