Seamless Visual Sharing with Color Vision Deficiencies
Supplemental File

Contents

S1 Results

To make our paper concise, we only show limited results in the main body of the paper. Here we show more results and comparisons. Fig. S1 and Fig. S2 show results of images from Sajadi's paper and compare their results with Kuhn's, Huang's, Chua's and ours for the most severe case of deuteranopia, since they only provide these limited results for deuteranopia. And the following figures compare Kuhn's, Huang's, Chua's and ours results for the most severe case of protanopia. Due to the reason that Kuhn's code provides results in CVD simulation only, so it is left blank for the normal vision cell of Kuhn's. And the other blank areas in the table is because CVDs perceives results in a dichoptic manner, such that the blending column is not applicable for CVD simulation.

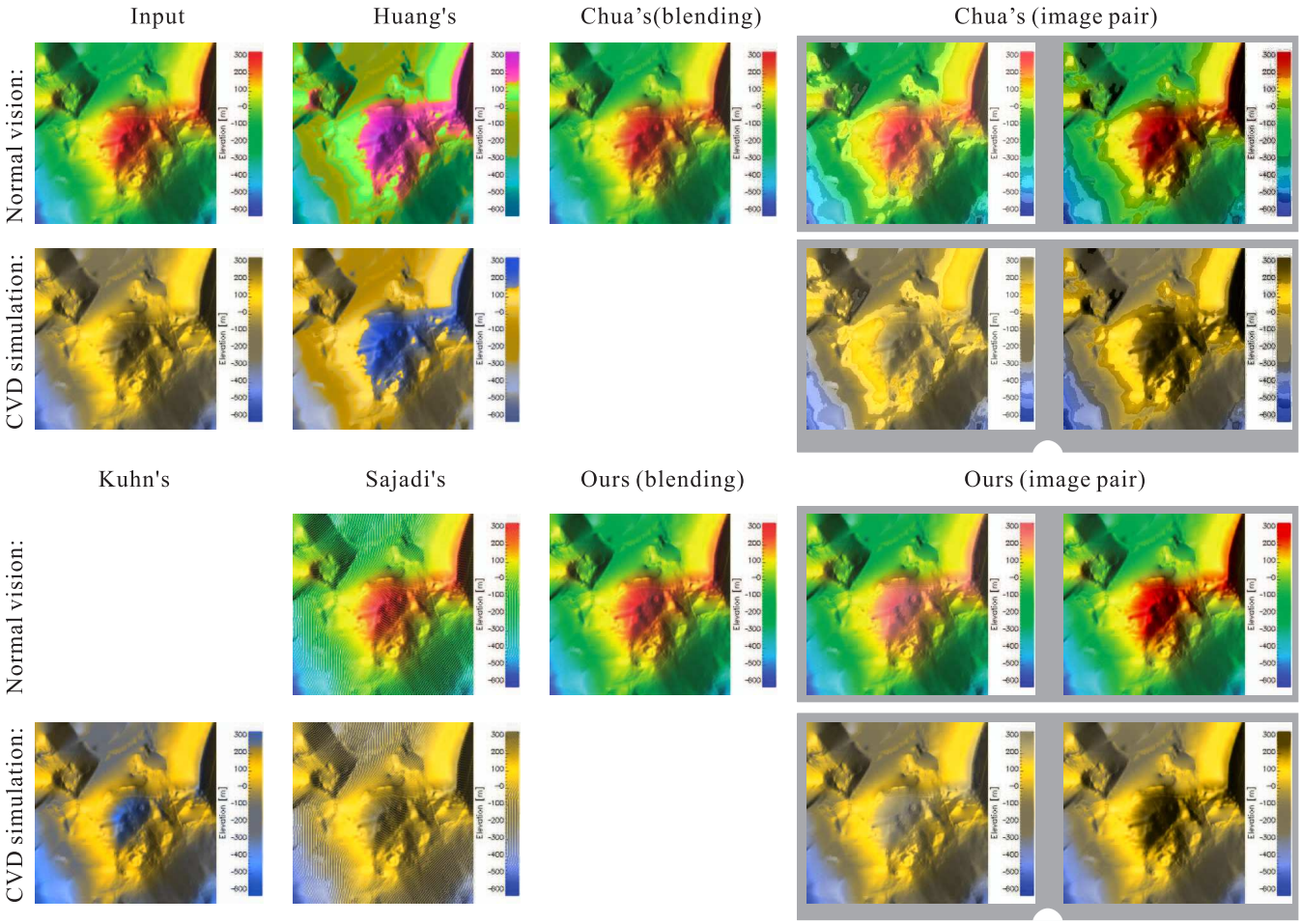


Figure S1: *Result of image "Mountain" from Sajadi's paper. Top row is in normal vision and bottom row is CVD simulation.*

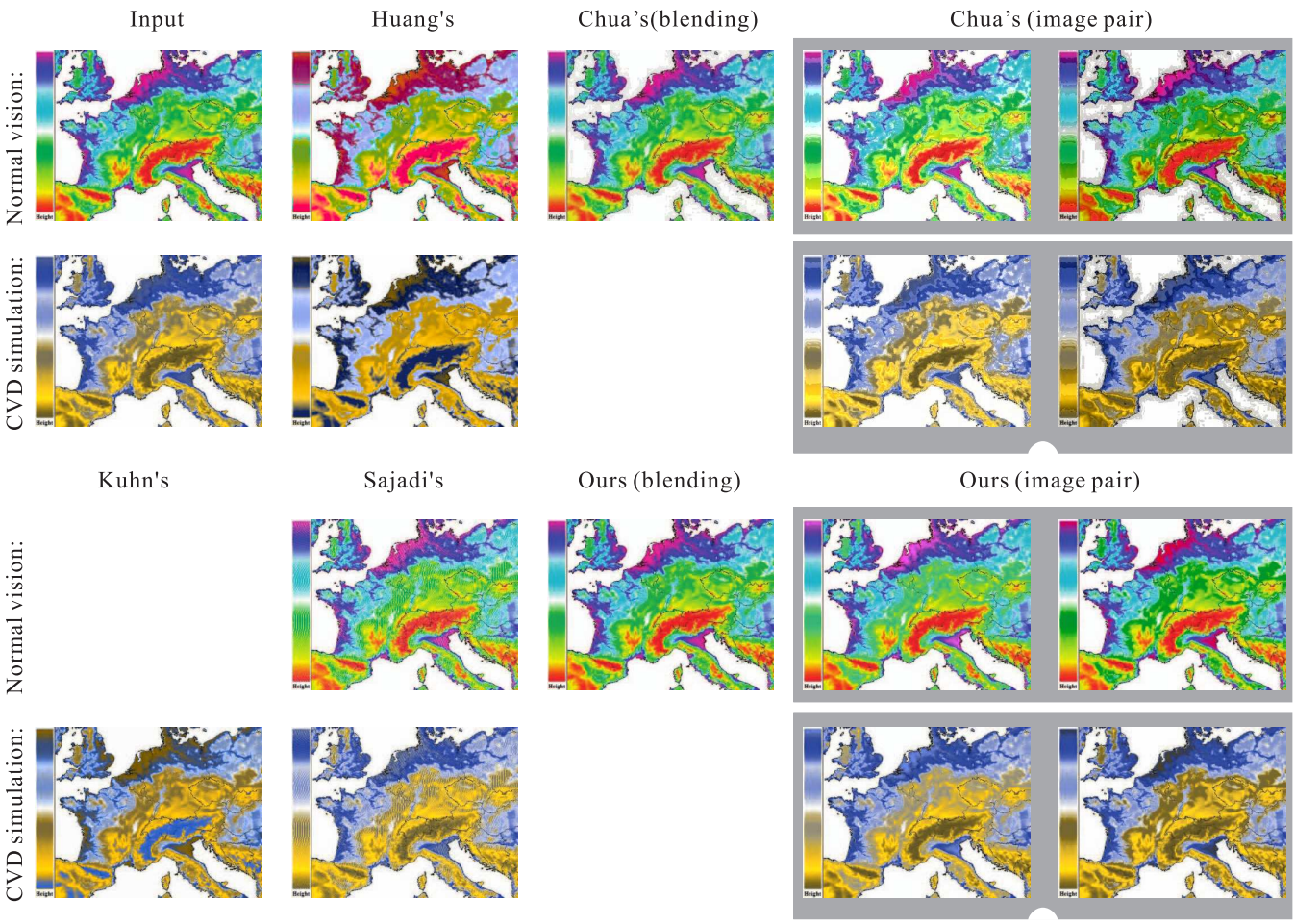


Figure S2: *Result of image "Map" from Sajadi's paper. Top row is in normal vision and bottom row is CVD simulation.*

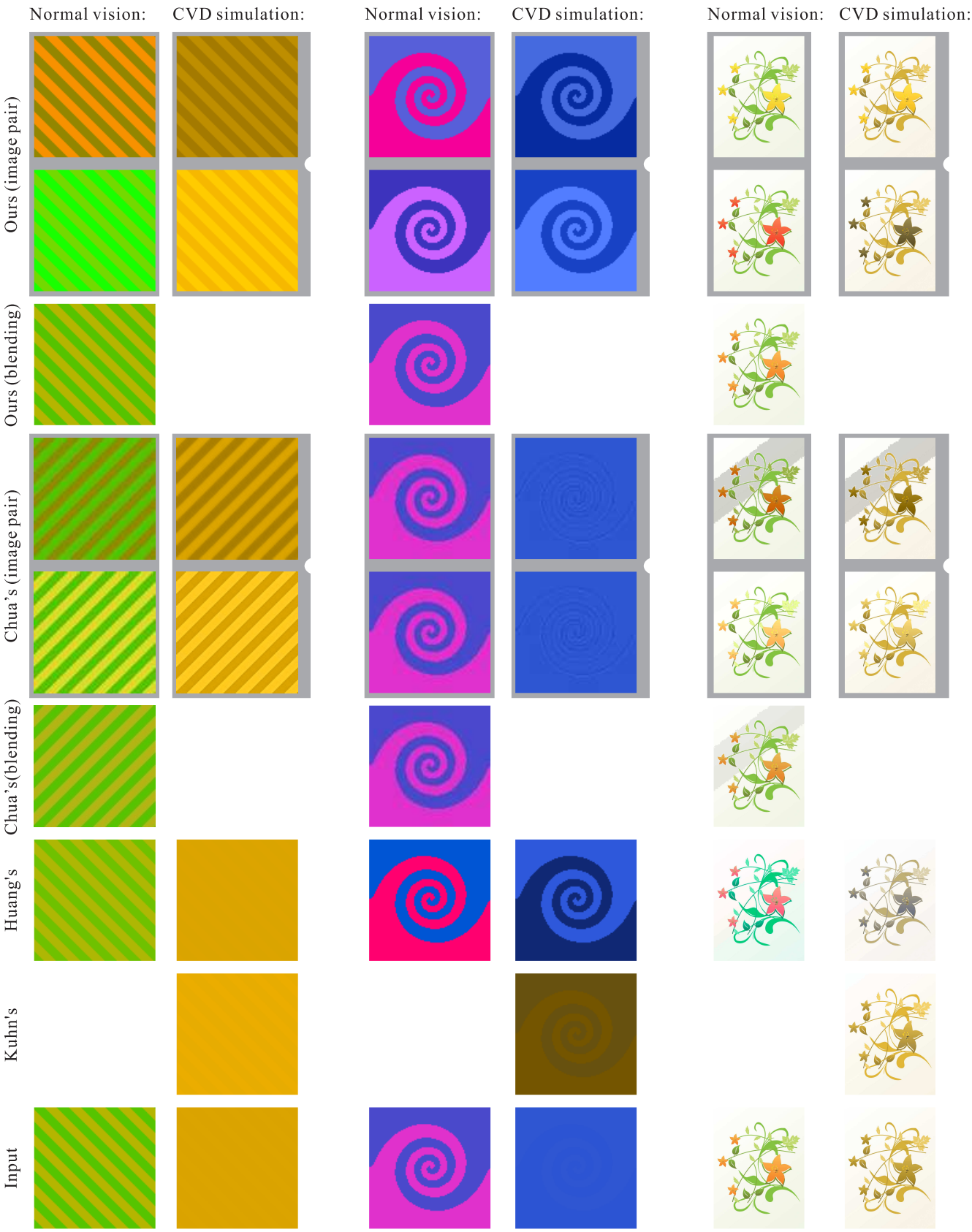


Figure S3: *Result of images "Strips", "Swirl" and "Flowers" referring to Fig. 4, Fig. 5 and Fig. 11 in main body. The odd rows are in normal vision and the even rows is CVD simulation.*

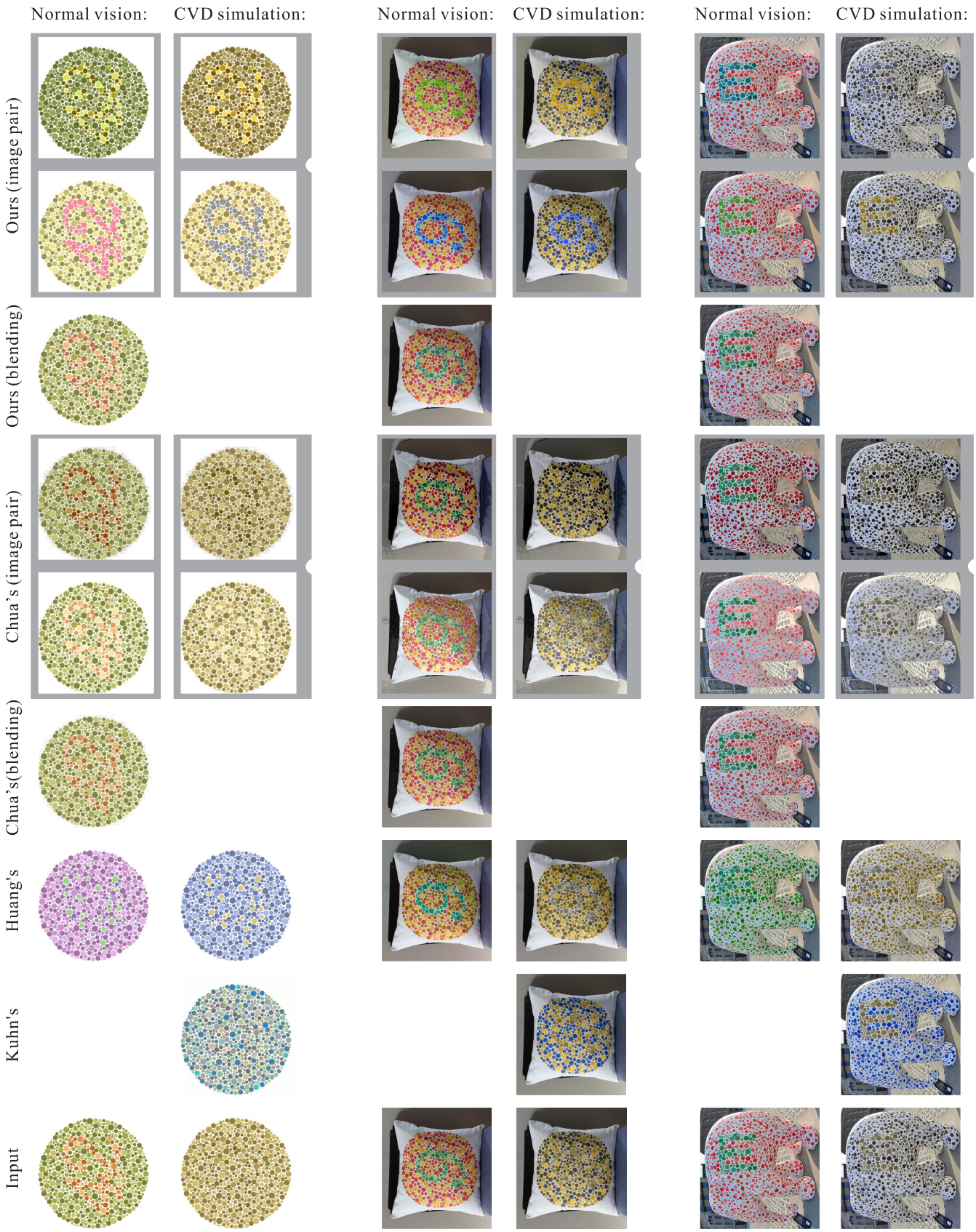


Figure S4: *Result of images "42", "9" and "Elephant and 'M' " referring to Fig. 11 and Fig. 1 in main body. The odd rows are in normal vision and the even rows is CVD simulation.*

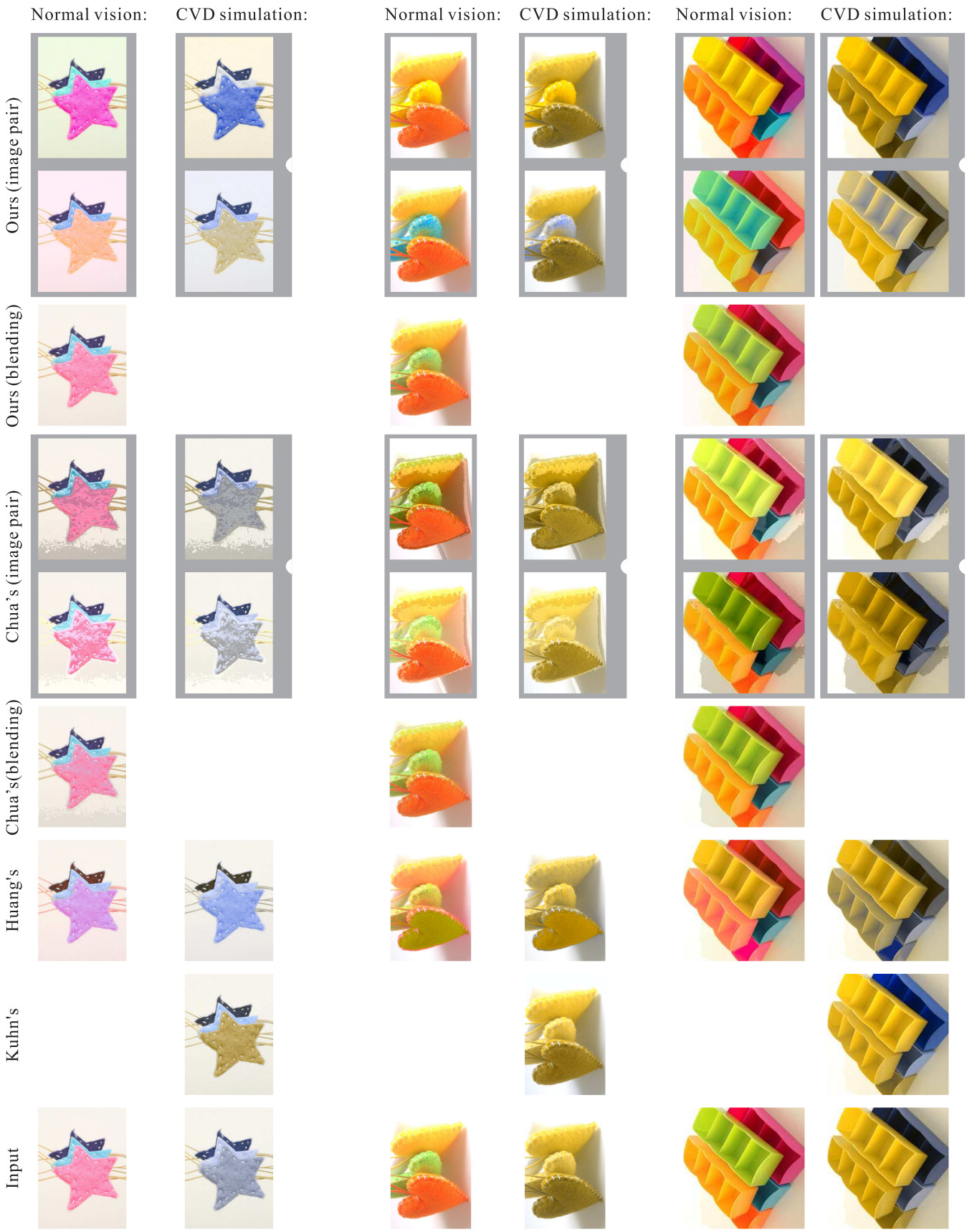


Figure S5: *Result of images "Stars", "Hearts" and "Boxes" referring to Fig. 11 and Fig. 2 in main body. The odd rows are in normal vision and the even rows is CVD simulation.*

