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Table top surface appraisal by school children under different lighting conditions tested in the SenseLab

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Abstract. To find out whether a surface finishing was preferred under different lighting conditions by school children, in the light test chamber of the SenseLab, 335 children from previous studied schools were asked to assess a desk surface during different light conditions. A two-way randomized design was used to test children's assessments for six school desks table tops (brown, yellow and grey wood, and, normal, matt and reflective white), under three different light conditions: energizing, calming, and focusing. A statistically relevant relationship was found for the three wooden surfaces, but none for the white ones. Such results may be due to the fact that better contrast between the participants' form and the surface appeared with the wooden-like surfaces, as opposed to that with the white surfaces. Similarly, white surfaces' characteristics seemed to be more difficult to assess (mattness, reflectiveness, opacity) as opposed to those for the wooden-like surfaces (colour yellow, brown, grey).

Introduction

In a recent field study of 54 classrooms of 21 primary schools in the Netherlands, was observed that desk finishing and lighting tend to be standard. Generally, desktops are of light wood laminate and lights were fluorescent with standard lighting [1]. Additionally, from the inspection of the classrooms was found that the colours of the floors had the most variation, while walls and ceilings were generally white. From studies with adults it is known that different colours can directly affect an individual's impression of environmental parameters [2]. Also, the colour/light combinations of indoor environmental surfaces seem to have an effect on perceptual performance of school children (e.g. colour of walls [3]) and their behaviour and mood [4]. Additionally, there is proof that light affects school children's concentration and comfort [1, 2, 5], but little is known about how a colour of the desktop affects comfort and whether the colour interacts with the effects of the lighting conditions. The objective of this study was to study the effect of a surface finishing under different lighting conditions as assessed by school children.

In the light test chamber of the SenseLab [6], children from the previous studied schools [1] were asked to assess a desk surface during three different lighting conditions: energizing (650lx; 12000K), calming (300lx; 2900K), and focusing (1000lx; 6500K). Standard (300lx, 3500K) was used as washout. The conditions were based on Philip's School Vision attributes [7]. Interchangeable surfaces comprised of white matte, white reflective, grey wood, brown wood, yellow wood. The SenseLab comprises of four test chambers (one for each IEQ factor: air, light, acoustics and thermal aspects) and the Experience room (a room for integral perception) [6].

Past studies have suggested that correlated colour temperature (CCT) can have an effect on both subjective comfort and preferences for the light itself [8]. Few studies have shown the appraisal of environmental characteristics based on the light conditions. A study did show that subjects in classrooms tend to perceive environmental spaces brighter when CCT is higher, even when illuminance levels are the same [9].

2 Methodology

2.1 Study design

This study was part of a series of tests performed with children from the previous studied schools, in the SenseLab [6]. A two-way randomized design was used to test the preferences of children for a range of six table top surfaces and the effects of the light conditions on such preferences.

2.2 Facilities

During the SenseLab studies the light test chamber of the SenseLab was used (see Figure 1). The light chamber was equipped with four student desks arranged facing

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each other and next to each other. Two desks on one side were labelled A, and the other two, B.

Figure 1. The light test chamber set-up.

Above the desks, two DMX-controlled LED bars were installed. The LED lights were programmed with Arduino to change the light conditions every minute. The lights were programmed with the following order: energizing, standard, calming, standard, focusing. The order of the table top surface was randomly generated, and a combination of two of the six surfaces was presented to each group. In Table 1, the six surfaces tested on the different days are presented.

2.3 Procedure

When the children arrived in the SenseLab, they filled in a one-page questionnaire with personal information and were divided into groups (randomly) of maximum 16 children per group. Per day, a maximum of three groups could perform the tests. One group started in the Experience room, one group was divided over the four test chambers (maximum of 4 children per test chamber) and the third group could start playing in the Science Centre (the location in which the SenseLab is located). After approximately 35 minutes the groups changed: group 1 went to the test chambers, group 2 could play in the Science Centre and group 3 went into the Experience room.

