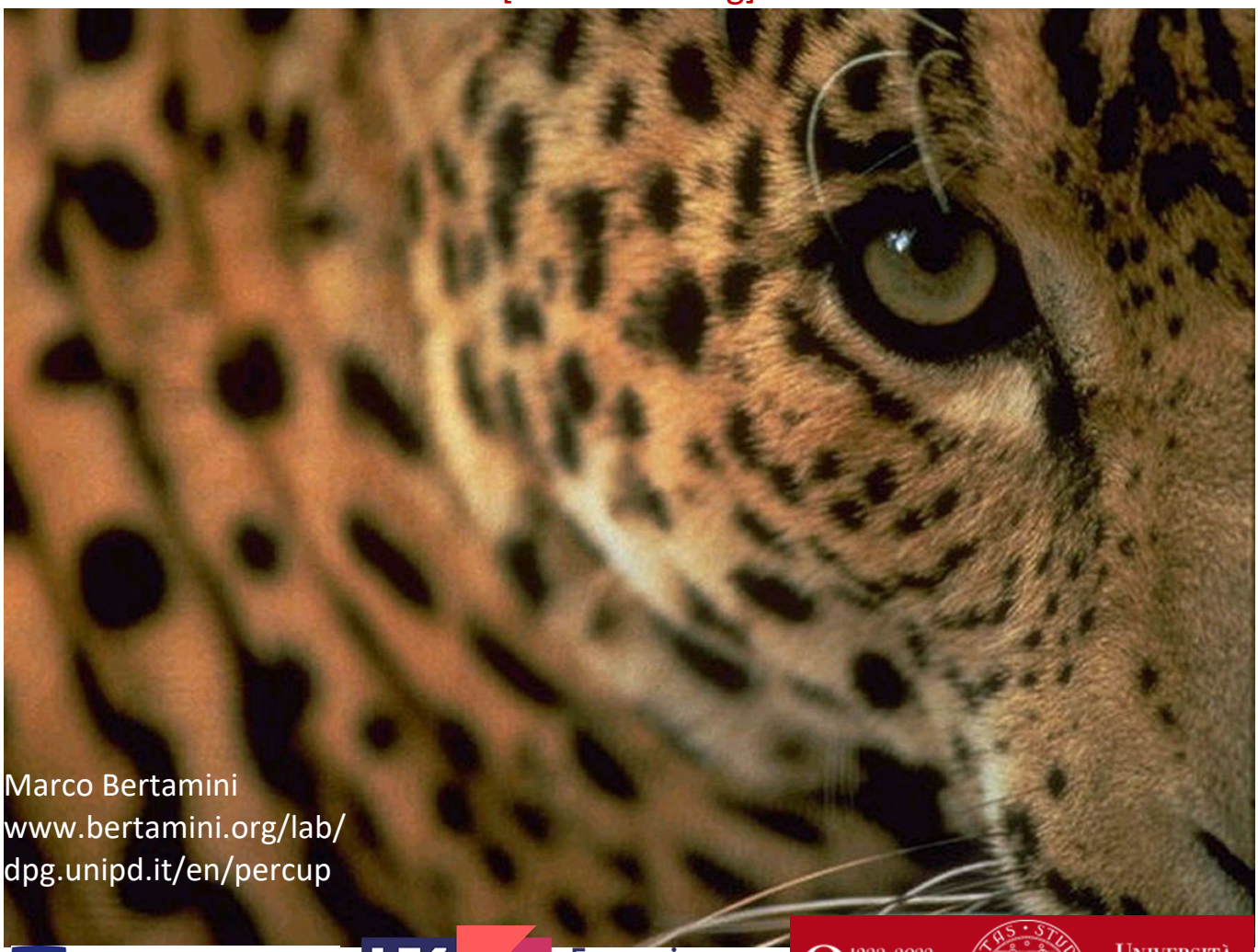
7th Visual Properties Driving Visual Preference workshop

VPDVP

Friday, 23th April 2021

[Zoom meeting]



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UNIVERSITY OF LIVERPOOL

UKRI Economic and Social Research Council

800 ANNI 1222·2022 Università degli Studi di Padova

Programme

11:25. Welcome from Organizers and introductions

11:35. Keynote 1 Chien-Chung Chen, National Taiwan University
https://www.researchgate.net/profile/Chien-Chung-Chen-8
Symmetry Modulates the Power Spectrum Slope Effect on Aesthetic Preference.

