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Expertise in Visual Art is Associated with Altered Perceptual Strategies Within and Across Domains: Evidence from Eye Tracking

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Abstract

Eye-movement research on expert visual artists suggests that experts in this particular domain differ from novices in their strategies for encoding to-be-rendered stimuli. However, it remains unclear if such differences are specific to the domain of expertise or independent of it (i.e., if the different strategies are utilized only in relation to perception with goals specific to rendering, or if they generalize to visual perception of any stimulus with perceptual goals other than rendering). Experiment 1 examined eye-movement strategies utilized by experts and novices when rendering familiar and novel stimuli. Experiment 2 examined performance in a recognition task that also utilized novel stimuli. Results suggest that experts possess both domain-specific *and* domain-independent advantages, in that they have more efficient visual encoding abilities both when rendering and not. The results of a concurrent analysis suggest a link between the encoding advantage and schizotypy, which is correlated with creative advantage, as well as with a neural profile of left hypofrontality. Implications for a two-stage model of creativity are discussed.

Keywords: Expertise; far transfer; schizotypy; visual art; creativity.

Introduction

Only in the presence of a meaningful configuration of stimulus features do experts in various domains, including chess (Chase & Simon, 1973), cars (Curby, Glazek, & Gauthier, 2009), and digit strings (Ericsson & Kintsch, 1995) outperform novices in terms of recall performance. Theoretically, long-term memory plays a role in such a domain-specific expert advantage (Ericsson & Delaney, 1999): Repeated practice yields a hierarchically organized memory structure for a class of stimuli, into which a stimulus representation can easily be encoded, provided that the stimulus generally fits the pattern with which an expert is familiar. Furthermore, as expertise increases, so does the number of features, or chunks, that the structure can accommodate. Such a structure would, *ipso facto*, not exist for a novel stimulus. Based on this account of expertise development, expert visual artists (henceforth *experts*) should perform as poorly as control participants (henceforth *novices*) when rendering novel stimuli and when performing perceptual tasks independent of rendering.

However, there is evidence that expertise unique to the domain of visual art confers an advantage that transfers outside of what is familiar, e.g., mathematics performance in elementary school (Luftig, 1994), math and verbal SAT scores (Vaughn & Winner, 2000), visual analysis of out-of-focus pictures and novel stimuli, and mental rotation of three-dimensional objects (Kozbelt, 2001). Expertise in visual art may transcend a rendering-specific advantage, as creating drawings or paintings from life (henceforth *renderings*) requires visual analysis of objects in one's environment. Such visual analysis may generalize to visual perception in general (i.e., to situations where there is no rendering requirement, just streams of visual stimulation). In addition to examining rendering performance, the current experiments are designed to shed light on how experts and novices process novel stimuli under the perceptual goal of recognition.

A potential mechanism underlying an expert advantage in encoding visual information is also examined. Divergent thinking is considered a mechanism central to creativity (e.g., Burch, Pavelis, Hemsley, & Corr, 2006; Mednick, 1962; Miller & Tal, 2007; Schuldberg, 2000-2001; but see Weisberg, 2006, for a different view). It benefits from access to multiple associates (i.e., thoughts, ideas, etc. that come from memory and/or the environment) as starting points for creative synthesis; the more qualitatively-different associates a person has access to, the more likely it is that she will find a meaningful, novel combination in them (insight), then create a tangible product (elaboration).

In normal participants, environmental sources of stimulation outside of a point of focus are attenuated or blocked from consciousness (e.g., Lubow & Gewirtz, 1995). However, such blocking has been shown to be detrimental to creativity; individuals who were less likely to block out a task-irrelevant stream of stimuli were more likely to be creative, as measured by lifetime creative achievement (Carson, Peterson, & Higgins, 2003). If experts encode visual stimuli more rapidly than novices, they might then have access to more of them as associates in working memory, thus potentially boosting their divergent thinking capacity.

