DOI: 10.2352/ISSN.2470-1173.2016.16HVEI-113

Individual Differences in Perceptual Preference

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Abstract

We present results from three research projects that illuminate individual differences (IDs) in perceptual preferences. First, we demonstrate that IDs in single-color preferences can be partly explained by ecological preferences for color-associated objects and institutions (e.g., people who like spinach tend to like dark-green more than those who dislike spinach, and people who like Berkeley tend to like Berkeley-blue and Berkeley-gold more than people who dislike Berkeley). Second, we show that IDs in preferences for pairs of colors also depend on an individual's degree of preference-for-harmony (PH) in the relation between the two colors, where colors of similar hue are more harmonious (e.g., people with high PH tend to like beige-on-brown more than orange-on-purple, whereas those with low PH tend to like orange-on-purple more than beige-on-brown). Finally, we show that PH is an ID that generalizes across visual and auditory domains (e.g., people who like beige-on-brown tend to prefer Mozart to Stravinsky, and those who like orange-on-purple tend to prefer Stravinsky to Mozart) and also depends on amount of training/expertise in the relevant domain. We discuss these findings in terms of stable IDs in the degree to which people like stimuli that "fit well" together.

IDs in Preferences for Single Colors

Several modern studies of average preferences for single colors (e.g., Fig. 1A) in the US and the UK have shown that average preferences for hues follow a relatively smooth, curvilinear function in which cool colors (greens and blues) are preferred to warm colors (reds, oranges, and yellows) and more saturated colors are preferred to less saturated ones (see Fig. 1B) (e.g., Hurlbert & Ling, 2007; Ling & Hurlbert, 2009; Ou et al., 2006; Palmer & Schloss, 2010). However, other studies show that color preferences are notoriously variable from one individual to another (e.g., McManus et al., 1981). How are such trends in average color preferences to be understood in the context of the large individual differences (IDs) that are clearly present?

One possibility is that such findings might be explained by retinal physiological. Perhaps the preference for cool colors over warm ones is related to IDs in the relative prevalence of medium (M) and long (L) wavelength cones over short wavelength (S) cones – even though it is unclear why colors that stimulate the more numerous M and L cones should be preferred less. IDs in warm/cool preferences might then correlate with IDs in the relative numbers of L, M, and S cones. Evidence against this hypothesis comes from findings that the relative numbers of L, M, and S cones – short of the complete absence of one or another class – have surprisingly little effect on people's ability to discriminate colors, as if the visual system represents color in a way that is quite invariant over IDs in the number of L, M, and S cone types (Brainard et al, 2000; Webster, 2016).

Another physiological hypothesis is the cone-contrast model, in which color preferences are based on differential weightings of the cone-contrast axes (L-M and S-(L+M)) for a given color against its background (Hurlbert & Ling, 2007). Ling and Hurlbert (2009) subsequently extended this model to include two additional factors – lightness (L+M+S) and saturation – that together explained 64% of the variance in their group-average data for 90 colors and also accounted for 48% of the variance in IDs in color preferences for those same colors.

A third hypothesis – the ecological valence theory (EVT) of Palmer and Schloss (2010) – is radically different, positing that that people like a given color to the degree that they like all of the "things" (objects, institutions, and abstract entities) that are associated with that color (Palmer & Schloss, 2010). They tested this account of average color preferences (Fig. 1B) for 48 subjects (Ss) by measuring the weighted affective valence estimates (WAVEs) for each of 32 colors (Fig. 1A). Four WAVE-related tasks were performed by four different groups of Ss: (a) rating how much they liked the 32 colors in Fig. 1A from "not at all" to "very much" on a continuous line-mark scale, (b) providing verbal descriptions of object-based associations to the same 32 colors, (c) rating how well a given color matched the characteristic color of a described object category, and (d) rating how much they liked the objects given only their verbal descriptions. They then defined the WAVE for each color (W_c) as the average of the products of the valence ratings for each object (v_o) times the match-score weightings for that object and that color (w_{co}): $W_c = (\Sigma(v_o * w_{co}))/n_c$, where n_c is the number of object categories associated with color c. 80% of the variance in the average preference data could be explained by average WAVE values for the 32 colors, with no free parameters. They also fit the cone-contrast model and the extended cone-contrast model to the same group data and found much lower agreement (21% and 37%, respectively) despite fitting additional free parameters (1 and 3 parameters, respectively).

