Associations between colors and shapes in Japanese observers

Na Chen, Kanji Tanaka, Daisuke Matsuyoshi, Katsumi Watanabe

Research Center for Advanced Science and Technology,
The University of Tokyo, Tokyo, Japan.
nanachen@fennel.rcast.u-tokyo.ac.jp

Abstract: Albertazzi et al. (2012) showed that people spontaneously associated certain colors with certain shapes in Italian participants. In order to examine whether the color-shape association would differ between different cultural backgrounds, we performed a similar experiment with 70 non-synesthetic Japanese participants. In the experiment, a geometric shape selected from 12 basic line drawing geometric shapes and the 40 Nature Color System (NCS) color circles were shown on a computer display. Participants were required to intuitively choose the most "appropriate" color for the presented shape. Results indicated that our Japanese participants naturally established systematic associations between certain colors with certain shapes: Circle was often associated with red; Triangle, rhombus, cone, and pyramid were frequently associated with yellow; square, trapezium, parallelogram, hexagon, truncated pyramid were associated more with blue and green color groups. While some of the color-shape associations were similar to those in the previous study, a few differences were also noted. The present results suggest that the spontaneous color-shape association contains both universal and culturally mediated components.

Key words: color, geometric shape, spontaneous association

1. Introduction

For a product with specific visual characteristics such as sharp edges or smooth curves, would it be more popular in certain color than others? Whether there were any general associations between shapes and colors has been a topic in both art and scientific research. Kandinsky, a renowned abstract painter, proposed the correspondence theory between primary colors and basic geometric shapes [15]. He claimed that there were implicit associations between colors and shapes: triangles are yellow, squares are red, circles are blue, etc. Although the concept became influential in arts and design theories, some fellow artists and researchers criticized the theory for not being based on empirical investigations but on Kandinsky's biased impression [2,26]. In these days, few people take the theory literally.

In fact, some art critics and researchers performed empirical studies to revisit Kandinsky's correspondence theory but found different results [3,7,8,10,11,14,21]. Jacobsen found assignments of red to triangle, blue to square, and yellow to circle, and suggested that everyday knowledge influenced the shape-color associations by referring to a warning red triangle, and the yellow sun [10,11]. Dumaitrescu discovered some correspondences between circle and sphere with red, square and cube with blue [8]. Most recently, Albertazzi et al found that people established natural biased associations between triangle and yellow, circle and square with red [3]. Although, most of the existing results are not fully consistent with Kandinsky's correspondence theory, they have verified the existence of some associations between geometric shapes and colors in normal population.

Studies on grapheme-color synesthesia found that some graphemes were consistently associated with particular colors [5,17,28,29,30,31]. Some of those grapheme-color associations appeared to be based on learning a written language (e.g., “b” is associated with blue), and other associations appeared to be related with the characteristics of letters’ shapes; round/angle or open/closed characteristic have been reported to affect the grapheme color association [4,12,13]. Besides, the similar color-shape associations also found in non-synesthesia populations [29,31]. Therefore, there might exist some associations between geometric shapes and colors based on visual characteristics of stimuli.

In the light of the above-mentioned studies, we hypothesized that there would exist some associations between colors and shapes, which would be mediated by universal processes but partly dependent on cultural backgrounds. In the present study, we adopted the experimental paradigm used in Albertazzi et al. [3] and applied it to non-synesthetic Japanese participants.

2. Method

2.1 Participants

Seventy non-synesthetic Japanese college students participated in the experiment (26 females, mean age = 21.6 year-old with SD = 2.7). All participates have normal or corrected to normal visual acuity and normal color vision.

2.2 Apparatus and Stimuli

Stimuli were displayed on a 15.5-inch LCD color monitor with 1920 × 1080 resolution at 60 Hz controlled by a laptop computer, viewed at a distance of 60 cm. The stimuli consisted of 40 hue-color filled-circles (with a radius of 0.64 cm; 1.22 deg in visual angle) taken from the Natural Color System Atlas, and one of 12 basic line-drawing shapes, including 8 types of 2-dementional shape (circle, triangle, square, rhombus, hexagon, trapezium, oval, and parallelogram) and 4 types of 2D projections of 3D shape (cone, pyramid, truncated cone, and truncated pyramid) (Figure 1a). The geometric shapes were all drawn with black lines with the width of 2.6 mm (0.03 deg) on a white background (100 cd/m^2). We prepared three sizes for the shapes: Small, Medium, and Large. The large sizes were approximately four times area as the medium sizes, and the small sizes were approximately sixteenth area of the medium sizes (Table 1). We adopted three levels of spatial rotation as each shape rotated for 0°, 15° and 345° except circle. Thus, we had 102 shape stimuli (11 shapes × 3 sizes × 3 rotations + 1 shape × 3 sizes = 102 shapes). The shape stimulus appeared at the center of the screen and the 40 color circles were on a circumference of an imaginary circle with a radius of 10.2 cm (19.4 deg) (Figure 1b).

