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Barva in hrup

Colour and Noise

Milena Pušlar-Čudina - Mirko Čudina

Učinek hrupa, kot ene od nezaželenih oblik zvoka, lahko ublažimo z uporabo različnih tehničnih metod ali z uporabo alternativnih metod, npr. z učinkom barve. Uporaba barve za blažitev učinka hrupa temelji na načelu spremembe zaznave v možganih ali na metodi odvračanja pozornosti ljudi od hrupa. Učinek barve na hrup je odvisen od osebe (človeškega bitja) samega in mnoge definicije so relativne, tako kakor je relativna definicija hrupa. Ta subjektivni učinek barve na hrup lahko v nekaterih primerih postane objektiven, če z interakcijo med vidnim in slišnim dosežemo neko novo lastnost, v kateri prevladuje učinek vidnega. Rezultat tega je občutek nižjega hrupa. V tem prispevku so opisane nekatere zakonitosti interakcije med barvo in zvokom ali hrupom.

(Ključne besede: hrup, svetloba, barve, zmanjševanje hrupa)

Noise is one of the undersirable forms of sound. Noise can be diminished by different engineering methods or its effects on people can be soothed by alternative methods, such as through the use of colour. Using a colour to soothe the effect of noise is based upon the method of turning the subjects attention away from the noise, thus changing the perception in the brain. Effects of colour to suppress noise depend on the subject (human beings) and many definitions are relative like the definition of noise. The subjective effect of colour on noise can in some cases become objective when with the interaction between the audible and the visible achieves a new quality in which the effect of the visible prevails. A result of this is a feeling of lower noise. In this paper, some laws of the interaction between colour and sound (noise) are described.

(Keywords: noise, light, colour, noise reduction)

0 UVOD

Vsi naši čuti, ki so usmerjeni v zunanji svet, nas na neki način določajo v njem. Zlasti sluh in vid nam dokazujeta obstoj zunanjega sveta in njegovih pojavov. Oko nam z vidnimi zaznavami predočuje predvsem "pojavno" stran sveta, medtem ko uho z zvočnimi zaznavami razodeva njegovo stvarnost - eksistenčno stran sveta. Združitev vidne in slušne zaznave opravlja živčni sistem, ki združuje funkcije vseh delov organizma v celoti na eni strani in v povezavi organizma z okoljem na drugi.

Barva in zvok imata kljub različnosti veliko skupnega, čeprav je povezava vidnega in slišnega izraza izrazito subjektivna. Subjektivnost v nekem trenutku lahko postane tudi objektivna, če uspe združitev vidnega in slišnega. V tem primeru se meja med njima zabriše, vidno in slišno prestopita v rezonanco in postaneta eno. Pri združitvi barve in zvoka (interaktu) gre za vzpostavitev dinamičnega ravnotežja (harmonizacija) med zvočnimi elementi in ustrezno obliko (barvo ali sliko) [5].

0 INTRODUCTION

All of human senses in some way determine our position in the external world. Hearing and sight, especially, provide the reality of the external world and its phenomena. The eye provides us first with the "phenomenological" side of the world, whereas the ear lets us know its reality - the existential side of the world. Integration between the visual and acoustical perceptions is performed by the nervous system, which integrates the functions of all parts of the organism into a whole, and relates the organism to the environment.

Colour and sound, in spite of differences, have a lot in common, although the connection between the visible and the audible expression is subjective. Subjective can in a given moment become objective, if we succeed in unifying the visible and the audible. In this case the margin between them is wiped out, and the visible and audible go over to resonance and become one. At the interaction between colour and sound it is important to restore the dynamic equilibrium (harmonization) between the sound elements and corresponding form (colour or picture) [5].

Tudi med barvo in hrupom obstaja povezava. Naša naloga je poiskati ta medsebojni vpliv z iskanjem skladnosti med barvo in hrupom oziroma med vidnim in slišnim, torej med prostorom in časom. Pravimo, da iščemo funkcionalno barvo, ki bo učinkovala pozitivno na ublažitev nezaželenega hrupa. Žal natančnih kolikostnih ali kakovostnih kazalcev o neki povezavi med barvo in zvokom nimamo, zato je v praksi pogosto v pomoč intuicija. Uporaba avdiovizualne interakcije je dobro znana v likovni umetnosti, v zabavnih prireditvah in industrijski psihologiji, [1] do [5] in [7]. Dostopne literature, ki bi obravnavala zmanjšanje hrupa z uporabo barve, ni, zato avtorja poskušava nekatere zakonitosti, ki veljajo za barvo in zvok (predvsem glasbo), uporabiti pri problemih hrupa.