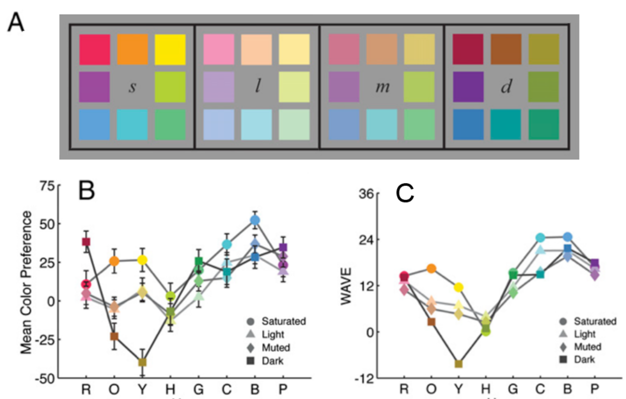

Figure 1. The 32 colors studied by Palmer and Schloss (2010) (A), the group-average preference ratings for those 32 colors (B), and the group-average WAVE values for the same 32 colors.

The group WAVEs in Fig. 1C reported by Palmer and Schloss (2010) were computed from average data over different Ss, but the relevant question for addressing IDs is whether WAVEs for individuals can also account for IDs in color preferences. To find

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DOI: 10.2352/ISSN.2470-1173.2016.16HVEI-113

out, Schloss, Hawthorne-Madell, and Palmer (2015) measured the personal WAVEs (P-WAVEs) for 48 different Ss for the same 32 colors by having each participant complete all four WAVE-related tasks in the order listed above. The group-average preference data were almost identical Palmer and Schloss's (2010) ($r(30) = .97$).

Because Ss rated their color preferences twice on different days, we were able to compare within-Ss variability to between-Ss variability in color preferences. Within-Ss correlations were quite high between the first and the second sessions for corresponding colors (average $r(30) = .85$), much higher than average between-Ss correlations (average $r(30) = .32$, $t(47) = 25.41$, $p < .001$). We thus confirmed the prior conclusion reported by McManus et al. (1981) that IDs in color preferences are both substantial and stable.

Next, we computed the P-WAVEs for each of the 32 colors for each of the 48 Ss using the standard set of 222 object categories reported by Palmer and Schloss (2010). The group-average of the P-WAVEs also closely replicated the previously measured group-averaged WAVEs ($r(30) = .94$, $t(30) = 15.09$, $p < .001$) and accounted for 76% of the variance in the present group-averaged color preferences. This amount is comparable to the 80% reported in Palmer and Schloss's (2010) original study. The within-Ss method of measuring P-WAVEs and color preferences in the present experiment is thus nearly indistinguishable from the between-Ss methods used previously.

Does the correlation between WAVEs and preferences observed in group averages also hold within individuals? To find out we first computed the correlation between each individual's 32 color preferences and his/her 32 P-WAVEs. The average within-S correlation ($r(30) = .55$) was significantly greater than zero ($t(47) = 16.02$, $p < .001$), thus indicating that the P-WAVEs reliably predict color preferences at the level of individuals.

If the EVT accounts for IDs in color preferences, then within-S preference/P-WAVE correlations should be stronger than between-S correlations. We tested this prediction by computing the average correlation between the P-WAVEs of each participant and the color preferences of every *other* participant. These between-S correlations averaged .41, significantly less than the average of the corresponding within-S correlations (.55, $t(47) = 7.87$, $p < .001$). IDs in color preferences thus have a reliable ecological component.

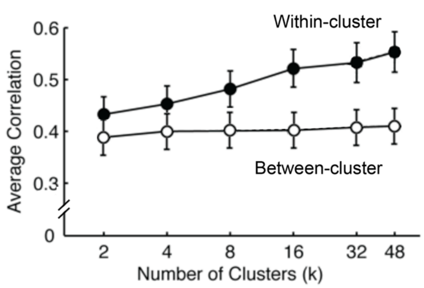

Figure 2. Average within-cluster versus between-cluster correlations for K-means clustering of k Ss based on color preference similarity.