2.3 Procedure

The experiment was carried out in a dimly lit room (1 lux on the wall). Participants were seated in front of the computer-monitor and instructed to intuitively choose one color from the 40 color circles that naturally matched to a centrally presented shape by clicking on the color patch. The shape stimulus appeared for 100 ms, disappeared for 50 ms, and reappeared with the 40 color circles until a response was made. The next trial started immediately after the response. Each shape stimulus was randomly chosen and displayed twice, resulting in 204 trials. For each trial, the orientation of the color circles was altered randomly. The experiment lasted about 10 min. Experimenters avoided using of any color terms during the task administration.

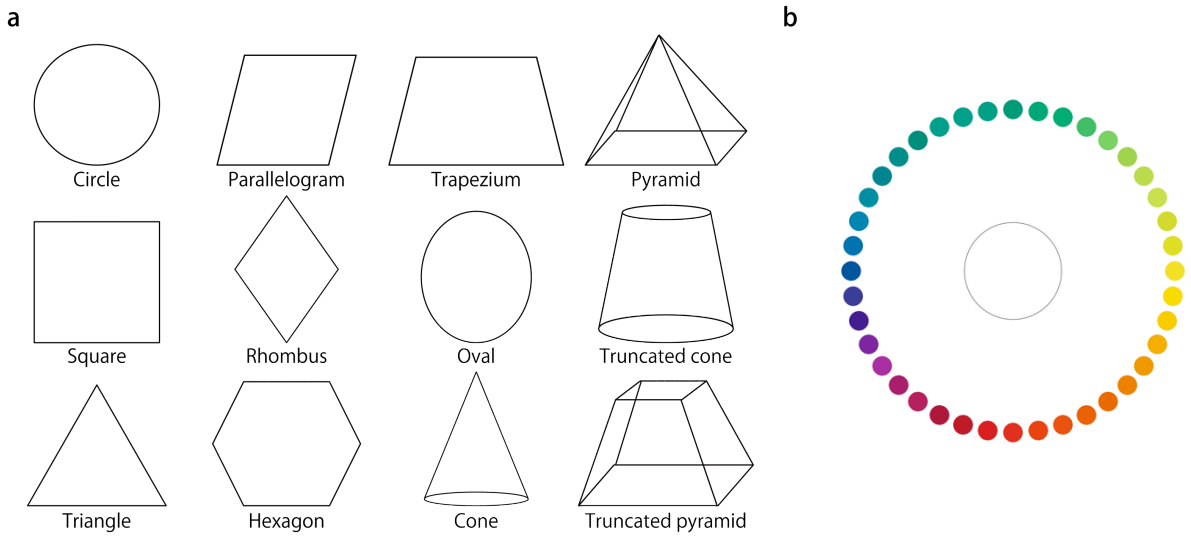

Figure 1. (a) Visual stimuli of shapes in present study (0° rotation). (b) An example of stimulus display

Table 1. Visual angle of all shapes in three sizes (Unit: deg in visual angle)

Shapes/sizes	Small		Median		Large	
	Height	Width	Height	Width	Height	Width
Circle	1.14	1.14	4.75	4.75	9.5	9.5
Square	1.14	1.14	4.75	4.75	9.5	9.5
Triangle	1.24	1.43	4.85	5.42	9.7	10.74
Parallelogram	1.14	1.24	3.99	4.85	7.79	9.03
Rhombus	1.71	1.24	6.75	4.56	12.54	8.46
Hexagon	1.33	1.52	4.94	5.7	8.46	9.69
Trapezium	1.1	1.52	3.89	6.08	7.32	11.4
Oval	1.52	1.24	5.6	4.56	9.69	7.79
Pyramid	2.1	2.5	4.85	5.79	4.85	5.79
Cone	2.0	1.52	6.18	2.47	6.18	2.47
Truncated cone	2.1	2.0	5.13	4.85	5.13	4.85
Truncated pyramid	1.8	2.5	4.66	6.27	4.66	6.27

