

Table S1. Inferential statistics for four types of NPS effects in Studies 1-8

Study	Mean response of NPS				Within-subject correlation with temperature					Within-subject correlation with pain					Between-subject correlation with pain		
	t	df	p	d	within-r	t	df	p	d	within-r	t	df	p	d	between-r	p	d
Study1	10.19	32	<0.001	1.77	0.27	6.25	32	<0.001	1.09	0.28	6.39	32	<0.001	1.11	-0.13	0.46	-0.27
Study2	13.86	27	<0.001	2.62	0.30	10.98	27	<0.001	2.07	0.33	8.69	27	<0.001	1.64	0.16	0.40	0.33
Study3	19.22	92	<0.001	1.99	0.22	9.27	92	<0.001	0.96	0.23	9.83	91	<0.001	1.02	0.04	0.70	0.08
Study4	5.02	16	<0.001	1.22	0.31	6.91	16	<0.001	1.68	0.34	6.58	16	<0.001	1.59	0.74	<0.001	2.20
Study5	17.07	49	<0.001	2.41	0.42	18.91	49	<0.001	2.67	0.35	13.56	49	<0.001	1.92	0.19	0.18	0.39
Study6	6.97	18	<0.001	1.60	0.05	2.32	18	0.03	0.53	0.14	5.22	18	<0.001	1.20	0.31	0.20	0.65
Study7	8.91	28	<0.001	1.65	0.30	11.65	28	<0.001	2.16	0.35	11.49	28	<0.001	2.13	0.04	0.86	0.07
Study8	10.60	25	<0.001	2.08	0.13	4.20	25	<0.001	0.82	0.17	4.81	25	<0.001	0.94	0.22	0.27	0.46
Mean				1.92					1.50					1.45			0.49

Note: One-sample t-tests treat the subject as the unit of observation (i.e., the subject is a random effect). In between-subject correlation, transformation between r and cohen's d, i.e., $d = \frac{2 \times r}{\sqrt{1-r^2}}$.

Table S2. Inferential statistics comparing effect size of whole-NPS with local NPS responses in Studies 1-8

	Rank	Mean response				Within-subject correlation with temperature				Within-subject correlation with pain				Between-subject correlation with pain			
		Brain region	Mean (se)	t	q-fdr	Brain region	Mean (se)	t	q-fdr	Brain region	Mean (se)	t	q-fdr	Brain region	Mean (se)	t	q-fdr
		NPS	1.92 (0.16)			NPS	1.50 (0.27)			NPS	1.45 (0.16)			NPS	0.49 (0.26)		
Positive regions	Rank 1	rmlns	1.72 (0.19)	1.63	0.148	rmlns	1.21 (0.26)	1.92	0.097	dACC	1.19 (0.12)	2.19	0.065	rdplns	0.40 (0.31)	0.65	0.539
	Rank 2	rdplns	1.43 (0.11)	3.79	0.007	dACC	1.12 (0.22)	2.65	0.033	rmlns	1.14 (0.14)	3.98	0.005	rmlns	0.37 (0.14)	0.67	0.526
	Rank 3	rS2	1.21 (0.15)	5.94	0.001	rdplns	1.00 (0.16)	3.56	0.009	lmlns	1.04 (0.10)	4.52	0.003	vermis	0.32 (0.11)	0.77	0.469
	Rank 4	lmlns	1.19 (0.18)	6.18	0.001	lmlns	0.92 (0.18)	4.36	0.003	rdplns	1.02 (0.14)	4.96	0.002	rThal	0.30 (0.16)	1.11	0.304
	Rank 5	dACC	1.01 (0.18)	9.26	<0.001	rS2	0.76 (0.15)	3.68	0.008	rThal	0.85 (0.08)	6.33	<0.001	lmlns	0.27 (0.11)	0.99	0.354
	Rank 6	rThal	0.70 (0.16)	6.99	<0.001	rThal	0.74 (0.14)	4.22	0.004	rS2	0.83 (0.09)	4.94	0.002	dACC	0.26 (0.18)	1.21	0.266
	Rank 7	vermis	0.44 (0.11)	10.04	<0.001	vermis	0.63 (0.15)	3.98	0.005	vermis	0.80 (0.11)	4.03	0.005	rS2	0.24 (0.20)	1.98	0.088
	Rank 8	rV1	-0.61 (0.28)	8.02	<0.001	rV1	0.17 (0.20)	3.97	0.005	rV1	0.19 (0.20)	4.24	0.004	rV1	0.21 (0.08)	1.21	0.265
Negative regions	Rank 1	riPL	0.73 (0.24)	4.42	0.004	riPL	0.24 (0.20)	3.95	0.006	riPL	0.17 (0.21)	6.42	<0.001	pgACC	0.10 (0.15)	1.64	0.144
	Rank 2	pgACC	0.60 (0.19)	5.59	0.002	ISTS	0.14 (0.20)	4.53	0.003	pgACC	0.15 (0.14)	7.03	<0.001	rLOC	0.08 (0.15)	2.11	0.072
	Rank 3	PCC	0.51 (0.28)	3.86	0.007	pgACC	0.09 (0.15)	4.44	0.003	ISTS	0.05 (0.20)	7.07	<0.001	rpLOC	-0.01 (0.12)	1.46	0.187
	Rank 4	ILOC	0.44 (0.27)	4.80	0.003	rLOC	0.06 (0.19)	4.69	0.002	rpLOC	0.03 (0.13)	9.81	<0.001	ILOC	-0.01 (0.15)	2.08	0.076
	Rank 5	rpLOC	0.34 (0.26)	5.41	0.002	rpLOC	0.04 (0.14)	4.81	0.002	IOLC	0.02 (0.16)	8.50	<0.001	ISTS	-0.06 (0.11)	1.84	0.108
	Rank 6	rLOC	0.33 (0.26)	5.23	0.002	ILOC	0.02 (0.19)	4.53	0.003	rLOC	-0.01 (0.21)	7.56	<0.001	PCC	-0.26 (0.17)	2.12	0.072
	Rank 7	ISTS	0.31 (0.11)	8.71	<0.001	PCC	-0.21 (0.24)	4.54	0.003	PCC	-0.33 (0.19)	9.66	<0.001	riPL	-0.27 (0.17)	2.83	0.025

