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The Impact of Depth of Aesthetic Processing and Visual-Feature Transformations on Recognition Memory for Artworks and Constructed Design Patterns

Tingting Wang[1], Jonathan S. Cant[2], and Gerald Cupchik[2]

Abstract

We conducted a study to examine how people perceptually encode and then recognize real artworks and constructed design patterns. We first manipulated depth of processing during an incidental perceptual encoding task (Phase 1) wherein participants made both affective/aesthetic and cognitive judgments. For painting stimuli, the contrast was between liking (yes/no) and a search for food in the paintings (present/absent). For design stimuli, the comparison was between liking and relative similarity of figure and ground in terms of color or texture. In Phase 2, we examined the effects of transforming visual features (i.e., color and texture) of the original stimuli on performance in a surprise recognition-memory task. Consistent with a *depth-of-processing* hypothesis, affective (i.e., liking) processing led to deeper perceptual encoding

[1]Research Center for Psychology and Special Education, National Institute of Education Sciences, Beijing, China
[2]Department of Psychology, University of Toronto Scarborough, Toronto, ON, Canada

Corresponding Author:
Jonathan S. Cant, Department of Psychology, University of Toronto Scarborough, 1265 Military Trail, Toronto, ON, Canada M1C 1A4.
Email: jonathan.cant@utoronto.ca

but, counter to our predictions, did not lead to better performance in the recognition-memory task. This benefit of aesthetic processing in the encoding phase was only observed with artworks but not with constructed design patterns that lacked salient semantic content. Moreover, texture transformations were discerned more accurately than color transformations across the different stimulus sets and tasks. This underscores the primacy of bottom-up processing of elementary stimulus features over top-down instructions to make affective judgments or search for semantic content.

Keywords
aesthetic perception, texture perception, depth of processing, recognition memory

In his 1901 *Dictionary of Philosophy and Psychology*, James Mark Baldwin (see Smith, 1901/1960) defined aesthetics as "the science of sensuous knowledge" (p. 20), following Baumgarten (1750). Art historians situate symbolically meaningful subject matter (i.e., iconography), along with the stylistic codes underlying *sensuous knowledge* in a cultural context (Panofsky, 1939; Schapiro, 1979). From a psychological perspective (Berlyne, 1971, 1974; Fechner, 1876; Moles, 1966), the subject matter of paintings (i.e., semantic information) emerges from organized physical-sensory qualities that define visual style (i.e., syntactic or esthetic information). In representational artworks, as in everyday life, physical-sensory qualities of style serve as affordances (Gibson, 1971) facilitating the identification of subject matter. By contrast, in highly expressive artworks, physical-sensory qualities are obtrusive and physiognomic (Werner, 1978), coloring our experience of subject matter and thereby lending it a metaphoric quality (Arnheim, 1954). Thus, haystacks or flowers painted with a soft Impressionist brush strokes engage the viewer and add warmth to the experience.

The processing requirements of aesthetic experience differ fundamentally from those evident in everyday reception. Whereas the pragmatic orientation of everyday life *discards* physical-sensory information en route to object identification (Craik & Lockhart, 1972), an *aesthetic attitude* (Hutcheson, 1725) examines artworks in such a way as to overcome this cognitive bias. In affirming the importance of deautomatizing the cognitive bias in perception, Shklovsky (1917/1988) argued that "the purpose of art is to impart the sensation of things as they are perceived and not as they are known" (p. 20). The goal of aesthetic reception is therefore to dishabituate the rush to object identification and attend to the structure of sensory qualities that underlie style and which are essential for having an aesthetic experience.

Consistent with the cognitive bias of current psychological theories of aesthetic processing, an emphasis has been placed on aesthetic fluency as a marker of competence at decoding art historical information embedded in artworks (Bullot & Reber, 2013). The goal is to achieve ease of processing by readily identifying features of subject matter and style (Reber, Schwarz, & Winkielman, 2004).This contrasts with Shklovsky's (1917/1988) point:

> The technique of art is to make things "unfamiliar" so as to increase the difficulty and length of perception because the process of aesthetic perception is an end in itself and must be prolonged. Art is a way of experiencing the artfulness of an object. The object is not important. (p. 20)

A balanced approach to aesthetic reception must take into account both cognitive and affective processes which are captured in the statement, "I know it was a good movie but I personally didn't like it all that much." Cognitive appraisals are focused on the work and can range from fluently identifying simple elements of subject matter to more complex stylistic codes associated with the artist, school, or cultural context within which a work was executed and appreciated. Affective processes similarly range from simple *feelings* of liking or attributions of *pleasingness* typically associated with style to complex *emotions* tied to personal or social meanings embedded in the subject matter.

A depth of processing model can be applied to both cognitive and affective dynamics. Superficial cognitive judgments may involve identifying aspects of subject matters or labeling style in an artwork. This is a self-terminating process which stops once the sought after information is attained. Deeper cognitive judgments go beyond iconography (the identification of symbolic elements of subject matter) to encompass iconology whereby a work is situated in the broader cultural context (Panofsky, 1939). As one can imagine, such deeper explorations tend to be open-ended and exhaustive because the ultimate meaning of an art, literary, or theatrical work can never be fully resolved.

Superficial affective responses can be accounted for by a principle of *affective covariation* whereby a person seeks out experiences, aesthetic or otherwise, that modulate transitory feelings typically associated with valence (pleasure) and arousal dimensions (Cupchik, 1995, 2016). More profound experiences are embodied in *emotional elaboration* whereby beholders are *moved* by the subject matter of artworks that are personally meaningful and elicit memories (Cupchik, 1995, 2016). This emotional encoding process encompasses the subject matter emerging from a structured stylistic background and binds the person to the work as a transitional object of personal attachment (Winnicott, 1965, 1971).

The study described here explored the depth of cognitive and affective processing and was conducted in accordance with Berlyne's (1974) account of *analytical* and *synthetic* research strategies (Berlyne, 1974). Whereas the *analytical* approach utilizes genuine artworks, the *synthetic* approach constructs stimuli that embody carefully chosen properties that evoke interest and encourage exploratory activity. Both kinds of materials were presented in a two-part experimental paradigm (in separate sessions). The genuine artworks were still-life paintings with compositions comprising vases or cups and saucers surrounded by plants and sometimes food. The artificial stimuli (i.e., constructed design patterns) involved foreground squares with straight or curved and colored lines (i.e., texture patterns) which either matched or contrasted with lines in the background.

In Phase 1 of each session, deeper affective and superficial cognitive judgments were compared in an incidental encoding, within-subjects, and repeated measures design. Participants viewed images with no knowledge that they would be tested on them in a subsequent recognition-memory task. For the genuine still-life paintings, affective *liking* judgments (yes or no) were contrasted with a cognitive search task which required the participant to determine the mere presence or absence of food in an artwork. For the constructed design patterns, participants had to indicate whether or not they *liked* the image and, in the cognitive condition, they judged whether or not the foreground and background areas shared similar color and line segment (i.e., texture) properties.

In Phase 2 of each session, which examined recognition memory, participants were exposed to the original stimuli as well as transformed variations and their task was to indicate whether the image had appeared in Part 1 (old) or not (new). For the paintings, the texture and color of the background in the painting had been transformed using Adobe Photoshop software. Thus, participants were exposed either to the original painting (the correct answer was old) or to images transformed in terms of texture, color, or both (the correct answer was new). The constructed design patterns were changed such that either the color or the texture (straight versus curved lines) differed from the original. Note that the recognition-memory task was designed to be purposely difficult, since participants initially encoded the stimuli with no knowledge that they would take part in a recognition-memory task in Phase 2, and old and new stimuli were constructed to differ in fairly subtle ways (see Figures 1 and 2). As such, we expected low, but reliable and above-chance, performance in Phase 2. Moreover, since previous studies demonstrating the influence of aesthetic processing on memory have used easy recognition tasks (Marzi & Viggiano, 2010), we were able to examine if the effects of aesthetic encoding on memory would be observed when using a purposely difficult recognition test.