3. Results

In order to facilitate analysis and interpretation, the 40 colors were grouped into 8 categories. Eight unique colors were grouped into 8 color categories with two adjacent colors in each side, namely, 4 basic color groups: yellow (YY), red (RR), blue (BB), and green (GG), and the other 4 transition groups: ‘YR’ the colors between yellow and red (orange), ‘RB’ colors between red and blue (purple), ‘BG’ colors between blue and green (blue-green), and ‘GY’ colors between green and yellow (yellow-green).

Figure 2 shows the relative choice frequency of color category for each shape. We accumulated the choosing times of each color category for each shape, and conducted a Pearson’s Chi-square test. The results revealed that

the choice of color was not independent of the presented shape (x^2 = 1153, df = 77, p < .01). The size and spatial rotation had no significant effect on the shape-color association for each shape (size: e.g., circle, x^2 = 13, df = 14, p = 0.1; spatial rotation (circle excluded): e.g., square, x^2 = 16.6, df = 14, p = 0.7). Table 2 shows the average choosing frequency of each color category for each shape. Some color categories were chosen more frequently with certain shapes (z > 2.5, p < .05). For circle, RR was found more frequently chosen than expected (with an adjusted residual z of 16.5). Other significant associations were found between square and BB (z = 6.6); triangle with YY (z = 11.1); parallelogram and BB (z = 4.04), GY (z = 2.8); rhombus with YY (z = 4.8); hexagon with RB (z = 7.6), BG (z = 3.3); trapezium with BG (z = 5.5); cone with YY (z = 3.4); pyramid with YY (z = 4.5); oval with YY (z = 4.5), YR (z = 8.2), RR (z = 6.8); truncated cone with YR (z = 4.1); truncated pyramid with BG (z = 4.7), GG (z = 7.5). T-test with Bonferroni correction (relative choosing frequency with chance level) was used as an assistant method, and the significant results were marked with underlined in Table 2.