In each of the test chambers (light, sound, air and thermal), different tests were performed. Every 7-8 minutes, the children changed to another test chamber, after all tests were performed. The tests performed in the light test chamber are presented here.

In the light test chamber four children performed the test, two on side A and two on side B. As soon as they sat, they were given a form, containing 5-point Likert scale questions to rate their appraisal of the surface. The experiment started when the researcher turned on the Arduino programme, enabling the lights to shine and change. After one to two minutes of an explanation and introduction presented by the researcher, the test started by turning on the LED bar.

The two children sitting on Side A were exposed to the same surface, and the two children sitting on Side B to another surface (Figure 1). In total six surfaces were tested: white matte, white reflective, grey wood, brown wood, and yellow wood. In Figure 2, all the six surfaces are shown.

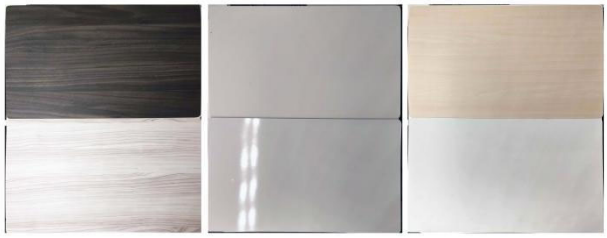


Figure 2. Six types of surfaces. CW from top left: brown wood, white matt, yellow wood, normal white, reflective white, grey wood.

During the test they filled in a one-page questionnaire that had the same question, repeated five times, one per light situation (see Figure 3). When they were finished, all four children moved on to the Acoustical test chamber for tests.

2.4 Data management and analysis

All data from the questionnaires were manually typed in and stored in IBM SPSS Statistics 24.0. A second person systematically checked the input of the questionnaire data. Descriptive statistics such as percentages, range or arithmetic mean with standard deviation were used to summarize the data. The 24 combinations were analysed. To study possible relationships between the different assessments, the assessment made by the children were given a number from 1 to 5. ANOVA (one-way) and Pearson, assuming a continuous scale and normal distribution, were used to analyse relationships.

2.5 Ethical aspects

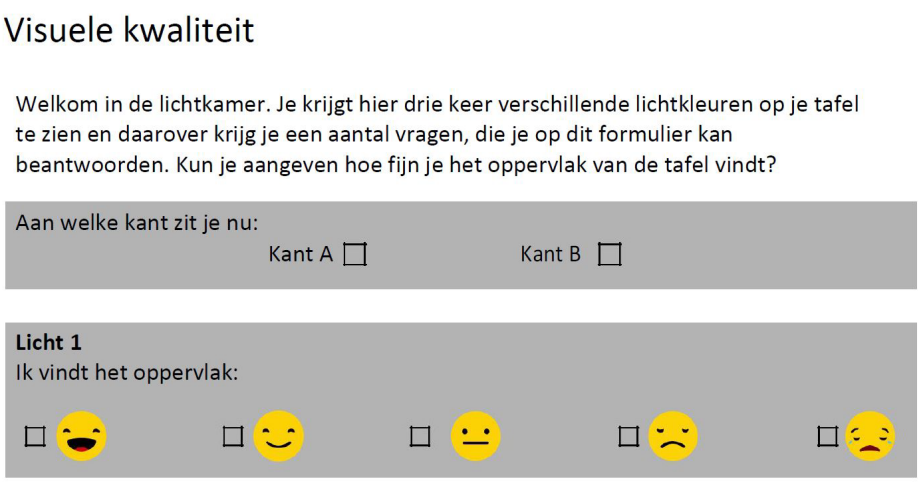
After recruitment of the schools, the parents received an information letter and a consent letter from the school management, which usually happened two weeks before the visit. On the day of the visit, the research team received the consent forms usually from the teachers accompanying the children. For the children without permission to join the experiments, the school management generally decided not to have them join the visit.

The Ethics committee of the TU Delft gave approval for the study.

Table 1. Testing scheme.

