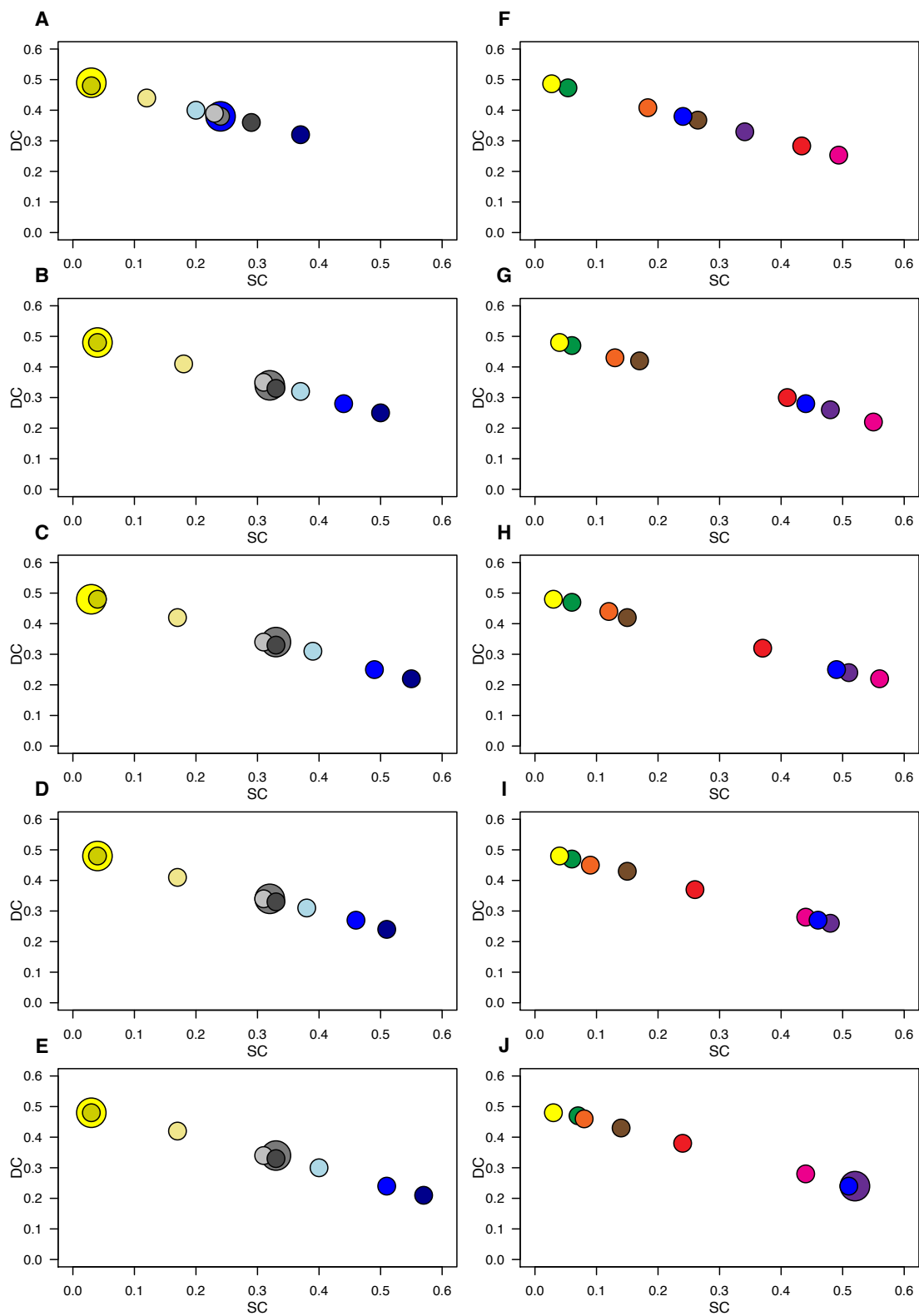


Fig. S1. (A) house hold tanks (B) Feeding apparatus for training (C) Photograph of fish during training (D) Photograph of fish during testing.(E) Multiple-choice cards used in Experiments 2 and 3. (F) Normalized reflectance of colors in Experiment 3. (G) Differential interference contrast (DIC) images of cone mosaic arrangements in *M. benetos*. A white arrow points out double cones while the red arrow a single cone. (H) a close-up of the square mosaic of cones is highlighted in white showing a single cone surrounded by four double cones.