The EVT further predicts that any partition of the 48 individuals into *n* groups based solely on similarities in their color preferences (i.e., higher average within-group correlations in color preferences than average between-group correlations) should exhibit stronger within-group preference/P-WAVE correlations than corresponding between-group correlations. We therefore conducted a *k*-means clustering analysis (Maechler et al., 2002) from $k = 2$ to 48 clusters, independent of P-WAVE data, and calculated the average within-cluster and between-cluster preference/P-WAVE correlations. Fig. 2 shows the average within-cluster and between-cluster correlations. Consistent with the EVT's predictions, the within-cluster correlations were higher than the between-cluster correlations ($F(1,47) = 227.72$, $p < .001$), and the difference increased as the number of clusters increases from $k = 2$ to the individual level ($k = 48$, $r = .55$), with a significant linear contrast ($F(1,47) = 19.23$, $p < .001$) that is not present for the between-S correlations ($F < 1$).

This is clear evidence that IDs in ecological valences of color-associated objects predict IDs in color preferences. Because these effects are purely correlational, however, it is possible that some portion of these effects are due to people's color preferences influencing their object preferences (e.g., I may like my favorite sweater precisely because it is my favorite shade of blue). Such effects are most likely to occur for artifacts that are available in a wide variety of colors, however, and such objects were explicitly excluded from the WAVE data we collected.

IDs in Preference for Color Pairs

Schloss and Palmer (2011) studied people's preferences for and perceived "harmony" of color combinations to test art theoretic proposals (e.g., Chevreul, 1839). The 992 possible pairs of the 32 colors in Fig. 1A were presented as 100px x 100px "figures" centered on 300px x 300px "grounds." Ss first rated every color pair for how much they *liked* the combination as a whole and later rated them for how *harmonious* they perceived them to be. Ss were told that "harmony" denoted "how well the colors *go together*" and that this was not necessarily the same as how much they *liked* the color pair. To clarify the difference between preference and harmony, they were given the following analogy: in music, some people like Mozart's music and others like Stravinsky's, even though everyone would agree that Mozart's music is more harmonious and Stravinsky's is more dissonant.

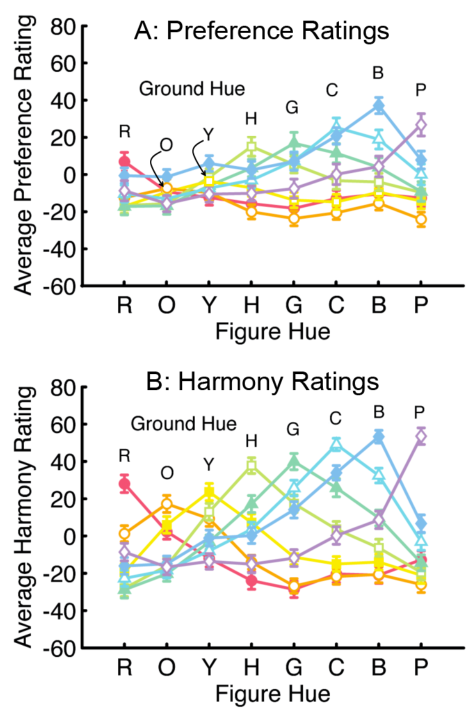

Figure 3. Group-average preference ratings (A) and harmony ratings (B) for color combinations by figure hue (x-axis) and ground hue (separate curves) of the pairs.

DOI: 10.2352/ISSN.2470-1173.2016.16HVEI-113

The group-average results for preference ratings of color pairs (Fig. 3A), averaged over saturation/lightness levels, show systematic patterns in the relation between the hues of the figure and ground. Most obviously, people tend to like color combinations that contain the same or very similar hues, such as light-blue against dark-blue or beige against brown. This effect is evident in the fact that the preference functions for each ground hue in Fig. 3 peak when the figural hue is the same as the ground hue and decrease as the figural hue becomes less similar. Another very general result is that people tend to like color combinations that contain single colors that they like: e.g., the hue functions are generally higher for cool hues (blues, greens, cyans, and purples) than for warm hues (reds, oranges, yellows, and chartreuses).

The group-average results for harmony ratings of color pairs (Fig. 3B) show the hue similarity effect even more clearly. This is because there is more agreement over people about which color combinations are harmonious than about which combinations are preferred: the correlations of each observer's harmony ratings with the group-average harmony ratings averaged +.51 and were reliably greater than the corresponding correlations of their preference ratings with the group average preference ratings, which averaged +.36 ($t(47) = 5.72$, $p < .001$).

