Trained visual art experts make more stable judgments of glossiness

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We investigated what visual artists learn during sketch training by comparing 3 groups (Experts, Trainees, and Novices). In 2 tasks (congruence detection and glossiness judgment), we manipulated the specular reflection component of bumpy glossy surface images by angular rotation and asked participants to compare original and modified versions. Effects of task order and type were not significant for Experts, while congruence detection improved the glossiness judgment of Novices and reduced that of Trainees. However, congruence detection did not differ by task order or group. Thus, although sketch training did not affect visual discrimination in figural congruence and gloss, it influenced the relationship between glossiness and highlight–shading congruence.

Keywords: sketch training, glossiness judgment, congruence detection, visual discrimination, expert, novice.

Experts, such as athletes and artists, who have acquired special knowledge and skills as a result of prolonged, concentrated training, show distinctive performance. We examined whether the training they have experienced actually improved their sensitivity or perceptual performance, or if they had just mastered certain strategies or rules. Specifically, we compared visual artists to novices in two different tasks: the congruence detection task and glossiness judgment task. In this section, we briefly introduce and review perceptual changes caused by experience, theories about what artists have acquired, optics on the surface, and the perception of surface gloss.

Perceptual changes caused by experience

Perceptual learning relates to changes in perceptual status or processes resulting from exposure to stimuli. Recent studies have revealed that perceptual learning can occur against the task-irrelevant stimulus (Sasaki, Náñez, & Watanabe, 2010; Seitz & Watanabe, 2005). Specifically, active movement plays an important role in perceptual learning regardless of whether it is aimed at the learned target or not. On the other hand, perceptual expertise refers to the interaction between perceptual and learning mechanisms, and includes nonperceptual higher order processes. Thus, perceptual expertise includes the concept of perceptual learning (Dosher & Lu, 2005).

Theories about what artists acquired

Previous studies have argued that artists, such as painters, should differ from novices in terms of their way of viewing world (Cohen, 2005; Kim, Bae, Nho, & Lee, 2011; Schlewitt-Haynes, Earthman, & Burns, 2002; Vogt & Magnussen, 2007). There are two theories about the differences between artists and novices. One notion, which was argued by art critics, such as John Ruskin, was practiced by the French impressionists, such as Claude Monet, and is termed the "innocent eye"; according to this theory, artists can eliminate the effects of cognition and prior knowledge from their sight. Thus, the essence of drawing is dealing with what is seen as a mere color mosaic—by removing the cognitions and the prior knowledge of the objects. Cohen and Bennett (1997) showed that the main reason for inaccurate drawing by novice adults is misperception of the object (see also Matthews & Adams, 2008; Taylor & Mitchell, 1997).

However, when a face image is flipped upside down to prevent visual processing for face perception (e.g., Thompson, 1980), drawing accuracy does not improve (Cohen, 2005). Further, the figurative artists are influenced by shape, size, and lightness constancy (Cohen & Jones, 2005; McManus, Loo, Chamberlain, Riley, & Brunswick, 2011; Ostrofsky, Kozbent, &...
Seidel, 2012; Perdreau & Cavanagh, 2011, 2013a). That is, recent studies indicated that all artists’ sight should be considered somewhat modulated; even trained artists cannot see their retinas (Perdreau & Cavanagh, 2011).

Nevertheless, artists can draw accurately, and the second theory argues that the knowledge of how to draw and associated skills make this possible. According to Gombrich (1961), the psychological processes that reveal what one sees are also components of the visual system; therefore, it is impossible to remove the effects of cognition from perception and he concluded, "The innocent eye is a myth." Rather, artists know that their sight is biased and can correct this because they possess schemata that allow them to understand and judge the validity of what is drawn faster than can people without such schemata (Kozbelt, Seidel, ElBassiouny, Mark, & Owen, 2010; Perdreau & Cavanagh, 2013b, 2014). Neuroimaging studies have also suggested the importance of knowledge to accurate drawing (Chamberlain et al., 2014; Seeley & Kozbelt, 2008; Soslo, 2001).

Through sketch training, artists learn how to realistically express the shape and surface properties of an illuminated object using lines and tones on canvas. In this process, perceptual learning about the shading of a visual image, and awareness of the surface properties of an object can be advanced. This study compared expert visual designers with novices to investigate the effects of sketch training on glossiness perception.