Individuals with schizotypic personality disorder (SPD), an attenuated form of schizophrenia, are also more likely to not attenuate irrelevant streams of stimulation (Baruch, Hemsley, & Gray, 1988). This population has a particular pattern of cortical activity: Left hypofrontality, whereby left prefrontal cortical (PFC) function is attenuated (Buchsbaum et al., 1997; Raine et al., 2002). Left PFC activity is associated with two types of processing pertinent to the current study. First, left PFC function has been shown to play a role in translating modality-specific information into abstracted information (e.g., Anderson, Qin, Yung, & Carter, 2007). Normal left PFC function is associated with a lack of accuracy in rendering, and accurate rendering emerges when left PFC function is suppressed using transcranial magnetic stimulation (Snyder et al., 2003). These findings strongly suggest that left hypofrontality plays a major role in accurate rendering, potentiating it via a lack of interference in the signaling among sensory pathways and motor control centers. Second, increased bilateral PFC function is associated with creativity. Jung et al. (2010) found a negative correlation between lifetime creative achievement and left prefrontal cortical thickness. Carlsson, Wendt, and Risberg (2000) found that highly creative participants (as judged by the Creative Functioning Test) utilized right PFC to a significantly larger extent than low-creative participants, who utilized only left PFC, when coming up with alternate uses for a brick. The responses in that study were not rated as varying in creativity between the groups, implying that creative individuals utilize the right hemisphere to a greater extent than non-creative individuals in any kind of task.

Elevated levels of SPD in experts would be consistent with a pattern of left hypofrontality, which may underlie both rendering and creative abilities.

Experiment 1: Domain-Specific Performance

Several inferences can be made regarding cognitive processing on the basis of tracking eye movements. Theeuwes, Olivers, and Chizk (2005) showed that maintenance of the spatial location of an item in working memory only (i.e., without its presence in the field of vision) causes saccades (i.e., eye movement trajectories) to deviate in the direction of the maintained item. Tremblay, Saint-Aubin, and Jalbert (2006) showed that participants' use of eye movements as overt rehearsal was not only a default strategy used to maintain spatial position and serial order of dots presented on a computer screen, but also that denying subjects use of such a strategy caused a significant decrease in accuracy of recall of order of presentation. Under unconstrained conditions, experts reference (i.e., move their eyes from paper to stimulus during rendering) to-be-rendered stimuli significantly more frequently than novices (Cohen, 2005; Tchalenko, 2009). Experimentally manipulating the refresh rate (i.e., alternately illuminating either the stimulus or drawing pad every 1, 5, or 15 s) affected blindly-judged accuracy of experts' renderings; lower refresh rates (i.e., stimulus visible only every 15 s) yielded significantly less accurate renderings (Cohen, 2005). The manipulation had no effect on novices' accuracy. However, these results apply only to relatively complex stimuli, including faces (Cohen, 2005) and standing nudes (Tchalenko, 2009). For rendering straight and curved individual lines and squares, there do not appear to be differences in eye movement patterns between experts and novices under unconstrained conditions (Tchalenko, 2007).

Therefore, in addition to the dimension of novelty, the content of a stimulus can be operationalized along a continuum of complexity. This experiment is the first to explicitly manipulate novelty and complexity in a rendering task and record the effect on eye movement strategies of experts and novices. If experts possess a visual encoding advantage, they should encode familiar and novel stimuli by utilizing the same cognitive strategy (as evidenced by similar eye movement patterns), while novices should utilize distinct strategies for encoding familiar and novel stimuli of varying complexity.

Method

Stimuli and Apparatus Stimuli rated as most familiar (Snodgrass & Vanderwert, 1980), and ones that are entirely novel (Chinese ideograms) were used. Within each of these categories, complexity was manipulated. Stimuli rated as most familiar were sorted according to rated complexity and the 10 simplest and 10 most complex were selected. The 10 familiar simple stimuli had a mean complexity rating of 1.60 out of 5 ($SD = 0.25$), and the 10 familiar complex stimuli had a mean complexity rating of 3.78 out of 5 ($SD = 0.31$), a significant difference ($p < 0.001$).

Unique Chinese ideograms were selected as novel stimuli, and their features (i.e., number of line segments) counted. The set of 10 novel simple stimuli had a mean of 5.50 features ($SD = 0.51$), and the set of 10 novel complex stimuli had a mean of 13.85 features ($SD = 1.66$), a significant difference ($p < 0.001$).

Thus, complexity was explicitly controlled for both novel and familiar stimuli in order to examine its effect on eye movement behavior.

