JPMTR-2215
DOI 10.14622/JPMTR-2215
UDC 531.3-028.25:159.937-035.67

Professional communication | 172
Received: 2022-06-20
Accepted: 2022-10-14

Effect of various ink types on naturalness perception of 2.5D prints

Altynay Kadyrova[1], *Marius Pedersen*[1], *Stephen Westland*[2] *and Clemens Weijkamp*[3]

[1]Department of Computer Science, Norwegian University of Science and Technology, 2802, Gjøvik, Norway — altynay.kadyrova@ntnu.no, marius.pedersen@ntnu.no
[2]School of Design, University of Leeds, LS2 9JT, Leeds, UK — s.westland@leeds.ac.uk
[3]Canon Production Printing Netherlands B.V., 5914 HH, Venlo, The Netherlands — clemens.weijkamp@cpp.canon

Abstract

Naturalness perception of 2.5D prints is content dependent and varies depending on the level of elevation used for reproduction. Moreover, various factors can influence the naturalness perception of 2.5D prints such as ink types, viewing angle, and illumination, to name a few. In this work, we focus on the effect of various ink types on the naturalness perception of 2.5D prints of wood images fabricated at 0.5 mm elevation. We found that the naturalness perception of 2.5D prints is influenced by the type of ink used. In particular, we found that 2.5D prints of wood images with matt inks were perceived by observers as more natural than with glossy inks. There were differences between the observers based on their level of expertise. The acquired findings can help to reproduce wooden content to be perceived as natural by using a specific type of ink.

Keywords: elevation, 2.5D printing, ink

1. Introduction

Ink used for printing is a colored liquid and its visual characteristics are color, transparency or opacity, intensity, and gloss (Leach, 2012). Gloss can attract attention to the product/print and glossier print might look more chromatic and darker to some extent (Kipphan, 2001). Samadzadegan, Blahová and Urban (2014) explained that darker samples were perceived more glossy than lighter ones due to the large contrast effect of specular gloss highlights on dark samples in their experiment.

There are various ink types on the market with various levels of gloss/matt. Ink types along with other parameters (e.g., print mode, substrate type) might affect the glossiness of the print (Samadzadegan, et al., 2015). Existing works have studied glossiness aspect of 2.5D prints (i.e., with surface elevation) via experimenting with inks (Baar, et al., 2014; Samadzadegan, Blahová and Urban, 2014). For example, Baar, et al. (2014) created two print modes, glossy and matt, that give almost constant gloss/matt appearance in the prints regardless of the ink coverage because, in standard print mode, an increase in ink coverage gives increase in glossiness. Nonetheless, limited research has been carried out on the perception of naturalness of 2.5D prints (Kadyrova, Pedersen and Westland, 2022a; 2022b). The effects of different parameters on naturalness perception of 2.5D prints were investigated in terms of elevation (Kadyrova, Pedersen and Westland, 2022b) and elevation and surface roughness (Kadyrova, Pedersen and Westland, 2022a). To the best of our knowledge, the naturalness perception of 2.5D prints fabricated with various ink types (i.e., with various glossiness) has not been investigated. Thus, this is the first work to look into the effect of various ink types on the naturalness perception of 2.5D prints.

According to industrial feedback, customers found 2.5D prints too glossy to look natural. Therefore, it is valuable to investigate the effect of various ink types with various glossiness on the naturalness perception of 2.5D prints because glossiness of the prints can be influenced by both the ink types and additional varnish layers. The elevation level affects the naturalness perception of 2.5D prints and it is content dependent (Kadyrova, Pedersen and Westland, 2022a). Based on the results of our previous work (Kadyrova, Pedersen and Westland, 2022b), observers found it natural when

2.5D prints of wood images were fabricated at 0.5 mm elevation. As a result, we work with 2.5D prints of wood images at 0.5 mm elevation fabricated with various ink types and assess effect of ink types on the naturalness perception of 2.5D prints at a given illumination and viewing distance. Based on the obtained results, we can recommend the use of a specific type of ink with a specific glossiness for the reproduction of natural-looking wooden content. For simplicity, by prints we mean 2.5D prints of wood images hereafter in the text.

