Form follows content: An empirical study on symbol-content (in)congruences in thematic maps

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Table S1. Mean valence of twelve topics, based on ratings of 116 participants.

| ID | Map topics                                      | Min. | Max. | Mean | Standard Deviation |
|----|------------------------------------------------|------|------|------|--------------------|
| positive |                                               |      |      |      |                    |
| 1  | City awarded for clean energy                  | -2   | 5    | 4.29 | 1.29               |
| 2  | National parks                                 | -1   | 5    | 3.65 | 1.58               |
| 3  | Urban park with high biodiversity              | -3   | 5    | 3.47 | 1.88               |
| 4  | Cities with excellent water quality            | -4   | 5    | 4.06 | 1.62               |
| neutral |                                              |      |      |      |                    |
| 5  | Art colleges                                   | -5   | 5    | 1.92 | 2.04               |
| 6  | Art galleries                                  | -5   | 5    | 2.12 | 2.00               |
| 7  | Lookout tower                                  | -2   | 5    | 2.45 | 1.87               |
| 8  | Outdoor stages                                 | -2   | 5    | 2.15 | 1.85               |
| negative |                                             |      |      |      |                    |
| 9  | Floods                                         | -5   | 4    | -3.44| 2.34               |
| 10 | Melting glaciers                               | -5   | 5    | -3.41| 2.40               |
| 11 | Traffic accident                               | -5   | 5    | -3.04| 2.74               |
| 12 | Smog polluted cities                           | -5   | 5    | -3.25| 2.52               |

Table S2. Map clusters: Conover-Iman test results.

Positive Map Cluster

| Differences: | Circle_pos | Triangle_pos | Rhomb_pos | Square_pos | AsymmStar_pos | Star_pos |
|--------------|------------|--------------|-----------|------------|---------------|----------|
| Circle_pos   | 0.000      | 74.233       | 29.438    | 131.560    | 486.457       | 39.446   |
| Triangle_pos | -74.233    | 0            | -44.795   | 57.328     | 412.224       | -54.787  |
| Rhomb_pos    | -29.438    | 44.795       | 0         | 102.123    | 457.019       | 10.009   |
| Square_pos   | -131.560   | -57.328      | -102.123  | 0          | 354.897       | -92.114  |
| AsymmStar_pos| -486.457   | -412.224     | -457.019  | -354.897   | 0             | -447.011 |
| Star_pos     | -39.446    | 34.787       | -10.009   | 92.114     | 447.011       | 0        |

p-values:

| Differences: | Circle_pos | Triangle_pos | Rhomb_pos | Square_pos | AsymmStar_pos | Star_pos |
|--------------|------------|--------------|-----------|------------|---------------|----------|
| Circle_pos   | 1.000      | 0.026        | 0.378     | <0.0001    | <0.0001       | 0.237    |
| Triangle_pos | 0.026      | 1            | 0.179     | 0.086      | <0.0001       | 0.297    |
| Rhomb_pos    | 0.378      | 0.179        | 1         | 0.002      | <0.0001       | 0.764    |
| Square_pos   | <0.0001    | 0.086        | 0.002     | 1          | <0.0001       | 0.006    |
| AsymmStar_pos| <0.0001    | <0.0001      | <0.0001   | 1          | <0.0001       | <0.0001  |
| Star_pos     | 0.237      | 0.297        | 0.764     | 0.006      | <0.0001       | 1        |

Bonferroni-corrected significance level: 0.0033

Neutral Map Cluster

| Differences: | Circle_neutra | Triangle_neutra | Rhomb_neutra | Square_neutra | AsymmStar_neutra | Star_neutra |
|--------------|---------------|-----------------|--------------|---------------|------------------|-------------|
| Circle_neutral| 0.000         | 292.623         | 197.838      | 229.216       | 665.308          | 236.502     |
| Triangle_neutral| -292.623     | 0               | -94.784      | -63.407       | 372.685          | -56.121     |
| Rhomb_neutral | -197.838     | 94.784          | 0            | 31.377        | 467.470          | 38.664      |
| Square_neutral| -229.216     | 63.407          | -31.377      | 0             | 436.093          | 7.287       |
| AsymmStar_neutra| -665.308     | -372.685        | -467.470     | -436.093      | 0                | -428.806    |
| Star_neutral  | -236.502     | 56.121          | -38.664      | -7.287        | 428.806          | 0           |

p-values:
### Table S3. Map #1: Conover-Iman test results.