Note: Paired t-tests between effect size of NPS and other brain regions treat study as the unit of observation (i.e., study is a random effect). To adjust the false positive rate in multiple comparisons, FDR corrected q values are reported. Ins denotes Insula, V1 primary visual area, S2 secondary somatosensory cortex, ACC anterior cingulate cortex, Thal thalamus, STS superior temporal sulcus, PCC posterior cingulate cortex, LOC lateral occipital complex, and IPL inferior parietal lobule. Direction is indicated with preceding lowercase letters as follows: r denotes right, l left, m middle, d dorsal, p posterior, pg perigenual.

Table S3. Short-term and long-term test-retest reliability of NPS and pain reports

Study	Type	NPS		Pain reports	
		ICC	95CI	ICC	95CI
Study1	ICC(3,k)	0.87	0.77 - 0.93	0.95	0.91 - 0.97
Study2	ICC(3,k)	0.88	0.79 - 0.94	0.89	0.80 - 0.95
Study3	ICC(3,k)	0.91	0.88 - 0.94	0.92	0.89 - 0.94
Study4	ICC(3,k)	0.73	0.38 - 0.89	0.85	0.65 - 0.94
Study5	ICC(3,k)	0.87	0.80 - 0.92	0.96	0.93 - 0.97
Study6	ICC(3,k)	0.85	0.66 - 0.93	0.93	0.85 - 0.97
Study7	ICC(3,k)	0.87	0.76 - 0.93	0.93	0.88 - 0.96
Study8	ICC(3,k)	0.75	0.52 - 0.87	0.92	0.84 - 0.96
Study9	ICC(3,1)	0.74	0.61 - 0.84	0.87	0.80 - 0.92
*Study10 - control group	ICC(3,1)	0.46	0.22 - 0.65	0.26	-0.15 - 0.49
*Study10 - placebo group	ICC(3,1)	0.17	-0.01 - 0.41	0.27	0.02 - 0.50
*Study10 - psychotherapy group	ICC(3,1)	0.34	0.09 - 0.55	0.18	-0.08 - 0.41

* In Study 10, we reported the control group results in the main text.