2. Methodology

We used the term realistic to mean naturalness following the methodology of our previous work (Kadyrova, Pedersen and Westland, 2022b). We worked with 20 wood images that represent various wood content such as wooden floor (4 images), roof (2 images), wall (6 images), and wicker (8 images). The original color images and their height maps were reproduced from 3D textures retrieved from a copyright-free website (3D textures, 2021). To reduce black edges and reach the intended maximum elevation, the height maps were Gaussian filtered (with $\sigma = 4$ being a standard deviation of the Gaussian distribution) and intensity adjusted, respectively. The color images and the processed height maps had a dimension of 782 × 782 pixels prior to being inputted for printing.

The optimal elevation that makes 2.5D prints of wood images (regardless of the wood content) perceptually natural was found to be 0.5 mm (Kadyrova, Pedersen and Westland, 2022b). Therefore, we used 0.5 mm elevation for all prints and varied ink types.

Table 1 shows the ink types used in our work. We used commercially available inks (Canon IJC UV-curable inks) with various coatings. For example, IJC 255a is IJC 255 ink with gloss coating – Royal Talens Amsterdam Acrylic Varnish (RTAAV) applied with 2 layers with brush, fabricated with Arizona flatbed printer – AZ480 with mercury curing lamps. Glossy/matt distribution was done based on industrial information and gloss measurements.

The gloss of flat color patches (light and dark brown which represent most of the colors in our prints) for six groups of inks was measured with a Konica Minolta multi gloss 268 plus glossmeter at 20°, 60°, and 85° (Table 2) in Gloss Units (GU) following ISO standard (International Organization for Standardization, 2014). These angles were chosen due to their common use in the printing industry (Ng, et al., 2003), where 20° geometry is recommended for measurement of high-gloss surfaces, 60° for semigloss surfaces, and 85° for matt surfaces. In Table 2, we can observe that dark colors have higher gloss than light colors within glossy inks (i.e., IJC 255a, IJC 255b, IJC 357).

We used a Forex substrate (PVC foam board with 3 mm thickness) and Arizona flatbed printers for the fabrication of the prints. Files for printing were prepared with Canon Touchstone Elevated Printing software and processed with Canon Advanced Layering Processing System (ALPS) engine that includes a raster imaging processor and uses a specific color profile. Canon optimized the ALPS engine for the best color and elevation output of the used inks. The prints were made in the quality mode at a print resolution of 450 × 450 dpi. The print size was 66.2 mm × 66.2 mm with an additional 3 mm on each side of the substrate to allow observers to hold the prints without touching the edges. There were 6 reproductions per image and 120 of 2.5D prints in total for the experiment.

A ranking experiment was carried out to assess the naturalness perception of the 2.5D prints. If we were to use, for example, the pair comparison method, then the experiment would have become long for observers due to the number of reproductions. Following the experiment design of our previous work (Kadyrova, Pedersen and Westland, 2022b), first, consent from the observers was acquired; second, the observers adapted to the illumination while reading the instruction followed by a training session with some representative prints. We presented the prints in a random order to the observer and they were placed on a table in a viewing room with D50 illumination (around 1900 lux). The instruction was to rank the 2.5D prints from the most to the least realistic representation of wooden floor/roof/wall/wicker and explain why. The keyword (i.e., wooden floor/roof/wall/wicker) was given as a reference, and we allowed observers to move and tilt the prints with gloves without touching the surface. The distance between the eyes of the observer and the prints was approximately 50 cm. We informed the observers that there was no time restriction. The average experiment duration was 41 minutes per observer, excluding the time of the training session which was around 3 to 4 minutes per observer on average. The experiment was carried out in English. The audio explanations given by the observers on their rankings were recorded for analysis purposes.

In total, we had 22 observers (20 males and 2 females) with an average age of around 46 years and a standard deviation of around 11 years, where 6 of them were with high-level expertise, 4 with low-level expertise, and the remaining were with medium-level expertise with backgrounds from chemistry, physics, electronics, and mechanics. Color vision and visual acuity were checked by using Ishihara plates and a Snellen chart, respectively. All observers had normal color

Table 1: Ink types used in our work with coating, printer, curing lamp, and glossy/matt information