Optics on the surface and the perception of them

Incident light is reflected, absorbed, and transmitted by objects. Reflected light can be approximated as the sum of specular and diffuse components (Shafer, 1985). Specular reflection is a mirror-like reflection, in which incident light is reflected into the angle equal to the incident angle. Although the specular component usually spreads because of surface roughness (Figure 1), it is often localized and its perceived intensity depends on the light source position, intensity, surface reflectance, and viewing position. The spectrum of the specular component is often independent of the spectral reflectance of a surface, and is perceived as being the same as that of incident light (Lee, Breneman, & Schulte, 1985). Generally, the specular component is perceived as highlights and ambient reflection, and highlights contribute to the perceived glossiness, orientation, and curvature of a surface (Beck & Pradny, 1981; Berzhanskaya, Swaminathan, Beck, & Mingolla, 2005; Fleming, Torralba, & Adelson, 2004; Koenderink & van Doorn, 1980; Tani et al., 2013). In contrast, the diffuse component is uniformly reflected at many angles, and its intensity is independent of the viewing position. The spectrum of the diffuse component is influenced by the spectral characteristics of a surface and contributes to the object’s color.

The perceived glossiness of an object is related to the specular component ($\rho_s$), the diffuse component ($\rho_d$), and the spread of the specular lobe ($\alpha$). The axes of the visual gloss space, contrast gloss, and distinctness of image gloss, are obtained by transforming them (Pellacini, Ferwerda, & Greenberg, 2000). Further, the gloss-selective neurons in monkeys’ inferior temporal cortex change their responses to this gloss space (Nishio, Goda, & Komatsu, 2012; Nishio, Shimokawa, Goda, & Komatsu, 2014).

If a highlight is in an inappropriate position in relation to the shading, it is perceived as a bright stain on a matte surface rather than a highlight (Kim, Marlow, & Anderson, 2011; Marlow, Kim, & Anderson, 2011). Anderson and Kim (2009) examined the effect of offsetting highlights relative to shadings on perceived glossiness. Participants compared images of a glossy surface and a modified version of it, and results showed that the probability of the original glossy version being selected as glossier was 100%, with the probability decreasing rapidly as the rotation angle increased; specifically, these were approximately 50% at 15°, and 10% at 30° (Anderson & Kim, 2009). Specifically, the relationship between highlights and shadings seems to be important for drawing glossy surfaces; thus, sketch training may improve artists’ abilities related to this. In this study, we hypothesize that pictures wherein the highlight and shading are congruent will appear glossier than pictures wherein the highlight and shading are incongruent.

The purpose of this study was to reveal the effect(s) of sketch training on cognitions of surface gloss. We focused on the acute sensitivity for glossiness or spatial congruence between highlight and shading, which could be considered as the result of perceptual learning and acquisition of schemata—which we here term as perceptual expertise—detailing how
highlight-shading congruency is closely related to the strength of glossiness. We executed two tasks: one was a congruence detection task (CD-task), which involved precise judgments of the congruence between bright and dark portions of a stimulus, and the other was a glossiness judgment task (GJ-task), which involved comparing and judging the glossiness of a stimulus. The former will reveal the visual acuity for or sensitivity to lower-level visual features, such as orientation. In contrast, the properties of glossiness perception, which is a relatively higher level perceptual property, should be accessed in the GJ-task. We postulate that visual sensitivity for lower level visual features forms the basis of the perception of relatively higher level perceptual properties. Thus, if the experience of the CD-task temporarily changes visual perception for lower-level features, then their performance on the GJ-task will be influenced as well.

**Experiment 1**

**Method**

**Participants.** Our participants were classified into the following three groups: “Novices,” “Trainees,” and “Experts.” Novices were 20 undergraduate and graduate students studying in science and engineering department, and none of them had previously experienced sketch training. Trainees were seven undergraduates of the College of Art, whose major were design and they had been learning to sketch for more than 6 years. Experts consisted of six professors of the College of Art, and two professional industrial and graphic designers. Most Novices had participated in visual psychological experiments; in contrast, none of the Trainees or Experts had. All participants had normal or corrected-to-normal visual acuity and color vision. After the experimental procedure was explained and before the experiment started, they gave written informed consent. The Committee for Human Subject Studies of our university approved that this study was in accordance with the

![Schematic of stimulus generation and examples of the stimuli.](image)
Declaration of Helsinki.

Stimuli. The stimulus images were created as follows. Four filtered noise patterns were used as height maps to generate the surface structure. They contained relatively high- and low-spatial frequency components (50–128 and 3–9 cycles per image width), and the central orientations were set orthogonally to each other to maximize the orientation variety and difference between components. The higher components were attributed to local structures, and the lower to the global shape.