The similarity of the harmony and preference ratings for two-color combinations suggests that there should be a high positive correlation between them. This is indeed the case when the group averages are compared for all 992 color combinations: $r = .79$ ($t(991) = 40.54$, $p < .001$). But is this also true at the individual level? To find out we examined IDs in these preference-for-harmony (PH) correlations, since every S provided complete ratings for both. IDs in these PH correlations were considerable, ranging from a high of +0.75 to a low of −0.03. To determine what might influence these correlations, we examined levels of PH for several different independent variables measured by questionnaire. The most important factor was an individual's level of formal training in color, which produced an inverted-U function ($F(1, 47) = 7.58$, $p < .01$), with highest PH among Ss with intermediate amounts of color training and lowest PH among Ss with either the little or a great deal of color training.

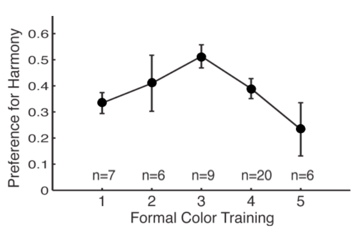

Figure 4. Preference-for-harmony correlations as a function of level of relevant training in color theory.

IDs in Preference for Harmony in 4 Domains

Palmer and Griscom (2013) then investigated PH further in several ways. They asked whether IDs in PH might be present in other perceptual domains, whether it might be a stable trait within individuals across different domains, and whether the range of PH correlations might be even broader for more diverse Ps.

We studied PH measures in four stimulus sets: 56 figure-ground color pairs (cf. Schloss & Palmer, 2011), 22 patterns of five black dots (cf. Palmer, 1991), 35 a single dot within a rectangle (cf. Palmer & Guidi, 2011), and 30 samples of solo piano music. Fig. 4 shows examples that include the most and least harmonious stimuli in the three visual domains. All stimuli were rated first for aesthetic preference and later for perceived harmony on a line-mark scale and transformed to range from -100 to +100. The "harmony" rating instructions for the color pairs were given in terms of the colors "going well together" (with the musical analogy, as stated above), for the dot patterns in terms of "figural simplicity and regularity," for framed dots in terms of "how well the dot fits within the rectangle," and for solo piano excerpts in terms of "musical harmony." Given the relation between PH and training in a relevant domain found by Schloss and Palmer (2011), we studied 30 psychology majors, 30 art practice majors, and 30 music majors to broaden the likely range of PH measures and levels of training in a relevant domain. We administered Schloss and Palmer's questionnaire for visual art training and a modified version of the Queens Questionnaire for Musical Background (Bhatara, et al., 2009) for musical training to all Ps. We also administered the 44-item Big Five Inventory (BFI; John et al., 1991) and the Sensation Seeking Scale (SSS; Zuckerman, 1979) as potential personality correlates of the present measures of PH.

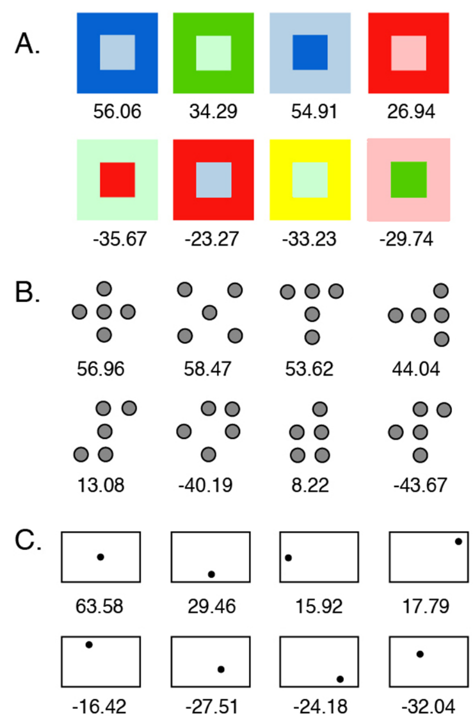

Figure 5. Example stimuli for color pairs (A), dot-pattern shapes (B), and framed dots. Numbers indicate group-average ratings of harmony for each stimulus on a scale from -100 to +100.

To analyze the results, we first computed the correlation between the group-average preference ratings and the group-average harmony ratings for each domain (Fig. 5, G-mean). We then computed the corresponding correlations for each individual S and found the mean (Fig. 5, S-mean), minimum (Fig. 5, Min.) and maximum correlations (Fig. 5, Max.) for the sample of 90 Ss.