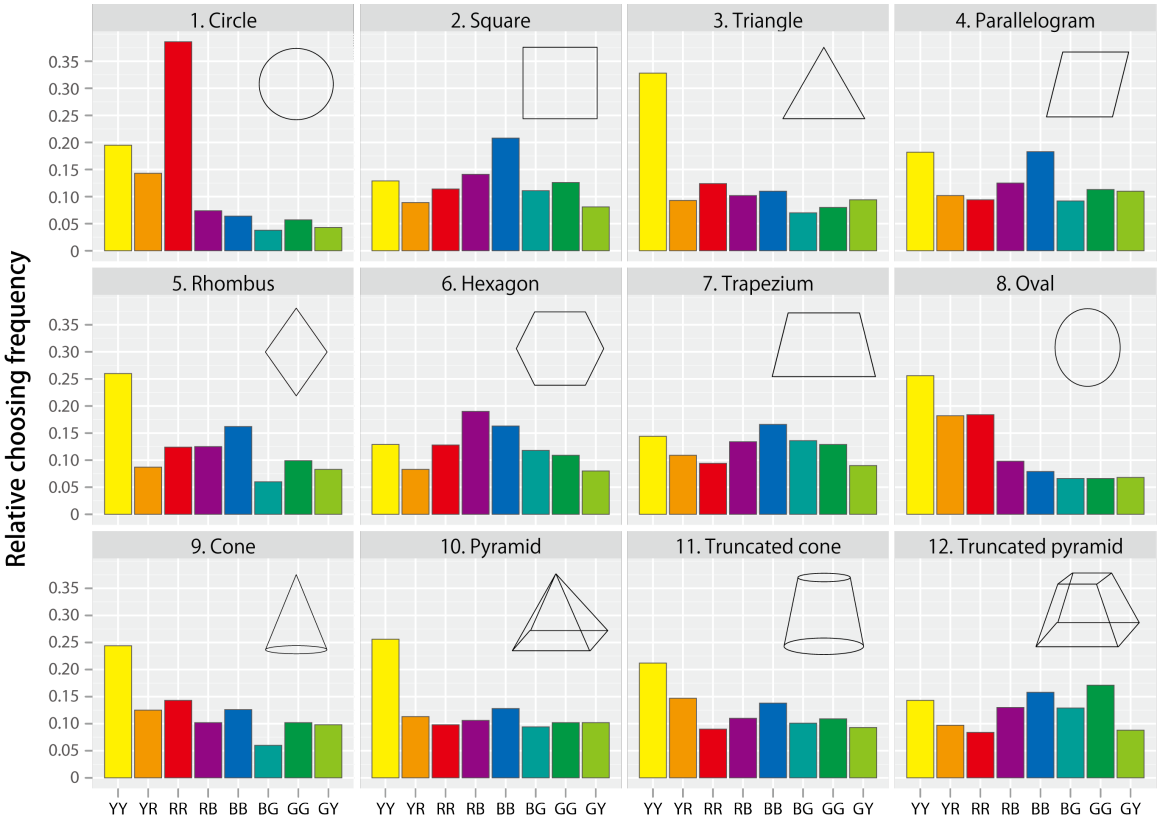

Figure 2. Relative choosing frequency of color groups

Table 2. Contingency table of colors for each shape

	YY	YR	RR	RB	BB	BG	GG	GY
Circle	19.5	14.3	**38.6**	7.4	6.4	3.8	5.7	4.3
Square	12.9	8.9	11.4	14.1	**20.8**	11.1	12.6	8.1
Triangle	**32.8**	9.3	12.4	10.2	11	7	8	9.4
Parallelogram	18.2	10.2	9.4	12.5	**18.3**	9.2	11.3	**11**
Rhombus	**26**	8.7	12.4	12.5	16.2	6	9.9	8.3
Hexagon	12.9	8.3	12.8	**19**	16.3	**11.8**	10.9	8
Trapezium	14.4	10.9	9.4	13.4	16.6	**13.6**	12.9	9
Oval	**25.6**	**18.2**	**18.4**	9.8	7.9	6.6	6.6	6.8
Cone	**24.4**	12.5	14.3	10.2	12.6	6	10.2	9.8
Pyramid	**25.6**	11.3	9.8	10.6	12.8	9.4	10.2	10.2
Truncated cone	21.2	**14.7**	9	11	13.8	10.1	10.9	9.3
Truncated pyramid	14.3	9.7	8.4	13	15.8	**12.9**	**17.1**	8.8

Note: Values displayed in bold and underline are significant at the level alpha = 0.05.

4. Discussion

In the present study, we investigated whether there would be any associations between geometric shapes and colors in Japanese participants. The results showed that some colors were assigned more frequently to particular shapes than others. While some of the color-shape associations were similar to those reported in Albertazzi et al., a few differences were also noted. For example, Albertazzi et al. [3] found associations between triangle and YY, circle and YY, RR, and squares with RR, BB for their Italian participants. For our Japanese participants, the strongest association was observed between circle and RR, and square only with BB. Thus, the present results suggest that the spontaneous color-shape association contains both universal and culturally mediated components.

Based on the present results with conjunction of Albertazzi et al. [3], we speculate that the shapes characterized with curved lines as circle, oval, truncated cone were more easily to be associated with 'warm' color groups, as RR (red), YY (yellow), and YR (orange), whereas the shapes with sharp apex angles like triangle, rhombus, cone, pyramid tended to be associated with color YY (yellow). In addition, the shapes with no curved lines and no sharp apex angles, as square, parallelogram, hexagon, trapezium, truncated pyramid might be more frequently associated with 'cold' color groups, as BB (blue), BG (blue-green), and GG (green). These putative associations of yellow with triangle, blue with square and red with circle were consistent with Dumaitrescu (red-circle and blue-square associations) [7,8], but in opposition with Kandinsky's correspondence theory (blue-circle and red-square associations) [15,16]. The red-circle association has been also found in several studies [3,7,8], and in our participants, it was the strongest association, which might be under some influences from cultural backgrounds, such as the Japanese flag effect.