Stimuli were presented using E-Prime software, version 2.0 on a Tobii 1750 eye tracker (Psychology Software Tools, Pittsburgh, PA) set to 1024 x 768 pixels screen resolution, sampling eye position at 50 Hz and with a screen refresh rate of 50 Hz. The eye tracker was calibrated at the outset of each session prior to data collection to ensure reliable eye tracking. Participants rendered using a stylus on the screen of a tablet PC running CogSketch software, version 1.131 with a simplified graphic user interface (SILC, Chicago, IL).

Participants Novices ($n = 8$, mean age = 19.9 years, three males) were recruited from Temple University's undergraduate subject pool, and given the option of course credit or cash for their participation. Experts ($n = 8$, mean age = 30.1 years, two males) were recruited using flyers posted around the Philadelphia community, and had to meet the following criteria: Have at least five years of formal art training, be at least 18 years old, and must draw or paint more than once a week, all this information being gathered via e-mail or telephone interviews prior to participation. Experts were compensated with cash.

All novices were screened for art expertise following their experimental session. All participants were screened for proficiency in reading, writing, and speaking Chinese[1].

Procedure Factor 1 (between-subjects) was expertise (novice or expert participant). Factor 2 (within-subjects) was stimulus familiarity (familiar or novel), which pertains to the presence or absence of long term representations: No subjects possess long-term representations of novel stimuli, and all subjects possess representations of familiar stimuli. Factor 3 (within-subjects) was stimulus complexity (simple or complex stimulus). Participants were informed that they had 60 s to render each of the 40 stimuli as accurately as possible, with the opportunity to rest between trials. If a participant finished rendering before 60 s elapsed, she pressed the space bar on the keyboard in front of the monitor. If she did not finish, the stimulus disappeared once 60 s elapsed. Following a practice trial to provide familiarization with the drawing stylus and tablet, all participants rendered all 40 stimuli in randomized order. The dependent variables were percentage of time spent per trial with eyes on the on-screen image (i.e., visual encoding of a stimulus), and mean duration of eyes on the on-screen stimulus. An on-screen epoch was operationalized as 60 consecutive ms or more of the eyes looking at the rectangular area subsuming a stimulus.

Results

An examination of eye movements to and away from to-be-rendered stimuli during rendering yielded a significant main effect of expertise ($F(1, 14) = 6.43$, $p < .05$), with novices' total encoding time significantly longer than experts' (see Figure 1A). A significant main effect of stimulus complexity was evidenced, as well ($F(1, 14) = 46.08$, $p < .001$; see Figure 1B). There was also a significant interaction between stimulus complexity and stimulus novelty ($F(1, 14) = 6.96$, $p < .05$), which resulted from a significant difference between familiar complex and novel complex stimuli ($t(15) = 2.47$, $p < .05$), and a lack thereof between familiar simple and novel simple stimuli (see Figure 1B).

In order to examine the above effects in more detail, individual epoch durations were analyzed. There was a significant main effect of expertise ($F(1, 14) = 7.79$, $p < .05$); experts' epochs were significantly shorter than novices' (see Figure 1C). As with overall encoding time, there was a significant main effect of stimulus complexity ($F(1, 14) = 56.85$, $p < .001$), with longer epochs for complex stimuli (see Figure 1C). There was also a main effect of stimulus novelty ($F(1, 14) = 79.29$, $p < .001$), with shorter epochs for novel stimuli (see Figure 1D). Of central importance were three significant interactions. The first of these was complexity by expertise ($F(1, 14) = 4.67$, $p < .05$; see Figure 1C); the second was novelty by expertise ($F(1, 14) = 21.16$, $p < .001$ see Figure 1D), and finally, complexity by novelty

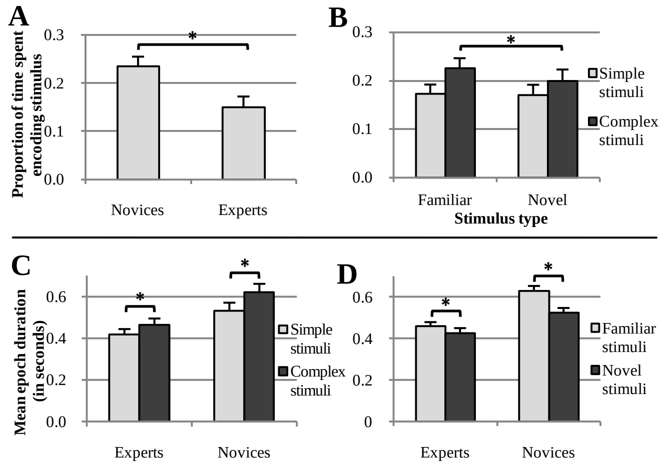

Figure 1: Effects of A) expertise, and B) stimulus type on total encoding time; C) stimulus complexity, and D) familiarity on epoch duration. Error bars represent one standard error.