12:20. Tamara Watson, Matthew Patten, Damien Mannion, Branka Spehar.
Power flowers: Symmetry, colour and complexity as determinants of the aesthetic appeal of gerberas.

12:40. Ronald Hübner, Martin Fillinger.
Symmetry, balance, or closeness: Which property is more important for visual preference?

13:00. Ana Clemente, Olivier Penacchio, Manel Vila-Vidal, Robert Pepperell, Nicole Ruta.
Contrasting perceptual and hedonic judgments of visual contour.

13:20. Keynote 2 Hans Op de Beeck, University of Leuven, Belgium
https://ppw.kuleuven.be/lbp/lbpMembers/00029058/
Neural representations and connectivity underlying symmetry perception.

14:05-15:00. Lunch and social games

15:00. Alexis Makin, John Tyson-Carr, Giulia Rampone, Yiovanna Derpsch, Marco Bertamini.
Scientific and meta scientific lessons from the complete SPN catalogue.

15:35. John Tyson-Carr, Alexis Makin.
The third cortical symmetry response.

15:55. Marco Bertamini, Alexis Makin, John Tyson-Carr, Giulia Rampone, Elena Karakashevska.
Finding symmetry through spatiotemporal integration.

16:15. Keynote 3: Peter J. Kohler, York University, Canada
https://www.kohlerlab.com/
Perception of Symmetries in Regular Textures.

17:00. Coffee break

17:20. Emmanouil Protonotarios.
Quantification of Order.

17:40. Manuel Petrucci, Francesco Mancini, Anna Pecchinenda.
The shapes of guilt: influence of deontological and altruistic guilt on the preference for visual symmetry.

18:00. Keynote 4: Elena Gheorghiu, University of Stirling, UK
https://www.stir.ac.uk/people/257378
The role of luminance polarity grouping and orientation in symmetry perception.

18:45. Onwards Roundtable discussion

Keynote Abstracts (alphabetical by last name)

Symmetry Modulates the Power Spectrum Slope Effect on Aesthetic Preference

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Regularity in image statistics can influence the human aesthetical preference to a complex visual stimulus. In particular, for a human observer, symmetric patterns are more aesthetically appealing than asymmetric ones. In addition, the correlation between pixels, manifested as the slope of the spectral power distribution of the image, is also known to have a strong impact on aesthetic preference. We investigated how these two factors jointly affect aesthetic preferences by manipulating both the power spectrum slope and the symmetric level of images to assess their effects on aesthetic preference on a 6-point Likert scale. Our results showed that the preference ratings increased with the symmetry level but had an inverted U-shaped relation to amplitude spectrum slope. In addition, a strong interaction existed between symmetry level and amplitude spectrum slope on preference rating, in that symmetry can amplify the amplitude spectrum slope's effects. A quadratic function of the spectrum slope can describe such effects. That is, preference is an inverted U-shaped function of spectrum slope whose intercept is determined by the number of symmetry axes. The modulation depth of the quadratic function manifests the interaction between the two factors.

The role of luminance polarity grouping and orientation in symmetry perception

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Symmetry is a salient visual feature to which the human visual system is highly sensitive. However, changes in visual features such as luminance polarity and orientation may modulate that salience. Here, we investigate whether symmetry detection mechanisms that rely on position-symmetry signals interact with: (1) luminance polarity-grouping mechanisms, and whether this interaction modulates the Sustained Posterior Negativity (SPN) response to the presence of symmetry, and (2) orientation signals in the perception of symmetry, and if they do, then how these signals combine.

Experiment 1: Stimuli were dot patterns arranged either symmetrically (mirror, radial, translation) or quasi-randomly, and by luminance polarity about a grouping axis (i.e. same luminance-polarity on one side and opposite luminance-polarity on the other). We varied the relative angular separation between the symmetry axis and polarity-grouping axis: 0, 30, 60, 90 deg. Participants performed a two interval-forced-choice (2IFC) task indicating which interval contained the symmetrical pattern. We found higher accuracy when symmetry and polarity-grouping axes were aligned or separated by a small angle (30 deg) for all types of symmetry. The SPN amplitude for the radial symmetry, but not for mirror and translation symmetry, was modulated by the relative separation between symmetry and polarity-grouping axes, with larger SPN amplitude for aligned and orthogonal axes than intermediate angular separation. This suggests that luminance polarity grouping mechanisms interact with symmetry detection mechanisms.