Table S4. Inferential statistics comparing the reliability of whole-NPS with local NPS responses in Studies 1-8

	Rank	Brain	Mean (se)	t	q-fdr
		NPS	0.84 (0.02)		
Positive Region	Rank 1	rS2	0.83 (0.03)	0.70	0.508
	Rank 2	rmlns	0.80 (0.04)	1.48	0.182
	Rank 3	rV1	0.78 (0.05)	1.32	0.229
	Rank 4	rdplns	0.75 (0.06)	2.12	0.072
	Rank 5	dACC	0.75 (0.08)	1.57	0.161
	Rank 6	lmlns	0.72 (0.11)	1.26	0.247
	Rank 7	rThal	0.61 (0.08)	3.72	0.007
	Rank 8	vermis	0.58 (0.16)	1.84	0.109
Negative Region	Rank 1	ISTS	0.72 (0.07)	1.99	0.086
	Rank 2	PCC	0.70 (0.08)	2.31	0.054
	Rank 3	ILOC	0.64 (0.11)	2.24	0.060
	Rank 4	rpLOC	0.63 (0.14)	1.63	0.147
	Rank 5	rIPL	0.63 (0.10)	2.37	0.050
	Rank 6	rLOC	0.60 (0.16)	1.75	0.123
	Rank 7	pgACC	0.58 (0.08)	4.27	0.004

Note: Paired t-tests of reliability, i.e., ICC(3,k), between NPS and other brain regions treat study as the unit of observation (i.e., study is a random effect). To adjust the false positive rate in multiple comparisons, FDR corrected q values are reported. Ins denotes Insula, V1 primary visual area, S2 secondary somatosensory cortex, ACC anterior cingulate cortex, Thal thalamus, STS superior temporal sulcus, PCC posterior cingulate cortex, LOC lateral occipital complex, and IPL inferior parietal lobule. Direction is indicated with preceding lowercase letters as follows: r denotes right, l left, m middle, d dorsal, p posterior, pg perigenual.

Table S5. Comparison of NPS performance in effect size and reliability among three computation methods in Studies 1-8

Index	Mean response			Within-subject correlation with temperature			Within-subject correlation with pain			Between-subject correlation with pain			Reliability		
	Mean (se)	F	p	Mean (se)	F	p	Mean (se)	F	p	Mean (se)	F	p	Mean (se)	F	p
Dot product	1.92 (0.16)	0.87	0.43	1.50 (0.27)	0.30	0.74	1.45 (0.16)	0.70	0.51	0.49 (0.26)	0.18	0.83	0.84 (0.02)	0.03	0.98
correlation	2.28 (0.23)			1.27 (0.22)			1.17 (0.20)			0.29 (0.24)			0.84 (0.02)		
cosine	2.19 (0.21)			1.27 (0.23)			1.19 (0.19)			0.31 (0.26)			0.84 (0.02)		

Note: One-way ANOVAs of NPS effect sizes and reliability, i.e., ICC(3,k), treat the study as the unit of observation (i.e., the study is a random effect).