Three different hypotheses were formed related to initial responses to the stimuli in the perceptual encoding phase and subsequent recognition accuracy. From a depth of processing perspective, participants should more accurately recognize images based on *liking* in comparison with cognitive judgments. The reason for this is that *liking* judgments were more exhaustive and encompassed both subject matter and style, whereas a simple search for the mere presence or absence of food is narrowly defined and focused only on subject matter. This leads to the *depth-of-processing* hypothesis that participants should spend more time on affective compared with cognitive judgments of paintings in the initial encoding phase and should be more accurate in Phase 2 at recognizing paintings first viewed from an affective *liking* set in comparison with a more cognitive set involving a search for food. Note that this hypothesis pertains only to the

Figure 1. An example of an original artwork (a), along with examples where color (b) and texture (c) have been transformed.

paintings and not to the constructed design patterns. This is because the paintings, but not the constructed design patterns, contain rich semantic details that can cue top-down knowledge for use in both initial encoding and retrieval during subsequent recognition. This leads to the *semantic-content* hypothesis that, in general, paintings should be processed faster and more accurately than constructed design patterns. The intersection of the depth-of-processing and semantic-content hypotheses states that effects of aesthetic (compared with cognitive) processing will only be observed with the paintings and not with the constructed design patterns.

A question then arises as to which transformation condition would result in a greater number of correct rejections of images as not having been seen in Phase 1. To answer this question, we return to research conducted in the 1970s involving multidimensional scaling judgments of paintings (Berlyne & Ogilvie, 1974; Cupchik, 1974) . Those studies demonstrated that the primary dimension underlying judgments of similarity between pairs of paintings was *hard-edge* versus *soft-edge*. This

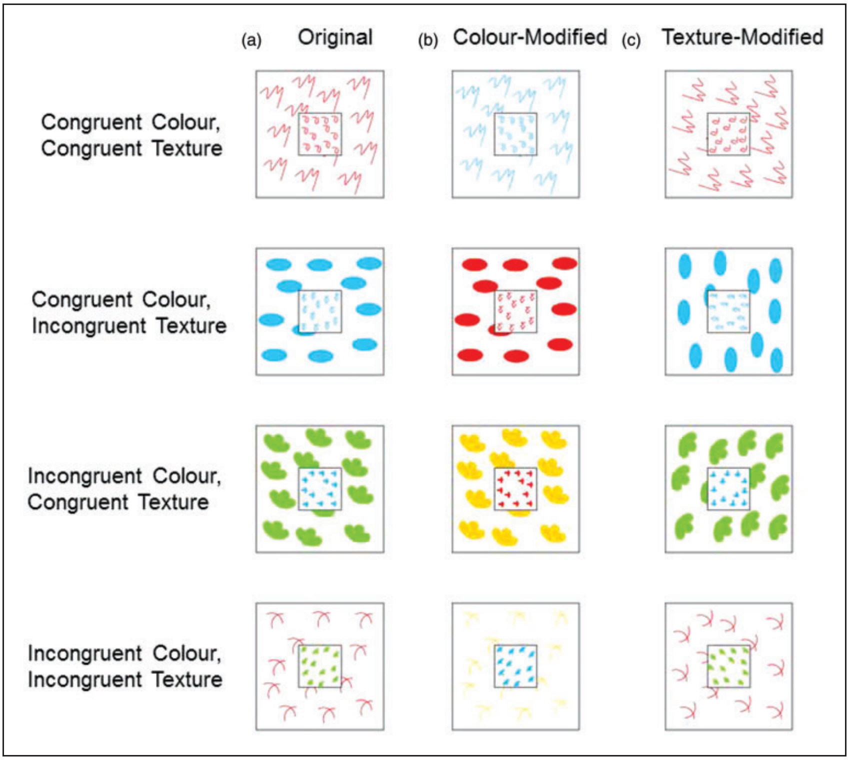

Figure 2. Examples of the constructed design patterns used including the original pattern (a), the color-transformed pattern (b), and the texture-transformed pattern (c). Examples of the four possible relationships (i.e., congruent or incongruent) between the colors and textures in the foreground and background regions of each pattern are shown in each row.

dimension had been formally described in art historical circles as a contrast between *linear* painting style, typical of Renaissance and Neo-Classical painting, and *painterly* style associated with Baroque or Impressionist painting (Wölfflin, 1915/1950). The contrast was also shown to underlie an *aesthetic-attitude* in a functional magnetic resonance imaging (fMRI) study of everyday perception versus aesthetic judgments (Cupchik, Vartanian, Crawley, & Mikulis, 2009). The role of edges in defining the emerging boundaries of colored areas in Abstract Expressionist paintings has also been demonstrated in a study of fractal properties of artworks by Jackson Pollock and the Quebec Automatistes (Mureika, Cupchik, & Dyer, 2004).

Decisions around color were considered to express the artist's unique viewpoint and played a secondary role in the multidimensional scaling studies (Berlyne & Ogilvie, 1974; Cupchik, 1974). This suggests a *visual-feature-transformation* hypothesis to the effect that participants should more accurately reject (see as new) paintings and constructed design patterns involving texture transformations in comparison with color transformations. The reason for this is that texture changes more closely reflect the fundamental dimension underlying image perception which involves the role of density gradients and lines in defining the boundaries around objects. Consistent with this idea, classic examinations of visual perception and cognition have suggested that texture, compared with color, may be more automatically linked with ground in Gestalt perception (Julesz, 1975). More recent neuroimaging findings have demonstrated that texture, but not color, is a primary feature represented in regions of cortex involved in visual scene perception (Cant & Xu, 2012). For these reasons, we predicted that participants would perform more accurately with the texture-transformed images compared with the color-transformed images (for both paintings and constructed design patterns) since the effect of low-level image manipulations may not be affected by whether or not high-level semantic information is present in the image.

Methods

Participants

Forty college-aged participants (28 female, 12 male; age range: 17–22 years; mean age = 18.08 years; five left-handed) from the University of Toronto Scarborough, Canada, were recruited and given course credit for their participation. Recruitment was restricted to individuals who had no previous training in art and had normal or corrected-to-normal visual acuity without color blindness. All participants took part in both sessions (for both the artwork and constructed design pattern sessions: Phase 1, which consisted of perceptual encoding, and Phase 2, which consisted of recognition memory, were run on the same day; see later for more details) and gave informed consent before participating in the study, which was approved by the University of Toronto Ethics Review Board. Participants completed each session on different days (the order of which was counterbalanced across participants), with the requirement that the second experimental session had to occur within five days of the first session.

An initial outlier analysis based on overall accuracy was conducted in each session (and phase) separately, to determine if any individual participants needed to be removed from the study based on low accuracy scores in either the initial encoding or recognition phase (i.e., we removed participants whose overall accuracy was less than two standard deviations from the grand mean for a particular condition, as these data were less reliable and difficult to interpret). This analysis resulted in five participants being eliminated from the analysis for the artwork session and five participants being eliminated from the analysis for the constructed design pattern session, which yielded a total number of 33 participants that were used in the full analysis combining data from both experimental sessions (since each session had three common outlier participants that were removed). Subsequent standard outlier analyses were conducted on the reaction time (RT) data for each remaining participant in each session separately (see Data Analysis section for specific details).