Surfaces	Date* (n)	Without colour blind n	Colour blind n	Wearing glasses n (%)	Girls n (%)	Mean age Mean (SD)
White normal	1 (7); 2 (6); 3 (6**); 4 (7); 4 (7); 8 (8); 8 (6)	46	1	5 (10.9)	22 (47.8)	10.4 (1.0)
White matt	3 (6); 3 (6); 5 (7); 5 (6); 6 (7**); 9 (8)	39	1	4 (10.3)	27 (69.2)	10.7 (0.9)
Reflective white	3 (6); 4 (8); 4 (7); 7 (7); 7 (8)	49	0	7 (14.3)	21 (42.9)	10.9 (0.8)
Grey wood	1 (8); 2 (8); 5 (7); 6 (7); 6 (7); 8 (8); 9 (8)	53	0	7 (13.2)	26 (49.1)	10.3 (1.2)
Brown wood	1 (7); 2 (7); 2 (5); 3 (6); 4 (7); 5 (6**); 8 (8); 8 (8)	53	1	5 (9.4)	25 (47.2)	10.2 (1.1)
Yellow wood	1 (7); 3 (6); 4 (8**); 6 (7); 7 (8); 7 (7); 8 (8)	50	1	10 (20.0)	26 (52.0)	11.0 (1.1)
		290	4	38 (13.1)	147 (50.7)	10.6 (1.1)

*: dates: 1=15-02; 2= 20-02; 3=22-02; 4=08-03; 5=15-03; 6=20-03; 7=27-03; 8=03-04; 9=05-04
**: means there's a colour-blind child in this group; All the percentages presented are among the children who don't have colour blind.


Visuele kwaliteit

Welkom in de lichtkamer. Je krijgt hier drie keer verschillende lichtkleuren op je tafel te zien en daarover krijg je een aantal vragen, die je op dit formulier kan beantwoorden. Kun je aangeven hoe fijn je het oppervlak van de tafel vindt?

Aan welke kant zit je nu:
Kant A ☐ Kant B ☐

Licht 1
Ik vindt het oppervlak:
☐ ☐ ☐ ☐ ☐

Figure 3. Excerpt from lighting test questionnaire.

3 Results

3.1. Participants

In total 335 children from seven primary schools participated to the SenseLab experiments that were held from February 13 to April 5 at 10 different days. For the tests performed in the light test chamber, 24 combinations, excluding the first day of testing (which was taken as a pilot) and the last day (to have a more even number of respondents per surface), and children who did not complete their form, resulted in responses of a total of 290 children with an average age of 10.6 years (SD of 1.1 years) and comprising of 51% girls (see Table 1). Four of them claimed to be colour blind and were therefore not included in the analysis.

3.2 Descriptives

The descriptives are presented in Tables 2 and 3.

For the answer "I find the surface", the first two possible answers were combined and the last two answers were combined, resulting in three answers: good, normal and bad. Descriptives were produced in two different ways: by comparing light conditions and by comparing surface colour.

Additionally, the washout conditions were pulled out of the other three conditions as control conditions. For the energizing light, the most liked surface was brown wood, with 59.7% of children rating is as good, while white normal was the most disliked (23.9%).

The best rated surface under calming conditions was white matt (46.2% good), compared to the worst rated grey wood with 52.8% bad. Under focusing light, brown wood was the best rated (58.2%), and white normal the worst rated (37%). Under the first washout session, grey wood was the best rated (53.8%) while white matt was the worst rated (30.8%). The second washout session showed different results, with the better appraised surface brown wood (76.1%) and the worst appraised white matt (23.1%) (See Tables 2 and 3).

3.3 Comparison of evaluations

The children's evaluations during the two washouts were compared for the different surfaces tested (Table 4). When the surfaces were reflective white or brown wood, there was a statistically significant difference between the evaluations of surfaces during these two washouts (respectively p=0.013 and p=0.000). Children liked the surface during the second washout more than during the first one: The mean values of children's valuations during the first washout was higher than the second one. While for the other surfaces, there was no significant difference between the evaluations during these two washouts.