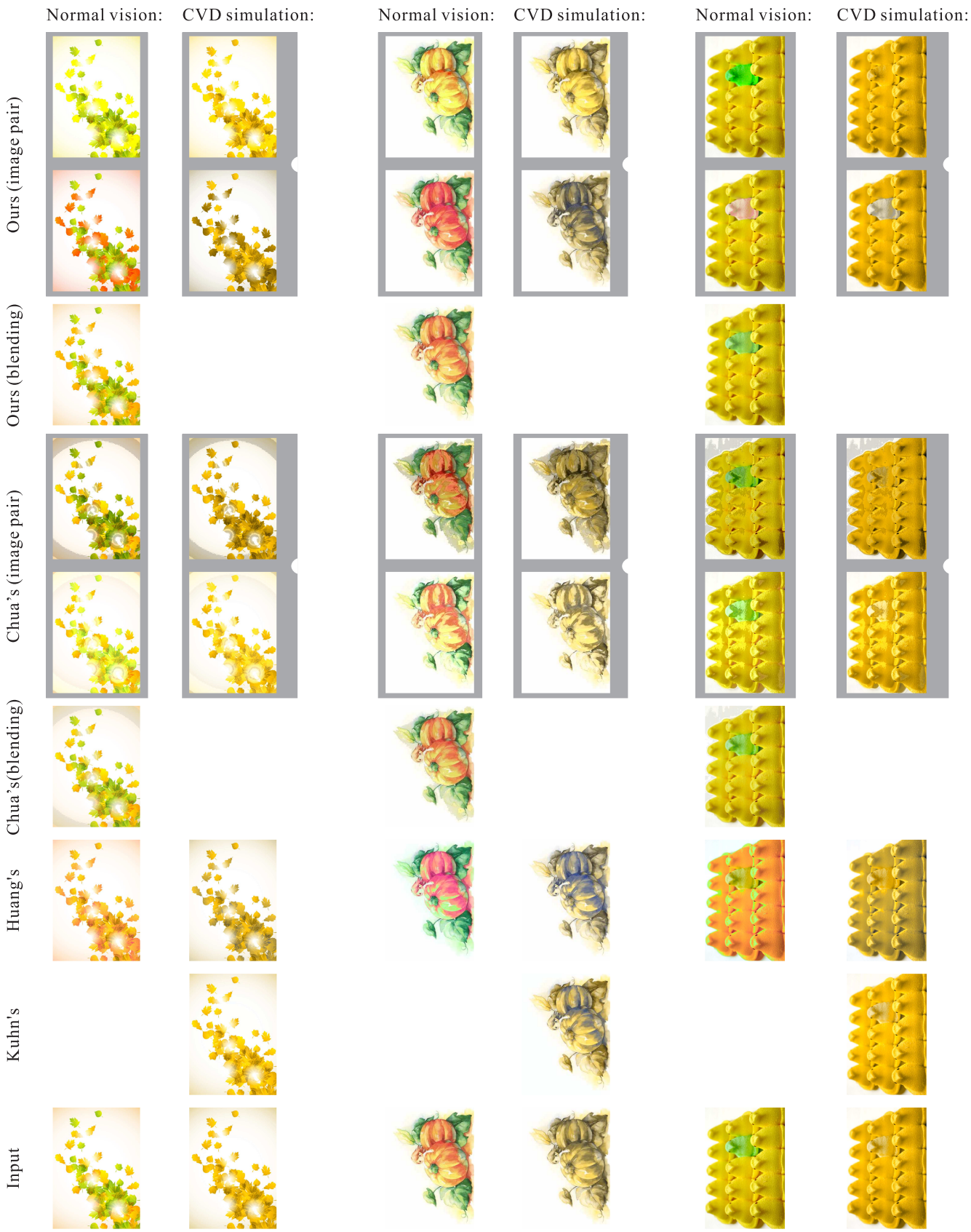


Figure S6: *Result of images "Leaves", "Pumpkin" and "Birds" referring to Fig. 11 in main body. The odd rows are in normal vision and the even rows is CVD simulation.*

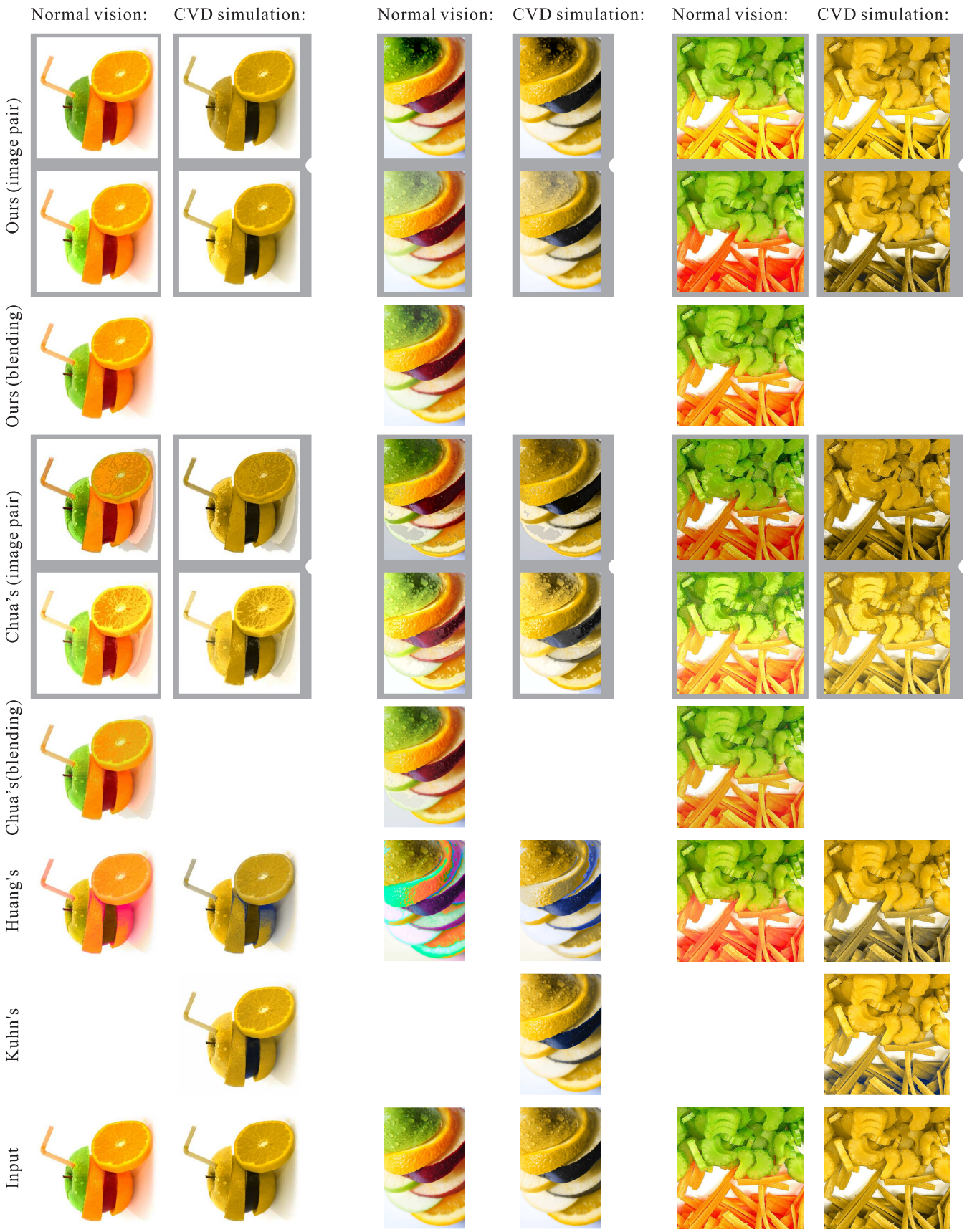


Figure S7: *Result of images "Fruits1", "Fruits2" and "Veggies" referring to Fig. 11 in main body. The odd rows are in normal vision and the even rows is CVD simulation.*

Figure S8: *Result of images "Tornado", "Football" and "Six eggs" referring to Fig. 6, Fig. 11 and Fig. 5 in main body. The odd rows are in normal vision and the even rows is CVD simulation.*

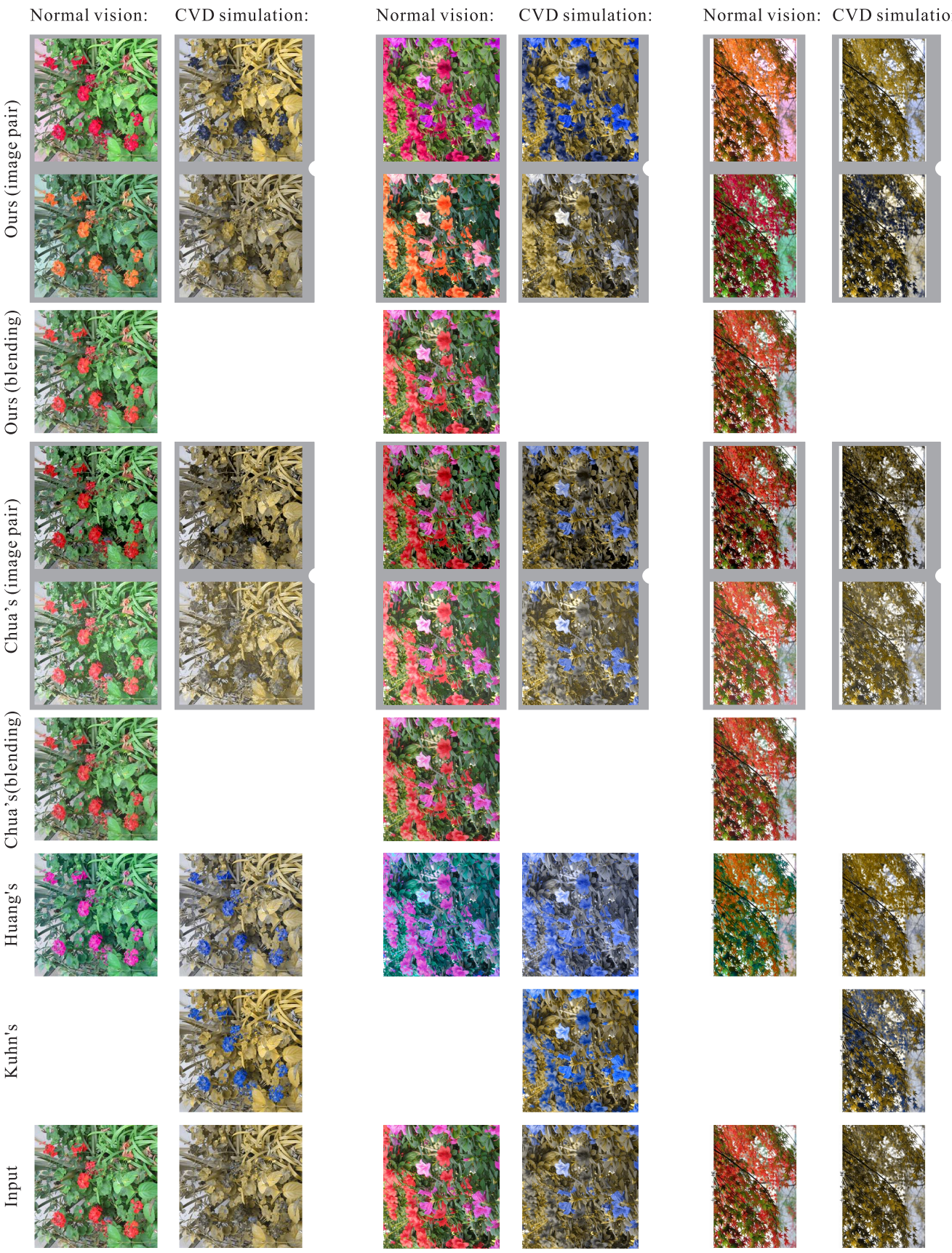


Figure S9: *Result of images "Flowers2", "Flowers3" and "Maple". The odd rows are in normal vision and the even rows is CVD simulation.*

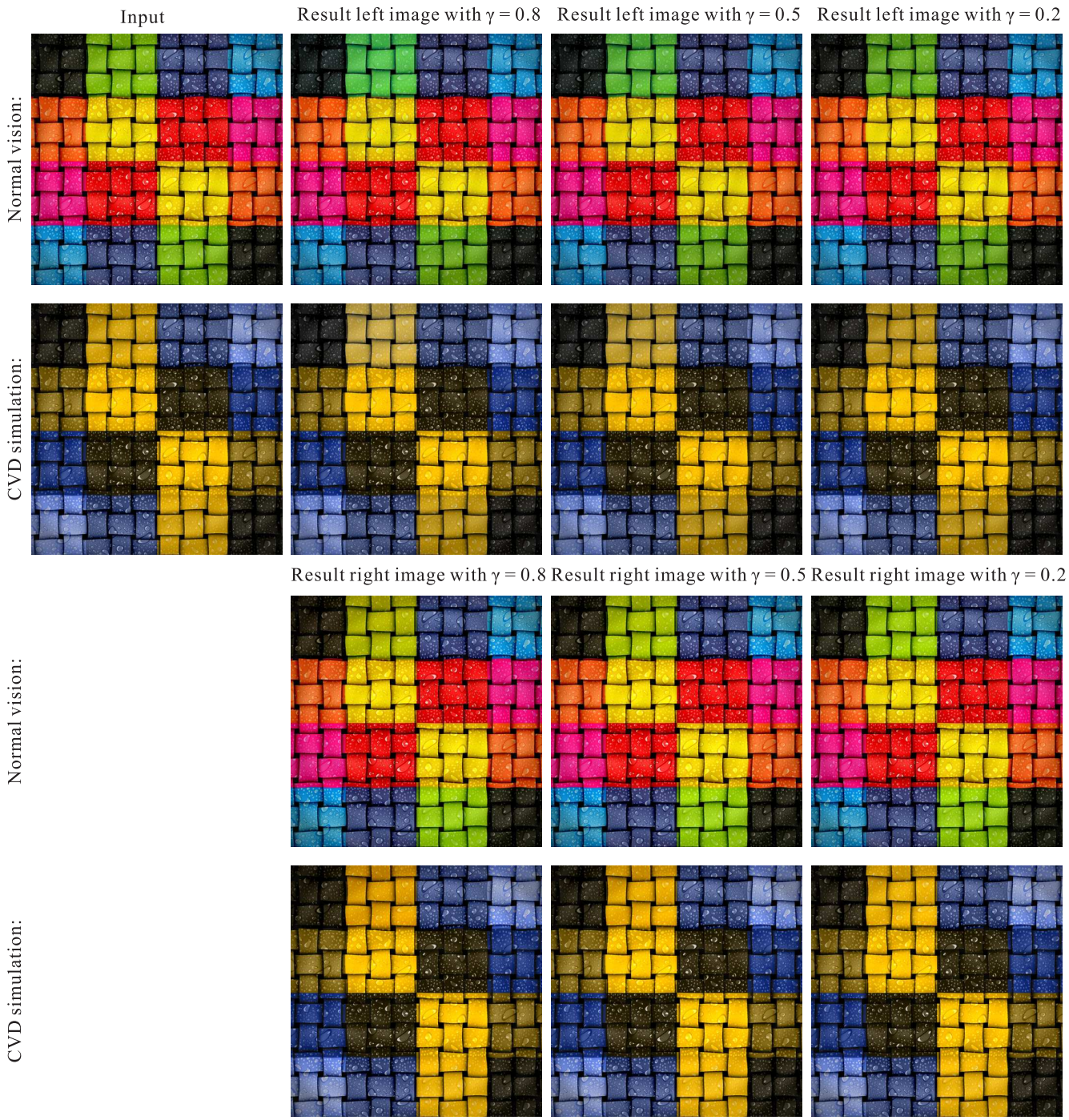


Figure S10: *Result of images "Knit" with different value of γ. The odd rows are in normal vision and the even rows is CVD simulation.*

In the following we show results for CVDs with different types and severities.