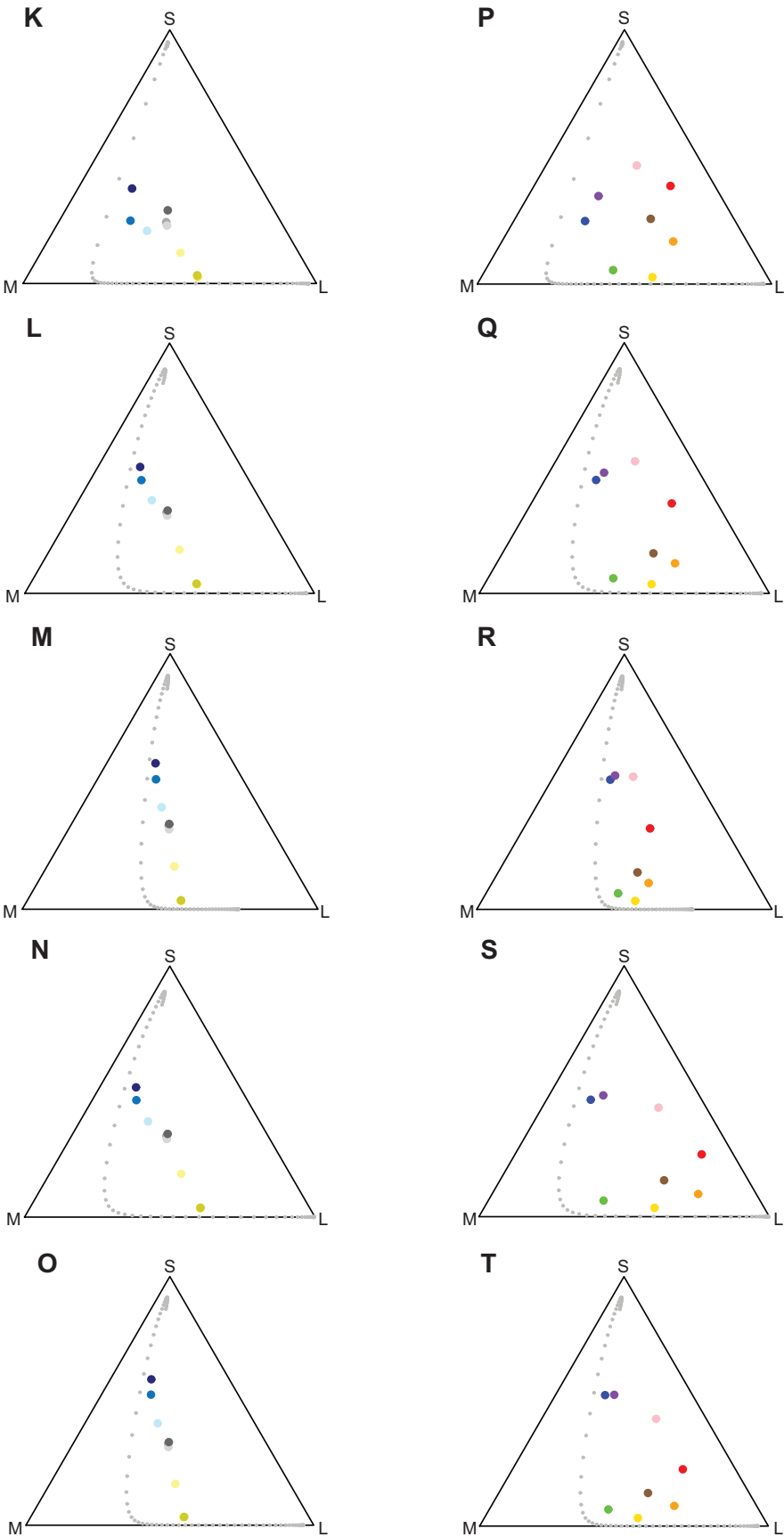


Fig. S2. Quantum catches in dichromatic and trichromatic visual systems. (A-J) show normalized quantum catch of colors in Experiments 1, 2 and 3. In a dichromatic visual system, photoreceptor's stimulations are plotted as signals in single cones (SC, x axis) and as summed signals in double cones (DC, y axis). Quantum catches were normalized using Eqn 1 & 2 for S-, M- and LWS cones. Combined signal-stimulation (summed) of double cones (DC) was calculated with Eqn 4. (A and F) represent quantum catch when there is pure opsin expression (SWS1, RH2B, RH2A α) whereas (B-E and G-J) represents opsin coexpression combinations 1-4 respectively (SWS1/SWS2B, RH2A β /RH2B, LWS/RH2A α , Table S2A). Bigger dots are used to reveal overlapping data-points in the SC-DC space. For a trichromatic visual system, photoreceptor stimulations are plotted in chromaticity diagrams with target colors plotted in the color space of *M. benetos* for experiments 1, 2 and 3 in a trichromatic visual system (K-T). Target colors are represented as a colored circle in the receptor space where each axis corresponds to the quantum catches of short/UV (S), medium (M) and long (L) sensitive photoreceptors. Monochromatic loci at 5 nm intervals are represented by gray dots. (K and P) represent quantum catch when there is pure opsin expression whereas (K-O and P-T) correspond to the four opsin coexpression combinations respectively.