Finally, a separate group of 21 participants (12 female; 9 male; age range = 18–33 years; mean age = 20.62 years; three left-handed; recruited from the same community and using the same inclusion/exclusion criteria outlined earlier) took part in a pilot experiment to investigate the perceptual dissimilarity between the various image transformations and the original images used in each session (see Materials section for specific details).

Materials

Artworks. Sixty oil still-life artworks were selected from the archives of http://www.artcyclopedia.com. Artworks were resized to fit within a 500 by 500 pixels frame. These paintings will be referred to as original paintings. Next, each of these original paintings was transformed in various ways, using Adobe Photoshop CS3 software. Specifically, we altered the background of each painting in three different ways: only the background color was changed, only the background texture was changed, or both the background color and texture were changed, yielding a stimulus set of 240 unique images (60 original, 180 transformed; see Figure 1). We conducted a pilot experiment on a separate group of participants (none of whom took part in the main study) to investigate participants' perception of how noticeably different the modified artworks were from the originals. Participants were shown pairs of images (one original and one modified artwork) and were asked to rate the similarity of the two artworks by pressing 1 (*very different*) to 7 (*very similar*) on the computer keyboard. Importantly, results from this pilot experiment revealed that there were no significant differences observed among the above three versions (one-way repeated-measures analysis of variance [ANOVA] with modified version [color-modified, texture-modified, both-modified] as the single factor: $F(2, 40) = 0.91$, $p > .05$). This demonstrates that any differences in results between the color-modified, texture-modified, and both-modified images found in the main experiment are not likely to be attributed to differences in perceptual saliency between the three modified versions.

Constructed design patterns. Sixty-four constructed design images (i.e., containing mostly low-level visual information and no prominent semantic details) were created using Microsoft PowerPoint (Office Professional 2010; Redmond, WA, USA) and Adobe Photoshop CS3 software (Adobe Systems Inc., San Jose, CA, USA). Each image (measuring 500 by 500 pixels) contained a small square centered within a large square, and a collection of 11 to 12 objects was grouped and bound within each square (small objects within the small square and large objects within the large square; see Figure 2). Thus, each image contained two unique patterns that were arranged to create prominent foreground and background visual information. These patterns contained both color (i.e., red, blue, yellow, and green) and texture features (i.e., the objects comprising the patterns were made solely from straight or curved lines).

When comparing the foreground and background patterns across the 64 images (32 images were used in each of the two tasks conducted in Phase 1; see *Procedure* section), eight had congruent color and texture information, eight had congruent color and incongruent texture, eight had incongruent color and congruent texture, and eight had incongruent color and texture. The 64 original images were then transformed to create one set where only the color of the patterns differed (e.g., red patterns became blue patterns; green patterns became yellow patterns; all color combinations were equally represented), and one set where only the texture of the patterns differed (the original image was rotated 90° clockwise to create an image that contained a perceptually distinct texture pattern; see Figure 2), yielding a stimulus set of 192 unique images (64 original, 128 transformed).

We should note that these texture-modified images can also be referred to as pattern-modified or orientation-modified. In a general sense, we are agnostic to the precise term used. Regardless of the precise term used, it is true that rotating the original image 90° clockwise does not alter the perception of the color of the image but does produce a noticeable change to the appearance of the surfaces in the image (both foreground and background), which collectively contain a number of repeating elements that can vary in features such as size and orientation. Indeed, this description of surfaces is consistent with a well-established operational definition of texture derived using computational methods (Portilla & Simoncelli, 2000), and as such, we refer to these images as texture-modified throughout.

Results from the pilot experiment investigating participants' perception of how noticeably different the modified images were from the originals revealed that there were no significant differences in how similar/dissimilar participants rated the color-change and texture-change images from the originals (paired-samples t test: $t(20) = 0.35$, $p > .72$). This demonstrates that any differences in results between the color-change and texture-change images found in the main experiment are not likely to be attributed to differences in perceptual saliency between the images.

Apparatus

Participants sat at a desk in a darkened room with their head mounted in a head rest and stimuli were presented on an LCD monitor (1920 by 1080 pixels) located directly in front of them. Stimulus presentation was controlled by E-Prime Version 2.0 (Psychology Software Tools Inc., Sharpsburg, PA, USA). Stimuli were presented at the center of the computer screen, and the distance from the participant's eyes to the screen was approximately 40 cm. In the aesthetic task of Phase 1 (both sessions, i.e., artworks and constructed design patterns), participants indicated whether they liked or disliked the image presented on the screen by pressing either the F or J key on the computer keyboard with their left and right index fingers, respectively. In the search task of Phase 1 (artworks), participants decided whether or not the painting presented on the screen contained food by pressing either the F (there is food present in the artwork) or J (there is no food present) keys. In the low-level visual-discrimination task of Phase 1 (constructed design patterns), participants decided whether or not the patterns in the foreground and background of each image were the *same* or *different* (see Procedure section for more details), by pressing either the F (same) or J (different) keys, respectively.

In the recognition task of Phase 2 (both sessions), participants indicated whether the image presented on the screen was old (i.e., encountered in Phase 1) or new by pressing the F (old) or J (new) keys, respectively. The assignment of keyboard responses in all of these tasks was counterbalanced across participants. Finally, in the confidence task of Phase 2 (both sessions), participants used the computer keyboard to give a confidence rating of their response in each trial of the recognition task using a 5-point scale from 1 (*not at all confident*) to 5 (*extremely confident*). RT and accuracy measures were recorded by E-Prime software. A fixation cross was always present on the computer screen.

Procedure

The various tasks used in each session were divided across two distinct phases.

First phase of artwork session. Participants were first given verbal instruction about the nature of the stimuli and tasks that they would encounter in Phase 1 (but not Phase 2) and then were shown examples of the different stimuli and tasks on the computer screen. Importantly, participants were not informed that they would be taking part in a recognition task in the second phase of the experiment, which ensured that they would likely not use different mnemonic strategies to encode information in the aesthetic and search tasks encountered during this phase (all of the above also applies to the first phase of the constructed design pattern session).

The 60 original artworks were evenly split across the aesthetic and search tasks for each participant (i.e., 30 images used in each task; no image was repeated across tasks). Artworks were presented in 10 blocks of six trials each (five blocks for the aesthetic task and five blocks for the search task; one artwork presented on each trial). The assignment of artworks to each task, and the order of the tasks themselves, was counterbalanced across participants. In the aesthetic task, participants were instructed to examine the entire image carefully (in a subjective and engaged manner), trying to experience the feeling it evoked in them, and then to press F if they liked the image or J if they disliked it (the stimulus remained on the screen until response).

In the search task, participants were instructed to determine whether or not there was food present in the artwork, by pressing either the F (there is food present in the artwork) or J (there is no food present) keys. Each trial within each block (six trials per block) began with 0.5 s of central fixation and was then followed by the presentation of a single image, which was erased from the screen after 3.5 s, or the participant's response, whichever came first. Fixation periods were interleaved in between each block, which lasted for 2 s and instructed participants which task they would be performing in the ensuing block of trials.

First phase of constructed design pattern session. The 64 original constructed design patterns were evenly split across the aesthetic and low-level visual-discrimination tasks for each participant (i.e., 32 images used in each; no image was used in both tasks). Images were presented in eight blocks of eight trials each (four blocks for the aesthetic task, four blocks for the low-level visual-discrimination task; one image presented on each trial). The assignment of images to each task, and the order of the tasks themselves, was counterbalanced across participants. The details of the aesthetic task are identical to those described in the first phase of the artwork session (the only difference being the stimuli used). The low-level visual-discrimination task was split into two different versions (participants completed both versions, and their order of presentation was counterbalanced across participants). In both versions, participants were asked to evaluate whether the patterns in the foreground and the background of each image were the same or different, by pressing either the F (same) or J (different) keys, respectively.