Label	Ink name	Coating	Printer	Curing lamp	Glossy/ matt
IJC 255a	IJC 255	Gloss coating (RTAAV) applied with 2 layers with brush	AZ480	Mercury	Glossy
IJC 255b	IJC 255	Gloss coating (RTAAV) applied with 1 layer with spray can	AZ480	Mercury	Glossy
IJC 357	IJC 357	Without coating	AZ2380XTF	LED	Glossy
IJC 255c	IJC 255	Canon IJC 257 varnish printed on top	AZ480	Mercury	Matt
IJC 255d	IJC 255	Matt coating (RTAAV) applied with 1 layer with spray can	AZ480	Mercury	Matt
IJC 358	IJC 358	Without coating	AZ1380XT	LED	Matt

Table 2: Measured gloss values of patches of ink types at 20°, 60°, and 85°, given in GU

Degrees	Patches	IJC 255a	IJC 255b	IJC 357	IJC 255c	IJC 255d	IJC 358
20°	Dark brown	4.0	4.0	3.5	0.6	0.3	0.3
	Light brown	3.7	3.5	2.3	1.2	1.0	0.9
60°	Dark brown	27.4	27.9	22.5	6.0	4.2	3.5
	Light brown	24.8	23.8	16.0	6.3	4.9	3.8
85°	Dark brown	36.0	37.0	21.3	4.5	8.8	3.9
	Light brown	31.8	30.0	17.0	4.7	7.5	3.4

vision except one observer, who was color deficient. The recruited observers were from Canon Production Printing Netherlands and the majority of them were Europeans.

3. Results and discussion

We present *Z*-scores (Engeldrum, 2000) (calculated from raw ranked data) of all wood images by all observers, of images in each wood content by all observers, and of high-medium-low level expertise observers for all images to find the effects of various ink types on the naturalness perception of 2.5D prints. An error bar plot was used to visualize *Z*-scores. Mean *Z*-scores are shown by a circle in the centre of the vertical lines. We calculated confidence intervals (CI) via Equation [1] (Green and MacDonald, 2011).

$$\mathrm{CI} = 1.96\frac{\sigma}{\sqrt{N}} \qquad [1]$$

where N is the number of observations, and σ is the standard deviation which in the case of *Z*-score can be computed as $1/\sqrt{2}$ (Bertalmío, 2019). The 95 % CI is the mean *Z*-scores ± CI. In Figures 1 to 8, we provide ink labels and average gloss values for 60° that were computed as average gloss values of two colors in GU from Table 2.

In Figure 1, we can observe that the observers perceived prints with matt inks as more natural compared to prints with glossy inks. In particular, they perceived prints with IJC 255d ink as the most natural. Generally, wood represents natural material. The natural materials are matt and have rough surface (Karana, 2012). Therefore, it is logical that the observers perceived prints of wood images with matt inks as natural. In addition, matt appearance preference over glossy might be application dependent. For example, matt food packaging might enhance naturalness perception of food (Marckhgott and Kamleitner, 2019).

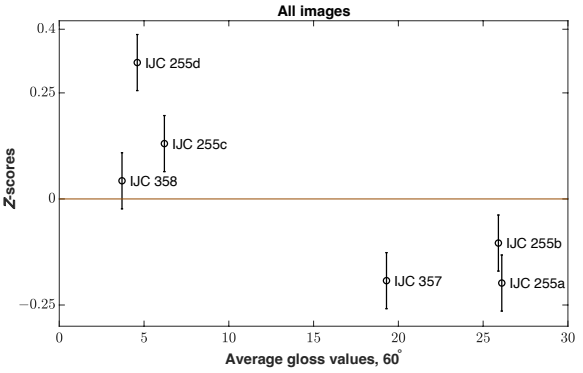

Figure 1: Z-scores of all wood images by all observers: mean Z-score values are given with 95 % CIs and average gloss values are given in GU

Based on audio data of the observers, the prints with IJC 255d ink were perceived as the most natural because the prints seemed to have the right contrast, more fine details, less elevation, and they seemed to be easy for the eyes and not blurry. A binomial sign test was applied on raw data with Bonferroni correction with a significance level of α / n (where $\alpha = 0.05$ is the desired alpha value and n is the number of comparisons: 0.05/15) (Bonferroni, 1936) to determine whether

there are statistically significant differences between ink types. According to the *p*-values (Table 3), there were no statistically significant differences between glossy inks (i.e., IJC 255a, IJC 255b, and IJC 357).