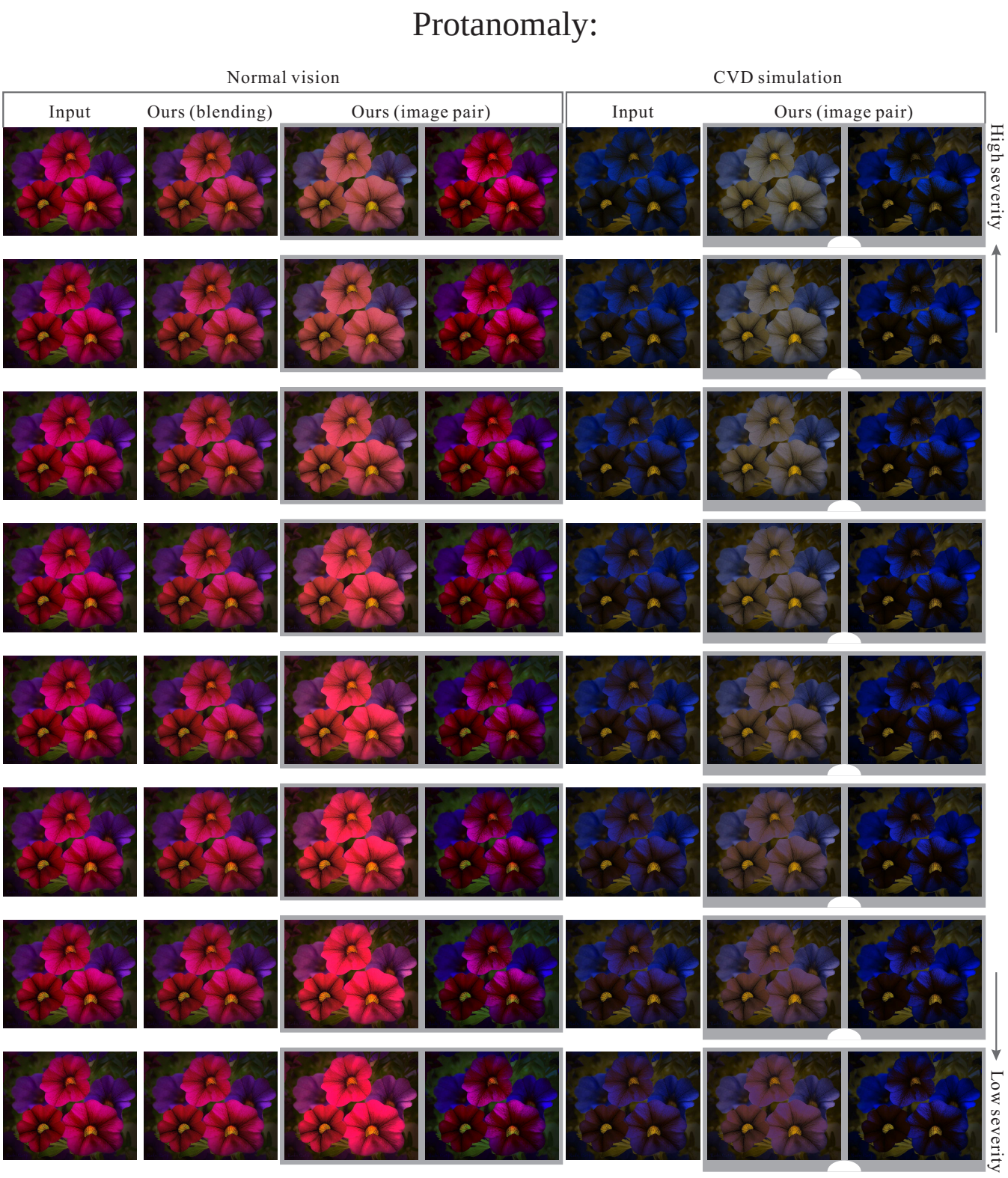


Figure S11: *Result "Petunia" for protanomaly from level 20 to level 13.*

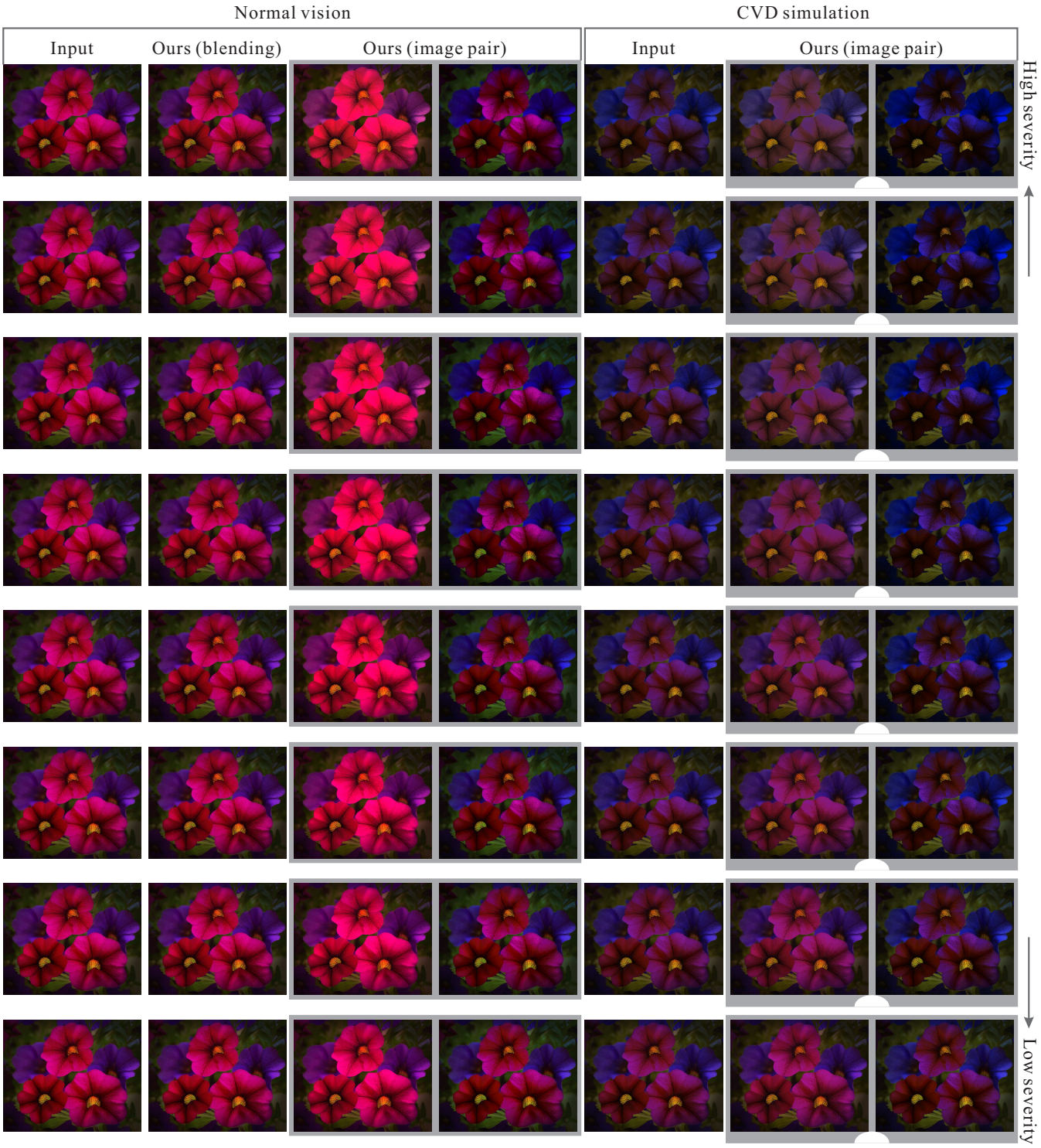


Figure S12: *Result "Petunia" for protanomaly from level 12 to level 5.*

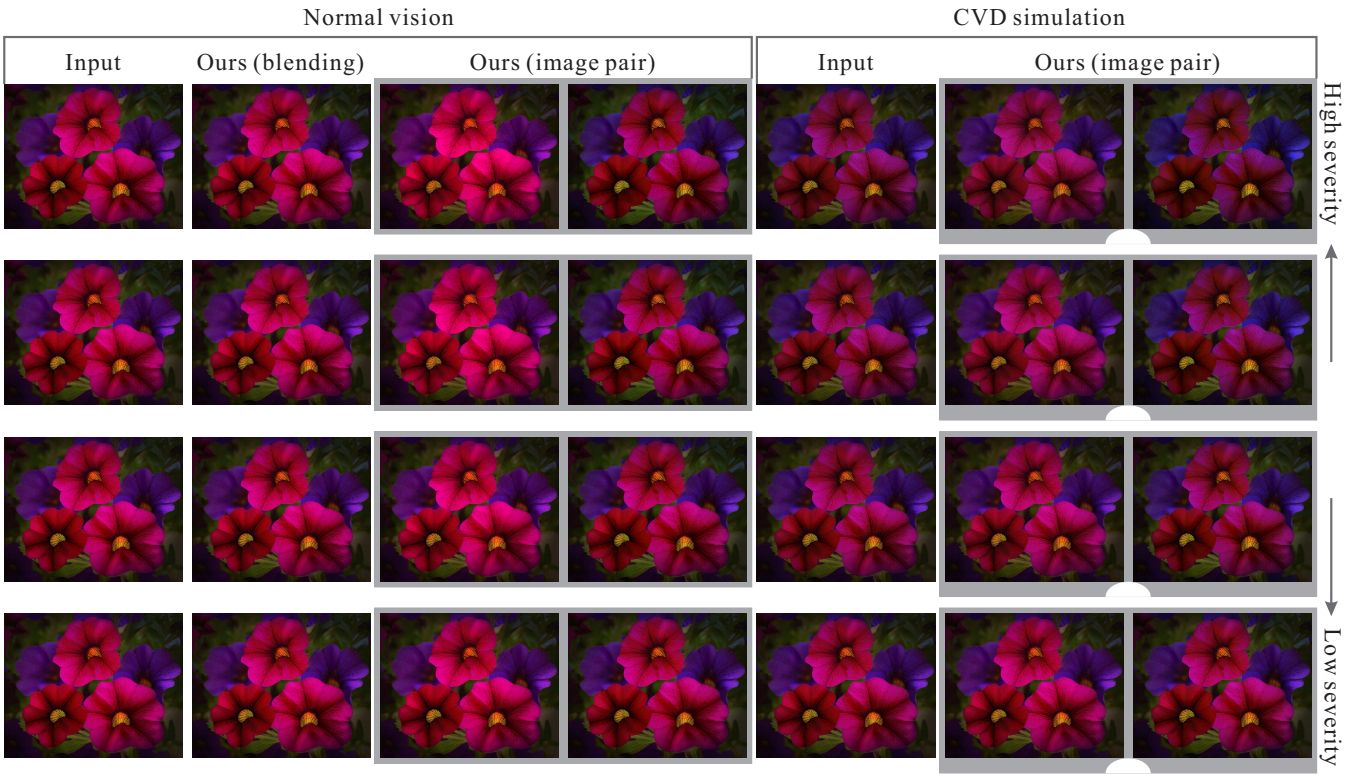


Figure S13: *Result "Petunia" for protanomaly from level 4 to level 1.*

Deuteranomaly:

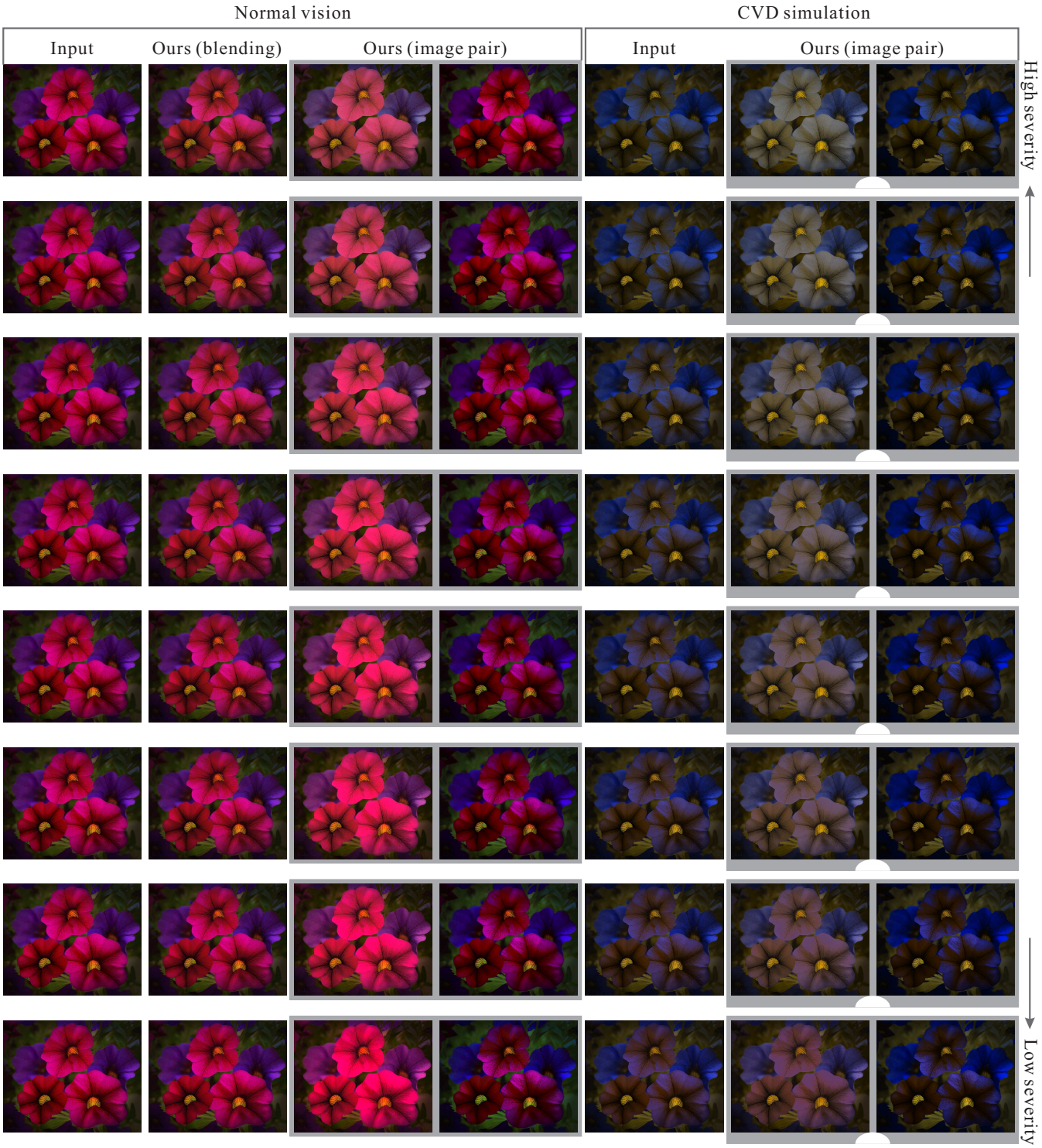


Figure S14: *Result "Petunia" for deuteranomaly from level 20 to level 13.*

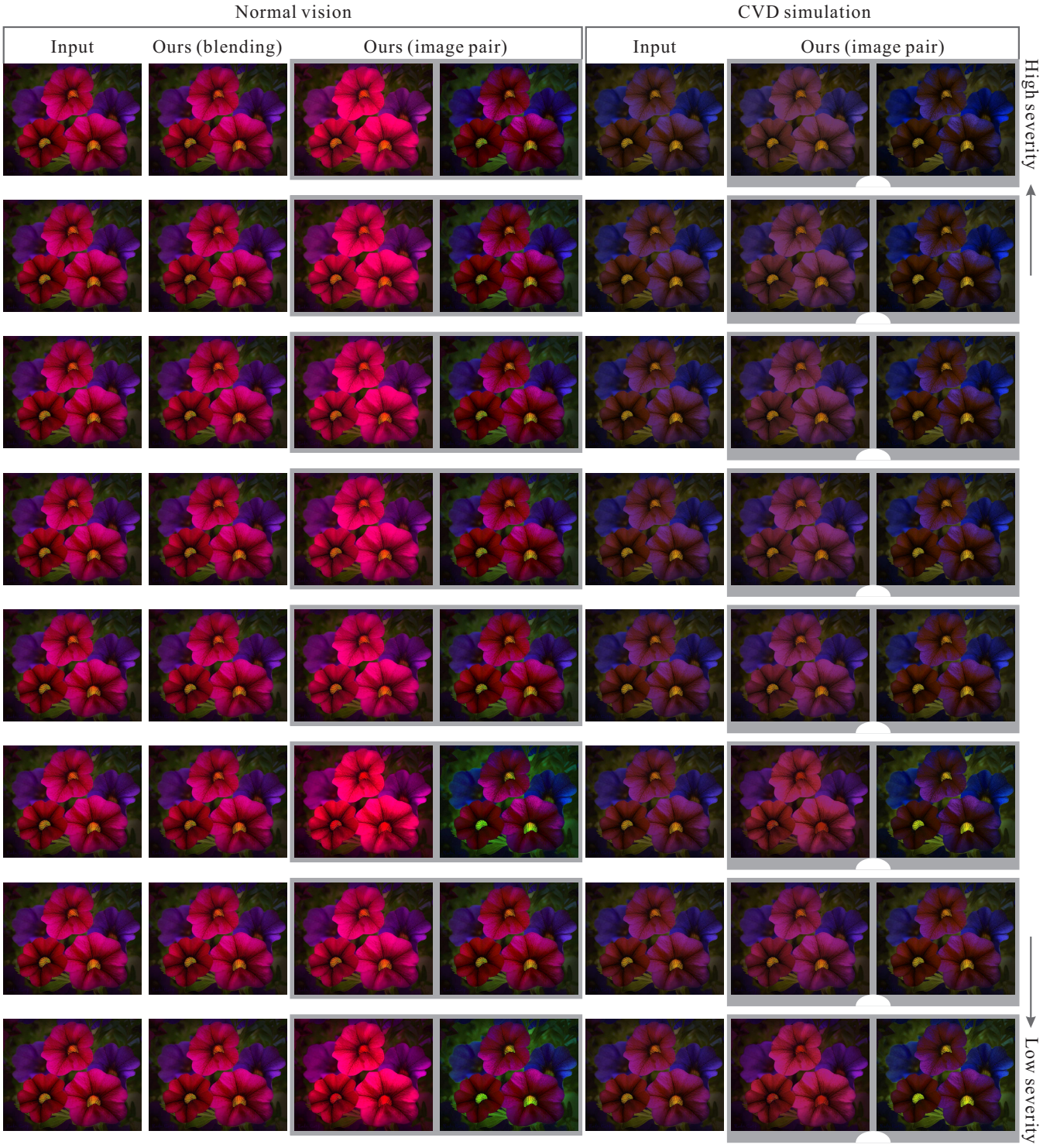


Figure S15: *Result "Petunia" for deuteranomaly from level 12 to level 5.*

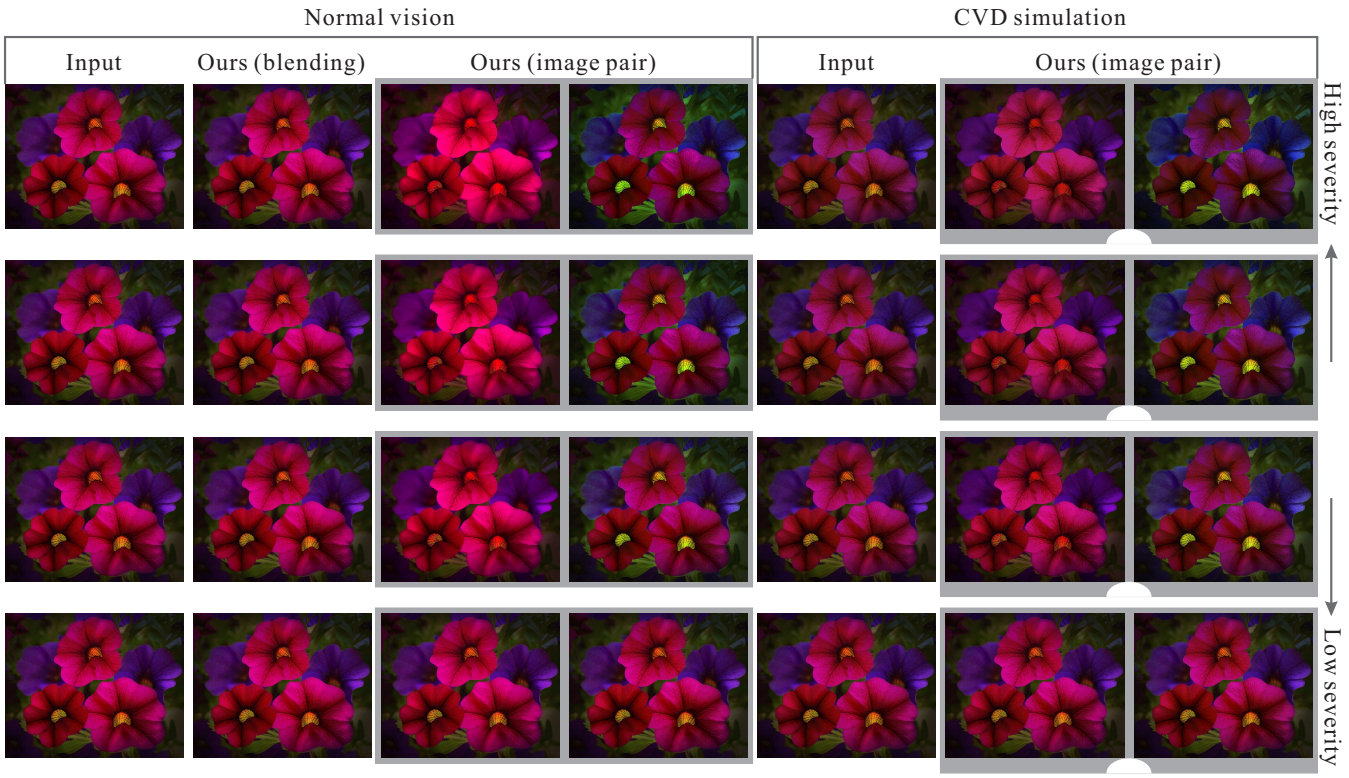


Figure S16: *Result "Petunia" for deuteranomaly from level 4 to level 1.*

S2 Energy Weights Estimation Statistics

In this section we show the result images with different energy weights and their user evaluation statistics. We first show the scores of average of normal and CVD audiences and then show the scores of each group of audiences.