**Map #1: City Awarded For Clean Energy**

| Differences | Circle_neg | Triangle_neg | Rhomb_neg | Square_neg | AsymmStar_neg | Star_neg |
|-------------|------------|--------------|-----------|------------|---------------|----------|
| Circle_neg  | 0.000      | 8.481        | 125.567   | 174.483    | -244.433      | -101.325 |
| Triangle_neg| -8.481     | 0            | 117.086   | 166.002    | -252.914      | -109.806 |
| Rhomb_neg   | -125.567   | -117.086     | 0         | 48.916     | -370.000      | -226.892 |
| Square_neg  | -174.483   | -166.002     | -48.916   | 0          | -418.916      | 143.108  |
| AsymmStar_neg| 244.433    | 252.914      | 370.000   | 418.916    | 0             | 143.108  |
| Star_neg    | 101.325    | 109.806      | 226.892   | 275.808    | -143.108      | 0        |

**p-values:**

| Differences | Circle_neg | Triangle_neg | Rhomb_neg | Square_neg | AsymmetricStar_neg | Star_neg |
|-------------|------------|--------------|-----------|------------|-------------------|----------|
| Circle_neg  | 1.000      | 0.806        | 0.000     | <0.0001    | <0.0001           | 0.003    |
| Triangle_neg| 0.806      | 1            | 0.001     | <0.0001    | <0.0001           | 0.001    |
| Rhomb_neg   | 0.000      | 0.001        | 1         | 0.156      | <0.0001           | <0.0001  |
| Square_neg  | <0.0001    | <0.0001      | 0.156     | 1          | <0.0001           | <0.0001  |
| AsymmetricStar_neg| <0.0001 | <0.0001 | <0.0001 | <0.0001 | 1 | <0.0001 |
| Star_neg    | 0.003      | 0.001        | <0.0001   | <0.0001    | <0.0001           | 1        |

**Bonferroni-corrected significance level: 0.0033**

### Table S4. Map #2: Conover-Iman test results.

**Map #2: National Parks**

| Differences | Circle | Triangle | Rhomb | Square | AsymmetricStar | Star |
|-------------|--------|----------|-------|--------|----------------|------|
| Circle      | 0.000  | 42.381   | 23.690| 44.117 | 147.714        | -14.939 |
| Triangle    | -42.381| 0        | -19.691| 1.736  | 105.333        | -57.321 |
| Rhomb       | -23.690| 18.691   | 0     | 20.427 | 124.024        | -38.630 |
| Square      | -44.117| -1.736   | -20.427| 0      | 103.597        | -59.057 |
| AsymmetricStar| -147.714| -105.333| -124.024| -103.597| 0              | -162.654 |
| Star        | 14.939 | 57.321   | 38.630| 59.057 | 162.654        | 0     |

**p-values:**

| Differences | Circle | Triangle | Rhomb | Square | AsymmetricStar | Star |
|-------------|--------|----------|-------|--------|----------------|------|
| Circle      | 1.000  | 0.007    | 0.112 | 0.005  | <0.0001        | 0.337 |
| Triangle    | 0.007  | 1        | 0.230 | 0.915  | <0.0001        | 0.000 |
| Rhomb       | 0.112  | 0.230    | 1     | 0.190  | <0.0001        | 0.013 |
| Square      | 0.005  | 0.915    | 0.190 | 1      | <0.0001        | 0.000 |
| AsymmetricStar| <0.0001 | <0.0001 | <0.0001| <0.0001| 1              | <0.0001 |
| Star        | 0.337  | 0.000    | 0.013 | 0.000  | <0.0001        | 1     |