The observers perceived prints with glossy inks as less natural in all wooden floor (Figure 2), roof (Figure 3), and wicker (Figure 4) images. In the case of all wooden wall images (Figure 5), the observers perceived prints with both glossy and matt inks as less natural except with IJC 255d ink (i.e., matt ink) which were perceived as the most natural. The observers perceived prints with at least one matt ink as more natural for wooden floor, roof, wicker, and wall images. Wooden floor and wall can be considered for an indoor applications whereas wooden roof and wicker (can be used also for indoor) for an outdoor applications. Matt (i.e., low gloss) values can be preferred for indoor applications

Table 3: The p-values obtained by a sign test for all wood images, where green cells are those that have a statistically significant difference whereas red cells are those that do not have a statistically significant difference; the threshold used in the Bonferroni correction is 0.05/15 = 0.0033

	IJC 255a	IJC 255b	IJC 357	IJC 255c	IJC 255d	IJC 358
IJC 255a	–	0.0115	0.7386	9.2672×10^{-6}	1.2117×10^{-7}	3.4958×10^{-4}
IJC 255b		–	0.4177	1.1268×10^{-4}	9.0922×10^{-7}	0.0019
IJC 357			–	2.0322×10^{-7}	1.2277×10^{-10}	3.4958×10^{-4}
IJC 255c				–	1.1268×10^{-4}	0.3168
IJC 255d					–	1.4023×10^{-8}
IJC 358						–

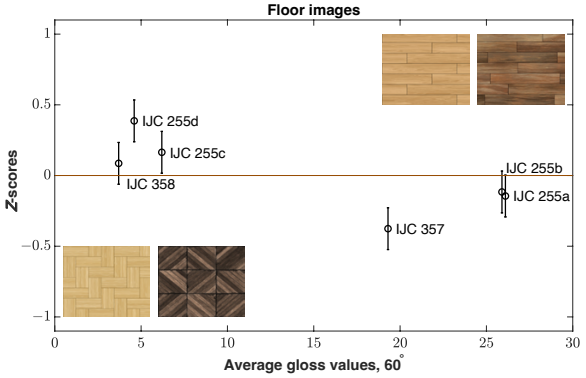

Figure 2: Z-scores of all wooden floor images by all observers: mean Z-score values are given with 95 % CIs and average gloss values are given in GU

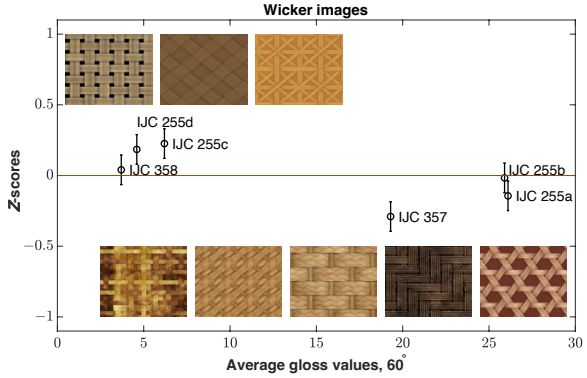

Figure 4: Z-scores of all wooden wicker images by all observers: mean Z-score values are given with 95 % CIs and average gloss values are given in GU

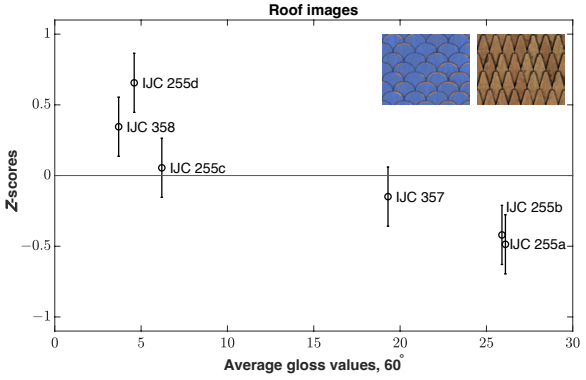

Figure 3: Z-scores of all wooden roof images by all observers: mean Z-score values are given with 95 % CIs and average gloss values are given in GU