Figure 3. Schematic of the experimental procedure. This shows the time (t) sequence of one trial. The stimulus duration was randomly chosen from among 50, 100, 500, and 1,000 ms. After the stimuli disappeared, the participant answered by pressing a corresponding key.

Figure 4. Results of Experiment 1. The left-hand column shows the percentages at which the original image was chosen as congruent by Experts (●), Trainees (▲), and Novices (■). The right-hand column shows the percentages at which the original image was chosen as the glossier image by Experts (○), Trainees (△), and Novices (□). The abscissa of the upper row shows the rotation angles of the glossy map, and that of the lower row shows the stimulus durations. Error bars show the 95% confidence intervals.
Each bumpy surface was rendered twice using LightWave (ver. 11): once as a glossy surface and once as a matte surface. The intensity of gloss was determined by the authors to be moderate to make the effect of offsetting obvious. To isolate specular highlights (the "gloss map") from a glossy surface, the intensity map of the matte version was subtracted from that of the glossy version. After it was rotated circularly, the gloss map of each surface was added to the matte version. These procedures imitated those of Anderson and Kim (2009).

The rotation angles were 0°, ±5°, ±15°, ±45°, and ±90°. Finally, for each level of surface geometry, the mean, standard deviation, and skewness of luminance of the original and modified versions were equated. We set four surface geometries and nine rotation angles, resulting in 36 stimuli (Figure 2). The luminance means of each geometry level were 46.8–53.2 cd/m², and the diameter of the stimuli was 8° in the visual angle.

Apparatus. All Trainees and six Experts completed the experiment in the cargo space of a truck converted into a dark room for psychological experiment, while the others did so in the dark room of a building. During the experiment, the visual environments or possible influential factors, such as degree of lightness, were almost the same. The cathode ray tube monitor (TOKOKU CV722X, 60 Hz), personal computer (DELL Vostro430), keypad, chin rest, desk, and chair used in both environments were the same. The monitor was viewed at a distance of 57 cm.

Procedure. In the CD-task, meaningless stimuli, such as Gabor patches, might be suitable for the purpose described above; however, we chose to use the same stimuli as those of GJ-task, which were analogous to the drawn objects or surfaces used in sketch training. One reason for this decision was that our participants were inexperienced with such meaningless stimuli and the experimental setting. Further, in the context of task-relevant perceptual learning, the effects of learning are limited to the range of the learned parameters; however, we did not know the types and ranges of parameters learned through sketch training.

First, a fixation cross was presented at the center of a dark blank screen and the participants were instructed to focus on this cross until the stimuli were presented (300 ms). Two stimuli were presented on the right and the left sides of the fixation cross for one of four designated durations: 50, 100, 500, and 1,000 ms. The distance between the centers of the stimuli was 10°. Two stimuli were made from the same surface geometry but differed in rotation angle; one of them was always the original glossy image (0° rotation) and the other was a modified version. In the CD-task, participants chose the image that contained congruent bright and dark portions, while in the GJ-task they chose the one that seemed glossier. After the stimuli disappeared, participants responded by pressing the corresponding button within 3 s, and were not given any feedback (Figure 3). They completed two blocks, each of which contained one task comprising 256 trials and the order of the blocks was counterbalanced; four Experts, three Trainees, and 10 Novices completed the CD-task first, and the task order for the rest of the participants was inverted. (Hereafter, the task order is displayed as a superscript, such as "Experts\(^{5,5,3,3}\)".) An interval more than 10 min separated the two blocks and instructions about the following task were given just before the block started. During the interval, the participants talked to the experimenter about task-irrelevant issues. The aim of this conversation was to prevent participants from reviewing the task and to minimize the effects of the experience of the first task on the second task.

Results

The left panels of Figure 4 show the response rates for when the original image was congruent in the CD-task, and the right panels show the response rates for when the original image was glossier in GJ-task (hereafter, these rates are described as "original image percentages"). The upper panels show the averages for the original image percentage of all durations as functions of the rotation angle of the gloss map, and the lower two show the averages for the original image percentage of all rotation angles as functions of the stimulus duration. The original image percentage increased with rotation for all the groups; a similar, but slighter, trend was also apparent as duration increased. The differences between groups were small in the CD-task and obvious in the GJ-task. Experts showed a higher original image percentage than did the other two groups at larger rotation angles and across all durations. Further, in almost all conditions, the original image percentage of the CD-task was higher than that in the GJ-task.