**Bonferroni-corrected significance level: 0.0033**
Table S5. Map #3: Conover-Iman test results.

|          | Circle | Triangle | Rhomb | Square | Asymm.Star | Star  |
|----------|--------|----------|-------|--------|------------|-------|
| Circle   | 1.000  | 0.062    | 0.335 | 0.485  | <0.0001    | 0.058 |
| Triangle | 0.062  | 1        | 0.342 | 0.014  | <0.0001    | 0.000 |
| Rhomb    | 0.335  | 0.342    | 1     | 0.106  | <0.0001    | 0.005 |
| Square   | 0.485  | 0.014    | 0.106 | 1      | <0.0001    | 0.248 |
| Asymm.Star | <0.0001 | <0.0001 | <0.0001 | <0.0001 | 1          | <0.0001 |
| Star     | 0.058  | 0.000    | 0.005 | 0.248  | <0.0001    | 1     |

Bonferroni-corrected significance level: 0.0033

Table S6. Map #4: Conover-Iman test results.

|          | Circle | Triangle | Rhomb | Square | Asymm.Star | Star  |
|----------|--------|----------|-------|--------|------------|-------|
| Circle   | 0.000  | 27.662   | -1.538| 46.963 | 74.594     | -11.695|
| Triangle | -27.662| 0        | -29.199| 19.302| 46.933     | -39.357|
| Rhomb    | 1.538  | 29.199   | 0     | 48.501 | 76.132     | -10.158|
| Square   | -46.963| -19.302  | -48.501| 0     | 27.631     | -58.659|
| Asymm.Star | -74.594 | -46.933 | -76.132| -27.631| 0          | -86.290|
| Star     | 11.695 | 39.357   | 10.158| 58.659 | 86.290     | 0     |

Bonferroni-corrected significance level: 0.0033

Table S7. Map #5: Conover-Iman test results.

|          | Circle | Triangle | Rhomb | Square | Asymm.Star | Star  |
|----------|--------|----------|-------|--------|------------|-------|
| Circle   | 0.000  | 81.890   | 30.246| 71.607 | 166.540    | 61.267|

Bonferroni-corrected significance level: 0.0033
| Triangle   | -81.890 | 0     | -51.644 | -10.283 | 84.650 | -20.623 |
|-----------|---------|-------|---------|---------|--------|---------|
| Rhomb     | -30.246 | 51.644| 0       | 41.361  | 136.294| 31.021  |
| Square    | -71.607 | 10.283| -41.361 | 0       | 94.933 | -10.340 |
| Asymm.Star| -166.540| -84.650| -136.294| -94.933 | 0      | -105.272|
| Star      | -61.267 | 20.623| -31.021 | 10.340  | 105.272| 0       |

**Asymm.Star**

| Triangle   | -81.890 | 0     | -51.644 | -10.283 | 84.650 | -20.623 |
|-----------|---------|-------|---------|---------|--------|---------|
| Rhomb     | -30.246 | 51.644| 0       | 41.361  | 136.294| 31.021  |
| Square    | -71.607 | 10.283| -41.361 | 0       | 94.933 | -10.340 |
| Asymm.Star| -166.540| -84.650| -136.294| -94.933 | 0      | -105.272|
| Star      | -61.267 | 20.623| -31.021 | 10.340  | 105.272| 0       |

**Star**

| Triangle   | -81.890 | 0     | -51.644 | -10.283 | 84.650 | -20.623 |
|-----------|---------|-------|---------|---------|--------|---------|
| Rhomb     | -30.246 | 51.644| 0       | 41.361  | 136.294| 31.021  |
| Square    | -71.607 | 10.283| -41.361 | 0       | 94.933 | -10.340 |
| Asymm.Star| -166.540| -84.650| -136.294| -94.933 | 0      | -105.272|
| Star      | -61.267 | 20.623| -31.021 | 10.340  | 105.272| 0       |

**p-values:**

| Circle  | Triangle | Rhomb | Square | Asymm.Star | Star |
|---------|----------|-------|--------|------------|------|
| Circle  | 1.000    | <0.0001 | 0.043  | <0.0001    | <0.0001 |
| Triangle| <0.0001  | 1      | 0.001  | 0.527      | <0.0001 |
| Rhomb   | 0.043    | 0.001  | 1      | 0.008      | 0.048 |
| Square  | <0.0001  | 0.527  | 0.008  | 1          | <0.0001 |
| Asymm.Star| <0.0001 | <0.0001| <0.0001| <0.0001    | 1    |
| Star    | 0.000    | 0.205  | 0.048  | 0.525      | <0.0001 |