The group-average correlations are all reliably positive, showing that people generally exhibit an overall bias for preferring harmonious over disharmonious stimuli in all four domains ($p < .05$ in each case). For framed dots and music, these PH biases are so strong (+.95 and +.97, respectively) that one is tempted to believe that perceived harmony and preference are essentially identical, but the corresponding correlations for individual Ss

DOI: 10.2352/ISSN.2470-1173.2016.16HVEI-113

demonstrate that this only approximately true. For instance, despite the +.95 group-average correlation for framed dots, the average of the individual correlations is only +.36, with a broad range from -.65 to +.87, both of which are highly significant in opposite directions (p < .001). Thus, we see that even when the group-average ratings of preference and harmony are very highly correlated, IDs reveal that some individuals show opposite correlations. This means that high group-average correlations in PH can be an artifact caused by averaging over Ss with large IDs.

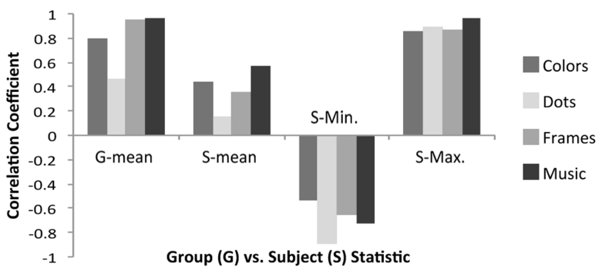

Figure 6. PH correlations by domains for group means, subject-means, subject-minima, and subject-maxima.

The next question we addressed is whether these IDs in PH are systematic within an individual. For example, if someone prefers harmonious color combinations to disharmonious ones (e.g., beige-on-brown over orange-on-purple), will they also tend to prefer harmonious music (e.g., Bach and Haydn over Stravinsky and Schoenberg)? To answer this question, we defined a difference-score measure of PH to avoid non-linearities in correlations. This measure (ΔPH_d) was the average unsigned difference over all stimuli in that domain: i.e., each participant's ΔPH score was calculated for a given domain (d) as 100 minus the average of the absolute values of the difference between that participant's preference rating (P_i) and harmony rating (H_i) for each stimulus (i) of the n_d items in that domain:

$$\Delta PH_d = 100 - 1/n_d\ (\Sigma\ |P_i - H_i|). \qquad (1)$$

We then computed the correlation between each Ss' ΔPH scores for each pair of domains. The results are shown in Table 1. In each case the correlations between the difference-score ΔPH measures were reliably positive, ranging from +.32 for music and dot-positions within a frame to +.60 for music and color combinations. These results suggest that PH is a stable ID between people that generalizes to some extent over these domains.

	Color	Shape	Frame	Music
Color	1			
Shape	.43**	1		
Frame	.37*	.39**	1	
Music	.60**	.46**	.32*	1

Table 1. Average correlations between difference-score ΔPH measures within individuals for each pair of the four studied domains.

A further issue concerns how PH is related to expertise and training in a relevant domain: i.e., how do the three groups of Ss (30 majors in each of psychology, art, and music) differ in terms of their ΔPH measures in the four domains? Fig. 6 shows the average ΔPH difference scores for the four domains separately for each of the three groups. Psychology majors (white bars) have the highest ΔPH scores in all four domains, as would be expected given that they tend to have no special expertise in either art or music. Art practice majors (dark gray bars) have the lowest ΔPH scores in the three visual domains and intermediate ΔPH scores in the musical domain. Music majors (light gray bars) have the lowest ΔPH scores in the musical domain and intermediate scores in the three visual domains. The clear pattern is that training and expertise in any aesthetic domain tends to lower ΔPH scores and that additional training and expertise in the most relevant domain tends to lower ΔPH scores even more.

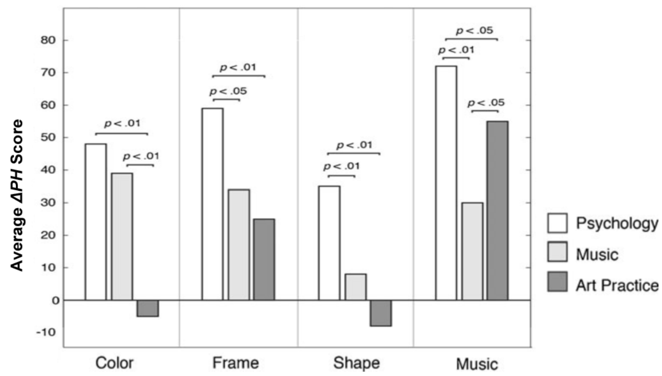

Figure 7. Average ΔPH scores separately for the four stimulus domains and the three educational majors.