In the texture-discrimination version, *same* referred to a situation where the patterns in the foreground and background of the image were both made of the same kinds of lines (either curved lines in foreground and background or straight lines in foreground and background; both possibilities were equally represented), and *different* referred to a situation where the patterns were made of different kinds of lines (either curved lines in foreground and straight lines in background or straight lines in foreground and curved lines in background; both possibilities were equally represented). In the color-discrimination version, *same* referred to a situation where the patterns in the foreground and background of the image shared the same color (e.g., both the foreground and background patterns were blue; all colors were equally represented), whereas different referred to a situation where the patterns did not share the same color (e.g., the foreground patterns were yellow and the background patterns were blue; all color combinations were equally represented). The timing and response parameters for each trial were identical to those described in Phase 1 of the artwork session.

Second phase of both sessions. Participants were first given verbal instruction about the nature of the stimuli and tasks that they would encounter in Phase 2, and after this instruction period, were then presented with 240 artworks in four blocks of 60 trials each, or 192 constructed design patterns in four blocks of 48 trials each. Rest periods were interleaved in between each block, which were self-paced and terminated when participants decided to start the next experimental block (by pressing S, for start, on the computer keyboard). Each block of trials in the artwork session contained equal numbers of original, color-modified, texture-modified trials, and both-modified trials (15 each), and their order of presentation was randomized in each block. Similarly, each block of trials in the constructed design pattern session contained equal numbers of original, color-modified, and texture-modified trials (16 each), and their order of presentation was randomized.

In both sessions, each trial began with 0.5 s of fixation, then a single artwork or constructed design pattern was presented for 3.5 s, which was followed by another fixation of 0.5 s, after which the participant was instructed to decide whether the artwork/pattern they just inspected was old (i.e., encountered in Phase 1) or new by pressing the F (old) or J (new) keys, respectively. Participants were informed that the modified artworks/patterns differed in a subtle way from the originals, and thus they should inspect each artwork/pattern carefully before deciding whether or not they encountered it in Phase 1 of the study. After they made this decision, participants were asked to rate how confident they were in their old/new judgment on a five-point scale from 1 (not at all confident) to 5 (extremely confident).

In summary, in Phase 2, we measured recognition accuracy on a test that was purposely designed to be quite difficult (participants were not informed that they would take part in a recognition test after Phase 1, and the differences between original and modified stimuli were quite subtle), and were interested in whether affective and aesthetic processing provides a deeper level of encoding compared with more pragmatic and cognitive processing (food/no-food judgments for artworks, and color/texture discriminations for constructed design patterns) which in turn might result in better recognition accuracy for items encoded in the aesthetic task (but only for artworks, which would speak to the role of semantic content in depth-of-processing models). Moreover, we measured participants' confidence in their recognition accuracy to determine if, in addition to affecting cognitive processes (i.e., memory), aesthetic processing also affects metacognitive processes (i.e., knowledge of how effective an item was encoded and subsequently remembered).

Data Analysis

Before data were fully analyzed, two analyses were performed to remove outlier participants. First, since the recognition task was quite difficult, and we expected some low accuracy scores, we did not set a specific threshold for accuracy, where if a given participant's score fell below this threshold, they would be removed from the study. Instead, we determined the average accuracy for all participants, and any individual who scored less than two standard deviations below this average was removed from the study (this was done separately for each task, phase, and session), as their data were considered less reliable and thus difficult to interpret. This resulted in five participants being removed from each session, yielding a total sample size of 33 participants (since each session had three common outlier participants that were removed). Second, following standard convention, individual trials that were two standard deviations above or below the mean RT for each task (done separately in each phase and session) were excluded from further analysis.

In both Phase 1 (incidental perceptual encoding) and Phase 2 (recognition memory), we combined the data from both sessions (i.e., artworks and constructed design patterns) to explore potential effects of depth-of-processing (affective vs. cognitive), visual-feature transformation (color vs. texture), and semantic content (artwork vs. constructed design pattern) inherent in our full experimental design. In Phase 1, this entailed collapsing the color- and texture-discrimination tasks together into a single cognitive task, since there was only one cognitive task utilized in the artwork session (i.e., search for food). We then conducted both repeated measures ANOVAs (e.g., Stimulus Type: artwork vs. constructed design pattern, by Task: aesthetic vs. cognitive) and paired-samples *t* tests ($\alpha = .05$; all two-tailed) to compare performance in the various tasks in Phase 1 (e.g., comparing RTs for aesthetic vs. cognitive judgments for both artworks and constructed design patterns). Moreover, we also examined differences in performance (using paired-samples *t* tests) in the color- and texture-discrimination tasks of the constructed design pattern session to reveal any dissociations inherent in the perceptual encoding of color and texture features for these images.

In order to combine the data from both sessions in Phase 2, we eliminated the both-modified (i.e., both color- and texture-modified) artwork condition, as this condition had no counterpart in the constructed design pattern session. We then conducted a number of different analyses (all $\alpha = .05$, two-tailed) on the full data set. In general, we conducted 2 (Stimulus Type: artwork vs. constructed design pattern) by 2 (Task: aesthetic vs. cognitive) by 3 (Image Transformation: original vs. color-modified vs. texture-modified) repeated measures ANOVAs to examine responses in both the recognition and confidence tasks in Phase 2. For all analyses, we conducted follow-up pairwise comparisons (all two-tailed) to examine differences across the levels of each particular factor (corrected for multiple comparisons using the Bonferroni procedure) (Bonferroni, 1936). All RT analyses are based on correct trials only. More details are provided in each relevant section.

Results

In two experimental sessions, we explored the effects of aesthetic versus pragmatic processing on the perception and recognition of real artworks and constructed design patterns, both of which contained prominent foreground and background information. In the first phase of each session, participants made aesthetic judgments (i.e., like/dislike) and nonaesthetic cognitive judgments relating to the presence versus absence of food in semantically rich artworks or the relationship between certain low-level visual features (i.e., same/different judgments of color and texture) in constructed design patterns that did not contain prominent semantic information. In the second phase of the session, participants took part in a surprise recognition task, wherein they were required to make old/new judgments of the images they encountered in Phase 1 (old), as well as color- and texture-modified versions of each old image (new).

First, based on the depth-of-processing hypothesis, we predicted that affective processing would lead to deeper initial perceptual encoding (evidenced by increased RTs to make aesthetic compared with cognitive judgments) and thus better performance in a subsequent recognition-memory task. Second, based on the semantic-content hypothesis, we predicted that this relationship would only be observed with artworks, and not constructed design patterns, since the latter lacked salient semantic content and thus may not benefit from deeper initial processing and more efficient perceptual encoding (Craik & Lockhart, 1972). Moreover, we predicted that in general artworks would be processed faster and more accurately compared with constructed design patterns. Third, since color and texture have been shown to be processed independently in object perception (Cant, Large, McCall, & Goodale, 2008), we predicted, in a visual-feature-transformation hypothesis, that the perceptual encoding of these features in Phase 1 may lead to dissociations in recognition performance in Phase 2. Specifically, consistent with the results of previous multidimensional scaling studies (Berlyne & Ogilvie, 1974; Cupchik, 1974), we predicted better performance with texture-transformed compared with color-transformed artworks and constructed design patterns.

