Crying colours and their influence on loudness judgments

Daniel Menzel, Thomas Dauenhauer, Hugo Fastl
[1] *AG Technische Akustik, MMK, TU München, Germany, Email: menzel@mmk.ei.tum.de*

Introduction

The German term "schreiende Farbe" denotes a very salient colour which stands out among other colours. It is usually translated as "loud colour", but to better convey the notion of a colour which actively attracts attention, the literal translation of "crying colour" also seems appropriate (Müller [1], p.100).

As it is known from previous studies that the colour of objects like trains or cars can influence loudness judgments (Fastl [2], Menzel et al. [3]), experiments were performed to determine if crying colours lead to higher loudness ratings compared to non-crying colours.

First, experiments are described which had the goal to identify colours perceived as crying. Then, results of loudness judgments performed while viewing crying and non-crying colours are presented.

Adjustment of colours

As an initial step, it had to be determined if there exists a common notion of a crying colour. A method of adjustment was chosen in which a subject could change certain properties of a colour patch presented on a screen until the impression of a crying colour was achieved.

Setup and procedure

The experiment took place inside a sound-proofed booth, the stimuli where presented on a calibrated 21" LC display (Eizo CG211, white point 6500K, 100 cd/m²). No other light sources were present. The adjustment was performed using the CIE 1976 (L*a*b*) colour space (Wyszecki and Stiles, [4]). A graphical user interface provided three faders to vary the three parameters L* (lightness), a* ("red-green content"), and b* ("blue-yellow content") of a colour patch (width 29 cm, height 19 cm) which was visible in the middle of the screen with a medium grey surrounding. The viewing distance was 70 cm.

Fifteen subjects (6f, 9m), aged between 22 and 25 years (median 24 years) participated in this experiment. They were instructed to generate as many crying colours as they wanted.

All subjects in this and the following experiments were screened for colour vision deficiencies using an Ishihara test (Ishihara [5]).

Results

Most of the resulting 105 colours could be separated by inspection into seven groups: bright red, bright green, pink, yellow, turquoise, dark blue, and orange colours. Figure 1 shows representatives of each group and how often colours of this group were produced by the subjects. Colours of the groups bright red, bright green, pink, and yellow account for almost 75% of all adjusted colours.

Dark blue was produced more often than orange in this experiment and was only chosen by female subjects. Other than that, male and female subjects seem to have quite similar understandings of what they perceive as a crying colour.

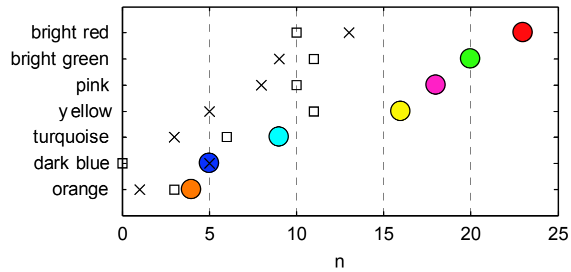

Figure 1: Representatives of crying colours and frequency of occurrence n as adjusted by all (filled circles), female (×), and male (□) subjects.

Rating of colours

In a second experiment, the "cryingness" of colours was evaluated to verify the results of the first experiment. For this purpose, representatives of the seven colour-groups found via adjustment plus eight additional colours had to be rated on a five point categorical scale: "not crying", "somewhat crying", "medium", "crying", and "very crying".

Setup and procedure

The same experimental setup as before was used but with two variants of colour presentation: full-screen without grey surroundings and smaller colour patches with grey surroundings, as in the previous experiment.

Fourteen subjects (4f, 10m), aged 22 to 25 years (median 24 years), each rated all 15 colours three times for both variants of presentation. They were instructed to categorize the colours by pressing keys from 1 ("not crying") to 5 ("very crying") on a computer keyboard. The keys were labelled with the German terms for the five categories ("nicht schreiend", "wenig schreiend", "mittel", "schreiend", "sehr schreiend").

Results

As only minor differences could be seen between the two variants of colour presentation (with or without grey surroundings), figure 2 can be regarded as a typical result of this experiment.