Previous works have suggested that simple visual shapes might be associated with certain adjectives [18,22,25,32], and colors might be associated with particular adjectives [1,6,9,35]. Colors could be warm or cold, and deep or light, etc. Shapes could be hard or soft, and round or sharp, etc. At the same time, it is not difficult to imagine "soft or hard" colors and "warm or cold" shapes. The semantic information conveyed by visual shape and

color features might be shared and associated. Albertazzi et al. [3] suggested the color-shape associations were determined by the "warmth" of both shapes and colors and the degree of "natural lightness" of hues. We hypothesized the spontaneous associations between color and shape might be interpreted by the images exuding between shape and color domains. A supplementary experiment examined this possibility showed that the "warm/cold" perception of colors and shapes accounted for most of those color-shape associations. 'Warm/cold' colors were more easily to be associated with the 'warm/cold' perceived shapes, like color red to circle, blue to square. Furthermore, the left little color-shape associations might be interpreted by the "soft/hard" perception. While we found the 'soft/hard' colors tended to be assigned to the 'hard/soft' shapes, like yellow to triangle. Those results implied that the visual system naturally modulated the color shape correspondence according to both consistent and complementary semantic images.

In all, we found the systematic color shape associations in Japanese population, which contain both universal and cultural components compared with previous studies. The shared semantic perception of "warm/cold" and "soft/hard" for both color and shape might interpret the associations between them. Future study could combine the lightness and saturation effect of color to investigate the color shape associations.

References

[1] Adams, F. M. and Osgood, C. E. (1973) *A cross-cultural study of the affective meanings of color*, Journal of Cross-cultural Psychology, vol. 4, pp 135-156.

[2] Arnheim, R. (2004) *Art and visual perception: A psychology of the creative eye*, Berkeley, CA, University of California Press.

[3] Albertazzi, L., Da Pos, O., Canal, L., Micciolo, R., Malfatti, M. and Vescovi, M. (2012) *The Hue of Shapes*, Journal of Experimental Psychology: Human Perception and Performance, vol. 39, no. 1, pp 37-47.

[4] Brang, D., Rouw, R., Ramachandran, V. S. and Coulson, S. (2011) *Similarly shaped letters evoke similar colors in grapheme-color synesthesia*, Neuropsychologia, vol. 49, no. 5, pp 1355-1358.

[5] Barnett, K. J., Finucane, C., Asher, J. E., Bargary, G., Corvin, A. P., Newell, F. N. and Mitchell, K. J. (2008) *Familial patterns and the origins of individual differences in synesthesia*, Cognition, vol. 106, no. 2, pp 871-893.

[6] D'Andrade, R. and Egan, M. (1974) *The colors of emotion*, American Ethnologist, vol. 1, no. 1, pp 49-63.

[7] Dumitrescu, A. (2003) *Study on Relationship between Elementary Geometric Figures and Basic Colors,* Politehnica University Scientific Bulletin, Series D, vol. 65, no. 1, pp 77-90.

[8] Dumitrescu, A. (2011) *New researches regarding relationship between elementary geometric shapes and basic colors.* Proceedings of the 22nd International DAAAM Symposium, vol. 22, no. 1, pp 1041.

[9] Hupka, R. B., Zaleski, Z., Otto, J., Reidl, L. and Tarabrina, N. V. (1997) *The colors of anger, envy, fear, and jealousy, a cross-cultural study*, Journal of Cross-cultural Psychology, vol. 28, no. 2, pp 156-171.

[10] Jacobsen, T. (2002) *Kandinsky's questionnaire revisited: fundamental correspondence of basic colors and forms?* Perceptual and Motor Skills, vol. 95, no. 3, pp 903-913.

[11] Jacobsen, T. and Wolsdorff, C. (2007) *Does history affect aesthetic preference? Kandinsky's teaching of color-form correspondence, empirical aesthetics, and the Bauhaus,* The Design Journal, vol. 10, pp 16-27.

[12] Ju¨rgens, U. T., Mausfeld, R. and Nikolic, D. (2010) *Grapheme–color synesthesia: Similar shapes take similar colors*, Abstract presented at the U.K. Synesthesia Association Conference, Brighton, U.K.

[13] Jürgens, U. and Nikolić, D. (2012) *Ideaesthesia: Conceptual processes assign similar colors to similar shapes*, Translational Neuroscience, vol. 3, no. 1, pp 22-27.

[14] Kharkhurin, A. V. (2012) *Is Triangle Really Yellow? An Empirical Investigation of Kandinsky's Correspondence Theory*, Empirical Studies of the Arts, vol. 30, no. 2, pp 167-182.