The results of the comparison of children's evaluations under the three different light types is presented in Table 5. When the surfaces were grey wood, or brown wood, or yellow wood, there were statistically significant differences among the evaluations of surfaces under three light types (p=0.006, p=0.000, and p=0.003 respectively). Children liked the surface more when the light was energizing or focusing light than when it was calming light.

4 Discussion

4.1 General

Comparing the surface preference under the three light conditions, energizing, calming, and focusing, only shows statistical significance for the three wood surfaces: grey wood, brown wood and yellow wood. However, the three white surfaces -normal, matt, and reflective- show no statistical significance. A few reasons can be suggested for this: first, it could be the case that the qualities of the white materials (opacity, mattness, and reflectiveness) did not stand out enough to be appraised differently; therefore, all are appraised as plain white. Conversely, the three wood surfaces are noticeably different, and may be easier to appraise. Another reason could be that children were influenced by the contrast between the form where they were writing and the surface; therefore, as white surfaces offered less contrast, they were rated lower than wooden surfaces that provided better contrast. Literature suggests that luminance ratios should not exceed 1:3 or 3:1 between the task (paper) and the adjacent surrounding (surface). This can be achieved by avoiding bright surroundings, which may be the case of the white surfaces in the present study [10]. Furthermore, it is suggested that following such luminance ratios can ensure that excessive contrasts as well as too much uniformity (monotony) are avoided. Therefore, a task on a surface should be slightly brighter than the immediate surrounding, so that attention is ensured, while avoiding distraction [10].

Finally, other elements that could influence the results are individual differences of children [11]. Research suggest that colour and light CCT can have an effect on the mood and the performance of people, however, these effects can depend on the individual preferences of the participant as well as on the environmental sensitivity of the participant – the level to which a person can screen out environmental stressors [12].

Table 2. Results of the three different assessments per surface tested.

Surface	n	Energizing			Calming			Focusing		
		Good n (%)	Normal n (%)	Bad n (%)	Good n (%)	Normal n (%)	Bad n (%)	Good n (%)	Normal n (%)	Bad n (%)
White normal	46	24 (52.2)	11 (23.9)	11 (23.9)	18 (39.1)	7 (15.2)	21 (45.7)	20 (43.5)	9 (19.6)	17 (37.0)
White matt	39	18 (46.2)	14 (35.9)	7 (17.9)	18 (46.2)	5 (12.8)	16 (41.0)	18 (46.2)	10 (25.6)	11 (28.2)
Reflective white	49	21 (42.9)	16 (32.7)	12 (14.5)	20 (40.8)	12 (24.5)	17 (34.7)	20 (40.8)	13 (26.5)	16 (32.7)
Grey wood	53	30 (56.6)	16 (30.2)	7 (13.2)	20 (37.7)	5 (9.4)	28 (52.8)	28 (52.8)	9 (17.0)	16 (30.2)
Brown wood	53	33 (62.3)	10 (18.9)	10 (18.9)	15 (28.3)	10 (18.9)	28 (52.8)	33 (62.3)	8 (15.1)	12 (22.6)
Yellow wood	50	27 (54.0)	13 (26.0)	10 (20.0)	18 (36.0)	5 (10.0)	27 (54.0)	24 (48.0)	14 (28.0)	12 (24.0)
	290	153 (52.8)	80 (27.6)	57 (19.6)	109 (37.6)	44 (15.2)	137 (47.2)	143 (49.3)	63 (21.7)	84 (29.0)

Table 3. Results of the washouts assessments for each surface tested.