Finally, after each response in the recognition task of Phase 2, we asked for participants' confidence of their recognition performance, to examine whether aesthetic processing, semantic content, and visual-feature transformations would influence participants' metacognitive ability to introspect on the accuracy of their memory. To the degree that aesthetic processing, semantic content, and the transformation of visual features (i.e., color and texture) influences recognition performance (as predicted earlier), we would expect it to also affect the metacognitive ability to reflect on the accuracy of that performance.

Results of the First Phase

An initial 2 (Stimulus Type: artwork vs. constructed design pattern) by 2 (Aesthetic Preference: like vs. dislike) repeated measures ANOVA investigating the number of like and dislike responses for artworks and constructed design patterns revealed a significant main effect of Stimulus Type ($F(1, 32) = 293.43$, $p < .001$), a marginally significant main effect of Aesthetic Preference

($F(1, 32) = 3.18$, $p = .08$), and a significant interaction between these factors ($F(1, 32) = 7.79$, $p < .01$). Post-hoc pairwise comparisons investigating this significant interaction revealed that participants made significantly more *like* ($M = 17.56$, $SE = 0.83$) than *dislike* ($M = 12.44$, $SE = 0.83$) responses for artworks ($t(32) = 3.09$, $p < .005$), but the number of like ($M = 15.58$, $SE = 0.82$) and dislike ($M = 16.06$, $SE = 0.82$) responses did not differ for the constructed design patterns ($t(32) = 0.30$, $p = .77$). The same analysis using RT as a dependent measure revealed a nonsignificant main effect of Stimulus Type ($F(1, 32) = 0.23$, $p = .63$), a marginally significant main effect of Aesthetic Preference ($F(1, 32) = 3.70$, $p = .06$), and a significant interaction ($F(1, 32) = 5.12$, $p < .05$). Post-hoc pairwise comparisons revealed results similar to those described earlier. Namely, when forming aesthetic preferences for the artworks, participants were faster to make like ($M = 1332.68$, $SE = 59.70$) compared with dislike responses ($M = 1447.33$, $SE = 54.47$; $t(32) = 3.39$, $p < .005$). This same difference was not significant when participants made their preferences for the constructed design patterns (like: $M = 1410.59$, $SE = 66.03$; dislike: $M = 1422.61$, $SE = 60.70$; $t(32) = 0.27$, $p = .79$). These results suggest that artworks containing rich semantic content were more effective at eliciting differences in aesthetic preferences across participants. Specifically, while, on average, participants liked more paintings than they disliked, artworks that were disliked may have been encoded at a deeper level (since it took longer to form these aesthetic preferences compared with like responses).

Participants performed well on the cognitive search task for artworks, scoring 90% overall ($SE = 0.01$). In contrast, participants found the low-level visual-discrimination task for constructed design patterns challenging, as overall accuracy (collapsing across color and texture judgments) was 69% ($SE = 0.01$). Interestingly, participants were significantly more accurate in their color judgments ($M = 71.78\%$, $SE = 0.02$) than their texture judgments ($M = 66.10\%$, $SE = 0.02$; $t(32) = 3.00$, $p < .005$), but this difference was not reflected in RTs (color: $M = 1255.34$, $SE = 48.00$; texture: $M = 1243.68$, $SE = 51.65$; $t(32) = 0.35$, $p = 0.73$). Importantly, accuracy rates for color and texture judgments were both significantly greater than chance performance of 50% (color: $t(32) = 13.71$, $p < .001$; texture: $t(32) = 8.29$, $p < .001$).

Finally, we conducted a 2 (Stimulus Type: artwork vs. constructed design pattern) by 2 (Task: aesthetic vs. cognitive) repeated measures ANOVA to investigate RT differences across the different stimuli and tasks. This analysis revealed a nonsignificant main effect of Stimulus Type ($F(1, 32) = 0.31$, $p = .58$), a significant main effect of Task ($F(1, 32) = 16.66$, $p < .001$), and a nonsignificant interaction between these factors ($F(1, 32) = 1.35$, $p = .25$). We next conducted pairwise comparisons to investigate our a priori depth-of-processing and semantic-content hypotheses. Critically, in accordance with our depth-of-processing hypothesis that aesthetic judgments would involve deeper processing than nonaesthetic judgments during encoding for artworks, RTs in the aesthetic task ($M = 1350.03$,

$SE = 57.74$) were significantly slower than those in the search task ($M = 1190.06$, $SE = 49.16$), $t(32) = 4.36$, $p < .001$. Moreover, consistent with our depth-of-processing and sematic-content hypotheses, participants' RTs in the aesthetic task ($M = 1338.81$, $SE = 62.31$) were not significantly different from those in the low-level visual-discrimination task ($M = 1249.51$, $SE = 46.91$) for constructed design patterns ($t(32) = 1.84$, $p = .08$; although note that this difference approached significance; see *Discussion* section for more details). Taken together, these results suggest that aesthetic judgments involved deeper processing than nonaesthetic judgments, but this only occurred for artworks which, compared with the constructed design patterns, contained more salient semantic details that could cue top-down knowledge during perceptual encoding.

Results of the Second Phase

The recognition task used in Phase 2 was quite difficult as (a) participants were not aware that they would be taking part in a recognition task after Phase 1 and thus were not likely to use different mnemonic strategies to encode the artworks and constructed design patterns in the different tasks used in Phase 1; and (b) the differences between old and new images were quite subtle (see Figures 1 and 2). As such, we expected overall accuracy (i.e., correctly labeling an original artwork/pattern as old and modified artwork/pattern as new) to be fairly low, which was indeed the case in both the aesthetic task (artworks: $M = 54.70\%$, $SE = 0.01$; constructed design patterns: $M = 58.40\%$, $SE = 0.01$) and nonaesthetic cognitive task (visual search for artworks: $M = 56.70\%$, $SE = 0.02$; low-level visual discrimination for design patterns: $M = 58.5\%$, $SE = 0.01$). Importantly, recognition accuracy in both tasks was significantly greater than chance performance of 50% (artwork aesthetic: $t(32) = 3.37$, $p < .005$; artwork search: $t(32) = 4.13$, $p < .001$; pattern aesthetic: $t(32) = 10.82$, $p < .001$; pattern low-level visual discrimination: $t(32) = 10.33$, $p < .001$), indicating that, despite being fairly low, participants' performance on a surprise recognition test was reliable and cannot be attributed to mere guessing.

Since this demonstrated that there was likely reliable information to be found in participants' recognition performance (as predicted), we performed a number of different analyses, outlined below, to further investigate the recognition and confidence ratings of the original and modified artworks and constructed design patterns encountered in Phase 2. That is, we conducted separate 2 (Stimulus Type: artworks vs. constructed design patterns) by 2 (Task: aesthetic vs. cognitive) by 3 (Image Transformation: original vs. color-modified vs. texture-modified) repeated measures ANOVAs on participants' recognition accuracy, recognition RTs, and confidence ratings of recognition responses to investigate our various hypotheses. Specifically, investigating the main effect of Task (and associated interactions) allowed us to examine the depth-of-processing hypothesis, investigating the main effect of Stimulus Type (and associated interactions) allowed us to examine the semantic-content hypothesis, and investigating the main effect of Image Transformation (and associated interactions) allowed us to examine the visual-feature-transformation hypothesis.