by expertise ($F(1, 14) = 7.08$, $p < .05$). Essentially, as stimulus complexity and novelty changed, so did the novices' encoding strategy, which was also the case for experts, albeit to a significantly lesser extent (see Figures 1C and 1D).

Discussion

The results support the hypothesis that stimulus novelty and complexity have differential effects on processing strategy. The significant three-way interaction is of most interest, in that the effects of stimulus complexity and novelty on encoding strategy were different for experts and novices. As can be seen in Figure 1 C and D, both experts' and novices' encoding strategies were affected by stimulus complexity and novelty in a similar fashion. However, the experts evidenced an attenuation of the differences caused by novel and complex stimuli. These results suggest that visual art training is associated with an advantage in encoding novel and complex stimuli when the goal of perception is rendering.

The absence of long-term representations affected experts less than novices, suggesting that experts use less top-down processing (associated with PFC), or use it more efficiently, than novices when rendering.

The results suggest that experts approach equal efficiency at encoding familiar and novel visual stimuli regardless of complexity when visual encoding is linked to the goal of domain-relevant action. In fact, these results indicate that experts encode novel stimuli as though they are familiar, at least when compared to novices.

Experiment 2: Domain-Independent Performance

Experiment 1 showed that novices require longer epochs than experts in order to effectively encode novel and complex stimuli when rendering. The experts' advantage

[1] One participant fluent in Chinese, excluded from analyses, evidenced patterns very similar to the expert group.

may or may not disappear if the domain-specific task of rendering is absent.

In order to examine whether this expert advantage can be observed in a task that does not entail an expertise-based motor component, in Experiment 2 the domain-specific requirement of rendering was removed from the perceptual task, and replaced by a binary stimulus recognition task. It was hypothesized that experts require less encoding time than novices to correctly identify a stimulus as being the same as or different from a briefly-encoded novel stimulus. However, there may be a complexity-based limit on this encoding advantage; thus, the advantage was predicted to be more pronounced for simple novel stimuli than for complex novel stimuli.

Method

Stimuli and Apparatus Eighty Chinese ideograms were used as novel stimuli. Forty were simple and 40 complex. The stimuli used in this experiment were unique (i.e., none overlapped with the stimuli used in Experiment 1). Stimuli were presented on the same computer monitor used in Experiment 1. Eye movements were not recorded in this experiment.

Participants The same participants that took part in Experiment 1 took part in Experiment 2. The order of experiments was counterbalanced across participants.

Procedure Experiment 2 consisted of a binary judgment recognition task, as follows. At the outset of each trial, explicit written instructions appeared on the computer screen for the participant to keep her eyes focused on the screen so as to avoid missing the briefly-presented stimulus, which appeared upon her pressing the space bar. The stimulus was on-screen for a variable amount of time (50, 125, 200, or 275 ms)[2], randomly selected by the computer. Then, following a 1500 ms interval, a second stimulus appeared, which was either the same ideogram, or the same ideogram with one of four slashes superimposed over it. The first ideogram may have had a superimposed slash, as well. The presence of a slash was randomly selected by the computer. This randomization yielded relatively equal numbers of trials for same and different conditions, as well as for all four encoding durations. Participants responded as to whether the second ideogram was the same as or different from the first ideogram by pressing "F" or "J" on the keyboard, respectively (the keys' meanings were displayed on-screen), with explicit instructions to use one index finger for each key. There were four practice trials, followed by eight sets of 10 trials each, with a prompt to take a rest between each set. Sets of trials alternated between simple and complex ideograms. The dependent variable was the proportion of correct answers (same or different) for each encoding duration.

[2] Pilot data obtained from a sample of novices (n = 23) indicated that these intervals should yield meaningful variation.