Examples of possible results in some conditions include Experts showing higher original image percentage than others, especially at a short duration or small rotation angle because of their artistry, and the original image percentage for the CD-task being higher than that for the GJ-task. To investigate these possible results, a five-way mixed-design analysis of vari-
Figure 5. The original image percentages for each rotation angle. Expertise, Order, and Type results are pooled. Error bars show the 95% confidence intervals.

Figure 6. The original image percentages for each duration. Expertise, Order, and Type results are pooled. Error bars show the 95% confidence intervals.

Figure 7. The original image percentages of each participant group (left: Experts, middle: Trainees, right: Novices). In each panel, the ordinate shows the original image percentage in both tasks and the abscissa shows the rotation angle. The filled symbols correspond to the CD-task, and the open symbols to the GJ-task. Results of participants who completed the CD-task first are represented by the dark colored lines, and those of participants who completed the GJ-task first are represented by the light colored lines. Error bars show the 95% confidence intervals.

**Effects of duration.** As shown in Figure 5, floor and ceiling effects were observed at 5° and 90°, respectively. Duration-related interaction effects, other than interaction of Duration and Rotation, were not significant, indicating that the effect of Duration did not vary according to Expertise, Type, or Order. The simple main effect of Duration was not significant at 5°, $F(3, 87)=0.52, p>.250, \eta^2_p=.018$. At 15°, $F(3, 87)=25.67, p<.001, \eta^2_p=.470$, all the differences between the original image percentages of each duration were significant, except those between 50 ms and 100 ms ($p>.250, r=.420$) and 500 ms and 1,000 ms ($p=.116, r=.512$). At 45°, $F(3, 87)=21.13, p<.001, \eta^2_p=.421$, the original image percentage of 50 ms was significantly lower than that of the other three duration levels (vs. 100 ms, $p<.001, r=.710$; vs. 500 ms, $p<.001, r=.778$; vs. 1,000 ms, $p<.001, r=.756$), and these did not vary statistically. At 90°, $F(3, 87)=6.38, p<.001, \eta^2_p=.180$, all the differences of the original image percentage were not significant, except those between 50 ms and 500 ms ($p=.016, r=.505$) and 50 ms and 1,000 ms ($p=.043, r=.492$).

On the other hand, the simple main effect of Rotation was more evident at all the duration levels: 50 ms, $F(3, 87)=233.32, p<.001, \eta^2_p=.889$; 100 ms, $F(3, 87)=21.67, p<.001, \eta^2_p=.428$; 500 ms, $F(3, 87)=619.82, p<.001, \eta^2_p=.955$; and 1,000 ms, $F(3, 87)=778.67, p<.001, \eta^2_p=.964$. As shown in Figure 6, all the differ-
ences between the original image percentages of each rotation angle were statistically significant except those between 5° and 15° at 50 ms ($p = .092$, $r = .288$), and 45° and 90° at 100 ms ($p > .250$, $r = .313$), at 500 ms ($p > .250$, $r = .025$), and at 1,000 ms ($p > .250$, $r = .070$).

**Effects of Expertise.** Although the main effect of Expertise was not significant, the interactions of Expertise and Type; Expertise, Type and Order; and Expertise, Type, Order, and Rotation were significant. Hereafter, the analyses of third-order interactions in each participant group and the difference between groups are described.

**Results of Experts.** The simple interaction effect of Type, Order, and Rotation was not significant, $F(2.21, 63.99) = 0.85$, $p > .250$, $η_p^2 = .028$. Further, no Type- or Order-related effects were significant: Type, $F(1, 29) = 1.07$, $p > .250$, $η_p^2 = .035$; Order, $F(1, 29) = 0.39$, $p > .250$, $η_p^2 = .013$; Type and Order, $F(1, 29) = 0.24$, $p > .250$, $η_p^2 = .008$; Type and Rotation, $F(2.21, 63.99) = 2.16$, $p = .114$, $η_p^2 = .069$; Order and Rotation, $F(1.87, 54.31) = 0.27$, $p > .250$, $η_p^2 = .009$. Only the effect of Rotation was significant, $F(1.87, 54.31) = 80.15$, $p < .001$, $η_p^2 = .734$. Regardless of Type and Order, the original image percentages for 45° and 90° were not significantly different, and they were higher than those for 5° and 15°. Further, the original image percentage for 5° was significantly lower than that for 45° (Figure 7).