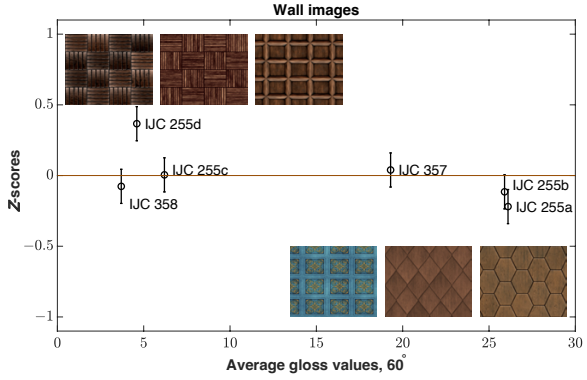

Figure 5: Z-scores of all wooden wall images by all observers: mean Z-score values are given with 95 % CIs and average gloss values are given in GU

and high-gloss values for outdoor applications (Leek, et al., 2022). The reason of selecting prints with matt ink as more natural for wooden roof by the observers was due to weather considerations. Some observers explained that wooden roof tends to be influenced by weather and time, and therefore matt look is more appropriate than glossy look for wooden roof to be perceived as natural. For wooden wicker, some observers commented that some level of gloss is needed but not too much or too less. Thus, wooden wicker should not be completely matt to be perceived as natural.

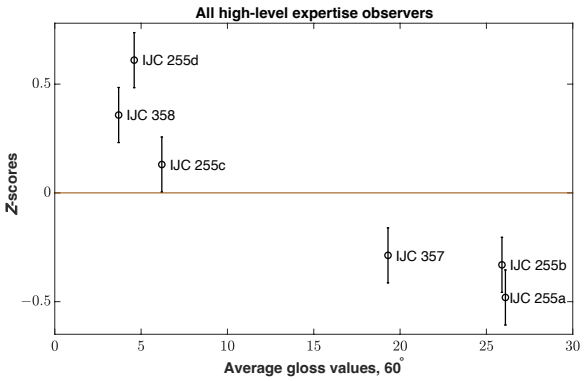

Figure 6: Z-scores of all high-level expertise observers for all images: mean Z-score values are given with 95 % CIs and average gloss values are given in GU

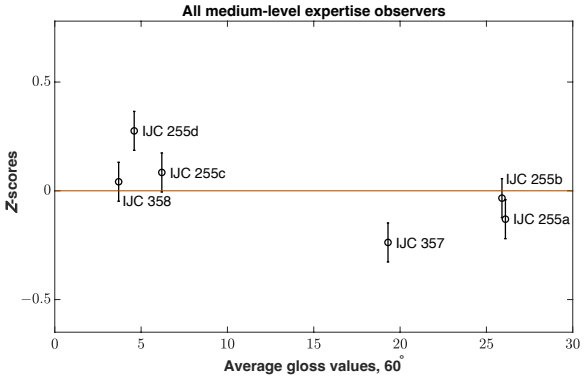

Figure 7: Z-scores of all medium-level expertise observers for all images: mean Z-score values are given with 95 % CIs and average gloss values are given in GU

There were differences in the naturalness perception of 2.5D prints within the observers with various level of expertise based on their *Z*-scores for all images. Both high-level (Figure 6) and medium-level (Figure 7) expertise observers perceived prints with matt inks as more natural than with glossy inks. More specifically, they perceived prints with IJC 255d ink (i.e., matt ink) as the most natural. Low-level expertise observers perceived prints with IJC 358 ink (i.e., matt ink) as the least natural while they perceived prints with IJC 255c ink (i.e., matt ink) as the most natural (Figure 8). In other words, low-level expertise observers perceived prints with matt inks as both natural and unnatural depending on type of matt inks. When these observers ranked prints with IJC 358 ink as the least natural, they commented that those prints with IJC 358 ink were perceived as having less 2.5D effect and a cartoonish look.