*Bonferroni-corrected significance level: 0.0033*

**Table S8.** Map #6: Conover-Iman test results.

### Map #6: Art Galleries

#### Pairwise Comparisons

| Differences: | Circle | Triangle | Rhomb | Square | Asymm.Star | Star |
|---------------|--------|----------|-------|--------|------------|------|
| Circle        | 0.000  | 87.111   | 70.492| 83.432 | 181.262    | 57.205|
| Triangle      | -87.111| 0        | -16.619| -3.679 | 94.151     | -29.906|
| Rhomb         | -70.492| 16.619   | 0     | 12.940 | 110.770    | -13.287|
| Square        | -83.432| 3.679    | -12.940| 0      | 97.830     | -26.226|
| Asymm.Star    | -181.262| -94.151 | -110.770| -97.830| 0          | -124.057|
| Star          | -57.205| 29.906   | 13.287| 26.226 | 124.057    | 0     |

| p-values: | Circle | Triangle | Rhomb | Square | Asymm.Star | Star |
|-----------|--------|----------|-------|--------|------------|------|
| Circle    | 1.000  | <0.0001  | <0.0001| <0.0001| <0.0001    | 0.000|
| Triangle  | <0.0001| 1        | 0.279  | 0.818  | <0.0001    | 0.062|
| Rhomb     | <0.0001| 0.279    | 1      | 0.399  | <0.0001    | 0.386|
| Square    | <0.0001| 0.818    | 0.399  | 1      | <0.0001    | 0.101|
| Asymm.Star| <0.0001| <0.0001  | <0.0001| <0.0001| 1          | <0.0001|
| Star      | 0.000  | 0.062    | 0.386  | 0.101  | <0.0001    | 1    |

*Bonferroni-corrected significance level: 0.0033*

**Table S9.** Map #7: Conover-Iman test results.

### Map #7: Lookout Tower

#### Pairwise Comparisons

| Differences: | Circle | Triangle | Rhomb | Square | Asymm.Star | Star |
|---------------|--------|----------|-------|--------|------------|------|
| Circle        | 0.000  | 53.333   | 57.453| 47.619 | 179.660    | 79.881|
| Triangle      | -53.333| 0        | 4.120 | -5.714 | 126.327    | 26.548|
| Rhomb         | -57.453| -4.120   | 0     | -9.834 | 122.208    | 22.428|
| Square        | -47.619| 5.714    | 9.834 | 0      | 132.041    | 32.262|
| Asymm.Star    | -179.660| -126.327| -122.208| -132.041| 0          | -99.780|
| Star          | -79.881| -26.548  | -22.428| -32.262| 99.780     | 0     |

| p-values: | Circle | Triangle | Rhomb | Square | Asymm.Star | Star |
|-----------|--------|----------|-------|--------|------------|------|
| Circle    | 1.000  | 0.001    | 0.001 | 0.003  | <0.0001    | <0.0001|
| Triangle  | 0.001  | 1        | 0.793 | 0.704  | <0.0001    | 0.078 |
| Rhomb     | 0.001  | 0.793    | 1     | 0.531  | <0.0001    | 0.154 |
| Square    | 0.003  | 0.704    | 0.531 | 1      | <0.0001    | 0.032 |
| Asymm.Star| <0.0001| <0.0001  | <0.0001| 1      | <0.0001    | 1    |
| Star      | <0.0001| 0.078    | 0.154 | 0.032  | <0.0001    | 1    |

*Bonferroni-corrected significance level: 0.0033*
Table S10. Map #8: Conover-Iman test results.