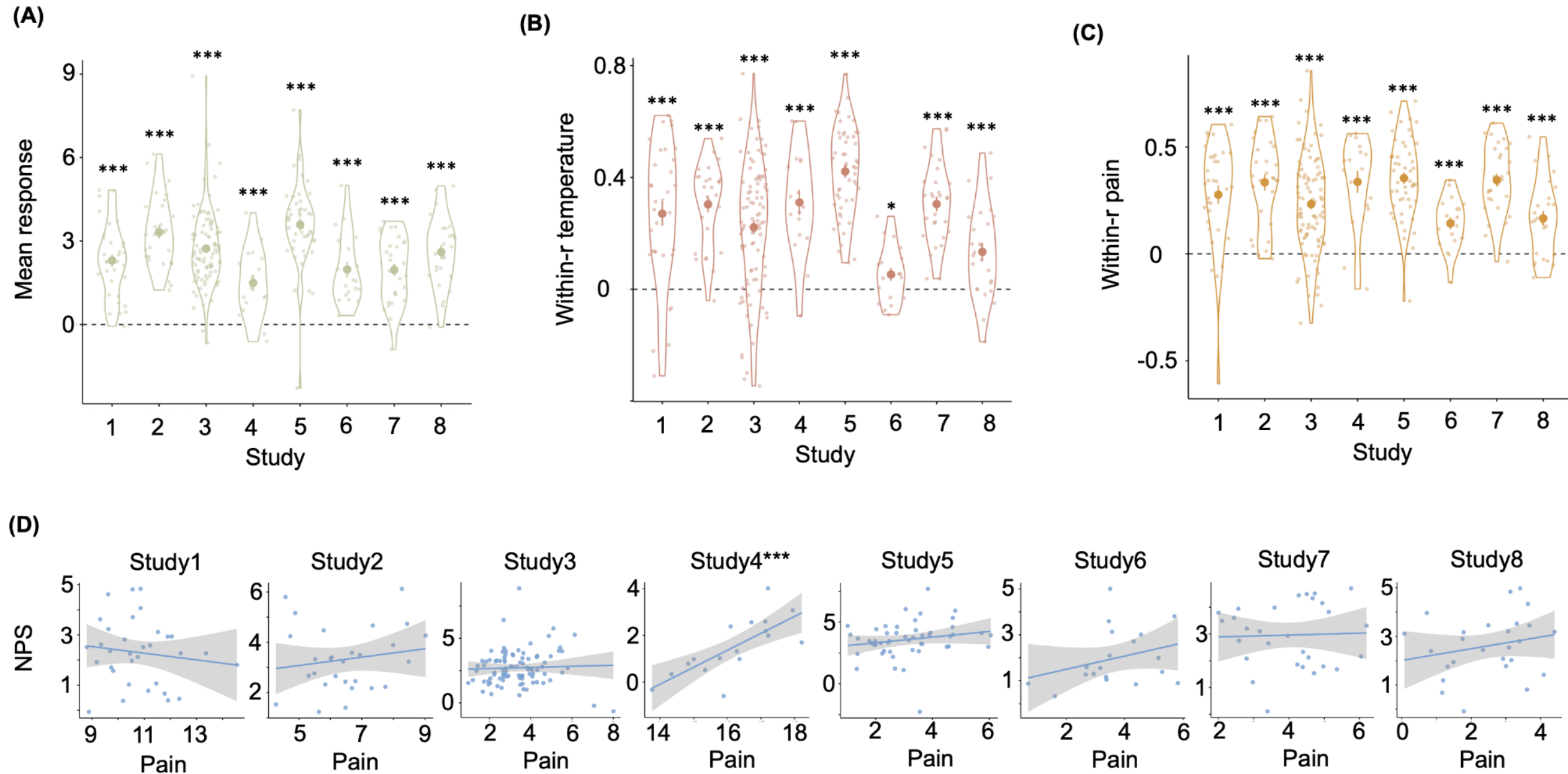


Figure S1. Four tests of NPS in response to pain stimuli. (A) Mean response of NPS. Each big dot represents the mean response of NPS in each study; the vertical bar represents the standard error; each small dot represents the mean NPS response of one participant, and the violin plot represents the distribution of all participants in each study. For display only and make the NPS values comparable across studies, we rescaled the NPS response by dividing the mean of the absolute deviations from the mean of all studies (using the *mad* function in MATLAB). **(B) Within-person correlation between the NPS response and the temperature.** Each big dot represents the mean r-value of the correlation between the NPS response and the temperature; the vertical bar represents the standard error; each small dot represents the r-value of one participant, and the violin plot represents the distribution of all participants in each study. **(C) Within-person correlation between the NPS response and the subjective pain reports.** Each big dot represents the mean r-value of the correlation between the NPS response and the subjective pain reports; the vertical bar represents the standard error; each small dot represents the r-value of one participant, and the violin plot represents the distribution of all participants in each study. **(D) Between-person correlation between the NPS response and participants' mean subjective pain reports.** Each dot represents one participant; the line represents the linear relationship between the mean of the subjective pain reports and the mean of the NPS response of each participant, and the shadow represents the standard error. The NPS response and pain ratings were rescaled by dividing the mean of the absolute deviations from the mean of all studies (using the *mad* function in MATLAB). *** $p < 0.001$; ** $p < 0.005$; * $p < 0.05$.