Male and female subjects generally seem to agree in their rating. Exceptions with differences between the genders of more than half a category are turquoise, rose, and brown, which male subjects tend to rate higher, i.e. more crying, than female subjects.

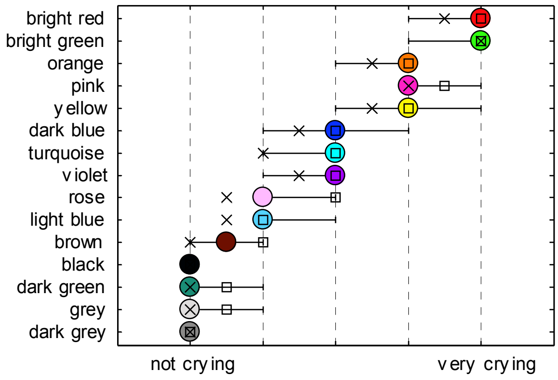

Figure 2: Rating of the "cryingness" of 15 colours presented as patches without grey surrounding. Filled circles and black lines indicate medians and interquartile ranges of all subjects. Medians of female (×), and male (□) subjects are given separately.

All colours adjusted to be crying in the first experiment were rated as "very crying" or "crying." Colours which did not occur during colour adjustment like light blue or dark grey were rated as "somewhat crying" or "not crying". Orange, which was previously only produced four times, was now rated as "crying" along with pink and yellow.

Apparently, when instructed to think of crying colours and subsequently adjust them, orange does not seem to be a frequent choice, although it is rated as "crying". A similar discrepancy between imagining a colour and seeing a colour was reported by Fastl et al. [6], where semantic differential ratings of the colour brown differed depending on whether subjects imagined the colour or saw the colour on a card.

Loudness judgments

To determine if crying colours are able to influence loudness judgments, two experiments were conducted. On the one hand, full-screen colour patches were used to see if abstract presentation of colours is sufficient to affect loudness ratings. On the other hand, images of coloured objects were presented with the intention of increasing realism and intermodal effects.

Stimuli

The same 15 colours as in the previous experiment were used. In the first part, they were presented full-screen, i.e. without grey surroundings, on the 21" LC display. For the second part, drawings of radios were used, because they could be easily adapted to different colours and could also be perceived as plausible sound sources (figure 3). Their size on screen was approximately 10 by 15 cm on a white background.

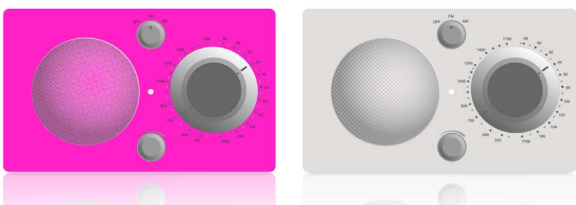

Figure 3: Two examples of drawings of a radio which were presented in different colours during the experiments.

Uniform exciting noise (Fastl and Zwicker [7], p. 170) with a duration of 1.5 sec and Gaussian gating was used as acoustic stimulus in both parts of the experiment. To minimize memory effects during loudness judgments, the sound pressure level of the noise was varied in 5 dB steps between 50 and 80 dB.

Method

Subjects indicated their loudness judgment by pressing with their finger on a horizontal white line which was visible on a small touch sensitive screen. The line was marked "extremely soft" on its left end, and "extremely loud" on its right end. The line was 24 cm long and had no subdivisions.

Setup and procedure

The setup for presenting the visual stimuli was the same as in the previous experiments. The smaller touch sensitive screen was mounted directly below the main display.

The acoustic stimuli were presented diotically via calibrated electrodynamic headphones Beyer DT48 with free-field equalizer as described by Fastl and Zwicker ([7], p. 7).

Fifteen normal hearing subjects (6f, 9m, 22 to 51 years, median 24 years) participated in these experiments. At the beginning of each session, all sounds were first presented from softest to loudest as orientation. Then, all combinations of the 15 colours (or images in the second part of the experiment) and seven sounds had to be rated three times in random order.