Recognition Performance for Artworks and Constructed Design Patterns

Accuracy. The analysis of recognition accuracy revealed marginally significant main effects of Stimulus Type ($F(1, 32) = 3.15$, $p = .09$) and Task ($F(1, 32) = 2.94$, $p = .10$), and a significant main effect of Image Transformation ($F(2, 64) = 20.40$, $p < .001$), which was qualified by a significant Stimulus Type-by-Image Transformation interaction ($F(2, 64) = 26.41$, $p < .001$; all other interactions were nonsignificant; all $Fs < 1.40$, all $ps > .25$). In order to investigate our a priori depth-of-processing and semantic-content hypotheses, we conducted post-hoc pairwise comparisons to investigate the Stimulus Type-by-Task interaction in greater detail. Contrary to our depth-of-processing prediction, the deeper aesthetic compared with cognitive encoding of artworks we observed in Phase 1 did not lead to better recognition performance in Phase 2. In fact, participants were slightly more accurate (i.e., correctly labeling an original artwork as old and modified artwork as new) with paintings encountered in the cognitive task compared with the aesthetic task, and this slight difference approached, but did not reach, significance ($t(32) = 1.73$, $p = .08$). Partially consistent with our semantic-content prediction, participants were equally accurate at recognizing constructed design patterns that were encountered in either the aesthetic preference or cognitive tasks ($t(32) = 0.10$, $p = .90$; see Table 1 and Figure 3). In other words, the lack of salient semantic content in these patterns did not enable deeper perceptual encoding of them in the aesthetic preference task in Phase 1, which in turn did not lead to differences in recognition accuracy in Phase 2 between patterns encoded using aesthetic versus nonaesthetic cognitive-processing styles. We should note, however, that contrary to our predictions, participants were not more accurate overall at recognizing artworks compared with constructed design patterns (in fact, performance was slightly better with the constructed design patterns, but this difference did not reach significance; see main effect of Stimulus Type above and Figure 3).

To investigate our visual-feature-transformation hypothesis, we conducted post-hoc pairwise comparisons to investigate the significant Stimulus Type by Image Transformation interaction in greater detail. For artworks, we found that accuracy was lowest for the color-modified paintings (compared with original paintings: $t(32) = 4.09$, $p < .001$; compared with texture-modified paintings: $t(32) = 6.06$, $p < .001$), and that accuracy for the original artworks did not differ from the accuracy for the texture-modified artworks ($t(32) = 0.47$, $p = .99$; see Table 1 and Figure 3). In contrast, for constructed design patterns, we found that accuracy was lowest for the original patterns (compare with

Table 1. Recognition and Confidence Measures in the Aesthetic and Cognitive Tasks for Both Image Types.

Task	Image	Recognition accuracy (% correct)		RTs (ms)		Confidence Rating (1–5)	
		M	*SE*	*M*	*SE*	*M*	*SE*
Artworks							
Aesthetic	Original	61.1	2.30	661.00	60.68	3.69	0.09
	Color-modified	41.8	2.90	670.35	59.00	3.71	0.10
	Texture-modified	61.3	3.30	661.01	63.39	3.81	0.08
Search	Original	60.9	2.30	662.02	56.07	3.63	0.10
	Color-modified	44.8	2.80	725.70	74.56	3.65	0.11
	Texture-modified	64.2	3.30	635.43	54.68	3.83	0.10
Constructed design patterns							
Aesthetic	Original	48.1	2.10	791.21	65.08	3.48	0.09
	Color-modified	56.8	2.10	866.07	68.57	3.50	0.11
	Texture-modified	70.3	1.40	720.59	43.57	3.70	0.11
Low-level visual-discrimination	Original	45.8	2.20	802.50	72.00	3.47	0.10
	Color-modified	59.6	1.90	827.22	59.90	3.56	0.12
	Texture-modified	70.2	2.40	768.63	57.05	3.62	0.10

RT = reaction time; ms = milliseconds; *M* = mean; *SE* = standard error.

color-modified patterns: $t(32)– = 3.0$, $p < .005$; compared with texture-modified patterns: $t(32) = 7.48$, $p < .001$) and highest for the texture-modified patterns (compared with color-modified patterns: $t(32) = 6.67$, $p < .001$).

Taken together, these results provide support for our visual-feature-transformation hypothesis that participants would perform more accurately with texture-transformed compared with color-transformed artworks and constructed design patterns (since for both stimulus types, participants were more accurate at labeling texture-modified images as new compared with color-modified images). Interestingly, performance with the original images (i.e., correctly labeling an original stimulus as old) was quite different across the two stimulus types: Participants performed fairly well with original artworks but quite poorly with original constructed design patterns. Perhaps this difference is relevant to both our semantic-content and visual-feature-transformation hypotheses and speaks to the nature of top-down versus bottom-up processing in perceptual encoding and recognition. Specifically, the salient top-down semantic content in the artworks led to fairly efficient perceptual encoding and subsequent recognition. However, the lack of such salient semantic features in the constructed design patterns led to a different type of perceptual encoding for these images. Namely, these patterns were encoded by focusing on

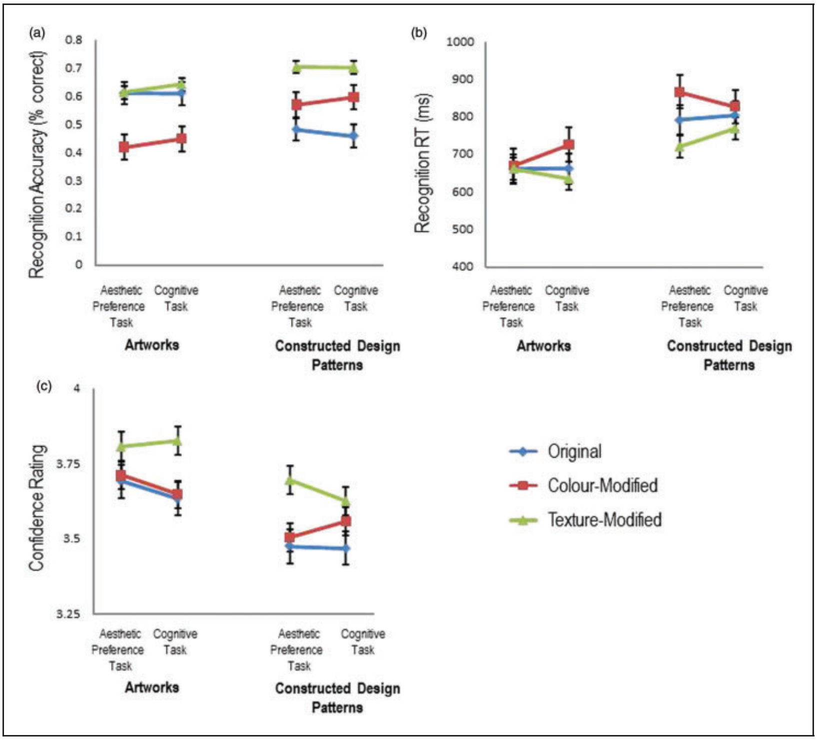

Figure 3. Recognition accuracy (a), recognition reaction time (b), and confidence ratings (c) in Phase 2 for original and transformed artworks and constructed design patterns, in both the aesthetic and cognitive tasks. (Error bars represent standard errors of the mean).

bottom-up image features, and these features were utilized in subsequent recognition. Indeed, the cognitive task in Phase 1 required participants to explicitly make color and texture judgments of the constructed design patterns, but this was not the case in the cognitive task in Phase 1 for the artworks (instead, participants searched for the presence vs. absence of discrete whole objects, i.e., food).

Finally, the pattern of results described earlier (i.e., better performance with old and texture-modified compared with color-modified artworks, and better performance with new compared with old constructed design patterns) was consistent with the results observed when comparing the recognition of each type of artwork and pattern to chance performance of 50% (original artwork: significantly greater than chance, $t(32) = 5.51$, $p < .001$; color-modified artwork: significantly lower than chance, $t(32)– = –2.55$, $p < .05$; texture-modified artwork: significantly greater than chance, $t(32) = 4.12$, $p < .01$; original pattern: marginally significantly lower than chance, $t(31) = 1.83$, $p = .08$; color-modified pattern:

significantly greater than chance, $t(32) = 4.59$, $p < .001$; texture-modified artwork: significantly greater than chance, $t(32) = 11.70$, $p < .001$).