Zaznavno povezavo med sliko in zvokom je poskušal dobiti že Tizian, ko je na svojih slikah upodabljal klavir. Kandinsky je med prvimi naredil vrsto primerjav med glasbo in barvami [4]. On in pozneje še mnogi drugi [6] so ugotovili, da imata glasba in likovna umetnost veliko skupnega, saj obstaja skladnost med problematiko vidnega in slišnega. To zvezo so pogostoma izražali umetniki v svojih umetniških oblikah. Prvotno predstavo o glasbi kot časovni in slikarstvu kot prostorski umetnosti so spreminjali tako, da so postopoma prostor širili v čas in tega v prostor. Čas je tako postal četrta dimenzija prostora tudi v umetnosti. Sam Kandinsky je čutil v glasbi podporo svojim avanturam v abstraktno slikarstvo. S harmonijo barv je poskušal ustvariti sliko, ki s svojo estetiko živi, zveni in utripa po zakonitostih, ki povezuje naš razum z naravo in povzroči vibracijo duše. Mnogi so ga pozneje posnemali zlasti v abstraktnem slikarstvu.

Dandanes pogosto slišimo slikarje, kako uporabljajo glasbene izraze ter govorijo o zvočnosti barve, o tonih, o akordih, o barvni harmoniji itn. Tudi glasbeniki uporabljajo likovne izraze in govorijo o linearni, ploskoviti in plastični glasbi, o horizontalnih in vertikalnih glasbenih vsebinah ter o barvi zvokov, o senčnih in svetlih zvokih, uporabljajo izraze, kakor so: princip zlatega reza, gramatične prvine, glasbeni kolaži itn. [5]. Tudi pri šumih (hrupu) govorimo o belem, oranžnem, rožnatem modrem šumu.

1 DEFINICIJA IN LASTNOSTI HRUPA IN BARVE

1.1 Lastnosti hrupa

Hrup je ena od oblik zvoka. Zvok nastane zaradi mehanskega valovanja snovnih delcev, ki

Between colour and noise there also exists an interaction. Our task is to search for this interaction by looking for the harmony between the colour and the noise between the visible and audible, respectively, and thus between the space and time. Here, we search for functional colours which will act positively, soothing undesirable noise. Unfortunately, we have no exact quantitative or qualitative indicators about the interaction between the colour and sound, therefore in practice we usually rely on intuition. The use of audio-visual interaction in painting art, in the entertainment business and industrial psychology is well known, [1] to [5] and [7]. There exists no available literature which deals with noise attenuation using colour, therefore the authors will try, on the basis of some laws which are valid for colour and sound (especially music), to define the effects of colour on noise problems.

In art, there are several examples of attempts to establish perceptive interaction between colour and sound. Tizian, for example, tried to establish perceptive interaction between picture and sound, by including the piano in his paintings. Kandinsky [4] was among the first who has drawn a series of parallels between music and painting. He, and later many others [6], have discovered that music and painting art have a lot in common, since there are similarities between the problems of the visual and audible world. Artists have often expressed these relations in their artistic forms. The concepts of music as temporal art and painting as spatial art have changed so that artists have gradually extended space into time and time into space. Time has thus become a fourth dimension also in art. Kandinsky himself saw in music support for his adventures in abstract painting. Through the harmony of colours he tried to create a picture, which would live, make sound, and pulse according to the laws which connect man's intellect with nature and evoke vibration of the soul. Many others have later imitated him, especially in abstract painting.

Today we can often hear painters using musical expressions and talking about the sounds of colour they speak of tones, chords, colour harmony, etc. On the other hand, musicians use terms taken from art and talk about linear, plane and plastic music, and about the horizontal and vertical musical components. When they speak of the colour of sounds, about shady and light sounds, they use additional expressions such as: principle of golden cut, grammatical elements, musical collage, etc., [5]. Also when we generally speak of noise, we often refer to it as a white, orange, pink or blue noise.