Results with colour patches

Subjects' ratings along the line were mapped linearly to a scale from 0 (extremely soft) to 1 (extremely loud). Inter-individual medians were calculated from intra-individual medians for each of the 105 combinations of 7 levels and 15 colours. To obtain a global indicator of possible colour influences on the loudness ratings, for each level the median over all colours was subtracted from the inter-individual medians. Then quartiles over the data at all levels were formed. The resulting global shifts in loudness judgments are depicted in figure 4.

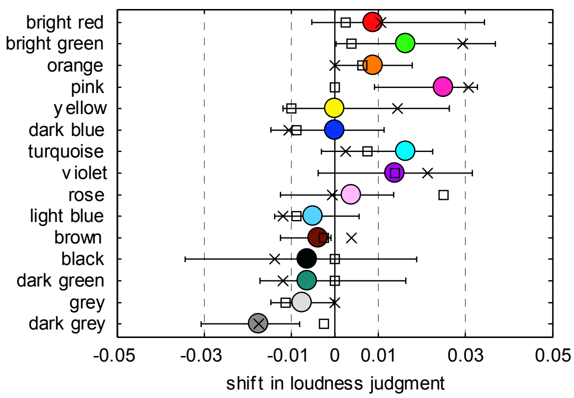

Figure 4: Differences from average loudness judgments of uniform exciting noise during presentation of full-screen colour patches. Filled circles and black lines indicate medians and interquartile ranges of all subjects. Medians of female (×), and male (□) subjects are given separately.

The medians shown can be interpreted as a measure of how much a particular colour caused loudness ratings to differ from the average rating. These differences are in the order of 1% of the total line length in the case of full-screen colour patches.

Colours previously rated as “crying” or “very crying” generally seem to cause an overestimation of loudness, with the exception of yellow. Some colours rated “medium crying” like turquoise and violet are also able to increase loudness ratings. Colours rated “not crying” or “somewhat crying” mostly cause a slight underestimation of loudness, albeit with notable variations in case of black and dark green.

The data suggest that female subjects are more strongly influenced in their loudness judgments by simultaneously presented colour patches. Differences between the genders are visible for example in the cases of bright green and pink, where male subjects are, on average, not much affected by the colour presentation, while loudness ratings of female subjects are increased. The opposite effect can be seen for the colour rose, where male subjects were more strongly affected. Male and female subjects do not agree on the direction of loudness shifts when viewing yellow.

The results so far were obtained using the global measure of colour dependent shifts in loudness judgment. To analyze the data in greater detail, a two-way repeated measures analysis of variance on the intra-individual medians with sound pressure level and colour as within-subject factors was performed. As expected, sound pressure level showed a significant main effect [$F(6,84) = 447$; $p < 0.0001$]. The effect of colour, on the other hand, failed to reach statistical significance [$F(14,196) = 1.42$; $p = 0.146$].

Results with coloured objects

Figure 5 shows the resulting global shifts in loudness judgments if, instead of abstract colour patches, drawings of coloured radios as seen in figure 3 are used as visual stimuli.

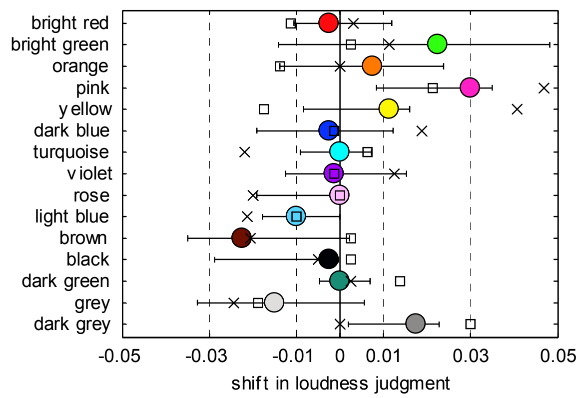

Figure 5: Differences from average loudness judgments of uniform exciting noise during presentation of drawings of coloured radios. Filled circles and black lines indicate medians and interquartile ranges of all subjects. Medians of female (×), and male (□) subjects are given separately.

Except for bright red, all crying colours cause positive shifts of loudness ratings up to 3% of the total line length, with bright green showing a large variability. Non-crying colours tend to lower loudness ratings, with the exception of dark grey.