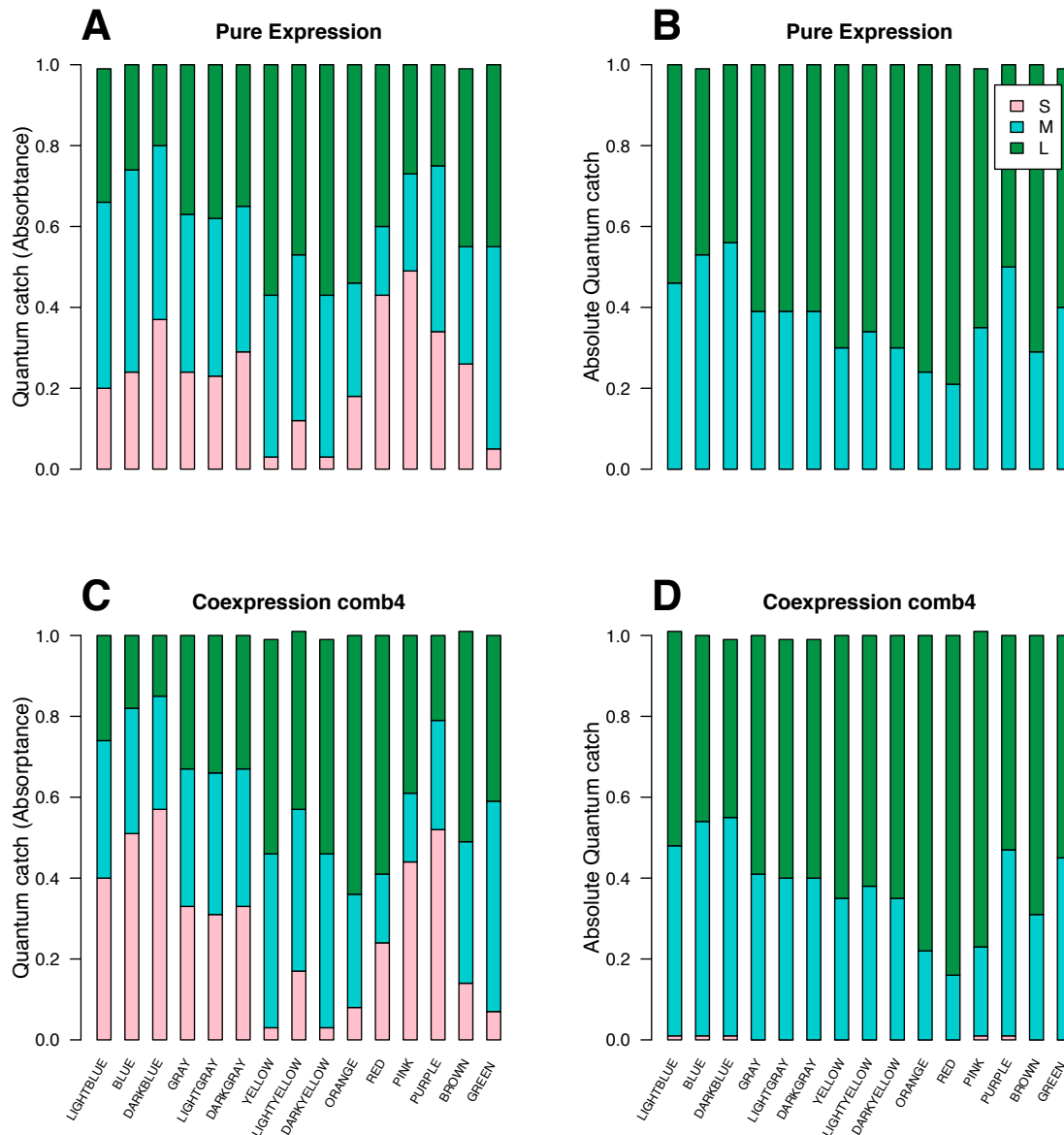


Fig. S3. Normalized quantum catch and absolute quantum catch for all colors in Experiments 1, 2 and 3. A & B represent visual systems based on pure opsin expression whereas C & D are based on opsin coexpression combination 4. A & C are quantum catches estimated with spectral absorbance whereas B & D are quantum catches estimated by absolute spectral sensitivity (Table S2B). Stacked color bars show the stimulation for each type of photoreceptor (S, M and L) for each color. Note that when photon shot noise is considered, quantum catch from the S photoreceptor is severely reduced in both scenarios.



Movie 1. Experiment 1, 2 & 3 test. Two alternative choice test, blue vs darkgray, multiple choice test, blue vs shades of gray, multiple choice test, blue vs different colors.

Table S1. a. Visual pigments and coexpression combinations, b. Lens transmission, c. Side dwelling irradiance in the fishroom, d. Color cards reflectances

[Click here to Download Table S1](#)

Table S2. A. Statistical results for behavioral tests, B. Quantum stimulation of colors for short, medium and long-wavelength sensitive cones (S-, M-, LWS)., C. Chromatic distance, ΔS (JNDs) for trichromat, D. Chromatic distance, ΔS (JNDs) for dichromat

[Click here to Download Table S2](#)