**Results of Trainees.** The simple interaction effect of Order, Type, and Rotation was significant, $F(2.21, 63.99) = 6.11$, $p = .002$, $η_p^2 = .174$. In the GJ-task, the original image percentages of Trainees$_{CG}$ were significantly lower than those of Trainees$_{GC}$ at 45° ($p = .021$, $r = .828$) and 90° ($p = .034$, $r = .706$). Further, Rotation only influenced Trainees$_{GC}$, such that their original image percentage significantly increased with the rotation angle increasing (5° vs. 45°, $p < .001$, $r = .947$; 5° vs. 90°, $p < .001$, $r = .910$; 15° vs. 45°, $p < .001$, $r = .926$; 15° vs. 90°, $p = .001$, $r = .843$).

In the CD-task, the rotation angles significantly influenced the original image percentages of Trainees$_{CG}$ and Trainees$_{GC}$ and they did not vary by Order: Rotation, $F(1.87, 108.62) =$

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Figure 8. The effects of Order. The upper panels show the results of the CD-task, and the lower panels show the results of the GJ-task. The left panels (dark lines) show the results of participants who completed the CD-task first, and the right panels (light lines) show those of participants who completed the GJ-task first. The circles represent the results of Experts, the triangles represent the results of Trainees, and the rectangles represent the results of Novices. Error bars show the 95% confidence intervals.
In both tasks, the differences in the original image percentages were significant except those between 45° and 90°.

The interaction of Task and Rotation was significant for Trainees\textsuperscript{CG}, $F(2.21, 63.99) = 13.69, p < .001$, $\eta^2_p = .321$, with the CD-task being significantly higher than the GJ-task at 15° ($p = .024, r = .837$), 45° ($p < .001, r = .930$), and 90° ($p < .001, r = .869$). However, it was not significant for Trainees\textsuperscript{GC}, $F(2.21, 63.99) = .50, p > .250, \eta^2_p = .017$. Instead, the effects of Task and Rotation, respectively, were significant: Task, $F(1, 29) = 5.35, p = .028$, $\eta^2_p = .156$; Rotation, $F(1.87, 54.31) = 42.47, p < .001, \eta^2_p = .594$ (Figure 7). These results suggest that completing the CD-task first reduce the original image percentage of the GJ-task.

Results of Novices. The simple interaction effect of Order, Type, and Rotation was significant, $F(2.21, 63.99) = 5.24, p = .005$, $\eta^2_p = .153$. In both tasks, Novices\textsuperscript{CG} and Novices\textsuperscript{GC} were not statistically different at all the rotation angles: CD-task, $F(1.87, 108.62) = 1.04, p > .250, \eta^2_p = .018$; GJ-task, $F(1.87, 108.62) = 3.07, p = .051, \eta^2_p = .050$. For Novices\textsuperscript{CG}, the original image percentages of both tasks did not differ at any rotation angles, $F(2.37, 68.62) = .59, p > .250, \eta^2_p = .020$; however, those of Novices\textsuperscript{GC} were significantly different except at 5° ($F(2.37, 68.62) = 13.88, p < .001, \eta^2_p = .324$; 5°, $p = .159, r = .414$; 15°, $p = .016, r = .770$; 45°, $p < .001, r = .810$; 90°, $p < .001, r = .863$. In both tasks, the differences in the original image percentages for Novices\textsuperscript{CG} were significant except those between 45° and 90°. Further, Novices\textsuperscript{GC} showed the same trends, except that they were significant between 5° and 15° in the GJ-task.

Contrary to Trainees\textsuperscript{CG}, Novices\textsuperscript{CG} showed higher original image percentages on the GJ-task, especially for large rotation angles (Figure 7).