Experiment 2: To examine the effect of orientation, stimuli were patterns made of oriented Gabors arranged either mirror-symmetric or quasi-random. We varied the amount of position-symmetry by changing the proportion of symmetric Gabors and measured symmetry detection thresholds using a 2IFC procedure, for two conditions: (i) 'segregated' condition in which position-symmetric Gabors had one orientation and the noise Gabors had a different orientation, and (ii) 'non-segregated' condition in which position-symmetric Gabors were of two orientations in equal proportions, as were the random-positioned Gabors. We varied the separation between the two orientations: 0, 30, 60, 90 deg. We found that symmetry detection thresholds were comparable for the segregated and non-segregated conditions, irrespective of orientation difference. Additionally, for almost all orientation differences conditions, probability summation between orientations is a better model than additive summation between orientations.

We conclude that symmetry detection mechanisms are not sensitive to orientation information. However, the separation between the symmetry axis and polarity-grouping axis affects the detection of symmetry and to some extent the SPN response to radial symmetry.

Perception of Symmetries in Regular Textures

Peter J. Kohler
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Symmetries are abundant in nature, have been appreciated by human cultures throughout history and have long been recognized as important for visual perception. My research focuses on *wallpaper groups*, a class of 17 distinct regular textures in which combinations of symmetries are repeated to tile the 2D plane. This approach is distinct from most research on visual processing of symmetries, which tends to focus on one or more symmetry axes in a single image location. Wallpaper groups represent the complete set of possible symmetries in images and generate strong responses throughout much of the visual processing hierarchy. We have used psychophysics, steady-state EEG and functional MRI in humans and macaque to measure responses to symmetries in textures. We find strong symmetry sensitivity in several areas of visual cortex, beginning in V3 and likely arising through feed-forward processing. The set of human visual areas that are sensitive to symmetries appear to be have a well-matched set of homologues in macaque visual cortex, and rotation and reflection produce nearly identical responses in the macaque brain. A comparison of EEG amplitudes and psychophysical symmetry detection thresholds for the complete set of wallpaper groups reveal that both measures are remarkably sensitive to the precise symmetry content of each group. Taken together, these results reveal that comprehensive representations of symmetries in regular textures exist in primate visual cortex, and that the symmetry content within a texture is coded with a high degree of precision. In current work, we explore the connection between these representations and behavior in more detail, by using visual search to probe how efficiently different symmetry types are processed. I will end by briefly discussing some future directions, including stimulus manipulations that may allow us to characterize and differentiate the cortical mechanisms that encode symmetries in objects and textures.

Neural representations and connectivity underlying symmetry perception.

Hans Op de Beeck
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The primate visual system starts from local feature detectors and gradually builds up a more holistic representation of the content of natural images. For example, Kubilius et al. (2011, Psychol. Sci.) showed how the perceptual phenomenon known as the configural superiority effect is related to a gradual shift from part-based coding in primary visual cortex to holistic representations in object-selective cortex. Symmetry detection is an interesting challenge to such a framework, because it requires establishing correspondences between local elements that are often far apart in the image, such as in the case of dot patterns. Neuroimaging studies have shown increased responsiveness to symmetric dot patterns in extrastriate areas, but the underlying representational changes have not been characterized until recently. We approached this question using functional magnetic resonance imaging together with multivariate decoding and connectivity analyses. We show that the increase in responsiveness is accompanied by a shift from part-based to holistic representations of dot patterns with vertical symmetry. In object-selective cortex, part information is lost. Interestingly, the inter-hemispheric connectivity was higher for symmetric compared to asymmetric dot patterns. This increase was significant at several levels in the system, including area V2 where there is not yet a difference in univariate or multivariate responses between asymmetric and symmetric stimuli. Together, these findings show how symmetric stimuli are represented and potentially computed throughout the primate visual system.