In summary, examining participants' recognition accuracy in Phase 2 did not provide support for our depth-of-processing hypothesis, provided partial support for our semantic-content hypothesis, and provided full support for our visual-feature-transformation hypothesis.

RT. The analysis of recognition RTs (for correct trials only) revealed significant main effects of Stimulus Type ($F(1, 32) = 5.86$, $p < .05$) and Image Transformation ($F(1, 32) = 4.22$, $p < .05$), and a nonsignificant main effect of Task ($F(1, 32) = 0.18$, $p = .68$). Since all interactions were nonsignificant (all $Fs < 1.94$, all $ps > .15$), we focused our analysis on the significant main effects described earlier (the nonsignificant main effect of Task, and lack of interactions with this factor, demonstrates that speed of processing does not differentiate between the tasks and stimuli that we used; thus, similar to the accuracy results in Phase 2, the RT results do not support our depth-of-processing hypothesis). The significant main effect of Stimulus Type revealed that participants were faster at correctly recognizing artworks ($M = 669.25$, $SE = 57.22$) compared with constructed design patterns ($M = 796.04$, $SE = 51.82$), which provides some support for the semantic-content hypothesis. The significant main effect of Image Transformation revealed that RTs for texture-modified stimuli were significantly faster than RTs for color-modified stimuli ($t(32) = 3.32$, $p < .01$; no other comparison reached significance: both ts < 1.75, both ps $> .26$; see Table 1 and Figure 3), which is consistent with the accuracy results described earlier and provides supportive evidence for our visual-feature-transformation hypothesis as measured by RTs.

Confidence Measures for Artworks and Constructed Design Patterns

Confidence ratings. Similar to the results with recognition RT, the analysis of participants' confidence ratings of their recognition performance (based on correct trials only) revealed significant main effects of Stimulus Type ($F(1, 32) = 6.95$, $p < .05$) and Image Transformation ($F(1, 32) = 8.31$, $p < .001$), but a nonsignificant main effect of Task ($F(1, 32) = 0.63$, $p = .43$) and no significant interactions amongst the three factors (all $Fs < 2.36$, all $ps > .10$). The nonsignificant main effect of Task (and lack of significant interactions with this factor) reveals that our depth-of-processing hypothesis was not supported when examining participants' metacognitive ability to reflect on the confidence of their recognition performance. However, the significant main effect of Stimulus Type revealed that participants were more confident overall when reflecting on their recognition performance with artworks compared with constructed design patterns (see Table 1 and Figure 3). Together with the recognition RT results described earlier, these results suggest that differences in the semantic content of visual images can lead to differences in both cognitive (i.e., faster recognition for images with salient semantic features) and meta-cognitive (i.e., increased confidence of recognition accuracy for images with salient semantic features) processing, and provide some support for our semantic-content hypothesis.

Post-hoc pairwise comparisons revealed that the significant main effect of Image Transformation was driven by higher confidence ratings for texture-modified stimuli (both artworks and constructed design patterns) compared with both original ($t(32) = 3.56$, $p < .005$) and color-modified stimuli ($t(32) = 3.33$, $p < .01$; confidence ratings for original and color-modified stimuli did not differ: $t(32) = 0.84$, $p = .99$). Taken together with the findings from the accuracy analysis, these results reveal that participants had the most difficulty labeling color-transformed paintings as new and original constructed design patterns as old, and these difficulties were accompanied by lower confidence ratings when actually making correct rejections of color-transformed paintings and correctly remembering original constructed design patterns. Moreover, these results reveal that modifications to the texture of an artwork or constructed design pattern had stronger effects on an individual's cognitive (i.e., recognition accuracy and RT) and metacognitive (i.e., confidence in recognition performance) processing capabilities compared with modifications to the color of the same original image, and provide strong support, across multiple dependent measures, for our visual-feature-transformation hypothesis concerning the superiority of texture processing which was based primarily on multidimensional scaling studies showing that color is not the fundamental dimension underlying the perception of artwork (Berlyne & Ogilvie, 1974; Cupchik, 1974).

Discussion

The present study explored the effects of aesthetic processing, semantic content, and visual-feature transformation on cognitive (i.e., recognition) and metacognitive (i.e., introspection about the confidence of one's memory) processes for both real artworks and constructed design patterns. Our depth-of-processing hypothesis was supported in Phase 1 of the study, in that participants perceptually encoded artworks at a deeper level in the aesthetic preference task compared with the cognitive search task (evidence by longer RTs in the former task). This effect was not observed for the constructed design patterns in Phase 1, which provided some support for our semantic-content hypothesis (i.e., images with little-to-no salient semantic content would not benefit from deeper perceptual encoding in the aesthetic preference compared with the cognitive task).

In contrast, in Phase 2, we failed to find evidence for strong effects of aesthetic processing on recognition performance and confidence ratings. That is, our depth-of-processing hypothesis was not supported as there were no differences between artworks encountered in the aesthetic versus the cognitive tasks across all measures examined in Phase 2 (i.e., recognition accuracy, recognition RT, and confidence ratings). We also observed no differences in cognitive and metacognitive measures for constructed design patterns across the aesthetic and cognitive tasks, but we expected this based on the lack of salient semantic features in the constructed design patterns. The fact that we did not find this effect with semantically rich artworks, however, runs counter to both our depth-of-processing and semantic-content hypotheses. Nevertheless, we did observe some support for the latter hypothesis, as we found faster recognition accuracy and higher confidence ratings of recognition performance for the artworks (compared with the constructed design patterns) in Phase 2. While it is true that low-level visual features (e.g., spatial frequency, brightness) were not completely equated across both types of stimuli, the fact that both artworks and constructed design patterns contained low-level visual features but only the artworks contained high-level semantic features makes it likely that this RT difference is explained by differences in semantic content between the two stimulus types.

Finally, our visual-feature-transformation hypothesis regarding the dominance of texture compared with color processing was supported by both cognitive (recognition accuracy, RT) and metacognitive (confidence ratings) measures. For both artworks and constructed design patterns, participants were more accurate with texture-modified compared with color-modified stimuli and were more confident in their (correct) responses to the former type of image transformation. Taken together, these results reveal strong support for the visual-feature-transformation hypothesis, partial support for the semantic-content hypothesis, and little-to-no support for the depth-of-processing hypothesis (with the exception of the results in Phase 1 for artworks).

Comparing Color Versus Texture Processing

The results from this study demonstrate a clear advantage for texture over color in the processing of both artworks and constructed design patterns, reflected in both cognitive (i.e., recognition accuracy and RT) and metacognitive (i.e., confidence ratings) measures. Taken together, how can we explain the dissociation in performance between the texture-modified and color-modified images across the two different types of stimuli? Our results are consistent with the idea that texture and color can be processed independently in visual perception (i.e., participants can easily ignore changes in color while attending to changes in texture and vice versa; (Cant et al., 2008)), and that their processing recruits different regions of the visual system, with color being processed in regions of early visual cortex (e.g., V1/V2, V4; for review, see Gegenfurtner, 2003), and texture (as a route to object identity) being processed in higher level regions (of course, when texture is used for simple image segmentation, it is likely processed in lower level visual regions; see Bergen & Adelson, 1988), overlapping the collateral sulcus in parahippocampal cortex (Cant & Goodale, 2007, 2011) . It is reasonable to suppose that if color and texture were not processed independently (and were processed jointly within the same brain regions), then we might not have observed a dissociation in performance between color-modified and texture-modified images. In other words, if color and texture were processed interactively, then attention (either implicit or explicit) to one feature (e.g., texture) during perceptual encoding in Phase 1 would also help in the encoding of the second feature (e.g., color), and this in turn may lead to equivalent recognition performance for the two features in Phase 2 of the experiment. This is not what we observed. Thus, the fact that color and texture can be processed independently, and are processed in separate cortical regions, may explain why we observed a dissociation between these two features, reflected in both cognitive and metacognitive measures. But while this may explain the dissociation observed between color and texture processing, it does not explain why participants consistently performed better with texture-modified images, compared with color-modified images.