As in the previous experiment, female subjects seem to be influenced more strongly, for example in the case of the colour pink. Also, yellow elicits quite different reactions from male and female participants.

Detailed examination of the underlying data using two-way repeated measures analysis of variance shows significant main effects of sound pressure level [$F(6,84) = 311$; $p < 0.0001$] and colour [$F(14,196) = 1.81$; $p = 0.039$] with no significant interactions between the factors.

Calculation of Tukey’s *honestly significant difference* ($\alpha = 0.05$) reveals that loudness judgments (expressed as percentage of total line length) for pink radios are significantly higher than for grey radios. This can be seen in figure 6.

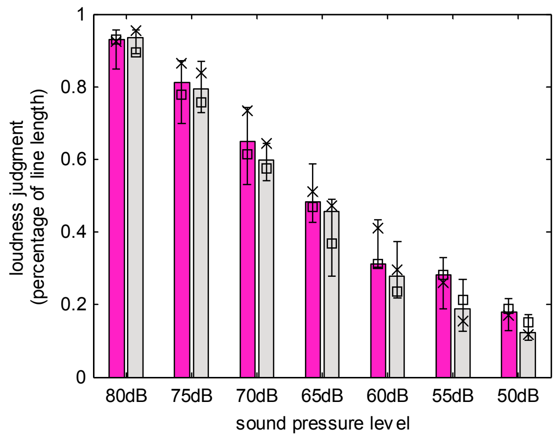

Figure 6: Loudness judgments while viewing drawings of pink (left) and grey (right) radios. Bars indicate medians, black lines show interquartile ranges. Medians of female (×), and male (□) subjects are given separately

Both male and female participants rate pink radios as being louder than grey radios, female subjects also tend to give higher overall ratings for sound pressure levels between 55 and 75dB.

Discussion

Subjects generally agree on what they perceive as crying colours and on how crying a given colour is. The concept of specific colours being more crying than others therefore seems valid.

Full-screen colour patches are able to influence loudness judgments of simultaneously presented uniform exciting noise in such a way that crying colours generally cause an overestimation of loudness compared to an average rating. Similar results are found when coloured radios are used as visual stimuli.

Using more detailed statistical analysis, it can be shown that significant colour influences occur while viewing drawings of coloured radios. This could be viewed as an indication that the depiction of objects instead of abstract colour patches may be able to enhance audio-visual interactions.

Previous studies (e.g. [2], [3]) showed that red trains or cars elicit higher loudness ratings compared to green ones, while the results presented here seem to indicate the opposite effect. This apparent discrepancy could be caused by the different shades of green which were used. The “crying” bright green is almost fully saturated and possesses a high luminance, compared to the more natural, less saturated green used in previous experiments.

This could be an indication that in the context of audio-visual interactions it is not sufficient to just specify colours with regard to their hue (e.g. “green”), but to further differentiate between the variations within the same hue in terms of e.g. saturation or brightness.

Acknowledgements

This work is supported by Deutsche Forschungsgemeinschaft by grant FA 140/5.

References

[1] Müller M.: Chips from a German Workshop Vol. II: Essays on Mythology, Traditions, and Customs. Scribner, Armstrong, and Co., New York, 1876

[2] Fastl H.: Audio-visual interactions in loudness evaluation. In: Proc. 18th ICA, Kyoto, Japan, 1161-1166, 2004

[3] Menzel D., Fastl H., Graf R., Hellbrück J.: Influence of vehicle color on loudness judgments. J. Acoust. Soc. Am. **123 (**2008), 2477–2479

[4] Wyszecki G., Stiles W. S.: Color Science: Concepts and Methods, Quantitative Data and Formulae. John Wiley & Sons, New York, 1982

[5] Ishihara, S.: The series of plates designed as a test for colour blindness: 24 plates edition. Kanehara, Tokyo, 1990

[6] Fastl H., Rader T., van den Boogart G., Kuwano S., Namba S.: Crosscultural comparison of colour evaluation using semantic differential. In: Fortschritte der Akustik - DAGA '08, 385-386, DEGA, Berlin, 2008

[7] Fastl H., Zwicker E.: Psychoacoustics - Facts and Models. Springer, Berlin, Heidelberg, 2007