Abstracts (alphabetical by last name)

Finding symmetry through spatiotemporal integration

Marco Bertamini[12], Alexis D.J. Makin[1], John Tyson-Carr[1], Giulia Rampone[1], Elena Karakashevska[1]
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A sustained response to visual symmetry can be measured with EEG every time we compare images with more and less symmetry. Stimuli used in the literature vary extensively in terms of parameters but usually symmetry is an image property. Here we present three cases that extend the nature of the stimuli and therefore the type of information extracted. (1) A sustained posterior negativity (SPN) is present for shapes defined by contours within random dot stereograms, thus showing that luminance information is neither necessary nor advantageous. (2) In a second project we used dynamic occlusion to present symmetry as a feature that relies on a memory trace. We found a transient posterior negativity for shapes that define symmetry as a relationship between frames. As for symmetry in perspective here participants have to engage in a task of symmetry detection. Attention therefore appears to be necessary. (3) In a third project we modified the dynamic occlusion paradigm so that the frame of reference itself was moving. Here the correspondence has to be found over time (comparing frames) and also in a way that is not linked to a retinotopic representation. We confirmed the transient posterior negativity. Overall, it appears that the symmetry-sensitive network is highly flexible and able to recover information about symmetry for all kind of contours (including cyclopean contours) and for symmetry relationships present over time and space. These findings constrain any model of symmetry detection as they suggest that processing has to go beyond the image at any one point in time.

Contrasting Perceptual and Hedonic Judgments of Visual Contour

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Sensory valuation is a fundamental aspect of human psychology, involving the assignment of hedonic value to a stimulus based on its sensory properties combined with personal and contextual factors. Contour is a prominent structural feature affecting evaluative judgments of visual objects, and preference for curvature seems to transcend cultural and species boundaries. Yet, perceptual sensitivity to visual contour and its relationship to hedonic sensitivity has not been systematically investigated. Our main aim was to understand perception and hedonic evaluation of visual contour and their relationship. To test this, we generated 88 abstract shapes, whose contour was defined by and systematically manipulated along three structural parameters: number of vertexes (7, 11), distance between adjacent vertexes (1, 5, 9, 13), and tension of the spline connecting adjacent vertexes (0–11). Then, we inquired into the impact on perceptual and liking judgments, and perceptual and hedonic (aka aesthetic) sensitivities of 50 participants. The results suggest that question polarity, i.e., asking about curvature or angularity, affects perceptual judgments; that these judgments are primarily determined by tension, and, to a lesser extent, by distance and number of vertexes; and that the impact of contour's structural properties (i.e., vertexes, distance and tension) are modulated by the task at hand. The results also revealed that distance is the main determinant of liking judgments, and that perceptual and hedonic judgments, and sensitivities to visual contour are to some extent independent. This suggests that the hedonic judgments of sensory stimuli—visual designs varying in contour, in this case—are not mediated by perceptual classifications such as whether they are curved or angular. This might imply a parallel processing of perceptual and hedonic judgments. We also discuss results from a machine-learning classifier of perceptual sensitivity to predict hedonic judgements.

Symmetry, balance, or closeness: Which property is more important for visual preference?

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Symmetry and balance are widely assumed to be basic visual properties driving visual preference. Some of the first experiments testing this assumption were conducted more than a century ago (1903) by Ethel Puffer in the lab of Hugo Münsterberg at Harvard. By asking several people to mechanically move a certain element in a picture composed of otherwise fixed elements so that the picture looks most beautiful, she observed that symmetry was more often produced than balance. Moreover, some people also produced closeness (clustered elements). Recently, Hübner and Thömmes (2019) repeated some of Puffer's experiments with modern methods and a larger group of participants. They replicated the result that symmetry was preferred over balance. However, to their surprise, most participants produced closeness. It seemed that they had adopted a local perspective and constructed a preferred object rather than a preferred picture as a whole. To test this hypothesis, we conducted two experiments. In one, our participants had to rate how much they liked pictures that we had constructed with elements used by Puffer (1903). The pictures systematically varied in balance, symmetry, and closeness. As a result, closeness had little effect on preference, whereas symmetrical pictures were liked the most. In the other experiment, we applied the same production method as in Hübner and Thömmes (2019). This time, however, participants could move all elements. Under these conditions, they mostly produced symmetrical pictures, many of them, however, with nearby elements. Together, our results show that symmetry is an important property for visual preference. However, if allowed by the method, people additionally also produce less important properties such as closeness.

Scientific and Meta scientific lessons from the complete SPN catalogue.