To explore this idea further, we analyzed the self-report data about expertise in art and music. As expected, the art majors had more years of artistic training (5.23) than did the psychology (1.07) or music majors (1.42), who did not differ reliably from each other. Analogously, the music majors had more years of musical training (12.27) than did the psychology (5.03) or art majors (4.09), who did not differ reliably from each other. The results therefore suggest that the training reliably influences measures of PH.

We then performed a confirmatory factor analysis, beginning with a saturated model containing all possible connections and then trimmed those that were non-significant. The nine factors were years of art training, years of music training, sensation seeking score (SSS composite), the five BFI scores (Extraversion, Agreeableness, Conscientiousness, Neuroticism, and Openness to experience), and a single latent factor representing the individual's preference-for-harmony. The resulting model (Fig. 8) with 11 parameters suggests that PH is best represented as a single general factor that influences ΔPH scores in all four domains about equally. Art and music expertise have additional effects that lower ΔPH (i.e., negative weights) only in relevant domains: dot frame and shape for art training and music for musical training. The personality variables from the BFI and SSS were not included in the model because they did not predict significant variance.

Our interpretation of these findings is that people can and do differ substantially in their "aesthetic personalities" and that at least part of this is related to their degree of PH. We suspect that people who are attracted to and successful at aesthetic endeavors (e.g., art and music) tend to have lower PH than the rest of the population. Those who pursue further training and develop expertise in art and/or music tend to have even lower PH in their own specialty, probably because of specific experiences they have in their education. One factor is probably that greater exposure to the range of alternative stimuli leads them to become more easily bored with more harmonious examples and more engaged with less harmonious ones. Another factor is that they may receive specific training that shapes their preferences toward novelty, which tends

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DOI: 10.2352/ISSN.2470-1173.2016.16HVEI-113

to include less harmonious stimuli. This is to be expected, given novelty's extremely high value in the aesthetic worlds of art, music, and literature.

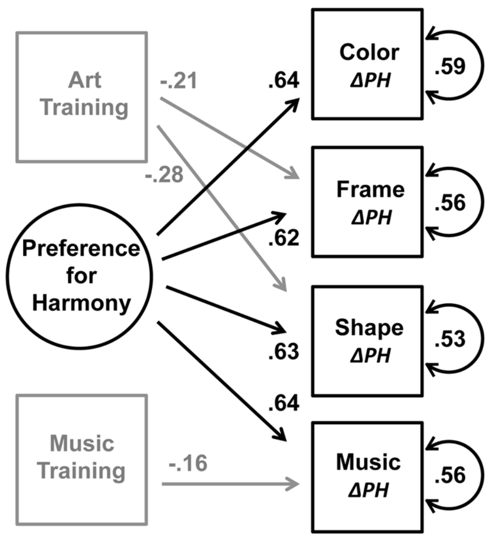

Figure 8. Trimmed structural equation model including only factors that explain significant variance (N = 90; goodness-of-fit = .97).

The present results can be related to Berlyne's (1971) hypothesis that the relation between stimulus complexity and hedonic value is an inverted U-shaped function that can be modified by experience and expertise (see Fig. 9). He famously suggested that people prefer stimuli that are moderately arousing, with those eliciting less-than-optimal arousal being disliked because they are perceived as boring and those that elicit more-than-optimal arousal being disliked because they are perceived as chaotic. The complexity of the stimuli that produce these arousal levels changes with experience and expertise in the relevant domain, however. People with little experience and expertise are optimally aroused by lower levels of complexity (Fig. 9, light-gray arousal function), finding even moderately complex stimuli chaotic and overly arousing. People with greater experience and expertise are optimally aroused by higher levels of complexity (Fig. 9, black arousal function), finding even moderately complex stimuli boring and not arousing enough.

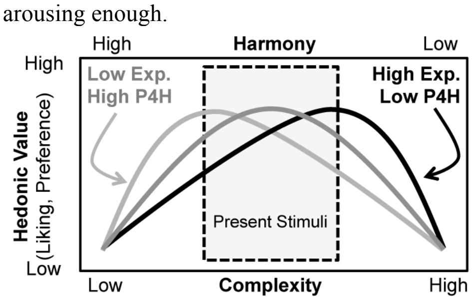

Figure 9. Berlyne's arousal theory of the relation between stimulus complexity and hedonic value (liking or preference judgements), as adapted to apply to the present results on IDs in PH.