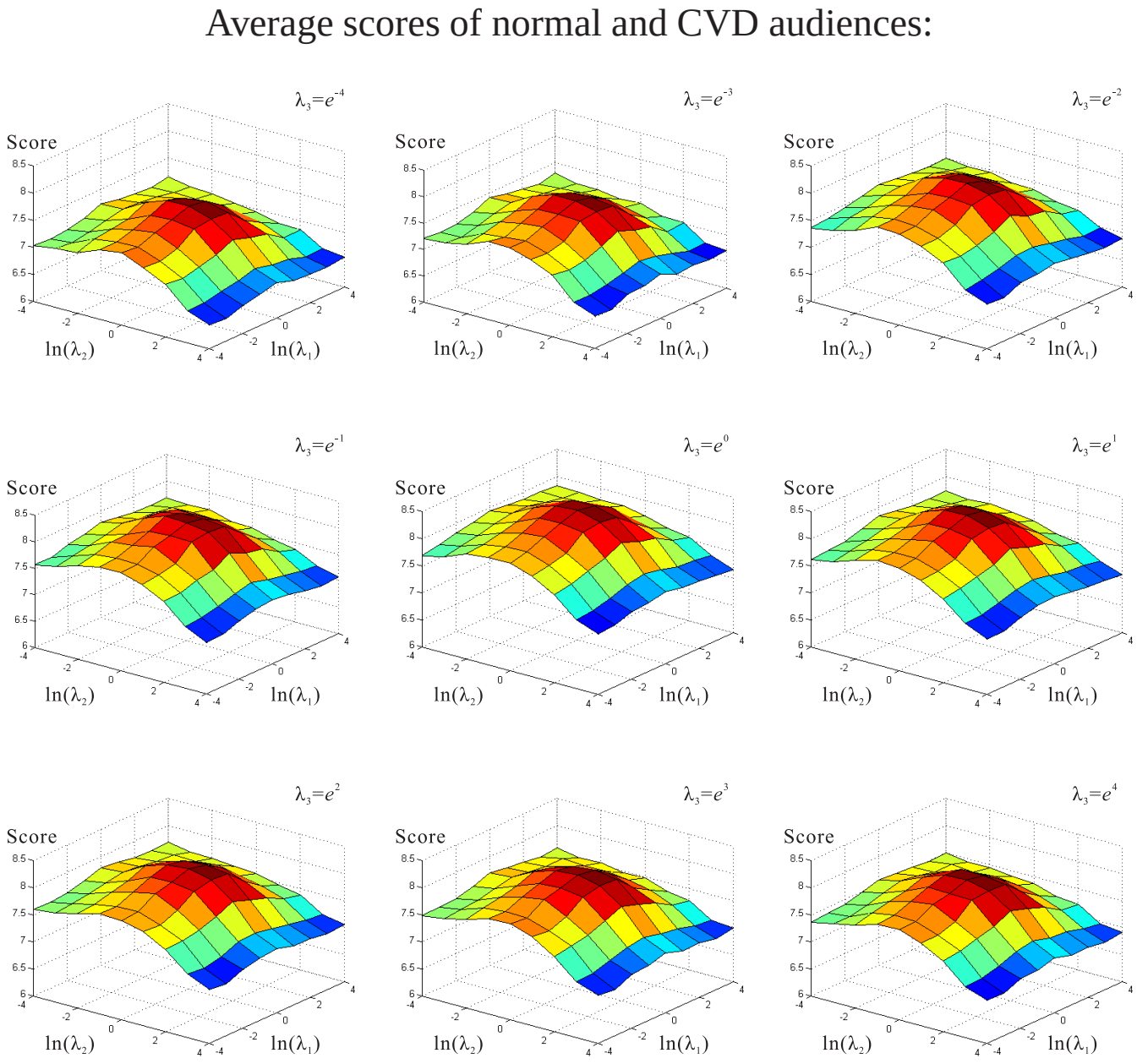


Figure S17: *Average scores of normal and CVD audiences.*

Average scores of CVD audiences:

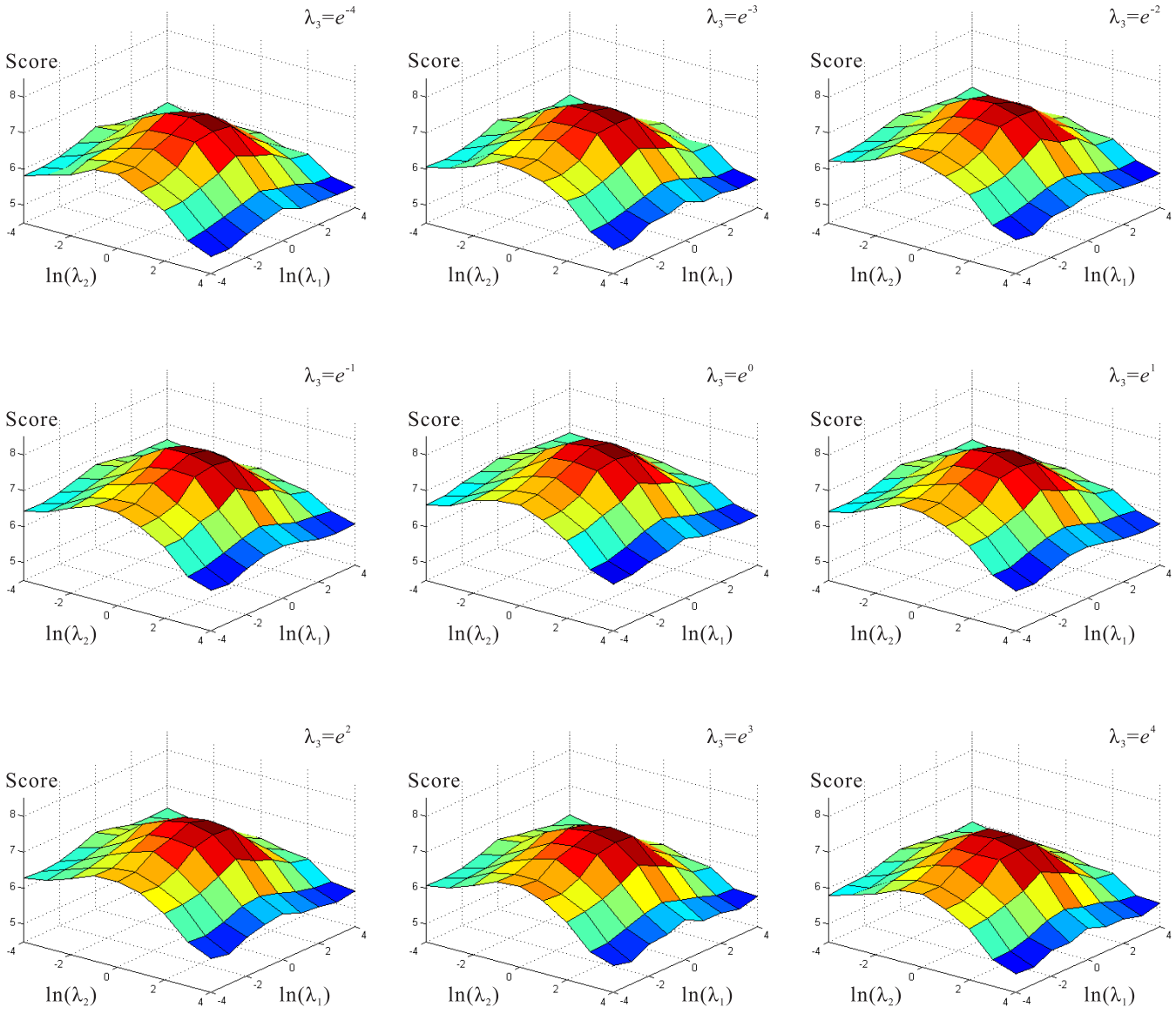


Figure S18: *Average scores of CVD audiences.*

Average scores of normal audiences:

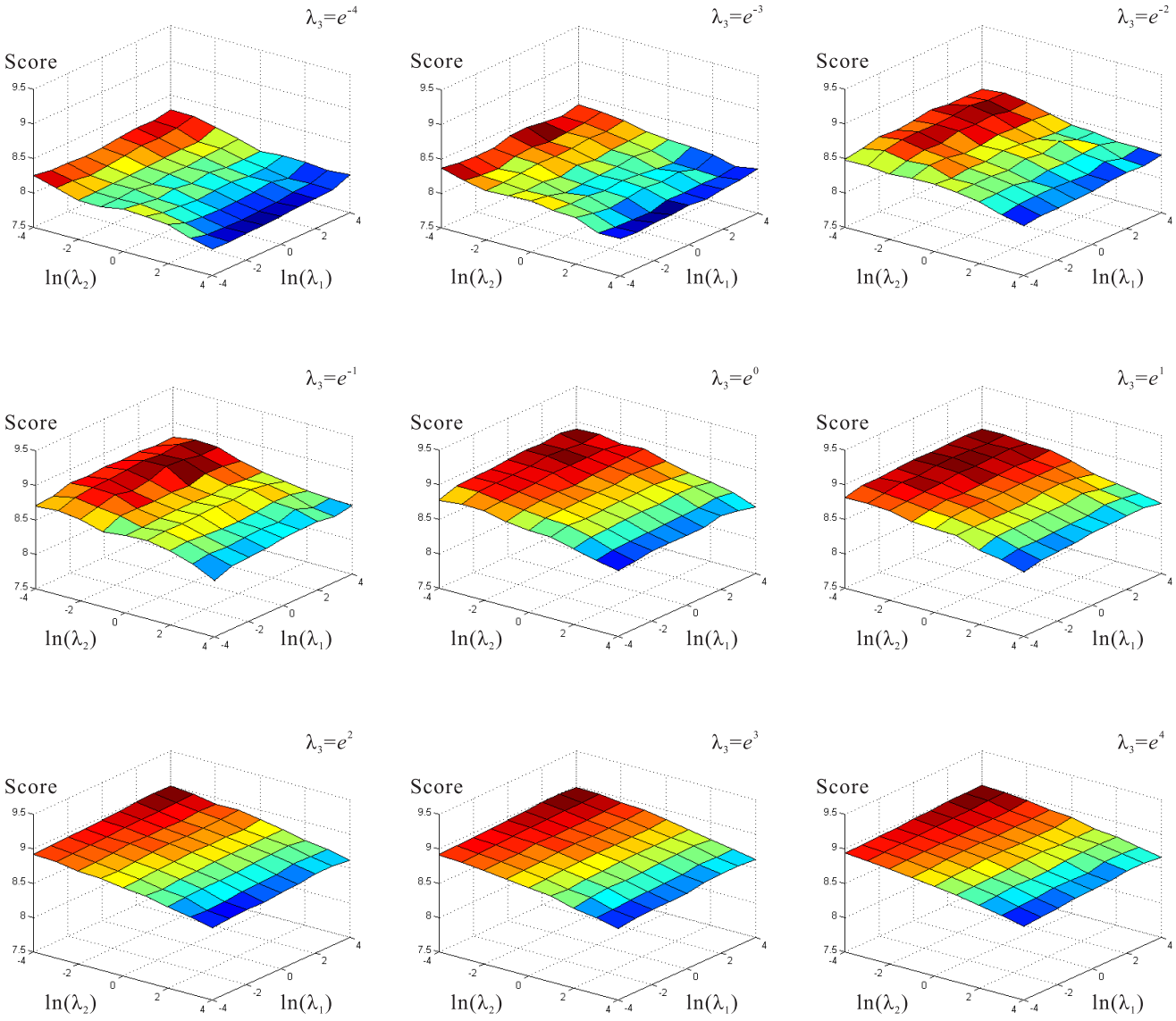


Figure S19: *Average scores of normal audiences.*

In the following we take the example “Petunia” in last section for most severe case of protanopia to illustrate how the choice of different weights affect the result.

Left result images:

$\lambda_3 = e^{-4}$:

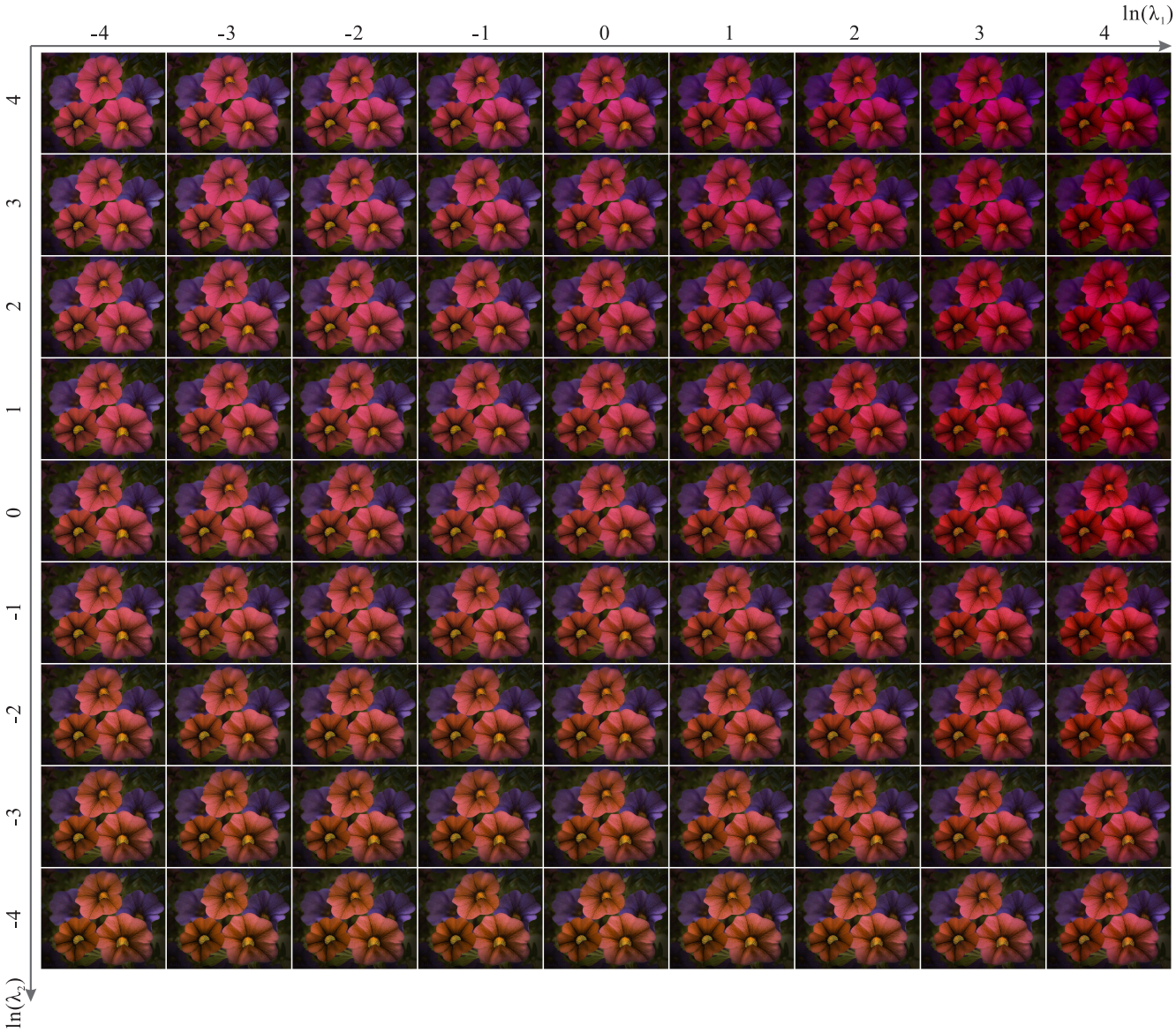


Figure S20: *Left result image of “Petunia” with* $\lambda_3 = e^{-4}$.

$\lambda_3 = e^{-2}$:

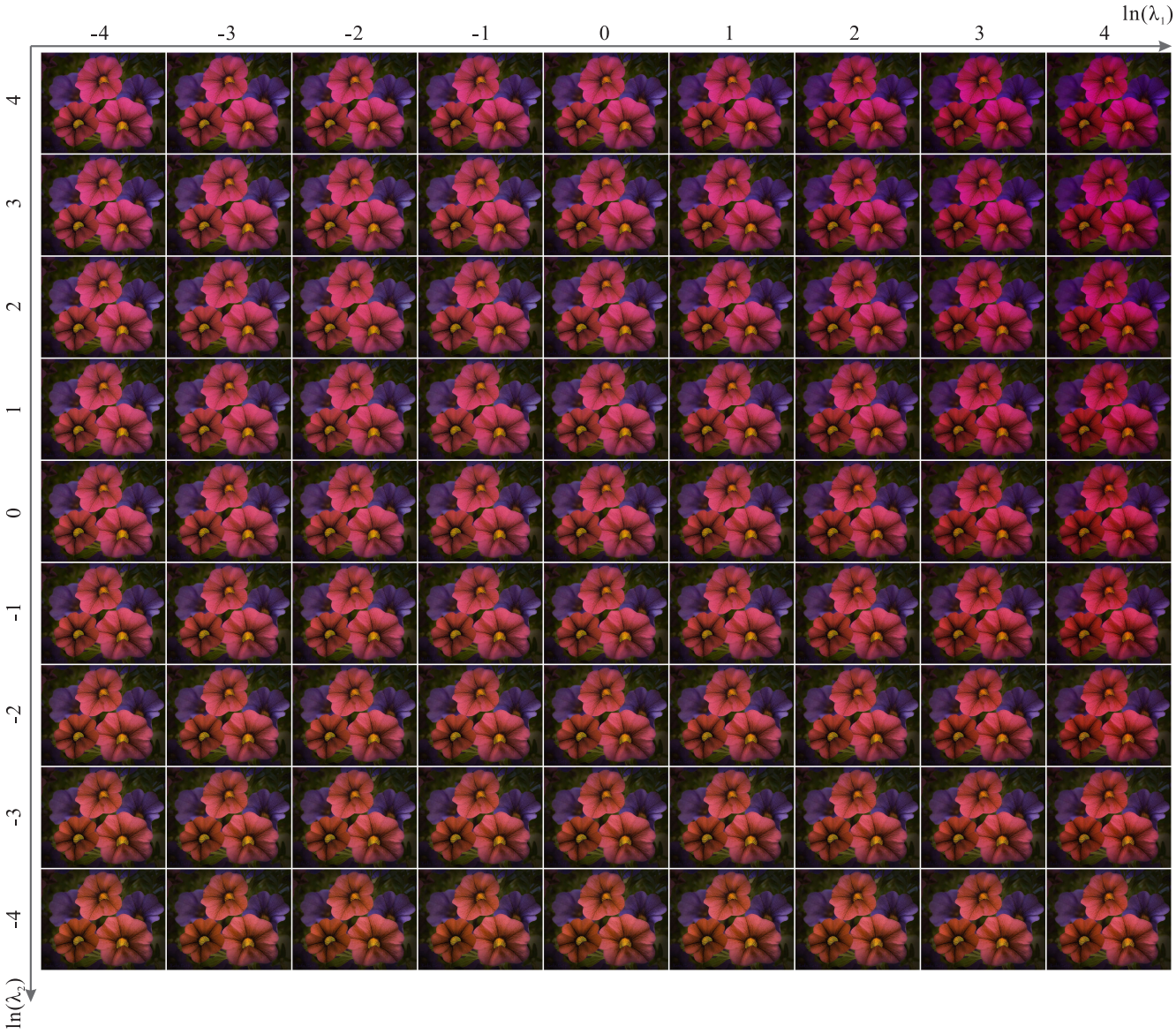


Figure S21: *Left result image of "Petunia" with* $\lambda_3 = e^{-2}$.

$\lambda_3 = e^0$:

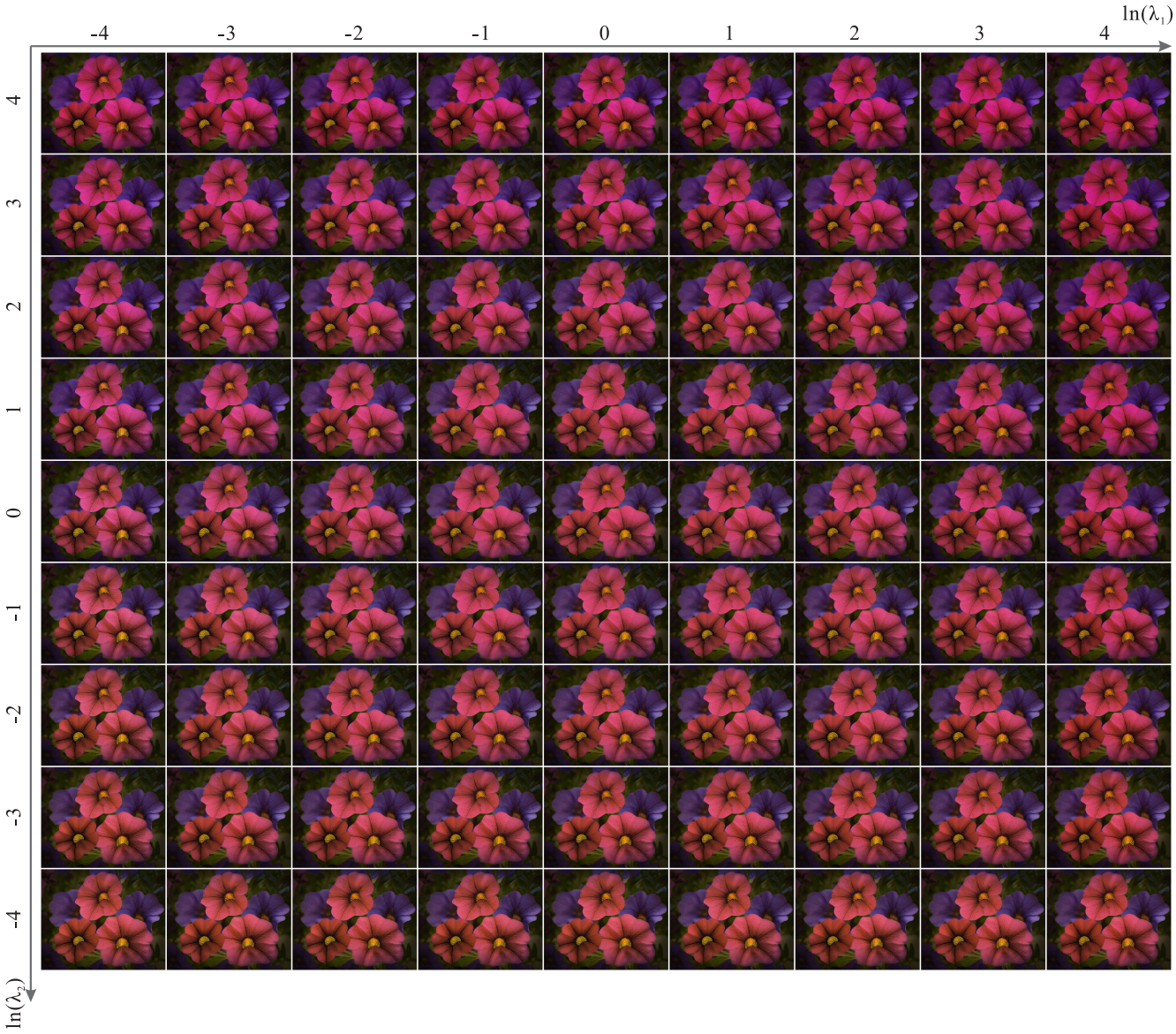


Figure S22: *Left result image of "Petunia" with* $\lambda_3 = e^0$.