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Technology allows scientists to publicly catalogue, organize and re-analyze all the data they accumulate. We demonstrate the advantages of this approach. For a decade, we have been measuring a brain response to visual symmetry called the Sustained Posterior Negativity (SPN). We catalogued all available SPNs (6674 individual SPNs from 2215 participants). The catalogue is easy to use, modular, and scalable. We demonstrate two uses of the SPN catalogue. First, we used the catalogue to obtain new insights into symmetry perception which could never be obtained from a single experiment. Second, we used it to evaluate our own data and practices. We applied Bishop's four horsemen framework (publication bias; statistical power; P-hacking; HARKing) using metrics and alternative analyses where appropriate. We illustrate positive and negative aspects, many of which are likely common to every lab. On the open science front, the complete SPN catalogue is now published (https://osf.io/2sncj/), along with uniform, user-friendly data extraction tools that make further analysis possible for everybody. This demonstrates a modern approach to cumulative science; if widely adopted it has the potential to make science more efficient, and also more trustworthy.

The shapes of guilt: influence of deontological and altruistic guilt on the preference for visual symmetry

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Introduction: Several theoretical models of OCD propose that compulsions (e.g. rituals, checking) represent attempts at avoiding responsibility for actions leading to catastrophic outcomes. This perspective has been refined by authors proposing that obsessive scenarios are not related to harming others (altruistic guilt, AG), but to moral violations (deontological guilt, DG). However, experimental evidence that DG is linked to ordering/symmetry compulsions is missing to date. Therefore, the aim of the present study is to investigate whether the induction of DG or AG differentially modulates the preference for visual symmetry.
Method: One-hundred-thirty college students were randomly assigned to one of three emotion induction conditions (DG vs. AG vs. neutral). The Implicit Association Test (IAT) was used to measure the preference for visual symmetry. Participants were asked to categorize affective words as positive or negative, and pictures as symmetrical or random by key pressing. After IAT performance, participants read short stories aimed at eliciting DG, AG, or no particular emotion. After emotional induction, participants performed the IAT again. Differences between reaction times in compatible vs. incompatible trials (D scores) were analyzed using a 2 x 3 mixed ANOVA with Manipulation (2: Before induction vs. After induction) and Group (3: DG vs. AG vs. Neutral).
Results: Participants in all the three groups showed a preference for symmetry in the first IAT performance, as indexed by positive D scores. This preference dropped after induction of AG and in the neutral baseline condition, but not in the DG condition, as shown by a significant Manipulation x Group interaction, $F(2, 129) = 3.189$, $p = .044$, $\eta_p^2 = .068$.
Discussion: This evidence suggests a shared mechanism for the preference of symmetry and DG.
Conclusions: This evidence could stimulate further research and help orienting clinicians in the treatment of ordering/symmetry OCD subtype.

Quantification of Order

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Order of varying degree appears in evolving natural systems. Accurate characterization of it is crucial in many disciplines, e.g., developmental biology. The human visual system responds to symmetry and regularities; however, it was not known whether observers agree on their perception of intermediate order, especially when multiple regularities coexist. Recently, we examined perception of order in diverse point patterns and developed analysis algorithms that quantify the attribute in accordance with perception of it. Based on pairwise ranking of point patterns by degree of order, we showed that judgements are highly consistent across individuals and that the perceptual dimension has an interval scale structure, spanning roughly 10 just-noticeable differences (jnds) between disorder and order. We designed a geometric algorithm that estimates order to an accuracy of half a jnd by quantifying the variability of the spaces between points and constructed an absolute interval scale of order. We demonstrated its utility in biology by quantifying the order of the Drosophila dorsal thorax epithelium during development. The psychophysical scaling method used relies on the confusion between stimuli with similar levels of order, and the resulting discrimination scale is expressed in jnds. To test whether a common scale can account for both sub- and supra-threshold judgments, we collected discrimination data, and data based on comparison of perceptual difference. Order attribute was restricted to one type of regularity: points of a regular square lattice were jittered to a varying amount. Our results indicate that a common scale would require a varying internal noise increasing toward the direction of decreasing regularity. We further tested a previous proposal that regularity is coded via the peakedness of the distribution of neural responses across receptive field size. Using a filter-rectify-filter model, we determined responses across scale, and found that discriminability correlates with a simple peakedness measure across different presentation conditions (dot number, size, and average spacing).