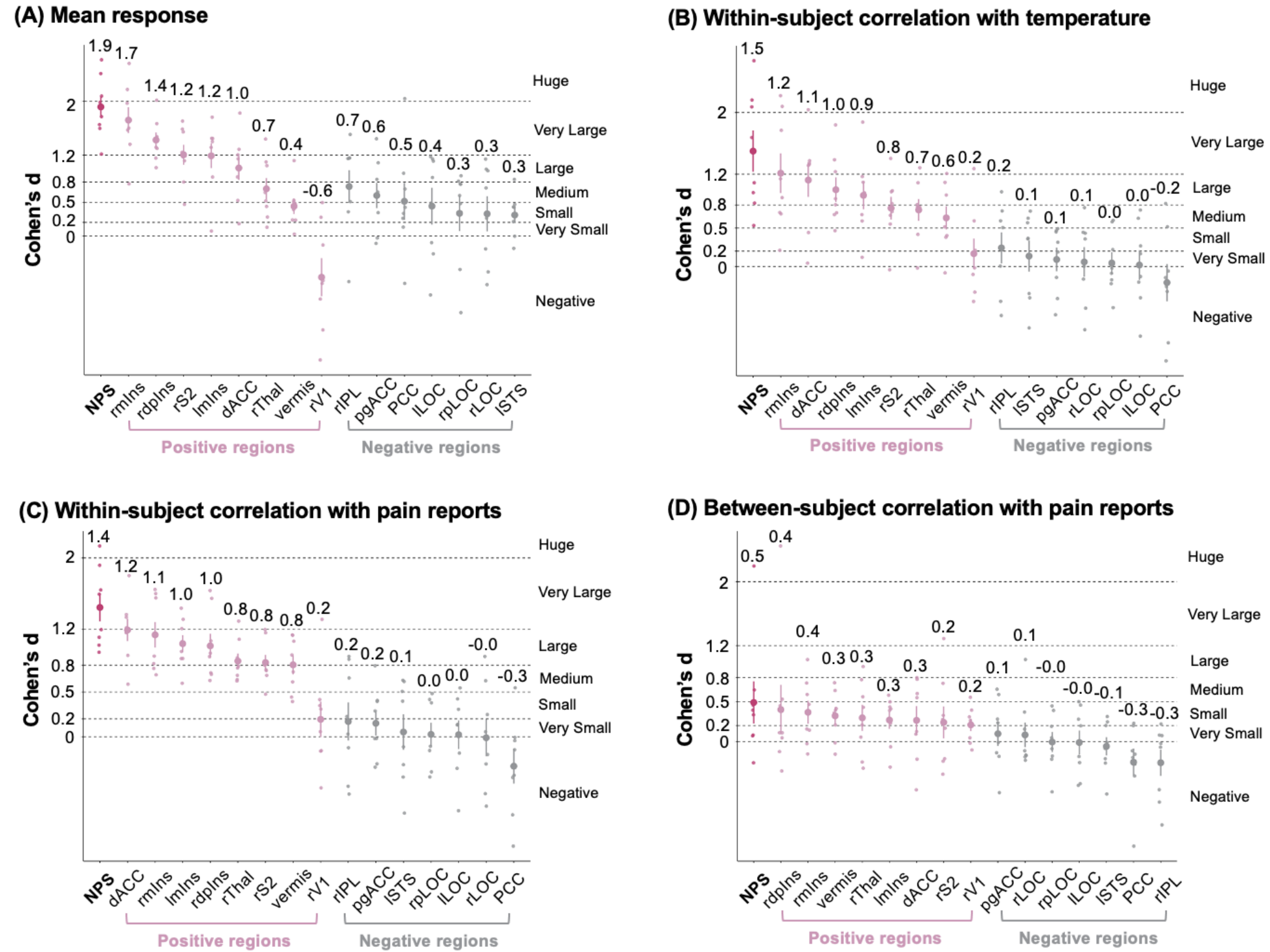


Figure S2. Four types of the effect size of NPS local brain regions. (A) The effect size of the mean response of NPS and local areas. (B) The effect size of the within-person correlation between brain and the temperature. (C) The effect size of the within-person correlation between brain and the subjective pain ratings. (D) The effect size of the between-subject correlation between brain and the subjective pain ratings. Each big dot represents the mean effect size across studies. Each small dot represents the effect size for an individual study (Studies 1 to 8). The vertical bar represents the standard error. Ins denotes Insula, V1 primary visual area, S2 secondary somatosensory cortex, ACC anterior cingulate cortex, Thal thalamus, STS superior temporal sulcus, PCC posterior cingulate cortex, LOC lateral occipital complex, and IPL inferior parietal lobule. Direction is indicated with preceding lowercase letters as follows: r denotes right, l left, m middle, d dorsal, p posterior, pg perigenual.