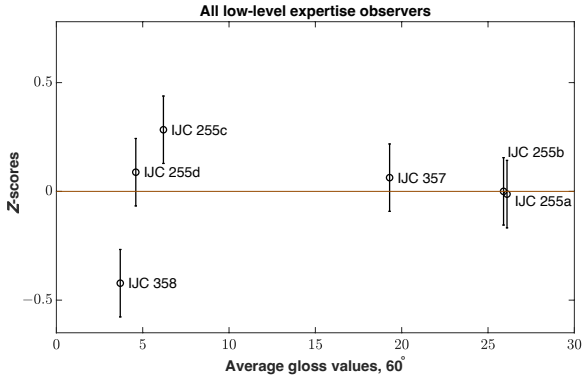

Figure 8: Z-scores of all low-level expertise observers for all images: mean Z-score values are given with 95 % CIs and average gloss values are given in GU

When the observers did ranking, they assigned each ink type (i.e., six reproductions per image) to six ranks: the most, second most, third most, third least, second least, and the least realistic for each image. We calculated standard deviation values of each rank across all images per observer. Afterwards, we calculated average of standard deviation values across ranks per observer. Based on acquired average standard deviation values, four observers were below 1.00 with minimum of 0.52, ten observers were higher than 1.50 with maximum of 1.70, and the remaining observers were in between. Those observers who were more consistent, they probably ranked based on glossiness of the inks in the prints while others probably considered content. Thus, some observers for some images probably included the content in their rankings and that could be the reason for them having larger standard deviation. For instance, in the case of prints of wooden floor images, some observers mentioned that they should be matt to be perceived as natural because too much gloss makes the prints look like plastic whereas some other observers mentioned that wooden floor should be glossy as it gives feeling of new floor. Additionally, we checked inter-observer variability by Spearman correlation coefficient and, on average for all images, it showed that the correlation varies between the observers. For gloss measurement values (Table 2), we assigned ranking and then we considered average of ranking of all measurements for 20°, 60°, and 85° for two colors (dark and light brown) which resulted in the following gloss measurement rank for the inks from glossy to matt: IJC 255a (being the glossiest),

IJC 255b, IJC 357, IJC 255c, IJC 255d, and IJC 358 (being the least glossy). Then we checked whether observer ranking correlated with the gloss measurement rank by Spearman correlation coefficient which is illustrated in Figure 9. If the correlation value is one, it means that the observers ranked the prints with the glossiest ink as the most natural. Similarly, if the correlation value is minus one, it means that the observers ranked the prints with the most matt ink as the most natural. The correlation value around zero means that the observers did not rank based on the gloss level. In Figure 9, we can observe that some observers ranked based on the gloss level while the others ranked, most probably, based on content.

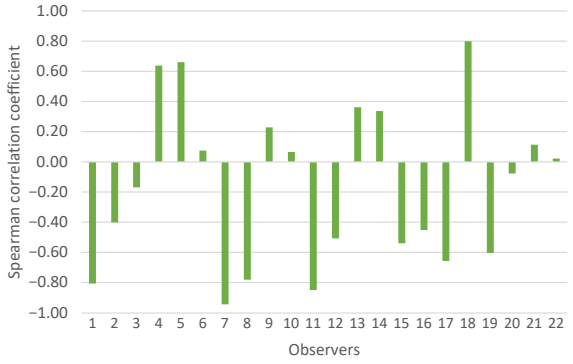

Figure 9: The correlation of observer ranking with gloss measurement rank

Figure 10 shows frequency of each ink type selection through all images for each rank by the observers (presented frequency count values are sum across all observers). We can observe that prints with IJC 255a ink were selected mostly as the least then second least, with IJC 255b ink as second least then second most, with IJC 357 ink as third least then third most, with IJC 255c ink as third most then second most, with IJC 255d ink as the most then second most, and with IJC 358 ink as the least then the most realistic representation of wooden images. Those observers who mostly ranked the prints with IJC 358 ink as the most realistic commented that the prints were perceived as being less grainy while those who ranked as the least realistic commented that the prints were perceived having less 2.5D effect, cartoonish look, and not wood color.

From audio data of observers where they provided their explanations on their rankings, we derived the most used attributes through frequency analysis. We observed that the observers were able to find that the prints had various gloss/matt levels (Figure 11).