$\lambda_3 = e^2$:

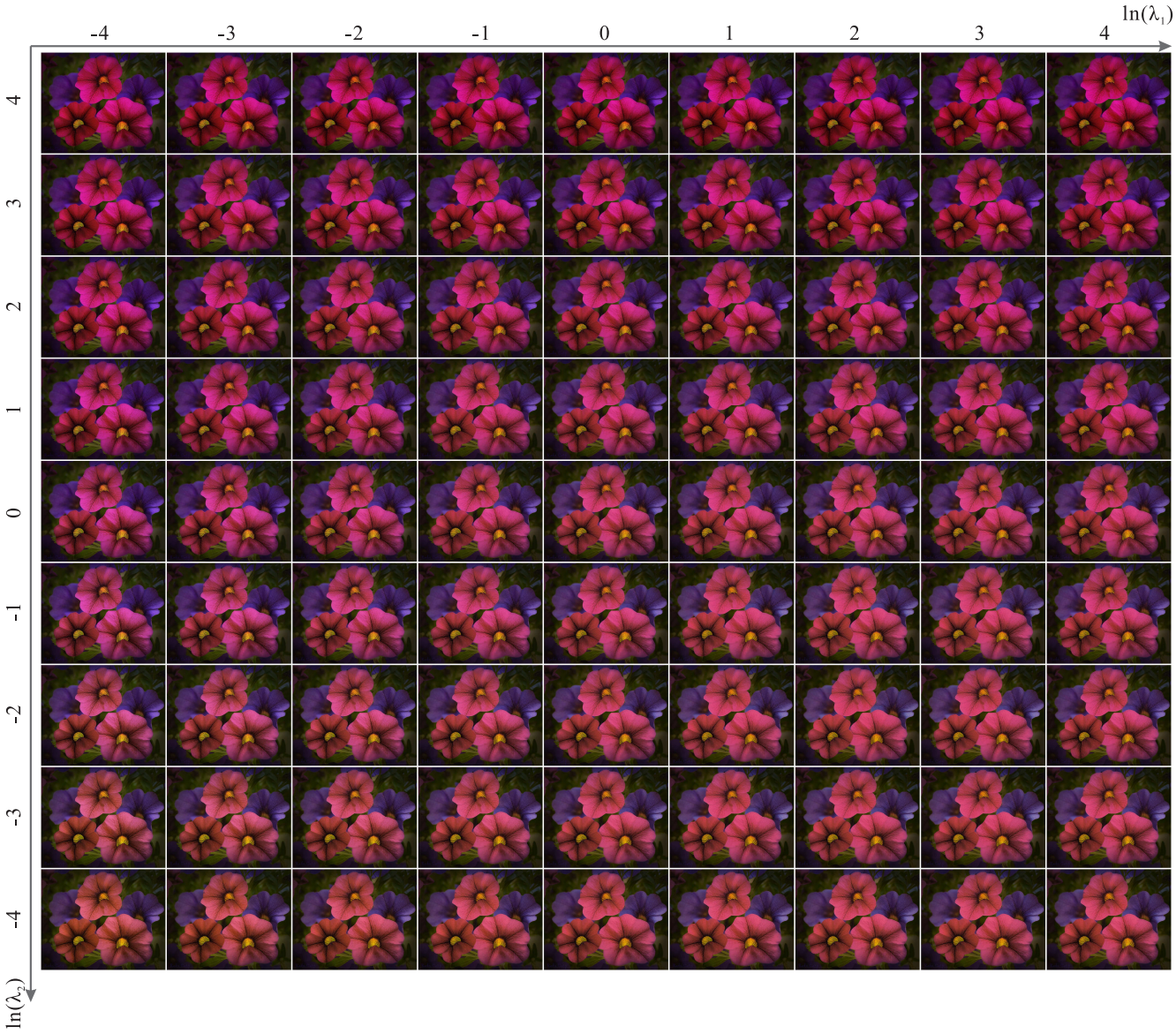


Figure S23: *Left result image of "Petunia" with* $\lambda_3 = e^2$.

$\lambda_3 = e^4$:

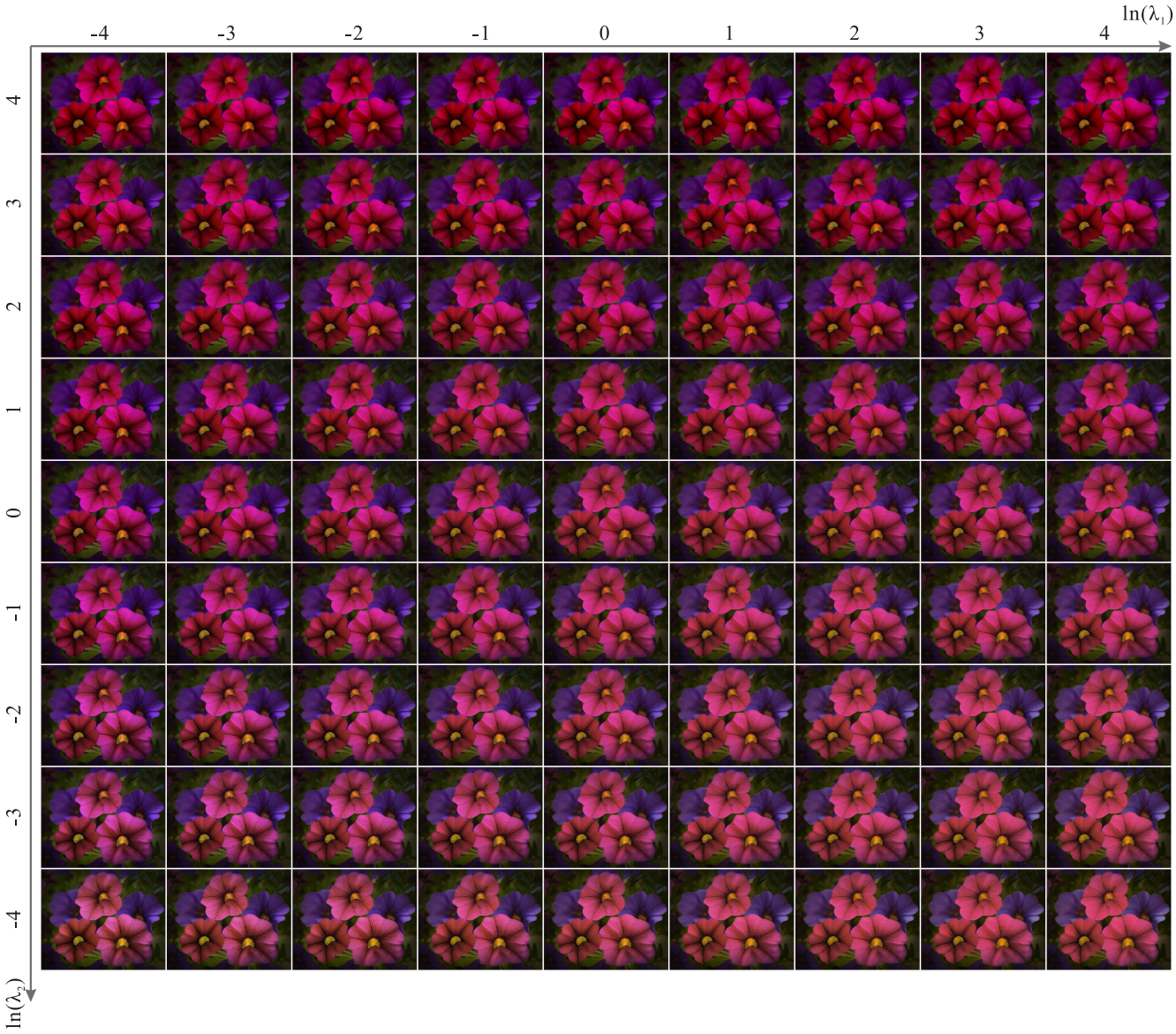


Figure S24: *Left result image of "Petunia" with* $\lambda_3 = e^4$.

Right result images:

$\lambda_3 = e^{-4}$:

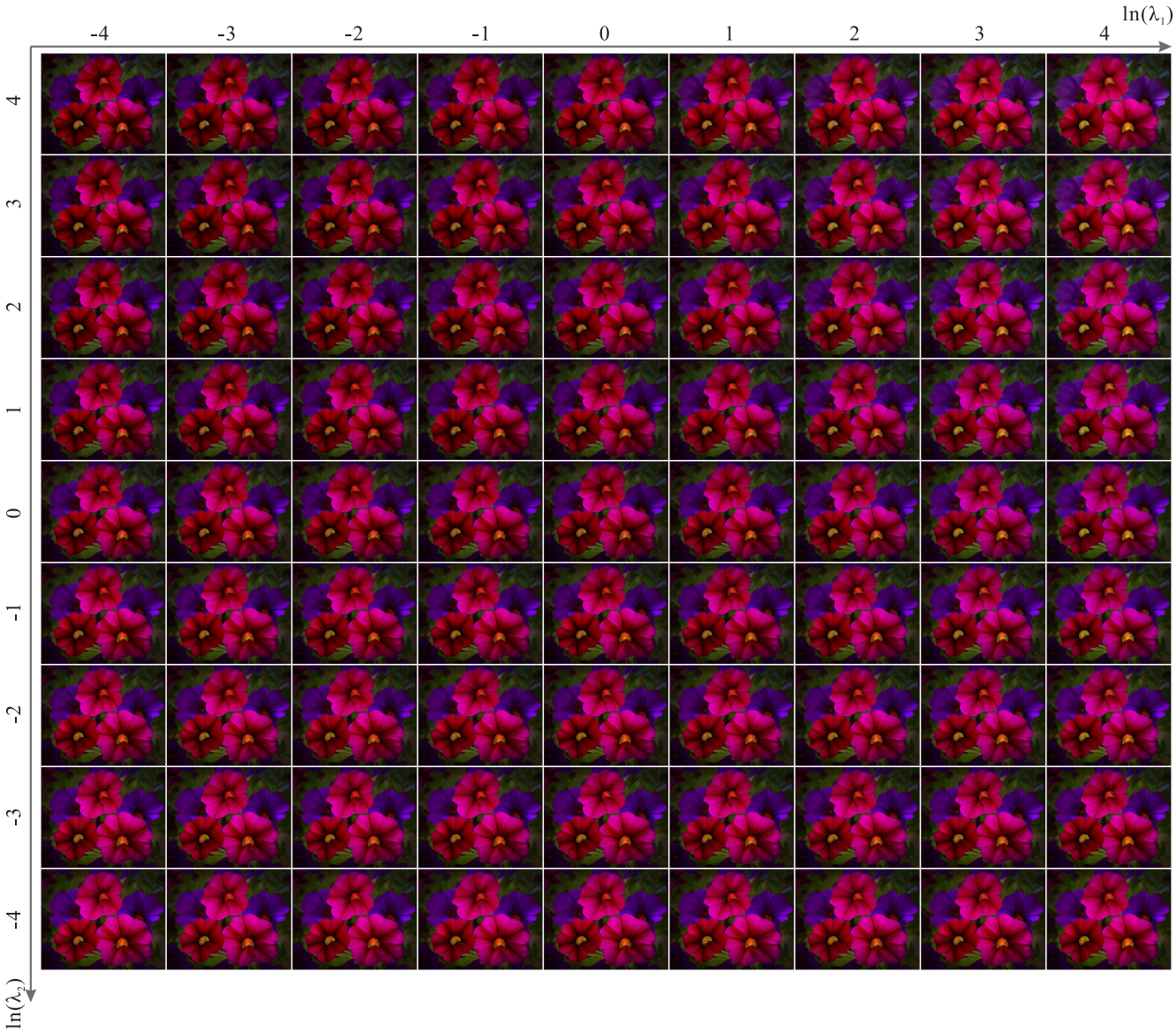


Figure S25: *Right result image of "Petunia" with* $\lambda_3 = e^{-4}$.

$\lambda_3 = e^{-2}$:

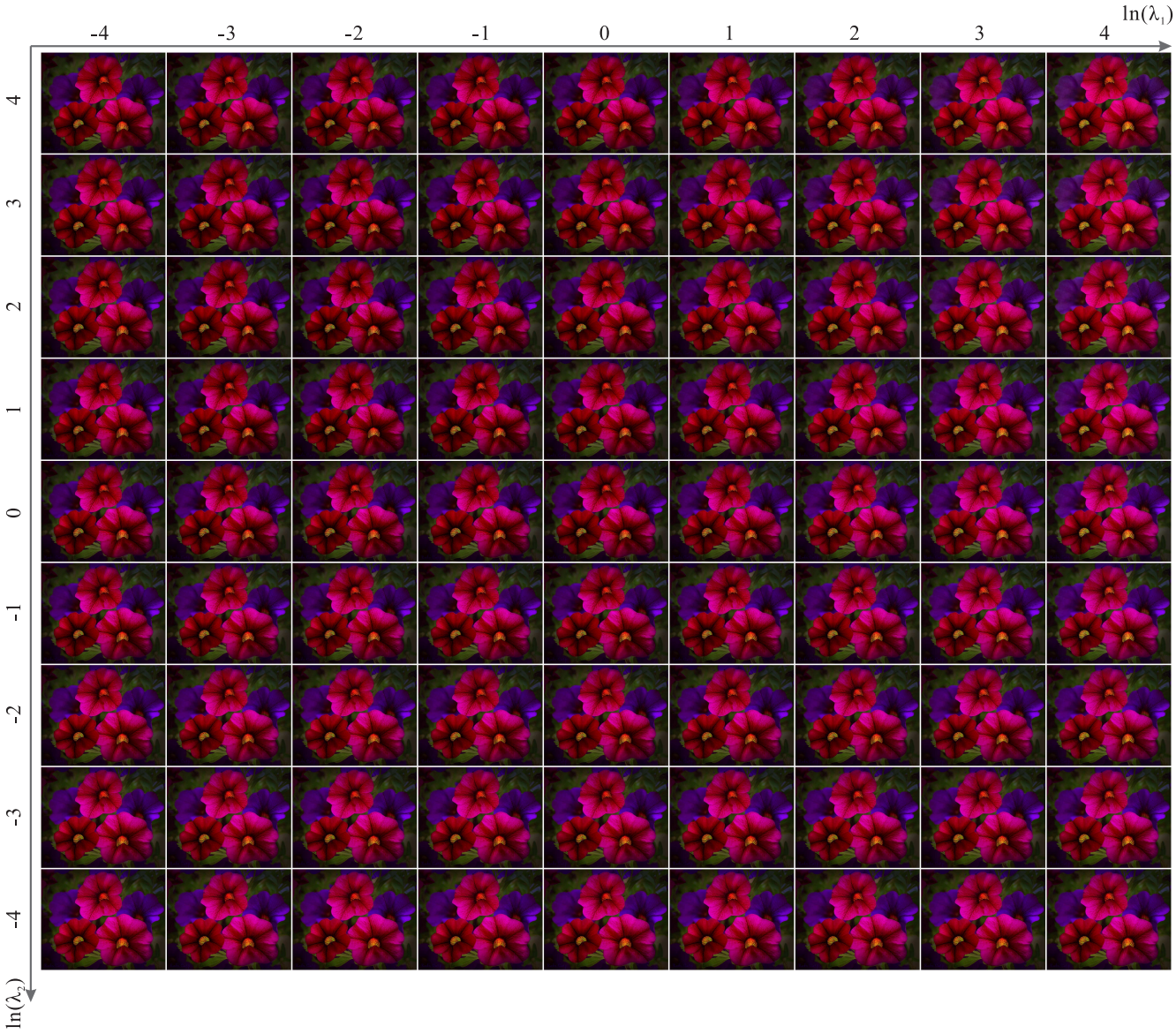


Figure S26: *Right result image of "Petunia" with* $\lambda_3 = e^{-2}$.

$\lambda_3 = e^0$:

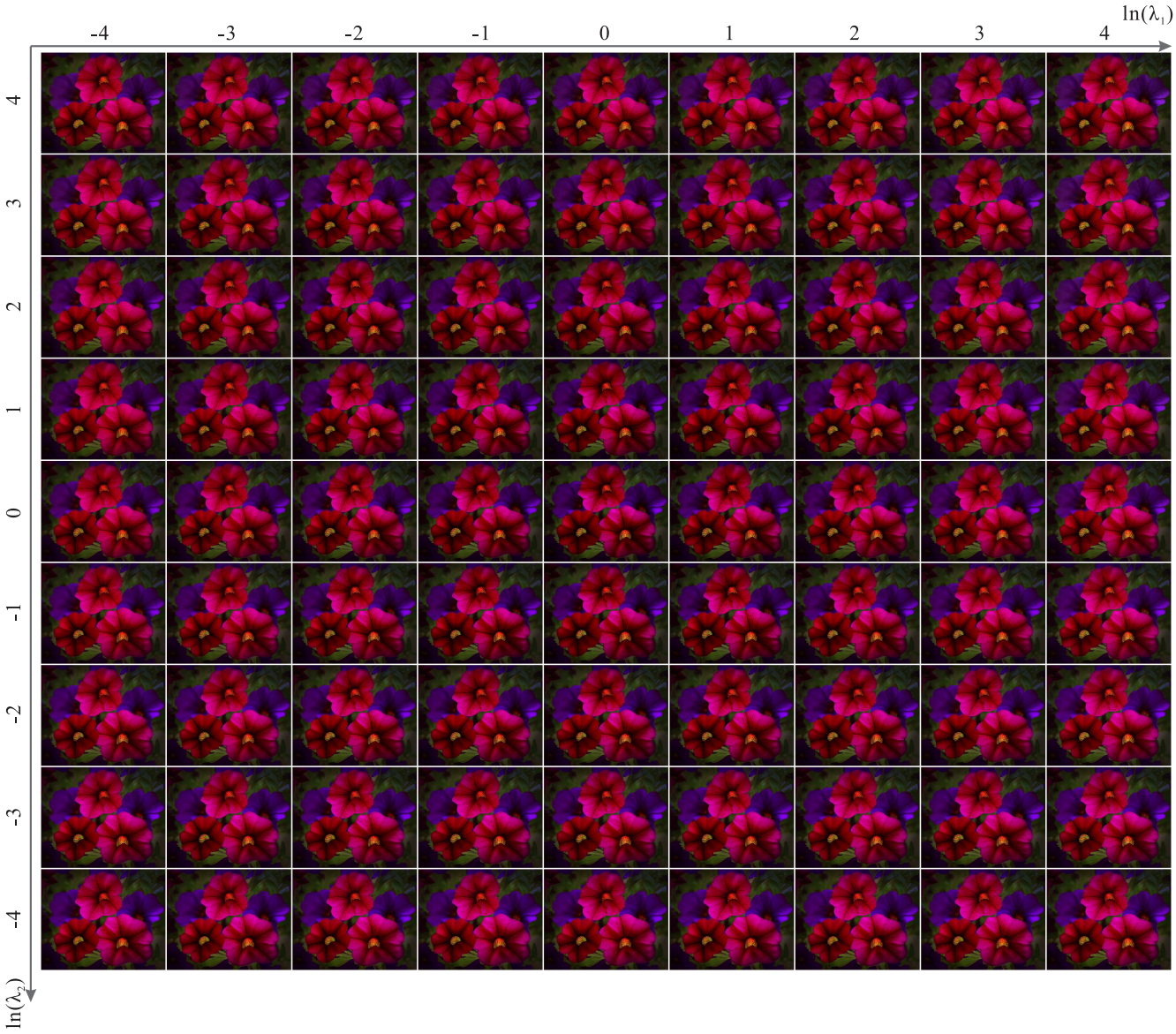


Figure S27: *Right result image of "Petunia" with* $\lambda_3 = e^0$.