Comparison between groups. In the CD-task, no effect of Expertise was observed, $F(2, 58) = 1.29, p > .250, \eta^2_p = .043$. On the other hand, a significant interaction of Expertise, Order, and Rotation was observed in the GJ-task, $F(3.75, 108.62) = 4.57, p = .002$, $\eta^2_p = .136$. The original image percentages of Trainees\textsuperscript{CG} were significantly lower than those of Experts\textsuperscript{CG} and Novices\textsuperscript{CG}, and the difference between Experts\textsuperscript{CG} and Novices\textsuperscript{CG} was not significant at 45° (Trainees\textsuperscript{CG} vs. Experts\textsuperscript{CG}, $p = .015, r = .864$; Trainees\textsuperscript{CG} vs. Novices\textsuperscript{CG}, $p = .042, r = .561$; Experts\textsuperscript{CG} vs. Novices\textsuperscript{GC}, $p > .250, r = .257$) or at 90° (Trainees\textsuperscript{CG} vs. Experts\textsuperscript{CG}, $p = .029, r = .783$; Trainees\textsuperscript{CG} vs. Novices\textsuperscript{CG}, $p = .050, r = .531$; Experts\textsuperscript{CG} vs. Novices\textsuperscript{CG}, $p > .250, r = .208$). In contrast, no differences were observed between Experts\textsuperscript{GC}, Trainees\textsuperscript{GC}, and Novices\textsuperscript{GC}, $F(2, 58) = 1.45, p = .243, \eta^2_p = .048$ (Figure 8).

Discussion

Even at 50 ms duration, the larger the rotation angle was, the higher the original image percentage became. Additionally, the interaction of Expertise and Duration was not significant, $F(6, 87) = 0.27, p > .250, \eta^2_p = .018$. These results suggest that our participants, regardless of the degree of expertise, could to some extent perceive both congruence and surface gloss at a glance. In contrast, even at longer durations, small rotation angles resulted in low original image percentages. Further, the interaction of Expertise and Rotation, $F(3.75, 54.31) = 0.85, p > .250, \eta^2_p = .055$, was not significant. These together results suggest that all participants needed a somewhat larger rotation angle to accurately judge congruence and glossiness.

No remarkable difference between the groups was observed in the CD-task. That is, sketch training does not improve the ability to judge the congruence between rendered highlights and shadings.

In the GJ-task, the original image percentages of Novices\textsuperscript{GC} were lower than those of Experts\textsuperscript{CG} and Trainees\textsuperscript{CG}; however, the differences were not statistically significant. In contrast, the original image percentages of Trainees\textsuperscript{CG} were significantly lower than those of Experts\textsuperscript{CG} and Novices\textsuperscript{CG}. The original image percentages of the participants\textsuperscript{CG} should reflect purer sense to gloss than those of the participants\textsuperscript{GC}. Considering our hypothesis that the original image would be glossier than the modified version, it would seem that sketch training does not appear to make people more sensitive to the differences in surface gloss. In that case, what did sketch training bring to them? We considered it from the difference between Experts and the others.

The task order influenced Trainees and Novices. For Trainees, completing the CD-task first negatively affected their original image percentages of the GJ-task and for Novices, it positively affected. On the other hand, Experts’ original image percentages of the GJ-task were not affected by the task order, that is, their glossiness judgments seemed stable. This should be brought by prolonged sketch training.

We should add further investigation for the instability of Trainees and Novices. Completing the CD-task first might have shown Novices how to complete the GJ-task. The experimental procedure was designed to counter the possibility of
this artifact; however, some Novices mentioned that both tasks were relevant to their automatically answering that the congruent stimulus was glossier. If many Novices CG adopted this strategy in the GJ-task, whether they intended or not, the original image percentage of their GJ-task would not be regarded as an index of sense to gloss. Thus, in Experiment 2, we tested the possibility that completion of the CD-task might act as a clue to the GJ-task for novices was tested.

**Experiment 2**

**Methods**

In this experiment, we investigated whether the experience of the CD-task increased the original image percentage of the GJ-task of Novices or whether the difference between Novices CG and Novices GC in the GJ-task was merely due to individual differences. We asked 10 engineering students, five Novices CG and five Novices GC in Experiment 1, to engage in both tasks again.

The procedure, conditions, and the number of trials of Experiment 2 were the same as those of Experiment 1, except for the task order. That is, participants who were assigned as Novices CG in Experiment 1 were asked to perform the GJ-task as the first task and the CD-task as the second task in Experiment 2, and vice versa. To visualize the effects of CD-task on GJ-task, we compared the original image percentages of the GJ-task performed as the first task (GJFT) and performed as the second task (GJST). For Novices CG, the GJFT corresponded to their result of Experiment 2, and the GJST corresponded to their result of Experiment 1 (Table 1). If the experience of the CD-task increased the original image percentage of the GJ-task, the original image percentage of the GJFT would be higher than the GJST. On the other hand, if the difference between Novices CG and Novices GC in the GJ-task of Experiment 1 was merely due to individual differences, then the original image percentages of the GJFT and the GJST would be almost the same, and the difference between Novices CG and Novices GC would be evident.