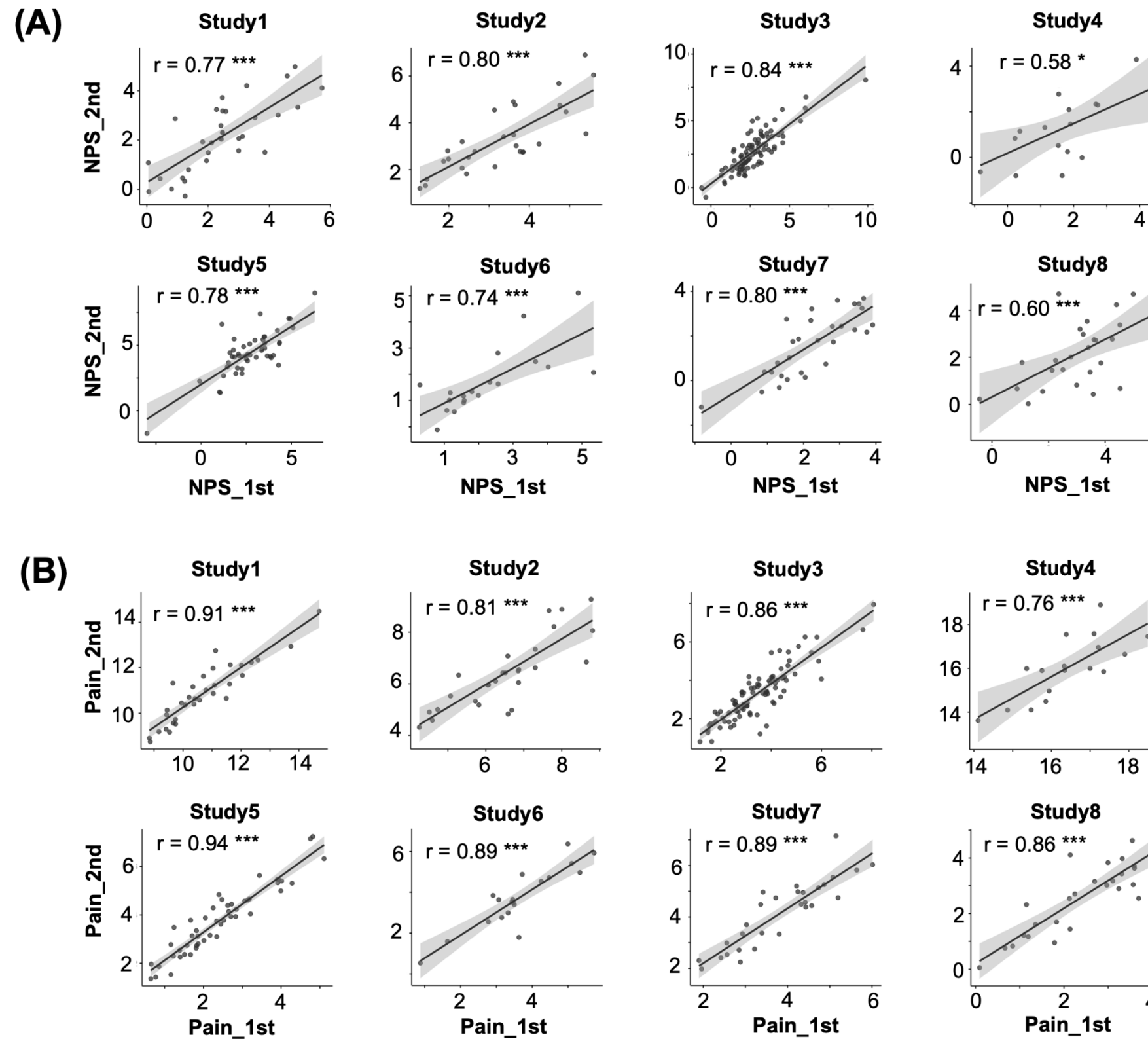


Figure S3. Illustration of short-term test-retest reliability of the NPS and subjective pain reports. (A) Correlation between the averaged NPS response of the first-half and second-half trials. (B) Correlation between the averaged subjective pain reports of the first-half and second-half trials. Each dot represents one participant; the line represents the linear relationship between the averaged measurements of the first-half and second-half trials. The NPS response and pain ratings were rescaled by dividing the mean of the absolute deviations from the mean of all studies (using the *mad* function in MATLAB). *** $p < 0.001$; ** $p < 0.005$; * $p < 0.05$.