$\lambda_3 = e^2$:

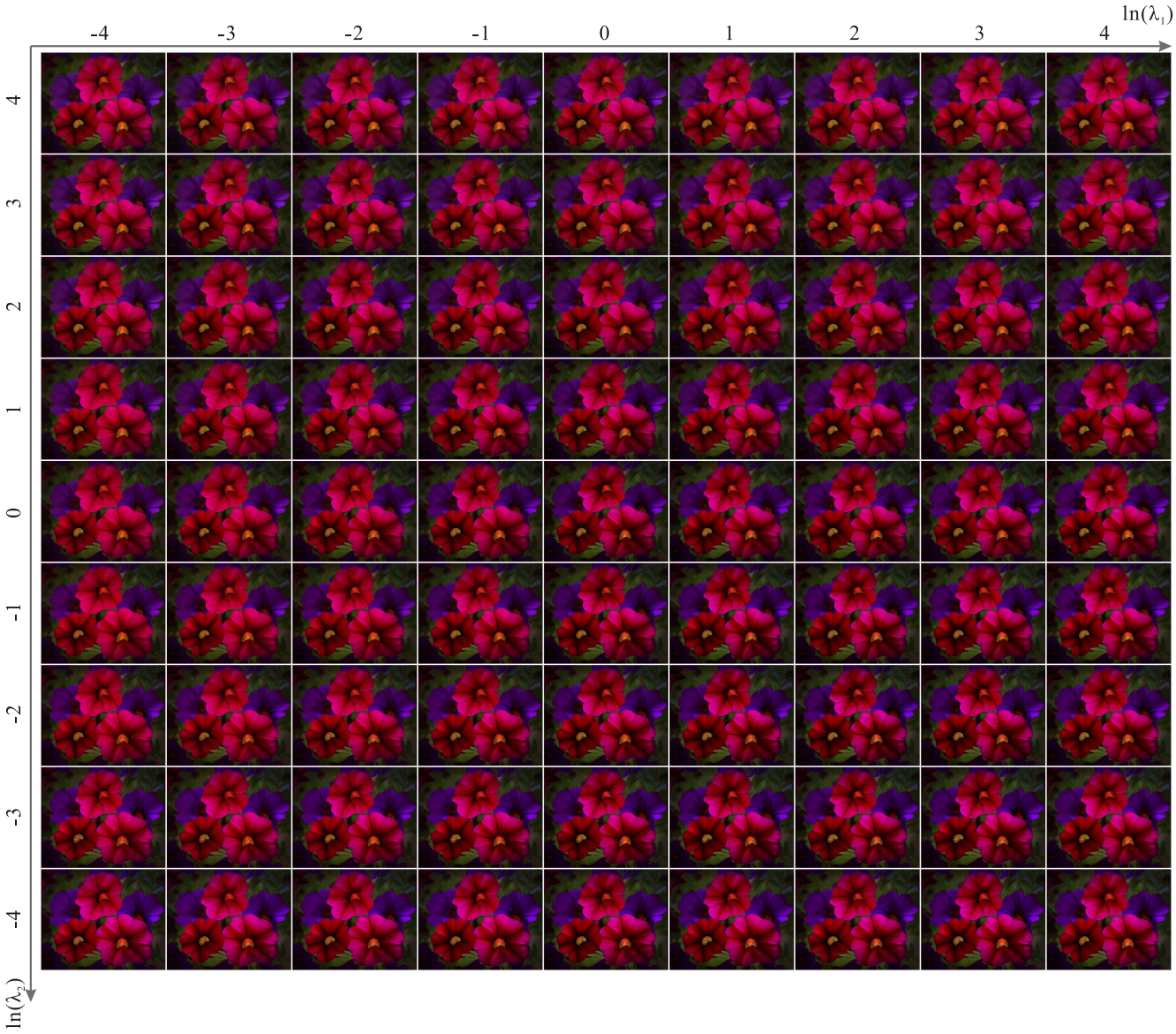


Figure S28: *Right result image of "Petunia" with* $\lambda_3 = e^2$.

$\lambda_3 = e^4$:

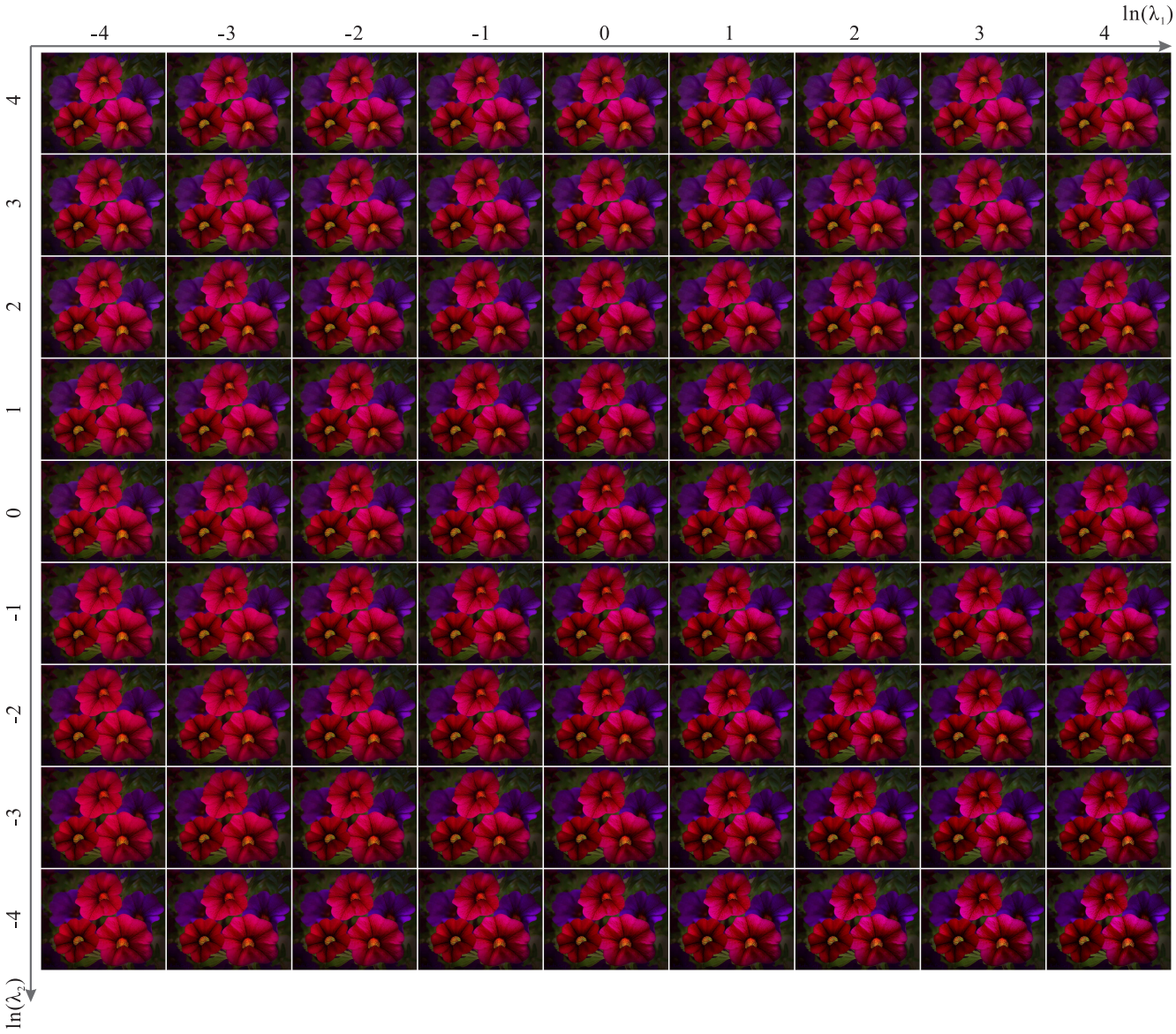


Figure S29: *Right result image of "Petunia" with* $\lambda_3 = e^4$.

S3 User Study Images and Statistics

In this section we show the user study images and statistics. To improve readability, we fix the position of results of different method. In our user study, the appearing positions is randomly assigned.

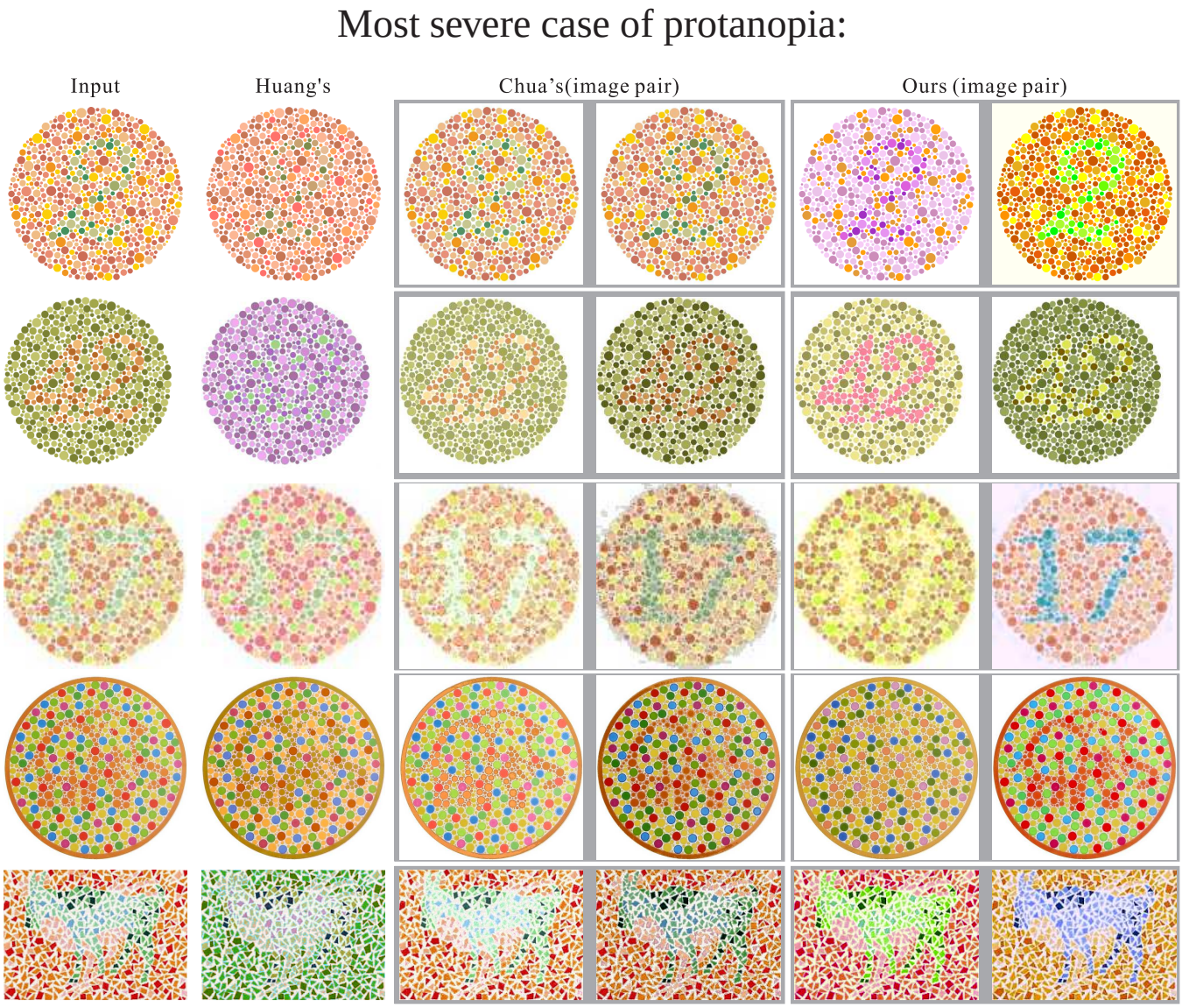


Figure S30: *User study Ishihara test images "2", "42", "17", "Elephant" and "Goat and rooster" for protanopia.*

Most severe case of protanopia:

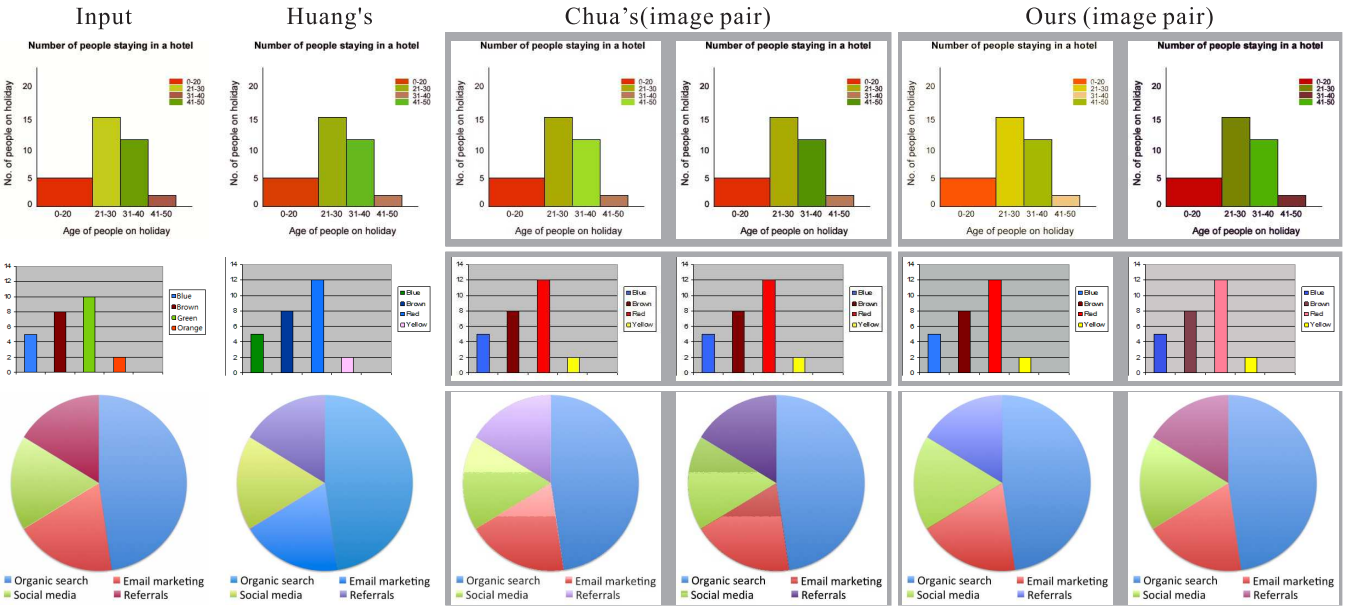


Figure S31: *User study color chart images "Bar1", "Bar2" and "Pie" for protanopia.*

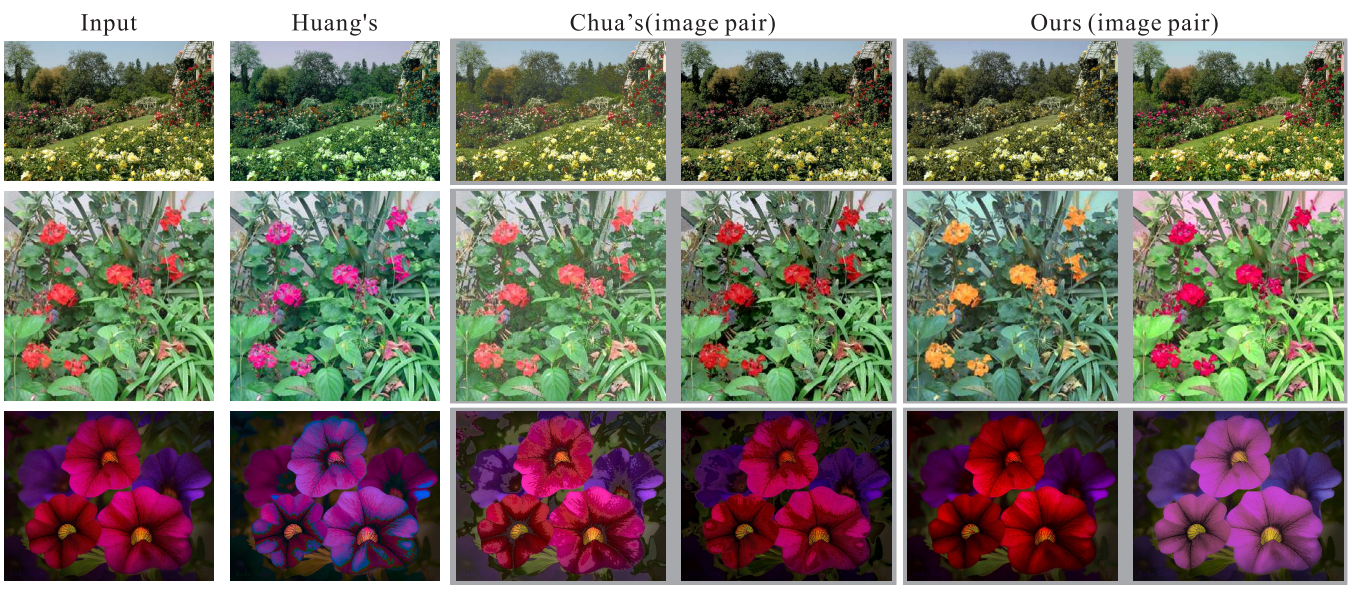


Figure S32: *User study natural images "Flowers4", "Flowers2" and "Petunia" for protanopia.*

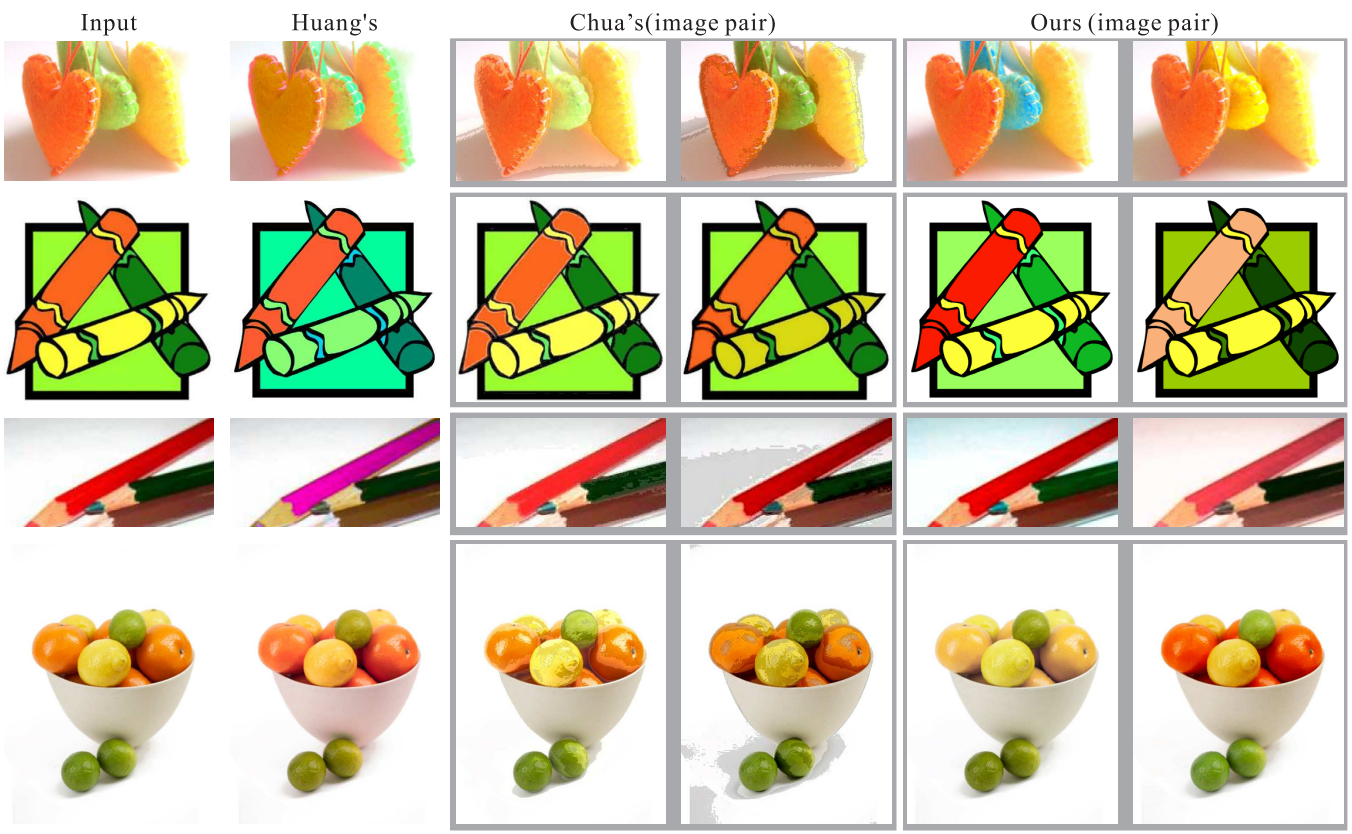


Figure S33: *User study natural images "Hearts", "Lb", "Pencils" and "Orange1" for protanopia.*