| Pairwise Comparisons | Differences: | Circle | Triangle | Rhomb | Square | Asymm.Star | Star |
|----------------------|--------------|--------|----------|--------|---------|------------|------|
| Circle               | Circle       | 0.000  | 75.552   | 40.689 | 33.933  | 136.208    | 37.378|
| Triangle             | Triangle     | -75.552| 0        | -34.863| -41.619 | 60.655     | -38.175|
| Rhomb                | Rhomb        | -40.689| 34.863   | 0      | -6.756  | 95.519     | -3.311 |
| Square               | Square       | -33.933| 41.619   | 6.756  | 0       | 102.274    | 3.444 |
| Asymm.Star           | Asymm.Star   | -136.208| -60.655 | -95.519| -102.274| 0          | -98.830|
| Star                 | Star         | -37.378| 38.175   | 3.311  | -3.444  | 98.830     | 0     |

p-values:

| Pairwise Comparisons | Differences: | Circle | Triangle | Rhomb | Square | Asymm.Star | Star |
|----------------------|--------------|--------|----------|--------|---------|------------|------|
| Circle               | Circle       | 1.000  | <0.0001  | 0.020  | 0.044   | <0.0001    | 0.026|
| Triangle             | Triangle     | <0.0001| 1        | 0.038  | 0.010   | <0.0001    | 0.018 |
| Rhomb                | Rhomb        | 0.020  | 0.038    | 1      | 0.687   | <0.0001    | 0.843 |
| Square               | Square       | 0.044  | 0.010    | 0.687  | 1       | <0.0001    | 0.830 |
| Asymmetric Star      | Asymmetric Star| <0.0001| 0.000    | <0.0001| <0.0001 | 1          | <0.0001|
| Star                 | Star         | 0.026  | 0.018    | 0.843  | 0.830   | <0.0001    | 1     |

Bonferroni-corrected significance level: 0.0033

Table S11. Map #9: Conover-Iman test results.

| Pairwise Comparisons | Differences: | Circle | Triangle | Rhomb | Square | Asymm.Star | Star |
|----------------------|--------------|--------|----------|--------|---------|------------|------|
| Circle               | Circle       | 0.000  | 36.664   | 23.509 | 29.601  | -60.434    | -1.590|
| Triangle             | Triangle     | -36.664| 0        | -13.155| -7.063  | -97.098    | -38.254|
| Rhomb                | Rhomb        | -23.509| 13.155   | 0      | 6.091   | -83.943    | -25.099|
| Square               | Square       | -29.601| 7.063    | -6.091 | 0       | -90.035    | -31.190|
| Asymmetric Star      | Asymmetric Star| 60.434 | 97.098   | 83.943 | 90.035  | 0          | 58.844 |
| Star                 | Star         | 1.590  | 38.254   | 25.099 | 31.190  | -58.844    | 0     |

p-values:

| Pairwise Comparisons | Differences: | Circle | Triangle | Rhomb | Square | Asymmetric Star | Star |
|----------------------|--------------|--------|----------|--------|---------|----------------|------|
| Circle               | Circle       | 1.000  | 0.038    | 0.200  | 0.093   | <0.0001        | 0.928|
| Triangle             | Triangle     | 0.038  | 1        | 0.455  | 0.675   | <0.0001        | 0.023|
| Rhomb                | Rhomb        | 0.200  | 0.455    | 1      | 0.729   | <0.0001        | 0.154|
| Square               | Square       | 0.093  | 0.675    | 0.729  | 1       | <0.0001        | 0.064|
| Asymmetric Star      | Asymmetric Star| 0.001  | <0.0001  | <0.0001| <0.0001 | 1              | 0.001|
| Star                 | Star         | 0.928  | 0.023    | 0.154  | 0.064   | 0.001          | 1     |

Bonferroni-corrected significance level: 0.0033

Table S12. Map #10: Conover-Iman test results.

| Pairwise Comparisons | Differences: | Circle | Triangle | Rhomb | Square | Asymmetric Star | Star |
|----------------------|--------------|--------|----------|--------|---------|----------------|------|
| Circle               | Circle       | 0.000  | -58.347  | 19.717 | 58.184  | -24.670        | -10.522|
| Triangle             | Triangle     | -58.347| 0        | 78.064 | 116.532 | 33.678         | 47.825 |
| Rhomb                | Rhomb        | -19.717| -78.064  | 0      | 38.467  | -44.387        | -30.239|
| Square               | Square       | -58.184| -116.532 | -38.467| 0       | -82.854        | -68.706|
| Asymmetric Star      | Asymmetric Star| 24.670 | -33.678  | 44.387 | 82.854  | 0              | 14.148 |
| Star                 | Star         | 10.522 | -47.825  | 30.239 | 68.706  | -14.148        | 0     |