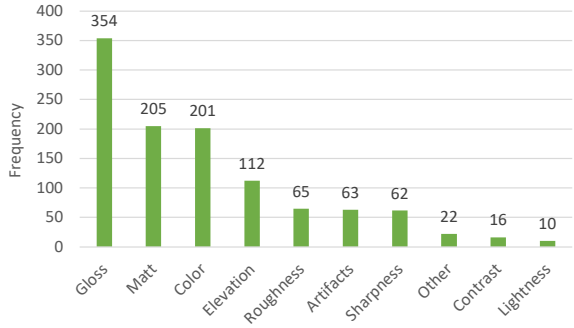

Figure 11: The most used attributes by the observers

Therefore, the two most used attributes were gloss and matt. Gloss attribute included gloss, shiny, and reflection sub-attributes. Color, bright color, saturated color, warm color, brown, yellow, and similar sub-attributes were grouped into color attribute. Elevation attribute included sub-attributes such as relief, height, elevation, 2.5D, and similar. Texture, coarseness, granularity, and smoothness were grouped into roughness attribute while noise, graininess, dots, defects, and artifacts were grouped into the artifacts attribute. Roughness was mentioned quite often in terms of coarseness and texture, and it is expected because the surface pro-

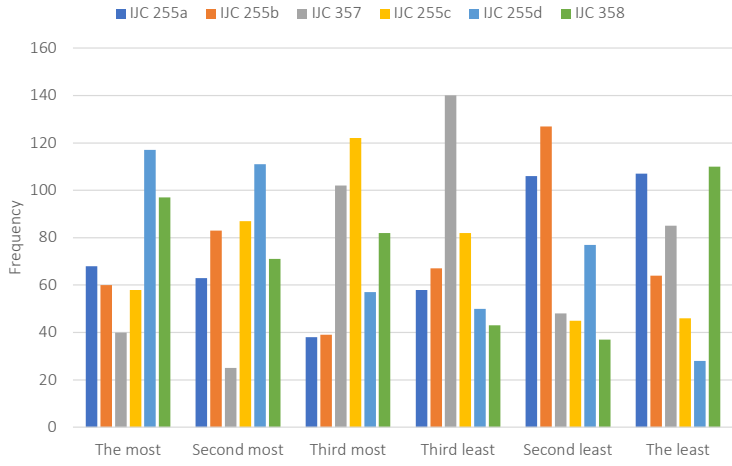

Figure 10: Each ink type selection frequency through all images in each rank

duced by UV-curable ink has a tendency to be granular (Arita, et al., 2017). Sharpness attribute included details, blurry, sharpness, and similar sub-attributes. Other attribute group included words such as plastic and cartoonish. Some observers mentioned that glossiness seems to emphasize 2.5D effect (i.e., elevation) in the prints while matt seems to make the prints look less elevated. They also mentioned that too much gloss is not preferred because it might make eyes to blink and it might make the prints look like plastic. Lightness attribute included darker and lighter sub-attributes.

Because we worked with wood images only, we assume that results might vary when considering other material images with respect to the effect of ink types on the naturalness perception of 2.5D prints. Thus, content and application might affect the results.

To conclude, the prints with matt inks were perceived as natural by the observers. Moreover, low-level expertise observers perceived the naturalness of the prints differently than other observers to some degree. Frequency analysis of the most used attributes showed that the prints had sufficient level of gloss because the observers were able to differentiate the prints based on the glossiness. We assume that the observers ranked the prints, most likely, based on the gloss level and content.

4. Conclusions and future works

We investigated the effect of various ink types on the naturalness perception of 2.5D prints of wood images fabricated at 0.5 mm elevation. We found that the gloss level of the ink affects the naturalness perception of 2.5D prints. Based on the results, the observers perceived prints with matt inks as more natural than with glossy inks. Moreover, prints with IJC 255d ink were perceived as the most natural by the observers. While high-level and medium-level expertise observers perceived prints with matt inks as more natural, low-level expertise observers perceived prints with matt inks as both natural and unnatural depending on matt ink types. Thus, there was a difference between high-medium levels and low-level expertise observers in the naturalness perception of the prints.

Our results might help industry in selection of appropriate ink types to reproduce natural-looking 2.5D prints of wood images at 0.5 mm elevation. Potential future work can be to conduct visual experiment with real wood surface and its reproduction and check whether observers can differentiate reproduction from the real wood in terms of naturalness. In addition, increasing the size of prints for the experiment can be considered.

Funding

This research was funded by the ApPEARS project from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement No 814158.

Acknowledgments

We would like to thank observers for participation in the experiment.

References

3D textures, 2021. *3D textures*. [online] Available at: <https://3dtextures.me> [Accessed 6 July 2021].