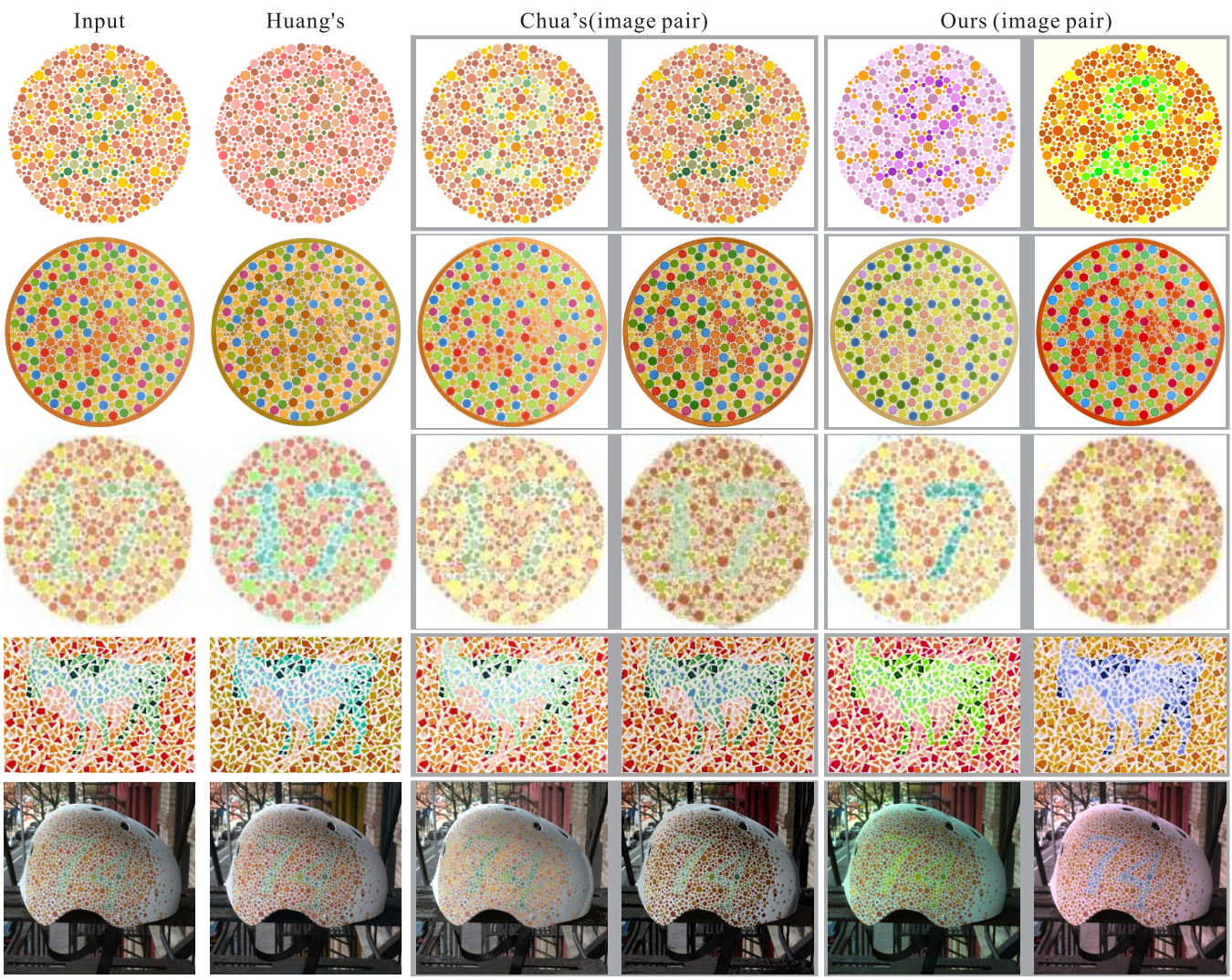


Figure S34: *User study Ishihara test images "2", "Elephant", "17", "Goat and rooster" and "74" for deuteranopia.*

Most severe case of deuteranopia:

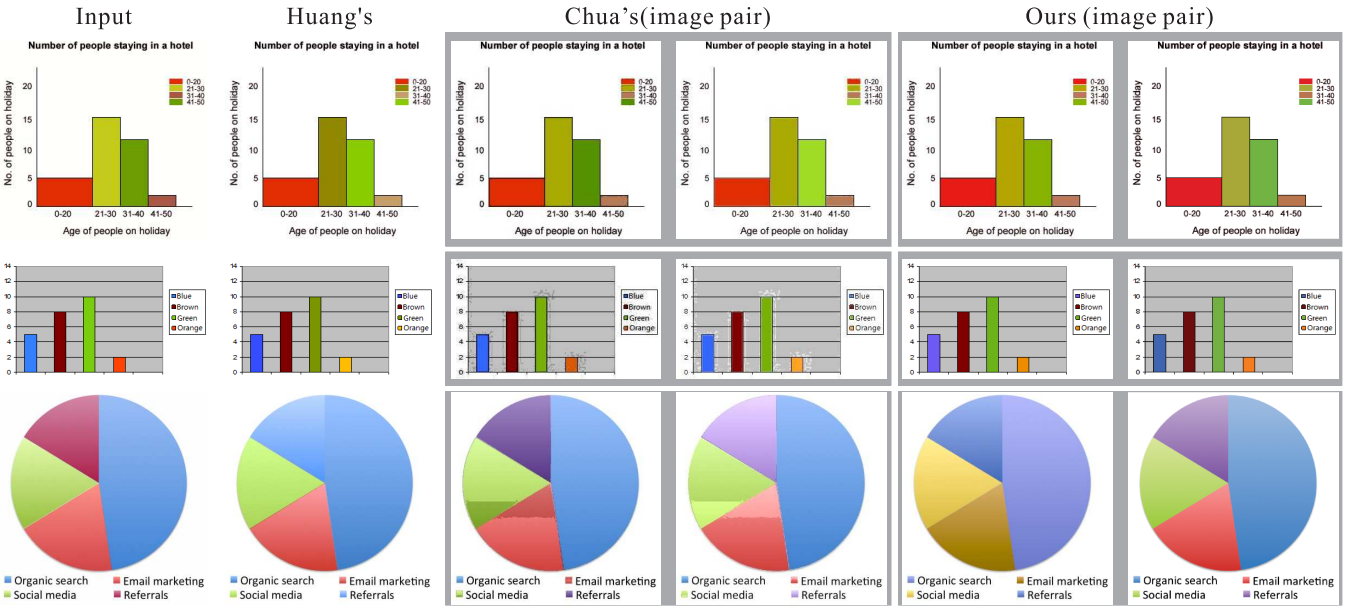


Figure S35: *User study color chart images "Bar1", "Bar2" and "Pie" for deuteranopia.*

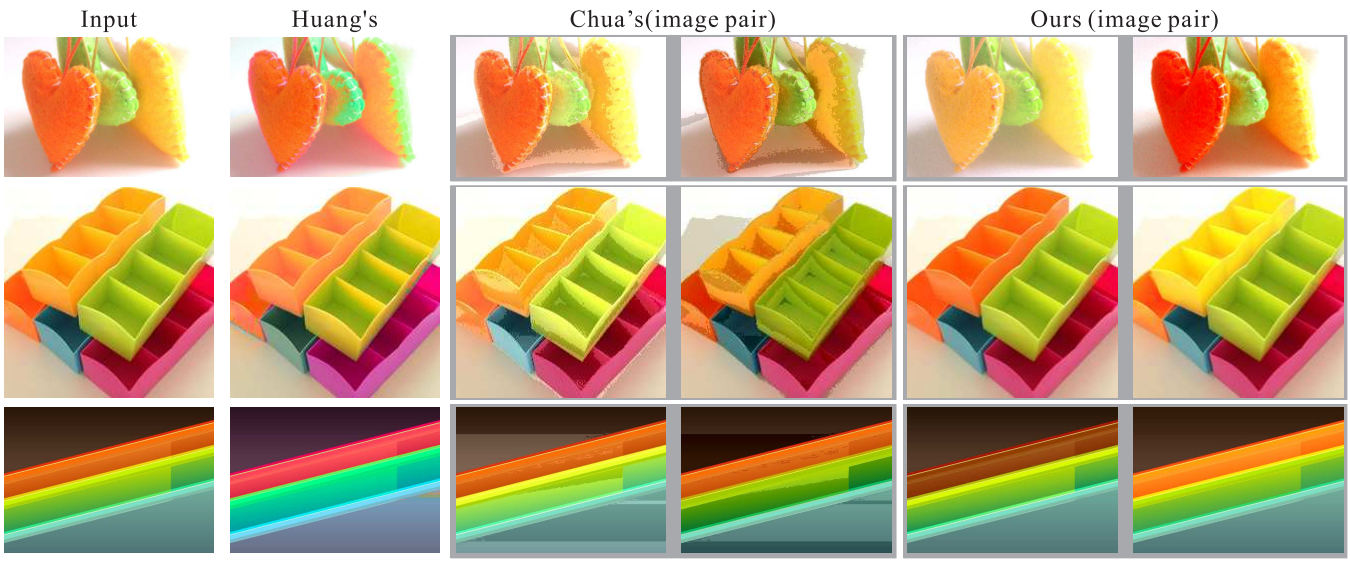


Figure S36: *User study natural images "Hearts", "Boxes" and "Bar3" for deuteranopia.*

Figure S37: *User study natural images "Flowers", "Bears", "Orange2" and "Orange1" for deuteranopia.*

In the following we show our user study statistics on above images. We first show breakdown of user study data respect to image types (ishihara test image, color chart and natural image) and then show user study statistics of CVDs and normal people.

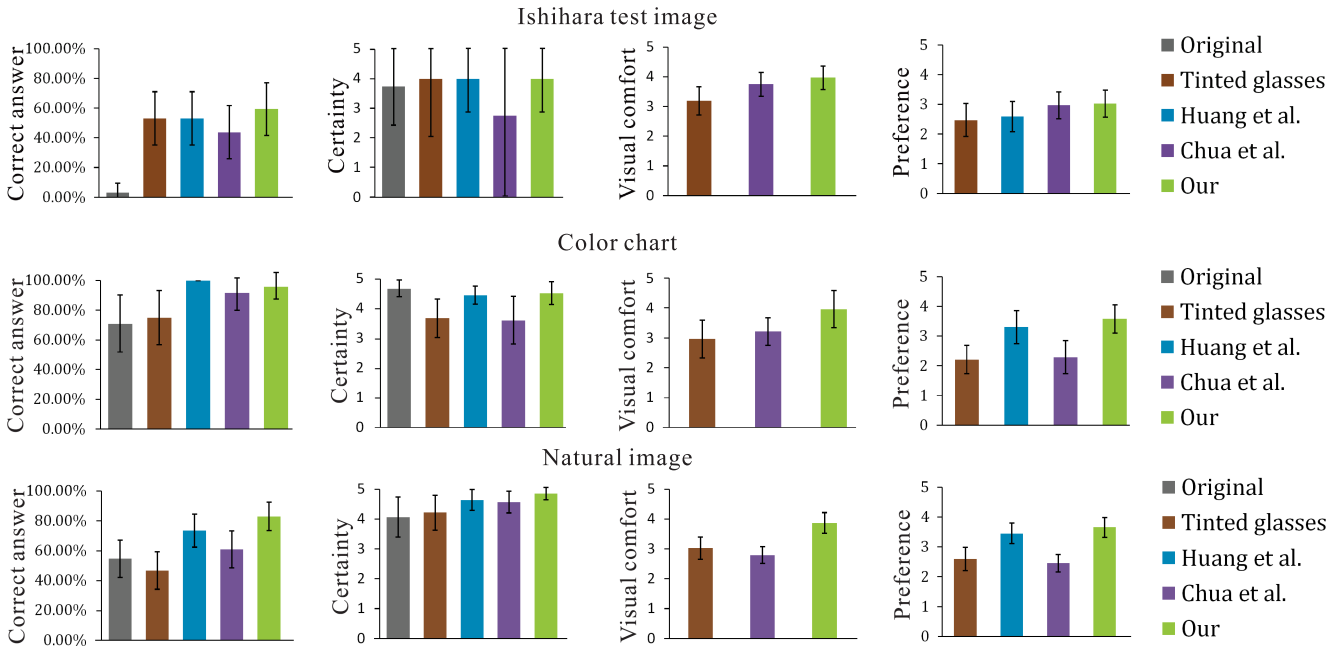


Figure S38: *Breakdown of user study data respect to ishihara test image, color chart and natural image.*

For CVDs, the correctness row is binary and it will be recorded as 1 if they can recognize the number or animal in the Ishihara test images correctly, or do a correct color matching on color chart images, or theStabley can correct distinguish objects in natural images. The certainty, comfort and preference rows allow CVDs to rating between 1 to 5, while 1 means lowest score and 5 means highest score. The stable row is also binary and CVDs need to answer whether they feel the binocular fusion is stable or not.

CVDs:

Image		"2"		"17"		"74"		"Bar1"	
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Original	Correct rate	0.0%	0.0000	12.5%	0.3307	0.0%	0.0000	37.5%	0.4841
	Certainty	0.0000	0.0000	3.0000	0.0000	0.0000	0.0000	4.6667	0.4714
Tinted glasses	Correct rate	75.0%	0.4330	75.0%	0.4330	0.0%	0.0000	62.5%	0.4841
	Certainty	3.0000	0.5774	3.6667	0.9428	0.0000	0.0000	4.0000	1.2649
	Comfort	3.2500	1.3919	3.1250	1.3636	2.8750	1.3636	3.0000	1.5811
	Preference	1.8750	1.2686	3.0000	1.4142	2.6250	1.2183	1.7500	1.0897
Huang's	Correct rate	12.5%	0.3307	25.0%	0.4330	0.0%	0.0000	100.0%	0.0000
	Certainty	1.0000	0.0000	3.0000	2.0000	0.0000	0.0000	3.5000	1.3229
	Preference	1.7500	1.2990	3.3750	1.1110	2.3750	1.2183	3.2500	1.1990
Chua's	Correct rate	12.5%	0.3307	62.5%	0.4841	0.0%	0.0000	87.5%	0.3307
	Certainty	2.0000	0.0000	1.8000	1.1662	0.0000	0.0000	2.5714	1.1780
	Comfort	3.8750	1.0533	3.5000	1.1180	3.1250	0.7806	3.3750	0.8570
	Preference	3.6250	0.9922	2.8750	1.1659	2.0000	1.1180	2.2500	1.4790
	Stable or not	100.0%	0.0000	100.0%	0.0000	75.0%	0.4330	87.5%	0.3307
Ours	Correct rate	12.5%	0.3307	75.0%	0.4330	100.0%	0.0000	100.0%	0.0000
	Certainty	2.0000	0.0000	4.1667	1.0672	4.5000	0.7071	3.8750	0.7806
	Comfort	4.1250	1.1659	4.0000	0.8660	3.7500	1.4790	3.5000	1.6583
	Preference	2.0000	1.0000	3.3750	0.6960	4.3750	0.6960	3.3750	0.9922
	Stable or not	62.5%	0.4841	87.5%	0.3307	87.5%	0.3307	87.5%	0.3307

Table S1: *Statistics of each test image.*

Image		"Bar2"		"Bar3"		"Bear"		"Elephant"	
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Original	Correct rate	87.5%	0.3307	75.0%	0.4330	62.5%	0.4841	0.0%	0.0000
	Certainty	4.7143	0.4518	3.5000	0.9574	4.0000	1.5492	0.0000	0.0000
Tinted glasses	Correct rate	75.0%	0.4330	37.5%	0.4841	25.0%	0.4330	0.0%	0.0000
	Certainty	3.1667	1.2134	4.0000	0.8165	4.0000	1.0000	0.0000	0.0000
	Comfort	2.8750	1.4524	3.2500	1.4790	3.7500	1.3919	3.2500	1.4790
	Preference	2.3750	0.8570	2.2500	1.3919	2.1250	1.0533	1.5000	1.0000
Huang's	Correct rate	100.0%	0.0000	100.0%	0.0000	87.5%	0.3307	87.5%	0.3307
	Certainty	4.3750	0.4841	4.6250	0.4841	3.7143	1.0302	3.8571	0.8330
	Preference	3.3750	1.3170	4.3750	0.6960	3.3750	1.3170	2.7500	1.3919
Chua's	Correct rate	87.5%	0.3307	75.0%	0.4330	87.5%	0.3307	87.5%	0.3307
	Certainty	2.2857	1.0302	4.6667	0.4714	3.7143	1.2778	3.5714	1.0498
	Comfort	3.1250	1.2686	2.2500	0.6614	2.8750	1.0533	3.2500	1.1990
	Preference	2.1250	1.0533	2.6250	1.4087	2.1250	0.7806	3.0000	1.5000
	Stable or not	87.5%	0.3307	75.0%	0.4330	87.5%	0.3307	100.0%	0.0000
Ours	Correct rate	100.0%	0.0000	87.5%	0.3307	100.0%	0.0000	75.0%	0.4330
	Certainty	4.7500	0.4330	4.5714	0.7284	4.5000	0.7071	4.3333	0.4714
	Comfort	3.8750	1.6910	4.1250	1.2686	3.8750	1.5360	3.5000	1.3229
	Preference	3.5000	1.4142	3.5000	1.4142	3.7500	1.1990	3.5000	1.3229
	Stable or not	100.0%	0.0000	87.5%	0.3307	100.0%	0.0000	62.5%	0.4841

Table S2: *Statistics of each test image.*

Image		"Flower"		"Heart"		"Hz"		"Jy"	
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Original	Correct rate	12.5%	0.3307	87.5%	0.3307	12.5%	0.3307	0.0%	0.0000
	Certainty	5.0000	0.0000	5.0000	0.0000	2.0000	0.0000	0.0000	0.0000
Tinted glasses	Correct rate	87.5%	0.3307	37.5%	0.4841	12.5%	0.3307	62.5%	0.4841
	Certainty	4.1429	0.8330	4.6667	0.4714	2.0000	0.0000	5.0000	0.0000
	Comfort	3.2500	1.2990	3.1250	1.6154	1.7500	0.8292	3.1250	0.9270
	Preference	3.1250	1.6910	2.1250	1.3636	3.2500	1.5612	3.5000	1.5000
Huang's	Correct rate	87.5%	0.3307	87.5%	0.3307	25.0%	0.4330	87.5%	0.3307
	Certainty	4.4286	0.4949	4.7143	0.4518	1.5000	0.5000	4.0000	0.7559
	Preference	3.6250	1.5762	3.3750	1.1110	2.1250	1.0533	2.5000	1.3229
Chua's	Correct rate	12.5%	0.3307	100.0%	0.0000	100.0%	0.0000	12.5%	0.3307
	Certainty	5.0000	0.0000	4.8750	0.3307	4.6250	0.4841	3.0000	0.0000
	Comfort	3.3750	0.9922	2.6250	1.3170	2.1250	1.0533	4.3750	0.6960
	Preference	3.1250	1.0533	1.8750	0.7806	2.1250	0.9270	2.3750	0.9922
	Stable or not	87.5%	0.3307	50.0%	0.5000	100.0%	0.0000	100.0%	0.0000
Ours	Correct rate	62.5%	0.4841	100.0%	0.0000	12.5%	0.3307	75.0%	0.4330
	Certainty	4.6000	0.4899	5.0000	0.0000	3.0000	0.0000	4.0000	0.5774
	Comfort	3.5000	1.5811	4.2500	0.9682	3.0000	1.4142	4.2500	0.6614
	Preference	3.2500	1.7854	4.0000	0.8660	3.0000	1.2247	3.2500	1.2990
	Stable or not	100.0%	0.0000	100.0%	0.0000	100.0%	0.0000	87.5%	0.3307

Table S3: *Statistics of each test image.*

Image		"Orange1"		"Orange2"		"Pie"	
		Mean	S.D.	Mean	S.D.	Mean	S.D.
Original	Correct rate	100.0%	0.0000	87.5%	0.3307	87.5%	0.3307
	Certainty	4.5000	0.7071	3.2857	1.0302	4.7143	0.4518
Tinted glasses	Correct rate	75.0%	0.4330	100.0%	0.0000	87.5%	0.3307
	Certainty	3.8333	1.2134	4.3750	0.6960	3.8571	0.6389
	Comfort	2.6250	1.3170	3.6250	1.4948	3.0000	1.4142
	Preference	2.0000	1.7321	3.2500	1.5612	2.5000	1.2247
Huang's	Correct rate	100.0%	0.0000	100.0%	0.0000	100.0%	0.0000
	Certainty	4.7500	0.4330	5.0000	0.0000	4.5000	0.5000
	Preference	4.1250	1.1659	4.2500	0.6614	3.2500	1.3919
Chua's	Correct rate	100.0%	0.0000	12.5%	0.3307	100.0%	0.0000
	Certainty	4.3750	0.6960	5.0000	0.0000	4.7500	0.4330
	Comfort	2.5000	1.3229	3.5000	0.8660	3.1250	1.0533
	Preference	3.0000	1.2247	2.7500	1.1990	2.5000	1.3229
	Stable or not	87.5%	0.3307	100.0%	0.0000	87.5%	0.3307
Ours	Correct rate	100.0%	0.0000	100.0%	0.0000	87.5%	0.3307
	Certainty	4.5000	1.0000	4.3750	0.8570	4.8571	0.3499
	Comfort	4.7500	0.4330	3.7500	1.3919	4.5000	0.5000
	Preference	4.0000	1.1180	3.3750	1.4087	3.8750	0.7806
	Stable or not	100.0%	0.0000	100.0%	0.0000	100.0%	0.0000

Table S4: *Statistics of each test image.*

For normal people, we allow them to choose the images closest to original image from results of different methods. Since we allow them to choose multiple images so the row sum can be larger than 1.