Results

The results of Experiment 2 are summarized in Figure 2. Non-parametric tests were used due to violations of normality and homogeneity of variance in some of the distributions. There was a significant difference for complex stimulus recognition between experts and novices at 125 ms ($U = 46.5$, $p < .01$). Likewise, for simple stimuli, there was a marginally significant difference between experts and novices at 200 ms ($U = 67.0$, $p = .06$). Furthermore, experts attained above-chance performance for all but the shortest encoding duration, whereas novices did not.

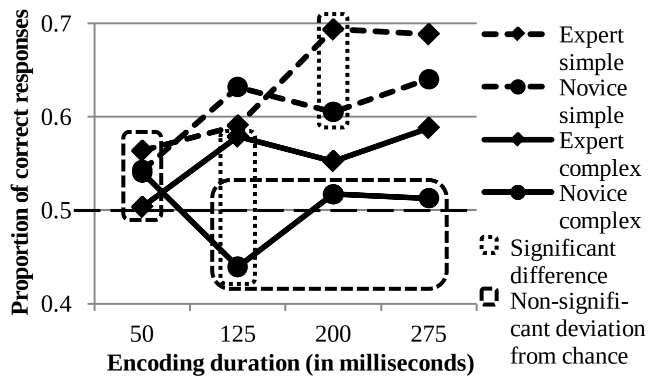

Figure 2: Rates of correct recognition of novel stimuli. 0.5 indicates chance performance.

Discussion

The results of Experiment 2 extended the results of Experiment 1, in that experts significantly outperformed novices at shorter encoding durations. The fact that a difference emerged at 200 ms for simple stimuli indicates that experts' advantage is somewhat limited; experts and novices were equally poor at encoding simple novel stimuli at short durations. Nevertheless, experts were able to encode simple novel stimuli significantly better than novices when given 200 ms or more, whereas novices required at least 275 ms to close the gap. Furthermore, when encoding complex novel stimuli, experts at least evidenced the ability to deviate from chance performance, whereas novices did not. This indicates that, although the experts' advantage appears to be limited, it does confer an advantage when encoding dense, unfamiliar patterns.

Clearly, experts' visual encoding advantage is not limited to rendering, insofar as in Experiment 2, experts were denied any synergistic boost from perceiving with the goal of rendering. Even with a lack of the rendering component, experts' encoding was superior, as evidenced by their higher performance on the recognition task.

Relation of Expertise to Schizotypy: Implications for the Neuroscience of Creativity

The question remains: What cognitive operations can experts perform while novices are still encoding?

Consistent with left hypofrontality in experts, novices encode visual information and abstract it, while experts use the same time to encode the same information and either plan motor commands (Experiment 1), or perform other cognitive tasks (Experiment 2), potentially including divergent thinking. In order to lend support to the theory that left hypofrontality underlies experts' more efficient encoding, self-report data on SPD were obtained, with the hypothesis that experts would evidence higher levels of SPD, an indirect measure of left hypofrontality.

Method

Stimuli, Apparatus, and Participants The schizotypal personality questionnaire, form B (SPQ-B; Raine & Benishay, 1995) was administered to assess schizotypic traits in the expert and novice samples. The SPQ-B is a reliable, 22-item binary judgment questionnaire that assesses three factors: Cognitive-perceptual aberrations, (ideas of reference, magical thinking, unusual perceptual experiences, and paranoid ideation), interpersonal dysfunction (social anxiety, lack of close friends, blunted affect, and paranoid ideation), and disorganization (odd behavior and odd speech). It was presented on the same computer as used in Experiments 1 and 2. Twenty eight novices and 18 experts filled out the questionnaire as part of ongoing investigations.

Results

For the disorganized factor, experts responded affirmatively to significantly more questions than novices (t = 2.46, p < .05). For questions that load onto the cognitive-perceptual factor, experts responded affirmatively marginally significantly more than novices (t = 1.86, p = .09). There was no difference between the groups on the interpersonal factor.

Discussion

Experts evidenced a pattern of elevated SPD relative to novices. There was no difference between experts and novices on the interpersonal factor, but there was a significant difference found on the disorganized factor, and a marginally significant difference on the cognitive-perceptual factor. These data provide a potential mechanism for experts' ability to render accurately, despite requiring less time to encode visual information. Hypoactive left PFC does not over-abstract stimulus representations (i.e., its functioning is attenuated) in expert cognition, allowing experts to perform well at modality-specific tasks (drawing is visual, writing is verbal, etc.).