p-values:

| Pairwise Comparisons | Differences: | Circle | Triangle | Rhomb | Square | Asymmetric Star | Star |
|----------------------|--------------|--------|----------|--------|---------|----------------|------|
| Circle               | Circle       | 1.000  | 0.001    | 0.272  | 0.001   | 0.169          | 0.541|
| Triangle             | Triangle     | 0.001  | 1        | <0.0001| <0.0001 | 0.051          | 0.004|
| Rhomb                | Rhomb        | 0.272  | <0.0001  | 1      | 0.026   | 0.014          | 0.079|
### Table S13. Map #11: Conover-Iman test results.

**Map #11: Traffic Accident**

| Differences | Circle | Triangle | Rhomb | Square | Asymm.Star | Star |
|-------------|--------|----------|-------|--------|------------|------|
| Circle      | 0.000  | 1.082    | 36.087| 41.601 | -131.183   | -99.267|
| Triangle    | -1.082 | 0        | 35.006| 40.519 | -132.264   | -100.349|
| Rhomb       | -36.087| -35.006  | 0     | 5.513  | -167.270   | -135.355|
| Square      | -41.601| -40.519  | -5.513| 0      | -172.783   | -140.868|
| Asymm.Star  | 131.183| 132.264  | 167.270|172.783 | 0          | 31.915 |
| Star        | 99.267 | 100.349  | 135.355|140.868 | -31.915    | 0     |

**p-values:**

| Differences | Circle | Triangle | Rhomb | Square | Asymm.Star | Star |
|-------------|--------|----------|-------|--------|------------|------|
| Circle      | 1.000  | 0.937    | 0.006 | 0.003  | <0.0001    | <0.0001|
| Triangle    | 0.937  | 1        | 0.011 | 0.005  | <0.0001    | <0.0001|
| Rhomb       | 0.006  | 0.011    | 1     | 0.687  | <0.0001    | <0.0001|
| Square      | 0.003  | 0.005    | 0.687 | 1      | <0.0001    | <0.0001|
| Asymm.Star  | <0.0001| <0.0001  | <0.0001|<0.0001 | 1          | 0.020 |
| Star        | <0.0001| <0.0001  | <0.0001|<0.0001 | 0.020      | 1     |

**Bonferroni-corrected significance level: 0.0033**

### Table S14. Map #12: Conover-Iman test results.

**Map #12: Smog-Polluted Cities**

| Differences | Circle | Triangle | Rhomb | Square | Asymm.Star | Star |
|-------------|--------|----------|-------|--------|------------|------|
| Circle      | 0.000  | 33.247   | 46.468| 43.587 | -7.159     | 19.851|
| Triangle    | -33.247| 0        | 13.221| 10.340 | -40.406    | -13.396|
| Rhomb       | -46.468| -13.221  | 0     | -2.882 | -53.627    | -26.618|
| Square      | -43.587| -10.340  | 2.882 | 0      | -50.745    | -23.736|
| Asymm.Star  | 7.159  | 53.627   | 50.745| 0      | 27.009     | 0     |
| Star        | -19.851| 26.618   | 23.736| 27.009 | 0          | 0     |

**p-values:**

| Differences | Circle | Triangle | Rhomb | Square | Asymm.Star | Star |
|-------------|--------|----------|-------|--------|------------|------|
| Circle      | 1.000  | 0.067    | 0.007 | 0.016  | 0.679      | 0.273|
| Triangle    | 0.067  | 1        | 0.465 | 0.583  | 0.026      | 0.477|
| Rhomb       | 0.007  | 0.465    | 1     | 0.873  | 0.002      | 0.142|
| Square      | 0.016  | 0.583    | 0.873 | 1      | 0.005      | 0.208|
| Asymm.Star  | 0.679  | 0.026    | 0.002 | 0.005  | 1          | 0.136|
| Star        | 0.273  | 0.477    | 0.142 | 0.208  | 0.136      | 1     |

**Bonferroni-corrected significance level: 0.0033**