Arita, M., Yoshino, M., Hatanaka, S. and Kamei, T., 2017. 2.5-dimensional inkjet fabrication using UV curable ink. In: *33rd International Conference on Digital Printing Technologies: Printing for Fabrication 2017*. Denver, CO, USA, 5–9 November 2017. Springfield, VA, USA: Society for Imaging Science and Technology, pp. 175–180.

Baar, T., Samadzadegan, S., Brettel, H., Urban, P. and Ortiz Segovia, M.V., 2014. Printing gloss effects in a 2.5D system. In: M.V. Ortiz Segovia, P. Urban and J.P. Allebach, eds. *Proceedings of SPIE 2018, Measuring, Modeling, and Reproducing Material Appearance*. San Francisco, CA, USA, 11 March 2014. SPIE, pp. 160–167. https://doi.org/10.1117/12.2039792.

Bertalmío, M., 2019. *Vision models for high dynamic range and wide colour gamut imaging: techniques and applications*. London, UK: Academic Press.

Bonferroni, C.E., 1936. Teoria statistica delle classi e calcolo delle probabilità. *Pubblicazioni del R. Istituto superiore di scienze economiche e commericiali di Firenze*, 8.

Engeldrum, P.G., 2000. *Psychometric scaling: a toolkit for imaging systems development*. Winchester, MA, USA: Imcotek Press.

Green, P. and MacDonald, L. eds., 2011. *Colour engineering: achieving device independent colour*. Chichester, West Sussex, UK: John Wiley & Sons.

International Organization for Standardization, 2014. *ISO 2813:2014 Paints and varnishes – Determination of gloss value at 20 degrees, 60 degrees and 85 degrees*. Geneva: ISO.

Kadyrova, A., Pedersen, M. and Westland, S., 2022a. Effect of elevation and surface roughness on naturalness perception of 2.5D decor prints. *Materials*, 15(9): 3372. https://doi.org/10.3390/ma15093372.

Kadyrova, A., Pedersen, M. and Westland, S., 2022b. What elevation makes 2.5D prints perceptually natural? *Materials*, 15(10): 3573. https://doi.org/10.3390/ma15103573.

Karana, E., 2012. Characterization of 'natural' and 'high-quality' materials to improve perception of bio-plastics. *Journal of Cleaner Production*, 37, pp. 316–325. https://doi.org/10.1016/j.jclepro.2012.07.034.

Kipphan, H. ed., 2001. *Handbook of print media: technologies and production methods*. Berlin, Germany: Springer.

Leach, R.H. ed., 2012. *The printing ink manual*. 4th ed. Dordrecht: Springer Science & Business Media.

Leek, K.M., Weijkamp, C.T., Van Der Asdonk, P. and Van Keulen, L., Canon Production Printing Holding B.V., 2022. *Method for applying an image*. U.S. Pat. 11,458,741 B2.

Marckhgott, E. and Kamleitner, B., 2019. Matte matters: when matte packaging increases perceptions of food naturalness. *Marketing Letters*, 30(2), pp. 167–178. https://doi.org/10.1007/s11002-019-09488-6.

Ng, Y., Zeise, E., Mashtare, D., Kessler, J., Wang, J., Kuo, C., Maggard, E. and Mehta, P., 2003. Standardization of perceptual based gloss and gloss uniformity for printing systems. In: *PICS 2003: Image Processing, Image Quality; Image Capture Systems Conference, Including MCS/05 Fifth International Symposium on Multispectral Color Science*. Rochester, NY, USA, 13–16 May 2003. Society for Imaging Science and Technology, pp. 88–93.

Samadzadegan, S., Blahová, J. and Urban, P., 2014. Color-printed gloss: relating measurements to perception. In: *22nd Color and Imaging Conference*. Boston, MA, USA, 3–7 November 2014. Society for Imaging Science and Technology, pp. 207–211.

Samadzadegan, S., Baar, T., Urban, P., Ortiz Segovia, M.V. and Blahová, J., 2015. Controlling colour-printed gloss by varnish-halftones. In: *Proceedings Volume 9398, Measuring, Modeling, and Reproducing Material Appearance 2015*. San Francisco, CA, USA, 13 March 2015. Society of Photo-Optical Instrumentation Engineers. https://doi.org/10.1117/12.2080805.