We do not believe that simple differences in perceptual saliency between the texture-modified and color-modified images (compared with the original images) can account for better recognition performance with texture-modified images in Phase 2 (with both artworks and constructed design patterns), since a pilot experiment investigating the perceptual dissimilarity between the various image transformations and the original images used in each session revealed that participants rated color- and texture-modified images as equally similar/dissimilar to the original images (for both types of stimuli). Moreover, we do not believe that difficulties in explicit perceptual encoding of color compared with texture in Phase 1 (for constructed-design patterns) can account for the superiority of texture in Phase 2, since participants actually performed better in the color-discrimination task in Phase 1 of the constructed-design pattern session.

It is certainly possible, however, that lower performance in the texture-discrimination task in Phase 1 of the constructed-design pattern session led to increased levels of attention while performing this task, since participants may have formed an online subjective impression that the texture task was more difficult than the color task, and hence focused more while engaged in this task. We cannot discount this possibility with our present results, but we would note that it applies more directly to the results using the constructed design patterns, since this session involved explicit encoding of color and texture in Phase 1, whereas the artwork session used a cognitive task (i.e., searching for food in the artworks) that did not explicitly examine color and texture perception in Phase 1 (but it is likely that color and texture were implicitly processed in this task, as these features can be processed pre-attentively in visual search tasks; see Treisman & Gelade, 1980). Yet in both sessions, which used completely different images (real artworks vs. constructed design patterns) and different tasks (visual search for food vs. visual discrimination of texture and color), we observed better performance with texture-modified images.

Thus, perhaps the superiority of texture over color observed in the present study speaks to a general processing difference between the perception and recognition of textures compared with colors. It may not be the case that this processing difference is entirely explained by a simple low-level versus high-level difference between the processing of color and texture, as the constructed design patterns contained colors and textures that were not associated with any salient semantic features, whereas the colors and textures of the artworks did, yet we observed superiority of texture recognition for both stimulus types. Instead, it may be the case that, compared with color, texture is more automatically linked with ground in Gestalt perception (Julesz, 1975), and thus global changes to the texture of an image (regardless of what type of image it is) are easier to classify as new compared with global changes to its color (note, this is not to imply that texture changes are more perceptually salient than color changes; see earlier).

Moreover, through a lifetime of experience, we may have developed perceptual priors which dictate that the color of objects and surfaces are more likely to undergo variation over time (e.g., with reference to Figure 1, the color of different tablecloths used, the color of paint on walls, the color of fruit) compared with the texture of objects and surfaces. As such, the visual system may be more likely to flag variation in texture, which would in turn lead to better recognition with texture-modified images. These ideas are speculative, of course (and are not necessarily mutually exclusive), and should be tested directly in future experiments. The contribution of the results of the present study is the suggestion that a general processing difference exists between color and texture perception and recognition in both aesthetic and nonaesthetic processing domains, and this can lead to the development of a number of novel and testable hypotheses regarding the superiority of texture processing across a number of different experimental tasks, stimulus sets, and psychological states.

Examining the Effects of Aesthetic Processing on Cognition and Metacognition

The results from the current study revealed that aesthetic appreciation did not influence cognitive or metacognitive processing of real artworks and constructed design patterns. While it is true that, as predicted in our depth-of-processing hypothesis, aesthetic encoding involved deeper processing than nonaesthetic encoding for artworks (evidenced by longer RTs in the aesthetic versus cognitive task in Phase 1), our recognition/retrieval results suggest that this deeper aesthetic encoding of real artworks did not confer benefits upon subsequent cognitive and metacognitive performance in Phase 2. What might explain the lack of support for our depth-of-processing hypothesis?

Previous studies demonstrating the influence of aesthetic processing on memory have used fairly easy recognition tasks (Marzi & Viggiano, 2010), and in this study we used a purposely difficult recognition test to examine if the effects of aesthetic encoding on memory would generalize to situations with increased task difficulty. Perhaps the fairly difficult recognition test used here prevented earlier aesthetic processing in Phase 1 from facilitating recognition performance in Phase 2. Thus, one may conclude that the benefits of aesthetic processing on cognition may be easier to observe when an individual is not engaged in a quite difficult cognitive operation. Future studies should thus manipulate task difficulty directly to examine this possibility in greater detail.

Image-based Versus Task-based Manipulations

The results of this study reveal the primacy of bottom-up (image-based) processing of elementary stimulus features related to color or texture over top-down (task-based) instructions to engage in affective (i.e., liking) processing, to search for food in artworks containing rich semantic content, and to make discriminations of simple visual features in constructed design patterns containing little-to-no semantic features. While participants spent more time making liking decisions in comparison with search efforts, this did not translate into greater recognition accuracy in Phase 2 of the study. This underscores the hierarchical nature of processing for aesthetic experience and scene perception. Accordingly, the extraction of semantic meaning is secondary to a more elementary analysis of the building blocks of a scene or visual array. It is also worth considering that decisions regarding the liking of a painting are not as deep as those that shape attachments to personally meaningful artworks (Cupchik, 2016). Such deeper attachments would lead to stronger Gestalts which might enhance recognition memory.

Conclusions

In conclusion, the results of the present study revealed an effect of aesthetic processing on perceptual encoding of artworks containing salient semantic features and complex objects, but not of constructed design patterns that were composed of mostly low-level visual features and contained little-to-no semantic content. These findings are partially consistent with our depth-of-processing and semantic-content hypotheses, but, inconsistent with our depth-of-processing hypothesis, the deeper processing for artworks did not manifest into improvements in recognition accuracy and confidence ratings of recognition performance for these stimuli (possibly because of the difficulty of the recognition task or the lack of personal attachment to the artworks or both).

Finally, consistent with our visual-feature-transformation hypothesis, we observed superiority of texture processing over color processing across the different stimulus sets and tasks used in this study, which speaks to the existence of a general processing difference between texture and color perception and recognition in both aesthetic and nonaesthetic processing domains. Taken together, these results hold strong implications for neural models of aesthetic versus cognitive processing, for increasing our understanding of the interactions between aesthetic processing and both cognitive and metacognitive processes, and for improving our understanding of the relationship between the perceptual encoding of various elementary visual features and memory retrieval.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Author Biographies

Tingting Wang completed her PhD in Psychology at South China Normal University and University of Toronto, and has been an Assistant Research Scientist in the Research Centre for Psychology and Special Education, at China National Institute of Education Sciences since 2014. Her research interests include neuroaesthetics and art therapy.

Jonathan S. Cant completed his PhD in Neuroscience at Western University in 2009, conducted a Postdoctoral Fellowship at the Vision Sciences Laboratory at Harvard University from 2009 to 2012, and has been an Assistant Professor in the department of Psychology at the University of Toronto Scarborough since 2012. His research interests include studying how different visual features (e.g., shape, texture) contribute to the perception of high-level stimulus categories (e.g., objects, scenes).

Gerald Cupchik is a Professor of Psychology at the University of Toronto since 1974. In his research on emotion and aesthetics he seeks to build a bridge between science and the humanities.