Normal people:

"Image"	Huang's		Chua's		Ours	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
"2"	0%	0.0000	100%	0.0000	50%	0.5000
"17"	0%	0.0000	100%	0.0000	100%	0.0000
"74"	0%	0.0000	20%	0.4000	100%	0.0000
"Bar1"	90%	0.3000	70%	0.4583	90%	0.3000
"Bar2"	0%	0.0000	0%	0.0000	100%	0.0000
"Bar3"	0%	0.0000	0%	0.0000	100%	0.0000
"Bear"	0%	0.0000	0%	0.0000	100%	0.0000
"Elephant"	0%	0.0000	100%	0.0000	40%	0.4899
"Flower"	0%	0.0000	100%	0.0000	0%	0.0000
"Hz"	0%	0.0000	0%	0.0000	100%	0.0000
"Heart"	0%	0.0000	0%	0.0000	100%	0.0000
"Jy"	0%	0.0000	80%	0.4000	90%	0.3000
"Orange1"	0%	0.0000	0%	0.0000	100%	0.0000
"Orange2"	0%	0.0000	0%	0.0000	100%	0.0000
"Pie"	0%	0.0000	0%	0.0000	100%	0.0000

Table S5: *Statistics of normal people.*

In the following we use the screen shots of ANOVA result to show whether the difference of the mean values of these groups is significant.

ANOVA

CorrectAns

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	9.607	4	2.402	10.928	.000
Within Groups	130.767	595	.220		
Total	140.373	599			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: CorrectAns

LSD

(I) Method	(J) Method	Mean Difference (I-J)	Std. Error	Sig.	95% ... Lower Bound
Original	Tinted glasses	-.100	.061	.099	-.22
	Huang	-.292*	.061	.000	-.41
	Chua	-.183*	.061	.003	-.30
	Our	-.350*	.061	.000	-.47
Tinted glasses	Original	.100	.061	.099	-.02
	Huang	-.192*	.061	.002	-.31
	Chua	-.083	.061	.169	-.20
	Our	-.250*	.061	.000	-.37
Huang	Original	.292*	.061	.000	.17
	Tinted glasses	.192*	.061	.002	.07
	Chua	.108	.061	.074	-.01
	Our	-.058	.061	.336	-.18
Chua	Original	.183*	.061	.003	.06
	Tinted glasses	.083	.061	.169	-.04
	Huang	-.108	.061	.074	-.23
	Our	-.167*	.061	.006	-.29
Our	Original	.350*	.061	.000	.23
	Tinted glasses	.250*	.061	.000	.13
	Huang	.058	.061	.336	-.06
	Chua	.167*	.061	.006	.05

Figure S39: *ANOVA on correctness.*

ANOVA

Certainty

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	10.104	4	2.526	3.091	.018
Within Groups	106.222	130	.817		
Total	116.326	134			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: Certainty

LSD

(I) Method	(J) Method	Mean Difference (I-J)	Std. Error	Sig.	95% ... Lower Bound
Original	Tinted glasses	.40741	.24602	.100	-.0793
	Huang	-.18519	.24602	.453	-.6719
	Chua	.25926	.24602	.294	-.2275
	Our	-.33333	.24602	.178	-.8201
Tinted glasses	Original	-.40741	.24602	.100	-.8941
	Huang	-.59259*	.24602	.017	-1.0793
	Chua	-.14815	.24602	.548	-.6349
	Our	-.74074*	.24602	.003	-1.2275
Huang	Original	.18519	.24602	.453	-.3015
	Tinted glasses	.59259*	.24602	.017	.1059
	Chua	.44444	.24602	.073	-.0423
	Our	-.14815	.24602	.548	-.6349
Chua	Original	-.25926	.24602	.294	-.7460
	Tinted glasses	.14815	.24602	.548	-.3386
	Huang	-.44444	.24602	.073	-.9312
	Our	-.59259*	.24602	.017	-1.0793
Our	Original	.33333	.24602	.178	-.1534
	Tinted glasses	.74074*	.24602	.003	.2540
	Huang	.14815	.24602	.548	-.3386
	Chua	.59259*	.24602	.017	.1059

Figure S40: *ANOVA on certainty.*

ANOVA

VisualComft

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	54.239	2	27.119	15.280	.000
Within Groups	633.625	357	1.775		
Total	687.864	359			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: VisualComft

LSD

(I) Method	(J) Method	Mean Difference (I-J)	Std. Error	Sig.	95% ... Lower Bound
Tinted glasses	Chua	-.07500	.17199	.663	-.4132
	Our	-.85833*	.17199	.000	-1.1966
Chua	Tinted glasses	.07500	.17199	.663	-.2632
	Our	-.78333*	.17199	.000	-1.1216
Our	Tinted glasses	.85833*	.17199	.000	.5201
	Chua	.78333*	.17199	.000	.4451

Figure S41: *ANOVA on comfort.*

ANOVA

Preference

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	84.373	3	28.124	14.973	.000
Within Groups	894.075	476	1.878		
Total	978.448	479			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: Preference

LSD

(I) Method	(J) Method	Mean Difference (I-J)	Std. Error	Sig.	95% ... Lower Bound
Tinted glasses	Huang	-.70833*	.17693	.000	-1.0560
	Chua	-.07500	.17693	.672	-.4227
	Our	-.99167*	.17693	.000	-1.3393
Huang	Tinted glasses	.70833*	.17693	.000	.3607
	Chua	.63333*	.17693	.000	.2857
	Our	-.28333	.17693	.110	-.6310
Chua	Tinted glasses	.07500	.17693	.672	-.2727
	Huang	-.63333*	.17693	.000	-.9810
	Our	-.91667*	.17693	.000	-1.2643
Our	Tinted glasses	.99167*	.17693	.000	.6440
	Huang	.28333	.17693	.110	-.0643
	Chua	.91667*	.17693	.000	.5690

Figure S42: *ANOVA on preference.*

S4 Quantitative Evaluation Statistics

In quantitative evaluation of main body, we show overall statistics comparing our results with Fidaner's and Huang's in terms of SSIM (normal), PSNR (normal) and CPR (CVD). Here we show the detailed statistics of each case.

Protanopia:

		SSIM (normal)	PSNR (normal)	CPR (CVD)
Case "17"	Chua	0.9544	31.2319	0.8643
	Huang	0.9356	26.9671	0.9211
	Ours	0.9942	38.2621	0.9646

Table S6: *Statistics of "17" for protanopia.*

		SSIM (normal)	PSNR (normal)	CPR (CVD)
Case "2"	Chua	0.9506	30.9181	0.9107
	Huang	0.9500	22.6635	0.9064
	Ours	0.9993	38.2091	0.9004

Table S7: *Statistics of "2" for protanopia.*

		SSIM (normal)	PSNR (normal)	CPR (CVD)
Case "42"	Chua	0.9816	31.0204	0.9510
	Huang	0.7471	14.5438	0.8431
	Ours	0.9991	39.1826	0.9588

Table S8: *Statistics of "42" for protanopia.*

		SSIM (normal)	PSNR (normal)	CPR (CVD)
Case "Bar1"	Chua	0.9764	34.2434	0.9875
	Huang	0.9615	32.9319	0.9936
	Ours	0.9957	55.3066	0.9911

Table S9: *Statistics of "Bar1" for protanopia.*

		SSIM (normal)	PSNR (normal)	CPR (CVD)
Case "Bar2"	Chua	0.9856	31.7481	0.9814
	Huang	0.8945	13.5001	0.9503
	Ours	0.9560	26.1072	0.9949

Table S10: *Statistics of "Bar2" for protanopia.*

		SSIM (normal)	PSNR (normal)	CPR (CVD)
Case "Elephant"	Chua	0.9895	39.0251	0.8671
	Huang	0.9478	25.1720	0.9497
	Ours	0.9988	47.0887	0.9784

Table S11: *Statistics of "Elephant" for protanopia.*

		SSIM (normal)	PSNR (normal)	CPR (CVD)
Case "Flowers4"	Chua	0.9600	30.4842	0.8729
	Huang	0.9416	23.5747	0.9717
	Ours	0.9982	41.9631	0.9942

Table S12: *Statistics of "Flowers4" for protanopia.*

		SSIM (normal)	PSNR (normal)	CPR (CVD)
Case “Flowers2”	Chua	0.9610	31.2789	0.8341
	Huang	0.9203	22.0369	0.8609
	Ours	0.9972	41.1322	0.9716

Table S13: *Statistics of “Flowers2” for protanopia.*

		SSIM (normal)	PSNR (normal)	CPR (CVD)
Case “Hearts”	Chua	0.9289	34.6043	0.8549
	Huang	0.8377	21.0710	0.8669
	Ours	0.9984	43.2163	0.9644

Table S14: *Statistics of “Hearts” for protanopia.*

		SSIM (normal)	PSNR (normal)	CPR (CVD)
Case “Goat and rooster”	Chua	0.9701	29.0023	0.8637
	Huang	0.7903	14.5169	0.8944
	Ours	0.9966	34.5399	0.9447

Table S15: *Statistics of “Goat and rooster” for protanopia.*

		SSIM (normal)	PSNR (normal)	CPR (CVD)
Case “Lb”	Chua	0.9778	33.0284	0.9421
	Huang	0.5231	10.6176	0.6741
	Ours	0.6573	14.1838	0.7013

Table S16: *Statistics of “Lb” for protanopia.*

		SSIM (normal)	PSNR (normal)	CPR (CVD)
Case “Orange1”	Chua	0.9611	34.6621	0.9418
	Huang	0.9672	28.7170	0.9805
	Ours	0.9781	34.2871	0.9910

Table S17: *Statistics of “Orange1” for protanopia.*

		SSIM (normal)	PSNR (normal)	CPR (CVD)
Case “Pencils”	Chua	0.8687	27.5106	0.9043
	Huang	0.8425	16.7087	0.8610
	Ours	0.9259	28.9228	0.9430

Table S18: *Statistics of “Pencils” for protanopia.*

		SSIM (normal)	PSNR (normal)	CPR (CVD)
Case “Petunia”	Chua	0.8344	30.4080	0.8103
	Huang	0.5738	16.6930	0.7652
	Ours	0.8265	24.9614	0.9244

Table S19: *Statistics of “Petunia” for protanopia.*

		SSIM (normal)	PSNR (normal)	CPR (CVD)
Case “Pie”	Chua	0.9828	38.1911	0.9651
	Huang	0.9370	15.7597	0.9601
	Ours	0.9999	53.9419	0.9774

Table S20: *Statistics of “Pie” for protanopia.*

Deuteranopia:

		SSIM (normal)	PSNR (normal)	CPR (CVD)
Case “17”	Chua	0.9640	31.8314	0.8687
	Huang	0.8793	24.7921	0.9471
	Ours	0.9982	43.9734	0.9608

Table S21: *Statistics of “17” for deuteranopia.*

		SSIM (normal)	PSNR (normal)	CPR (CVD)
Case “2”	Chua	0.9234	27.9283	0.8948
	Huang	0.9438	22.0268	0.9211
	Ours	0.9993	38.2169	0.9331

Table S22: *Statistics of “2” for deuteranopia.*

		SSIM (normal)	PSNR (normal)	CPR (CVD)
Case “74”	Chua	0.9841	39.3623	0.8191
	Huang	0.9723	32.8293	0.9803
	Ours	0.9741	37.8587	0.9700

Table S23: *Statistics of “74” for deuteranopia.*

		SSIM (normal)	PSNR (normal)	CPR (CVD)
Case “Bar1”	Chua	0.9713	32.2350	0.9862
	Huang	0.9884	36.6586	0.9945
	Ours	0.9804	43.1062	0.9963

Table S24: *Statistics of “Bar1” for deuteranopia.*

		SSIM (normal)	PSNR (normal)	CPR (CVD)
Case “Bar2”	Chua	0.9748	29.8306	0.9543
	Huang	0.9932	33.4314	0.9955
	Ours	0.9999	57.3533	0.9963

Table S25: *Statistics of “Bar2” for deuteranopia.*

		SSIM (normal)	PSNR (normal)	CPR (CVD)
Case “Bar3”	Chua	0.9798	37.9569	0.9164
	Huang	0.7504	13.3258	0.9314
	Ours	0.9922	32.1804	0.9771

Table S26: *Statistics of “Bar3” for deuteranopia.*

		SSIM (normal)	PSNR (normal)	CPR (CVD)
Case “Bears”	Chua	0.9900	41.3450	0.7715
	Huang	0.8757	19.9546	0.9469
	Ours	0.9990	43.7726	0.9794

Table S27: *Statistics of “Bears” for deuteranopia.*

		SSIM (normal)	PSNR (normal)	CPR (CVD)
Case “Elephant”	Chua	0.9909	39.4421	0.8978
	Huang	0.9169	23.4207	0.9447
	Ours	0.9402	31.6908	0.9312

Table S28: *Statistics of “Elephant” for deuteranopia.*

		SSIM (normal)	PSNR (normal)	CPR (CVD)
Case “Flower4”	Chua	0.9599	30.6103	0.8725
	Huang	0.9480	26.4479	0.9691
	Ours	0.9973	41.6910	0.9831

Table S29: *Statistics of “Flower4” for deuteranopia.*

		SSIM (normal)	PSNR (normal)	CPR (CVD)
Case “Hearts”	Chua	0.9340	32.7463	0.8276
	Huang	0.8963	22.4743	0.8977
	Ours	0.9998	59.2289	0.9487

Table S30: *Statistics of “Hearts” for deuteranopia.*

		SSIM (normal)	PSNR (normal)	CPR (CVD)
Case “Boxes”	Chua	0.9173	30.9398	0.8210
	Huang	0.8634	22.0390	0.8742
	Ours	0.9999	63.0951	0.9401

Table S31: *Statistics of “Boxes” for deuteranopia.*

		SSIM (normal)	PSNR (normal)	CPR (CVD)
Case “Goat and rooster”	Chua	0.9568	27.4653	0.8694
	Huang	0.9368	22.6460	0.9260
	Ours	0.9966	34.5399	0.9611

Table S32: *Statistics of “Goat and rooster” for deuteranopia.*

		SSIM (normal)	PSNR (normal)	CPR (CVD)
Case “Orange1”	Chua	0.9632	35.2215	0.9235
	Huang	0.9712	26.1210	0.9871
	Ours	0.9781	34.2957	0.9931

Table S33: *Statistics of “Orange1” for deuteranopia.*

		SSIM (normal)	PSNR (normal)	CPR (CVD)
Case “Orange2”	Chua	0.9491	33.6562	0.7546
	Huang	0.8762	24.9498	0.9523
	Ours	0.9830	39.6788	0.9815

Table S34: *Statistics of “Orange2” for deuteranopia.*

		SSIM (normal)	PSNR (normal)	CPR (CVD)
Case “Pie”	Chua	0.9780	37.7605	0.9614
	Huang	0.9508	20.7224	0.9769
	Ours	0.9990	38.3857	0.9772

Table S35: *Statistics of “Pie” for deuteranopia.*

S5 CVD Simulation Model Related Statistics

Due to spectral sensitivity peak shifting limits of different cone cells, each element in projection matrix T has its own range on values as following:

$$T = \begin{bmatrix} a_1 & a_2 & a_3 \\ a_4 & a_5 & a_6 \\ a_7 & a_8 & a_9 \end{bmatrix}$$

Protanomaly:

$$\begin{aligned} a_1 &\in [0.1523, 1.0000] \\ a_2 &\in [0.0000, 1.0526] \\ a_3 &\in [-0.2049, -0.0000] \\ a_4 &\in [0.0000, 0.1145] \\ a_5 &\in [0.7863, 1.0000] \\ a_6 &\in [0.0000, 0.0992] \\ a_7 &\in [-0.0039, -0.0000] \\ a_8 &\in [-0.0481, -0.0000] \\ a_9 &\in [1.0000, 1.0520] \end{aligned}$$

Deuteranomaly:

$$\begin{aligned} a_1 &\in [0.3673, 1.0000] \\ a_2 &\in [0.0000, 0.8606] \\ a_3 &\in [-0.2280, -0.0000] \\ a_4 &\in [0.0000, 0.2801] \\ a_5 &\in [0.6725, 1.0000] \\ a_6 &\in [0.0000, 0.0474] \\ a_7 &\in [-0.0118, -0.0000] \\ a_8 &\in [0.0000, 0.0429] \\ a_9 &\in [0.9689, 1.0000] \end{aligned}$$

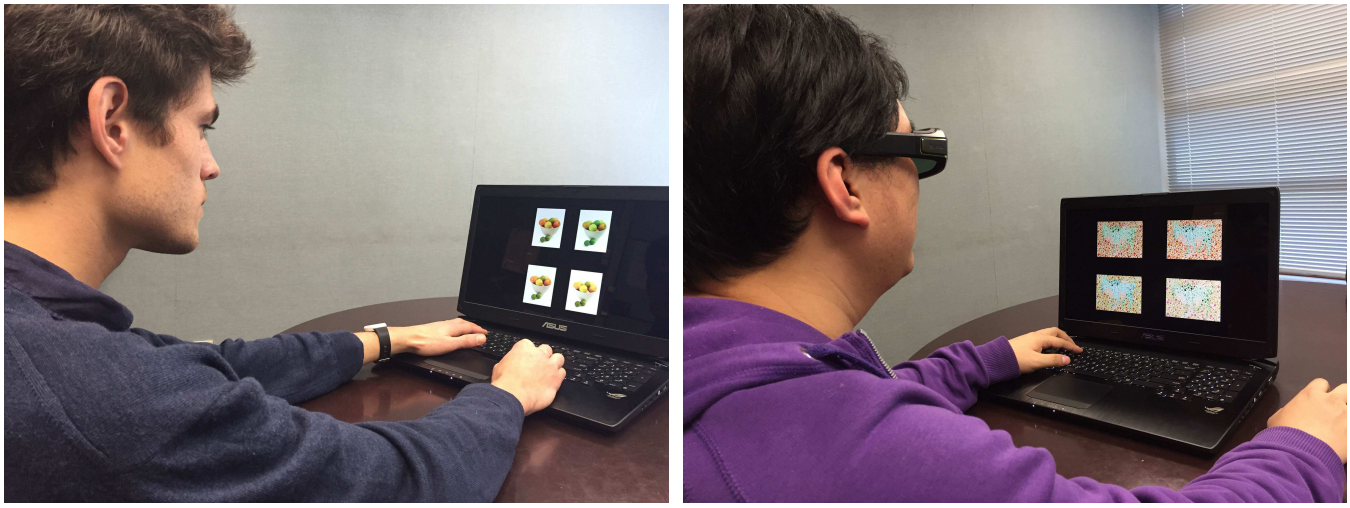
Since the CVD simulation model we adopt preserves perceived luminance in an opponent-color space, we need to transform simulated images to this opponent-color space to obtain the luminance channel. The projection matrix from RGB color space to opponent-color space is:

$$\begin{bmatrix} 0.3073 & 0.6367 & 0.0554 \\ 0.0952 & 0.1247 & -0.5732 \\ 0.1522 & -0.4136 & 0.2609 \end{bmatrix} \tag{1}$$

After projection, the first channel is the luminance channel and the remaining two are opponent-color channels. Thus, the ζ function in paper main body, which calculates the luminance perceived by CVD audiences, is $\zeta(p) = T_1 \cdot V_p$, where the T_1 is the first row vector of above projection matrix and V_p is the column vector composed of RGB values of pixel p.

S6 User Study Illustration

Finally we show two photos in the user studies for illustration.



(a) Normal people user study (b) CVDs user study

Figure S43: *User study processes.*