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Note. The names of the participants’ group were derived from the task order of Experiment 1.

Figure 9. The original image percentages of the GJFT and GJST. The upper panels show the results of Novices CG and the lower panels show the results of Novice GC. The ordinates show the original image percentage and the abscessas show the rotation angle. Error bars show the 95% confidence intervals.
Results

The upper panels of Figure 9 show the original image percentages of Novices\textsuperscript{CG}, and the lower panels show those of Novices\textsuperscript{GC}. The differences between GJ\textsuperscript{FT} and GJ\textsuperscript{ST} were apparently larger in Novices\textsuperscript{CG} than in Novices\textsuperscript{GC}. On the other hand, the difference between Novices\textsuperscript{CG} and Novices\textsuperscript{GC} was apparently small.

We performed a mixed-design of analysis of variance, with the between-subject factor being the participant group (Group; Novices\textsuperscript{CG}/Novices\textsuperscript{GC}) and the within-subject factors being Rotation, Duration, and Order. The main purpose of it was to investigate the effects of Order, in other words, to compare the original image percentages of the GJ\textsuperscript{ST} to those of the GJ\textsuperscript{FT}. The main effect of Order, $F(1,8) = 7.62, p = .025$, $\eta^2_p = .488$, and the interaction between Order and Rotation, $F(2.44, 19.53) = 3.95, p = .030$, $\eta^2_p = .300$, were significant and other Order-related interaction effects were not significant (interaction between Group and Order: $F(1,8) = 0.04, p = .250$, $\eta^2_p = .005$; interaction between Group and Duration: $F(3, 24) = 1.21, p = .250$, $\eta^2_p = .131$; interaction between Group and Rotation: $F(3, 24) = 1.40, p = .250$, $\eta^2_p = .149$; interaction between Group and Order: $F(1, 8) = 0.87, p = .250$, $\eta^2_p = .098$; interaction between Group, Duration, and Rotation: $F(8.06, 64.45) = 1.48, p = .183$, $\eta^2_p = .156$; interaction between Group, Duration, and Order: $F(3, 24) = 1.62, p = .212$, $\eta^2_p = .168$; interaction between Group, Rotation, and Order: $F(2.44, 19.53) = 1.25, p = .250$, $\eta^2_p = .135$; interaction between Duration, Rotation, and Order: $F(9, 72) = 1.50, p = .163$, $\eta^2_p = .158$; interaction between Group, Duration, Rotation, and Order: $F(9, 72) = 0.51, p = .250$, $\eta^2_p = .060$). The simple-main effect of Order was significant at the rotation angle of 15°, $F(1, 32) = 8.86, p = .006$, $\eta^2_p = .255$, and at 45°, $F(1, 32) = 8.08, p = .008$, $\eta^2_p = .503$. At these rotation angles, the original image percentage of the GJ\textsuperscript{FT} was significantly lower than that of the GJ\textsuperscript{ST} (Figure 10).

On the other hand, all of Group-related effect was not significant. (main effect: $F(1, 8) = 0.04, p = .250$, $\eta^2_p = .005$; interaction between Group and Duration: $F(3, 24) = 1.21, p = .250$, $\eta^2_p = .131$; interaction between Group and Rotation: $F(3, 24) = 1.40, p = .250$, $\eta^2_p = .149$; interaction between Group and Order: $F(1, 8) = 0.87, p = .250$, $\eta^2_p = .098$; interaction between Group, Duration, and Rotation: $F(8.06, 64.45) = 1.48, p = .183$, $\eta^2_p = .156$; interaction between Group, Duration, and Order: $F(3, 24) = 1.62, p = .212$, $\eta^2_p = .168$; interaction between Group, Rotation, and Order: $F(2.44, 19.53) = 1.25, p = .250$, $\eta^2_p = .135$; interaction between Group, Duration, Rotation, and Order: $F(9, 72) = 0.51, p = .250$, $\eta^2_p = .060$). These results suggested that the differences of the original image percentages of Novices\textsuperscript{CG} and Novices\textsuperscript{GC} of the GJ-task were not significant (Figure 10), and that those found in Experiment 1 could not be attributed to the individual difference.