This finding also has implications for creativity. Not only does left hypofrontality allow for modality-specific stimulus representation, it allows for attentional disinhibition. Thus, experts have better access to more visual associates upon which they can perform divergent thinking operations, and thus make *creative* modality-specific products.

General Discussion

Visual artists encode novel visual information more efficiently than control participants, both within the domain of rendering and in at least one task outside of it. This ability to transfer an encoding advantage outside of a domain of expertise implies that expert visual artists are prepared to perceive the unknown similarly to the way that novices perceive the familiar. However, novices' variable encoding strategies are only *attenuated* in experts, suggesting that training in visual art may allow for perceiving novel information in a manner only *similar* to that for familiar information. More extensive training may be associated with encoding strategies for novel and familiar stimuli that are indistinguishable. This possibility is of importance to the field of education, as students can be trained to encode novel information potentially as efficiently as familiar information. Neural plasticity caused by musical training has been demonstrated (Hyde et al., 2009), so there is potential for advantageous left hypofrontality to be an effect of visual art training.

With less time required to fully encode a novel stimulus, cognitive resources are free to be utilized for additional operations upon it and previously-encoded or recalled stimuli, including divergent thinking operations. In Experiment 1, experts encoded stimuli on average 157 ms faster than novices. In Experiment 2, experts attained levels of recognition that novices required an additional 75 ms to attain. Ecologically speaking, that additional processing time can be used to attend to other streams of stimulation, then make a creative connection. This process can be referred to as insight, and is distinct from elaboration, the phase during which the creative insight is turned into a tangible product. Martindale and colleagues (Martindale & Hasenfus, 1978; Martindale, Hines, Mitchell, & Covello, 1984) showed distinct brain activation patterns (as measured by electroencephalogram) during each of these two phases. The current results extend this two-stage theory of creativity; insight may be dependent upon processing on the scale of tens or hundreds of milliseconds, time made available by efficient encoding.

The results of the SPQ-B are consistent with the hypothesis that experts' creativity is based on attentional disinhibition, which allows them to make connections between far-flung associates; making distant connections on the basis of rapid encoding may be responsible for experts' self-reports of their speech or behavior being perceived by others as odd, as well as for having unusual perceptual experiences.

In order to more fully understand expert cognition, work currently under way by the authors examines experts' abilities to retain and manipulate novel visual information.

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References

Anderson, J.R., Qin, Y., Jung, K-J., Carter, C.S. (2007). Information-processing modules and their relative modality specificity. *Cognitive Psychology 54*, 185-217.

Baruch, I., Hemsley, D.R., & Gray, J.A. (1988). Latent inhibition and "psychotic proneness" in normal subjects. *Personality and Individual Differences, 9,* 777-784.

Buchsbaum, M.S., Yang, S., Hazlett, E., Siegel, B.V., Germans, M., Haznedar, M., O'Flaithbheartaigh, S., Wei, T., Silverman, J., & Siever, L.J. (1997). Ventricular volume and asymmetry in schizotypal personality disorder and schizophrenia assessed with magnetic resonance imaging. *Schizophrenia Research, 27*(1), 45-53.

Burch, G.J., Pavelis, C., Hemsley, D.R., & Corr, P.J. (2006). Schizotypy and creativity in visual artists. *British Journal of Psychology, 97,* 177-190.

Carlsson, I., Wendt, P.E., & Risberg, J. (2000). On the neurobiology of creativity. Differences in frontal activity between high and low creative subjects. *Neuropsychologia, 38,* 873-885.

Carson, S.H., Peterson, J.B., & Higgins, D.M. (2003). Decreased latent inhibition is associated with increased creative achievement in high-functioning individuals. *Journal of Personality and Social Psychology, 85*(3), 499-506.

Chase, W.G., & Simon, H.A. (1973). The mind's eye in chess. In W.G. Chase (ed.), *Visual information processing* (pp. 215-281). New York: Academic Press.

Cohen, D.J. (2005). Look little, look often: The influence of gaze frequency on drawing accuracy. *Perception & Psychophysics, 67*(6), 997-1009.

Curby, K.M., Glazek, K., & Gauthier, I. (2009). A visual short-term memory advantage for objects of expertise. *Journal of Experimental Psychology: Human Perception and Performance, 35*(1), 94-107.