The third cortical symmetry response

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Visual regularity activates a network of brain regions in the extrastriate cortex. Previous EEG studies have found that this response scales parametrically with proportion of symmetry in symmetry + noise displays. The parametric symmetry response happens in many tasks, but it is enhanced when the task requires active regularity discrimination. However, the origins and time course of this selective enhancement are unclear. Here we answered remaining questions with new source dipole analysis in a reanalysis of the data originally reported by Makin et al. (2020). As assumed, the parametric symmetry response found at the sensor level was generated by a pair of dipoles in the left and right extrastriate cortex, a finding substantiated by previous fMRI research. In accordance with original findings, this bilateral activity was itself enhanced during regularity discrimination. However, we identified a third, and later, symmetry response in the posterior cingulate during regularity discrimination. The spatial distribution of this component was characterised by a strong positive potential over the vertex of the scalp at approximately 580 ms. Unlike the extrastriate response, this previously unknown activation only indexes strong, task relevant regularity signals. With access to an extensive catalogue of data from previous SPN research, we make specific a priori predictions regarding which previous experiments this novel activity will be observed. We also outline an analysis pipeline to test our predictions, accounting for the bias often observed within scientific research procedures.

Power flowers: Symmetry, colour and complexity as determinants of the aesthetic appeal of gerberas

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Flowers are almost universally appreciated for their beauty (or appeal). Understanding the attraction to a complex natural stimulus with extensive permutations, like cut flowers, has the capacity to reveal which aspects of complex visual objects are relatively more important in eliciting a feeling of aesthetic appeal. To do this we parameterised the appearance of 2545 standardised, individual gerbera images using 33 computationally defined and 6 perceptually rated descriptors. Cut flower gerberas share a prototypical daisy shape, however an extensive number of permutations have been developed. The descriptors we created can be approximately grouped into features that describe complexity (texture), colour, contrast and symmetry. A set of 70 flowers were chosen from the larger set by carrying out principal components analysis on the descriptors, clustering of the flowers based on the outcomes and choosing one example flower from each cluster. These 70 flowers were then each shown to participants in an online study. Participants were asked to rate the appeal of each flower (n= 1,006 in experiment one) or to rate the appeal and the visual interest (n= 1,045 in experiment two). Outlier flowers and collinear descriptors were removed, leaving 66 flowers and 23 descriptors. We used multiple linear regression to model the relationship between participants' mean appeal ratings and our descriptors of the visual properties of the flower. A summary of the important descriptors (accounting for 90% of variance in ratings) suggests that more appealing gerberas are symmetrical, have a less complex texture and show contrast in the colouration in the form of a bullseye pattern. Conversely, visual interest was higher for gerberas that are less symmetrical, have more complex texture and with contrasting colours.

Participants

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Instructions and information

You can now download this full programme (pdf) including all abstracts from:
https://www.bertamini.org/lab/vpdvp.html

-. The virtual meeting wants to be as close as possible to a workshop where people sit next to each other. Imagine you are sitting around a table.
-. Download Zoom from https://zoom.us/download The web browser client will also automatically download when you join your first meeting, however, we recommend you manually download this prior to the workshop.
-. On April 22nd you will receive the link for the Zoom meeting.
-. Click and join the Zoom meeting approximately 15 minutes prior to start. Upon entering you will be in the virtual waiting room. Use this time to test your computer audio using the Zoom prompts. One of us will then admit you prior to the scheduled start time. We will recognise you by the email address you used at registration.
-. Do not run programmes in the background to avoid bandwidth problems
-. Use the scheduled breaks for coffee etc. If you have to take an extensive break let the chair know.
-. Keep the video always ON, and the mic on MUTE until called upon by the chair. Use a meaningful name, if necessary, use the "rename" function on the top right of image.
-. Book a question for the q&a session by typing in the chat window. If this is not visible click on "chat". The chair will collect the names.
-. Feel free to also use the chat to <individual> instead of chat to <everyone>.
-. At lunch time we will socialise, maybe play some games, feel free to volunteer anything, for instance if you play an instrument.
-. The workshop email will be monitored also during the day of the event:
<shapeandsymmetrylab@gmail.com>

In the occasion of the workshop we are also pleased to announce a new special issue in the journal Symmetry (MDPI) on "Visual processing of symmetry".

https://www.mdpi.com/journal/symmetry/special_issues/Visual_Processing_Symmetry

Special Issue Information

Dear Colleagues,

We are pleased to announce a new Special Issue in the journal *Symmetry*, associated with the 7th annual Visual Properties Driving Visual Preference (VPDVP) workshop (**https://www.bertamini.org/lab/vpdvp.html**) at the University of Liverpool. We welcome articles that report new insights into the neural processing of visual symmetry, obtained with either brain imaging or behavioural methods.

Guest Editors

Marco Bertamini
Alexis Makin
Peter J. Kohler

NOTES