Given that simple stimuli tend to be more harmonious and that complex stimuli tend to be less harmonious, the present findings can be translated into Berlyne's terms rather simply: people with high PH will tend to prefer simpler stimuli and those with low PH to prefer more complex stimuli. That does not mean that expertise and PH are the same thing, because PH appears to be an ID that is to some degree independent of experience and expertise – at least, as we measured them. If they were the same, the model would not have included the general latent variable of PH in addition to the variables for artistic and musical training.

It is also relatively easy to translate Berlyne's ideas about high versus low experience and expertise into low versus high PH, provided that the present stimuli fall generally in an intermediate range of complexity and harmony. As indicated in Fig. 9, the correlation between degree of harmony (top x-axis) and preference (y-axis) within that range will be positive for people with low experience and expertise and/or high PH (the portion of the light-gay line within the shaded box), neutral for people with moderate experience and expertise and/or moderate PH (the portion of the medium-gray line within the shaded box), and negative for people with high experience and expertise and/or low PH (the portion of the black line within the shaded box). The only difference is that these factors are inversely related: higher experience and expertise correspond to lower PH and vice versa.

There is some possibility that the trend toward PH might extend beyond perceptual preferences to social and interpersonal preferences. A person who prefers simple, harmonious color combinations and harmonious music might also tend to be more comfortable with harmonious personal interactions and more likely to avoid confrontational situations than another person, who prefers complex, disharmonious color combinations and music. We are pursuing the possibility in current research studies.

General Discussion

We have described three research projects concerned with understanding IDs in people's perceptual preferences. Is there any framework within which we can construct a unified and coherent account of all of them?

One possibility is the prevalent hypothesis in the preference literature of *processing fluency*: the proposal that the more quickly and easily people can process a stimulus, the more they will like it (e.g., Reber et al., 2004). Fluency theory provides a plausible explanation for the bias toward PH: people should generally like simple, harmonious stimuli more than complex, disharmonious ones, because the former are known to be processed more rapidly than the latter (Garner, 1974/2014). Nevertheless, fluency theory is hard pressed to provide a good account for why people like one color better than another, unless the preference functions conform to basic color terms or unique hues, which they do not (see Fig. 1B). Moreover, it is unclear why colors associated with more highly preferred objects should be processed faster than colors associated with less highly preferred objects, as we consistently find. A further problem with a fluency account is why people with negative PH correlations prefer complex, disharmonious stimuli to simple, harmonious ones, as occurred in Experiment 3. That would require fluency theory to posit that such individuals process complex stimuli more quickly and easily than simple ones.

The hypothesis we presently favor is that perceptual preferences are all related to what we will call "good fit to context" (GFC). In the case of individual colors, GFC means how well a given color fits the relevant context of "things that I perceive to be good for me," which ultimately boils down to "things I like." According to this hypothesis, a person will tend to like saturated blue to the extent that he/she likes all the things that are that shade of blue – clear sky, clean water, sapphires, blue hyacinths,

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Delftware, bluebirds, the uniforms and logos of certain sports teams and universities, etc. This proposal is just another way of framing a personal version of the EVT, one that is specific to an individual and general enough to include everything associated with the color in question. GFC thus seems able to explain color preferences, provided that the relevant context is "things I like."

What about people's preferences for color combinations, dot-pattern shapes, dot framing, and music? At the most general level, our results show that, when the relation between group averages of preference ratings and harmony ratings are analyzed, each domain shows a clear trend toward people preferring simple, harmonious stimuli in which their various parts fit together well: i.e., they produce a "good Gestalt." For some domains (e.g., music and dot framing), these correlations are almost perfect. The difficult question for the GFC hypothesis then is: how do these average tendencies toward the GFC hypothesis relate to the IDs we find in PH? Doesn't the GFC hypothesis imply that *everyone* should like more harmonious stimuli and therefore show positive PH correlations, with relatively small IDs between people? In contrast, the results of Experiment 3 show very large IDs, including some people for whom PH correlations are reliably negative. How can this happen if the GFC hypothesis is true?