Ericsson, K.A., & Delaney, P.F. (1999). Long-term working memory as an alternative to capacity models of working memory in everyday skilled performance. In A. Miyake & P. Shah (Eds.), *Models of working memory: Mechanisms of active maintenance and executive control* (pp. 257-297). New York, NY: Cambridge University Press.

Ericsson, K. A., & Kintsch, W. (1995). Long-term working memory. *Psychological Review, 102*, 211-245.

Hyde, K.L., Lerch, J., Norton, A., Forgeard, M., Winner, E., Evans, A.C., & Schlaug, G. (2009). Musical training shapes structural brain development. *The Journal of Neuroscience, 29*(10), 3019-3025.

Jung, R.E., Grazioplene, R., Caprihan, A., Chavez, R.S., & Haier, R.J. (2010). White matter integrity, creativity, and psychopathology: Disentangling constructs with diffusion tensor imaging. *PLoS ONE, 5*(3), 1-7.

Kozbelt, A. (2001). Artists as experts in visual cognition. *Visual Cognition, 8*(6), 705-723.

Lubow, R.E., & Gewirtz, J.C. (1995). Latent inhibition in humans: Data, theory, and implications for schizophrenia. *Psychological Bulletin, 117,* 87-103.

Luftig, R.L. (1994). *The schooled mind: Do the arts make a difference? An empirical evaluation of the Hamilton Fairfield SPECTRA+ Program, 1992-93,* Center for Human Development, Learning, and Teaching, Miami University, Oxford, Ohio.

Martindale, C., & Hasenfus, N. (1978). EEG differences as a function of creativity, stage of the creative process, and effort to be original. *Biological Psychology, 6,* 157-167.

Martindale, C., Hines, D., Mitchell, L., & Covello, E. (1984). EEG alpha asymmetry and creativity. *Personality and Individual Differences*, *5*(1), 77-86.

Mednick, S.A. (1962). The associative basis of the creative process. *Psychological Review, 69*(3), 220-232.

Miller, G.F., & Tal, I.R. (2007). Schizotypy versus openness and intelligence as predictors of creativity. *Schizophrenia Research, 93,* 317-324.

Raine, A., & Benishay, D. (1995). The SPQ-B: A brief screening instrument for schizotypal personality disorder. *Journal of Personality Disorders 9*(4), 346-355.

Raine, A., Lencz, T., Yaralian, P., Bihrle, S., LaCasse, L., Ventura, J., & Colletti, P. (2002). Prefrontal structural and functional deficits in schizotypal personality disorder. *Schizophrenia Bulletin, 28*(3), 501-513.

Schuldberg, D. (2000-2001). Six subclinical spectrum traits in normal creativity. *Creativity Research Journal, 13*(1), 5-16.

Snodgrass, J.G., & Vanderwart, M. (1980). A standardized set of 260 pictures: Norms for name agreement, image agreement, familiarity, and visual complexity. *Journal of Experimental Psychology: Human Learning and Memory, 6*(2), 174-215.

Snyder, A.W., Mulcahy, E., Taylor, J.L., Mitchell, D.J., Sachdev, P., & Gandevia, S.C. (2003). Savant-like skills exposed in normal people by suppressing the left fronto-temporal lobe. *Journal of Integrative Neuroscience, 2*(2), 149-158.

Tchalenko, J. (2007). Eye movements in drawing simple lines. *Perception, 36,* 1152-1167.

Tchalenko, J. (2009). Segmentation and accuracy in copying and drawing: Experts and beginners. *Vision Research 49,* 791-800.

Theeuwes, J., Olivers, C.N.L., & Chizk, C.L. (2005). Remembering a location makes the eyes curve away. *Psychological Science,16*(3),196–199.

Tremblay, S., Saint-Aubin, J., & Jalbert, A. (2006). Rehearsal in serial memory for visual-spatial information: Evidence from eye movements. *Psychonomic Bulletin & Review, 13*(3), 452-457.

Vaughn, K., & Winner, E. (2000). SAT scores of students who study the arts: What we can and cannot conclude about the association. *Journal of Aesthetic Education, 34*(3-4), 77-89.

Weisberg, R. W. (2006). *Creativity: Understanding innovation in problem solving, science, invention, and the arts.* Hoboken, NJ: John Wiley.