Figure 10. The effects of Order and Group. The upper panels show the effects of Order, or the difference between GJ\textsuperscript{FT} and GJ\textsuperscript{ST}, and the lower panels show the effects of Group, or the difference between Novices\textsuperscript{CG} and Novices\textsuperscript{GC}. The left panel of each row shows the main effect, and the right panel of each row shows the interaction effect (top: interaction between Rotation and Order, bottom: interaction between Group and Order). The abscissas show the original image percentage and error bars show the 95% confidence intervals.
Discussion

These results showed that the original image percentage of the GJ-task increased when it was performed second, especially at middle level of the rotation angles. Although no participant reported on the relevance of the two tasks in Experiment 2, these results suggested that Novices used their experience of the CD-task to answer the GJ-task.

General Discussion

In this study, we compared people who had experienced sketch training with those who had not. In Experiment 1, we found that Novices (engineering students) could detect the congruence of bright and dark regions at the same level as Experts (professional designers) and Trainees (art students). This suggests that the visual ability to detect the congruence between bright and dark regions in a figure is not improved by sketch training.

However, we also found a difference between groups on the GJ-task. Novices and Trainees, but not Experts, were significantly influenced by completing the CD-task first. Further, Trainees showed significantly lower original image percentages than did Experts and Novices, although Trainees did not differ from these other two groups. We focused on this effect of task order and conclude that Experts’ stable glossiness judgment would be derived from sketch training.

Further, we hypothesized that Novices used the preceding CD-task experience as a clue to answer the GJ-task. We thus randomly divided the novice participants into Novices or Novices; These groups had almost equal art experience and they showed no significant difference on the results of the CD-task. Nevertheless, only for Novices, the original image percentages of the GJ-task were lower than were those of the CD-task at the rotation angle of 15°, 45°, and 90°. It is natural that the sense to gloss is better reflected by the results of the GJ-task when it is performed as the first task than as the second task. In other words, for Novices, we thought that the results of the GJ-task would reflect not only their sensitivity to gloss but also other factors, such as taking a shortcut by using the first task as a clue (whether intended or not). We tested this in Experiment 2 and the results largely supported our expectations.

Why was this facilitative effect not evident for the Trainees (art students)? Indeed, the data from Trainees showed the opposite effect. Unfortunately, we could not clarify this, but, interviews with Trainees led us to speculate that this opposite effect can be attributed to their developing abilities. According to them, teachers always said to them, “Look at the object as it is, ignoring your preconceptions, and draw it as you see it.” Thus, when the GJ-task was completed first, they could regard the original image as the glossier one using their ability. However, if the CD-task was completed before the GJ-task, Trainees might perceive a relationship between the figural congruence and glossiness, and would try to avoid noticing this congruence in the GJ-task, as it was a preconception; this, in turn, would reduce their original image percentage. The group tendency followed this interpretation although the error bars of the GJ-task of Trainees were longer than were those of Trainees (see Figure 7). This indicates that the within-group deviation was larger in Trainees. Furthermore, their deviation of the results of the CD-task was smaller. These results suggested that some participants were more affected by the experience of the CD-task than were others. We speculate that this difference might relate to aspects of their personality, and would therefore be an interesting direction for research. Of course, if this interpretation is valid, it is unclear why the effect did not occur for Experts—prolonged sketch training ought to have made the relationship between the figural congruence and glossiness obvious, so identifying this should have been a matter of course for Experts. According to Anderson (1982), there are two stages and one transition process in the process underlying the acquisition of cognitive skill; the declarative stage, knowledge compilation, and procedural stage. Considering this, Trainees should be at the knowledge compilation, the acquired declarative knowledge should be being converted into a procedural form in their mind. On the other hand, Experts should be at the procedural stage, or autonomous stage called by Fitts (1964). This should be a reason why their original image percentages of the GJ-task showed the stability against the task order.

Additionally, if a different task, such as a “naturalness” judgment task, followed the CD-task, the effect of their previous experience of the task might manifest in a different way. For instance, if the figural naturalness is proportional to the rotation angle, we might expect all groups to show the same trend: namely, higher original image percentages when the naturalness judgment task is performed as the second task than when it is performed as the first task. The reasons for this are that the original image percentages of the three groups would be almost the same and the fact that congruence defines figural naturalness. In other words, their visual ability to
detect the congruence between light and dark portions of the figure would not differ, meaning that their answers would be based on the congruence in the naturalness judgment task.

Thus, we conclude that sketch training allows visual artists to acquire an awareness of the surface gloss and highlight-shading congruence relationship and to instill it. This does not appear to be a form of perceptual learning, but rather a kind of perceptual expertise or schemata learning.

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References


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