We suspect that the crucial difference between individuals lies in the nature of the "relevant context" within which the stimuli are judged to fit. For relatively naïve individuals in a given domain, the relevant context may well be the simplicity/harmony of the structure of the target stimulus relative to that of the other stimuli being considered: e.g., how well does the target dot fit within this frame when it is in this position in the context of the other positions tested? When judged in this context, the dot clearly fits best in the frame's center where it produces maximal simplicity and symmetry. In these individuals, perceptual fluency may also provide good accounts of the data. In more sophisticated people, however, the relevant context is likely to be much more complex (e.g., Leder et al., 2004), including information about how novel and interesting the stimulus is, how well it conforms to more complex regularities (e.g., balanced asymmetry and the "rule of thirds"), or even how strongly it conflicts with simple regularities. This hypothesis is highly speculative, of course, and a good deal of further research would be required to support it empirically. It nevertheless seems a promising direction to pursue.

References

[1] Bhatara, A. K., Quintin, E., Heaton, P., Fombonne, E., & Levitin, D. J. (2009). The effect of music on social attribution in adolescents with autism spectrum disorders. *Child Neuropsychology*, *15*(4), 375-396.

[2] Berlyne, D. E. (1971). *Aesthetics and psychobiology*. New York, NY: Appleton-Century-Crofts.

[3] Brainard, D., Roorda, A., Yamauchi, Y., Calderone, J., Metha, A., Neitz, M., . . . Jacobs, G. (2000). Functional consequences of the relative numbers of L and M cones. *Journal of the Optical Society of America, 17*, 607-614.

[4] Chevreul, M. E. (1839). *The principles of harmony and contrast of colors*. Birren, F. (Ed.) (1987). New York: Van Nostrand Reinhold.

[5] Garner, W. R. (1974/2014). *The processing of information and structure*. Psychology Press.

[6] John, O. P., Donahue, E. M., & Kentle, R. L. (1991). The Big Five Inventory—Versions 4a and 54. Berkeley, CA: *University of California, Berkeley, Institute of Personality and Social Research*.

[7] Hurlbert, A. C., & Ling, Y. (2007). Biological components of sex differences in color preference. *Current Biology, 17*(16), 623-625.

[8] Leder, H., Belke, B., Oeberst, A., & Augustin, D. (2004). A model of aesthetic appreciation and aesthetic judgments. *British journal of psychology*, *95*(4), 489-508.

[9] Ling, Y., & Hurlbert, A. C. (2007). A new model for color preference: Universality and individuality. In *Color and Imaging Conference* (Vol. 2007, No. 1, pp. 8-11). Society for Imaging Science and Technology.

[10] McManus, I. C., Jones, A. L., & Cottrell, J. (1981). The aesthetics of colour. *Perception, 10*, 651-666.

[11] Ou, L.-C., Luo, M. R., Woodcock, A., & Wright, A. (2004a). A study of colour emotion and colour preference. Part III: Colour preference modeling. *Color Research & Application, 29*(5), 381-389.

[12] Palmer, S. E. (1991). Goodness, gestalt, groups, and garner: Local symmetry sub-groups as a theory of figural goodness. In G. Lockhead & J. Pomerantz (Eds.), *The perception of structure* (pp. 23–40). Washington, DC: American Psychological Association.

[13] Palmer, S. E., & Guidi, S. (2011). Mapping the perceptual structure of rectangles through goodness-of-fit ratings. *Perception*, 40, 1428–1446.

[14] Palmer, S. E., & Schloss, K. B. (2010). An ecological valence theory of human color preference. *Proceedings of the National Academy of Sciences, 107*(19), 8877-8882.

[15] Reber, R., Schwarz, N.,&Winkielman, P. (2004). Processing fluency and aesthetic pleasure: is beauty in the Perceiver's processing experience? Personality and Social Psychology Review, 8, 364–382.

[16] Schloss, K. B., Poggesi, R. M., & Palmer, S. E. (2011). Effects of university affiliation and "school spirit" on color preferences: Berkeley versus Stanford. *Psychonomic Bulletin & Review, 18*, 498-504.

[17] Schloss, K. B., Strauss, E. D., & Palmer, S. E. (2013). Object color preferences. *Color Research & Application, 38*(6), 393-411.

[18] Webster, M. A. (2016) Individual differences in color vision. In A. J. Elliot, M. D. Fairchild, & A. Franklin (Eds.), *Handbook of color psychology*. Cambridge, UK: Cambridge University Press.

[19] Zuckerman, M. (1979). Sensation seeking: Beyond the optimal level of arousal. Hillsdale, NJ: Erlbaum.

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