[15] Kandinsky, W. (1912/1994) *On the spiritual in art*. In K. C. Lindsay P. Vergo (Eds.), Kandinsky, Complete writings on art, New York, Da Capo Press.

[16] Kandinsky, W. (1947) *Point and line to plane.* New York, Solomon R. Guggenheim Foundation, First German edition, 1926.

[17] Lau, C., Schloss, K. B., Eagleman, D. M. and Palmer S. E. (2011) *Color-grapheme associations in non-synesthetic: Evidence of emotional mediation*, Presented at the 11th Annual Meeting of the Vision Sciences Society, Naples, FL.

[18] Larson, C. L., Aronoff, J. and Stearns, J. (2007) *The shape of threat: Simple geometric forms evoke rapid and sustained capture of attention*, Emotion, vol. 7, no. 3, pp 526-534.

[19] Leder, H. and Belke, B. (2004) *A model of aesthetic appreciation and aesthetic judgments*, British Journal of Psychology, vol. 95, no. 4, pp 489-508.

[20] Lupton, E. and Miller, J. A. (1991) *The ABC's of design: The Bauhaus and design theory*, New York, NY: Princeton Architectural Press.

[21] Lupton, E. and Miller, J. A. (Eds.). (1993) *Dreieck, Quadrat, Kreis: Bauhaus und Design-Theorie heute [Triangle, square, circle: Bauhaus and design theory today],* Basel, Switzerland: Birkhauser.

[22] Nakano, M. (1972) *An analytical study of combined affective value of color and form*, Japanese Journal of Psychology, vol. 43, no.1, pp 22-30.

[23] Osgood, C. E., Suci, G. and Tannenbaum, P. H. (1957) *The measurement of meaning*, Urbana, University of Illinois Press.

[24] Ou, L. C., Luo, M. R., Woodcook, A. and Wright, A. (2004) *A study of color emotion and color preference. Part I: Color emotions for single colors*, Color Research and Application, vol. 29, no. 3, pp 232-240.

[25] Oyama, T. (2003) *Affective and symbolic meanings of color and form: Experimental psychological approaches*, Empirical Studies of the Arts, vol. 21, no. 2, pp 137-142.

[26] Poling, C. V. (1987) *Kandinsky's teachings at the Bauhaus: Color theory and analytical drawing*, New York, Rizzoli.

[27] Palmer, S. E. and Schloss, K. B. (2010) *An ecological valence theory of human color preferences*, Proceedings of the National Academy of Sciences, vol. 107, no. 19, pp 8877-8882.

[28] Rich A. N., Bradshaw J. L. and Mattingley J. B. (2005) *A systematic, large-scale study of synesthesia: implications for the role of early experience in lexical-color associations*, Cognition, vol. 98, no. 1, pp 53-84.

[29] Simner, J., Ward, J., Lanz, M., Jansari, A., Noonan, K., Glover, L. and Oakley, D. (2005) *Non-random associations of graphemes and color in the synesthetic and normal populations*, Cognitive Neuropsychology, vol. 22, no. 8, pp 1069-1085.

[30] Spector, F. and Maurer, D. (2008) *The Color of Os: Naturally biased associations between shape and color*, Perception, vol. 37, no. 6, pp 841-847.

[31] Spector, F. and Maurer, D. (2011) *The colors of the alphabet: Naturally-biased associations between shape and color*, Journal of Experimental Psychology: Human Perception and Performance, vol. 37, no. 2, pp 484-495.

[32] Sakuta, Y. and Gyoba, J. (2006) *Affective Impressions and Memorability of Color-Form Combinations*, The Journal of General Psychology, vol. 133, no. 2, pp 191-207.

[33] Ward, J., Huckstep, B. and Tsakanikos, E. (2006) *Sound-color synesthesia: To what extent does it use cross-modal mechanisms common to us all?* Cortex, vol. 42, no. 2, pp 264-280.

[34] Wagner, K. and Dobkins, K. (2011) *Synaesthetic associations decrease during infancy*, Psychological Science, vol. 22, no. 8, pp 1067-1072.

[35] Watson, D. G., Blagrove, E., Evans, C. and Moore, L. (2012) *Negative triangles: Simple geometric shapes convey emotional valence*, Emotion, vol. 12, no. 1, pp 18-22.