Surface	N	Washout 1			Washout 2		
		Good n (%)	Normal n (%)	Bad n (%)	Good n (%)	Normal n (%)	Bad n (%)
White normal	46	23 (50.0)	16 (34.8)	7 (15.2)	29 (63.0)	14 (30.4)	3 (6.5)
White matt	39	17 (43.6)	10 (25.6)	12 (30.8)	21 (53.8)	9 (23.1)	9 (23.1)
Reflective white	49	23 (46.9)	13 (26.5)	13 (26.5)	36 (73.5)	8 (16.3)	5 (10.2)
Grey wood	53*	28 (53.8)	12 (23.1)	12 (23.1)	37 (69.8)	8 (15.1)	8 (15.1)
Brown wood	53	20 (37.7)	14 (26.4)	19 (35.8)	42 (79.2)	7 (13.2)	4 (7.5)
Yellow wood	50	23 (46.0)	14 (28.0)	13 (26.0)	32 (64.0)	12 (24.0)	6 (12.0)
	290	134 (46.4)	79 (27.3)	76 (26.3)	197 (67.9)	58 (20.0)	35 (11.1)

*one missing vote for washout 1.

Table 4. Comparison of children's evaluations of surfaces during washouts.

	N	Washout 1 (Mean)	Washout 2 (Mean)	P*
White normal	46	2.46	2.22	0.236
White matt	39	2.82	2.49	0.244
Reflective white	49	2.67	2.10	**0.013**
Grey wood	53	2.50	2.09	0.096
Brown wood	53	2.85	1.87	**0.000**
Yellow wood	50	2.62	2.28	0.131
Together	290	2.65	2.16	**0.000**

*P=P-value from ANOVA. P-values in bold refer to significant relationships at 5% level.

Table 5. Comparison of children's evaluations of surfaces under three different light types.

	N	Energizing (Mean)	Calming (Mean)	Focusing (Mean)	P*
White normal	46	2.63	3.04	2.76	0.332
White matt	39	2.54	2.90	2.64	0.491
Reflective white	49	2.76	2.90	2.82	0.859
Grey wood	53	2.36	3.15	2.55	**0.006**
Brown wood	53	2.40	3.32	2.26	**0.000**
Yellow wood	50	2.48	3.26	2.50	**0.003**
Together	290	2.52	3.11	2.58	**0.000**

*P=P-value from ANOVA. P-values in bold refer to significant relationships at 5% level.

4.2 Procedure and Washouts

Comparing the surfaces under the washout lighting yielded to statistically significant differences for brown wood and reflective white. In principle, none of the surfaces should yield to differences in appraisal under the washout sessions as they were the same lighting conditions. Several reasons exist for such outcome. First, it is a possibility that not enough surface differences emerged under the different light conditions. Second, it is possible that, since the Calming light had the worst appraisal of all lights – presumably due to its yellower and dimmer qualities - the second washout had the best appraisal, except for brown wood, maybe due to the high contrast with the previous Calming light; thus, explaining the differences in appraisals for the washouts. Finally, it could be argued that one minute per light condition could be too short for the human eye to habituate to the CCT and illuminance level of each light condition. However, research suggests that 1000ms is enough for the human pupil to adjust to luminance levels [13].

4.3 Preferences of different lights and surfaces

An interesting result from this study is the fact that for all surfaces, the calming light was perceived as the worst and the energizing light as the best (except for the dark wood surface); for the wooden-like surfaces these differences were statistically significant. With respect to surfaces, the children preferred the brown wood under focusing light the best and again the brown wood under calming light the worst. For energizing light, grey wood scored the best, while for focusing light, brown wood. These findings indicate that different surfaces most likely require different types of lighting, and vice versa.

5 Conclusions

The study presented was part of a larger study in which primary school children performed several tests in four test chambers and a workshop in the experience room. This study was a first attempt to study the effect of different surface finishing under different lighting conditions on the table top preference of children.

Although under the special light conditions wooden type surfaces were better appraised over white ones and calming light was evaluated the worst, more tests are needed to confirm these results. Future tests could comprise of tests in which an individual child appraises several desk surfaces under a single light condition and in which measures are taken to counterbalance possible carryover effects as was seen in some of the washout assessments. Furthermore, future tests could take into account mood or environmental sensitivity of respondents, as these are factors that can also contribute in discrepancies of appraisal.

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