1 DEFINITION AND PROPERTIES OF NOISE AND COLOUR

1.1 Properties of noise

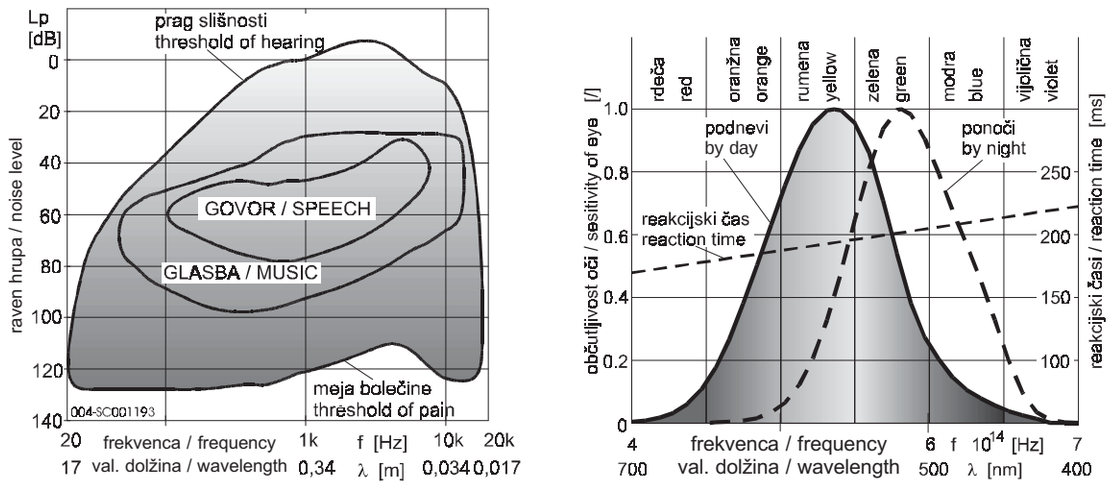
Noise is one of the forms of sound. Sound is a consequence of mechanical waves moving

imajo maso in elastičnost (v vakuumu se torej zvok ne širi). Vsak zvok nosi določeno informacijo, ki je lahko razumljiva ali nerazumljiva, koristna ali nekoristna. Večina zvočnih pojavov vsebuje tako koristno kakor tudi nekoristno informacijo. Če v informaciji prevladuje razumljiva in/ali koristna komponenta, govorimo o govoru, signalu ali melodiji, če pa v informaciji prevladuje nerazumljiva in/ali nekoristna komponenta, govorimo o motnji ali hrupu (tudi šumu in trušču). Hrup je torej nezaželena oblika zvoka, katerega definicija ni odvisna od jakosti zvoka ali njegove frekvence, ampak od poslušalca samega (njegovega zdravstvenega stanja, starosti, spola, socialnega, kulturnega in ekonomskega položaja, od njegove utrujenosti), časa in kraja. Hrup je torej predvsem subjektivna kategorija, ki negativno vpliva na zdravje in počutje ljudi (in živali). Prekomerni hrup povzroča poškodbo sluha, psihofizične motnje, poškodbe, motnje v krvnem obtoku, utrujenost, vpliva na koncentracijo pri delu, študiju in počitku. Hrup povzročajo najrazličnejši stroji in naprave, transportna sredstva in ljudje.

Človeško uho lahko zaznamuje najrazličnejše tone, zvene, šume in njihove lastnosti (višino, trajanje, jakost, barvo itn.), vendar vse to samo v določenem obsegu frekvenc in višine zvočnega tlaka. Uho zdravega mladega človeka sliši v frekvenčnem območju med 20 in 20000 Hz. Pod 20 Hz je polje neslišnega infrazvoka in nad 20000 Hz pa polje neslišnega ultrazvoka. Uho lahko sliši le zvok med ravnijo zvočnega tlaka 0 dB (prag slišnosti) in 120 dB (meja bolečine). Slišnost človeškega ušesa ni enakomerna pri vseh frekvencah. Uho najbolje sliši v frekvenčnem območju med 1000 in 4000 Hz. Pod 1000 Hz slišnost ušesa zelo hitro upada; pri 20 Hz je

through material particles which have mass and elasticity (sound cannot occur in vacuum). Each sound wave carries information which can be understandable or unintelligible, useful or useless. If the understandable and/or useful component prevails in the sound we talk about signal or melody. But if the unintelligible and/or useless component prevails, we talk about speech, disturbance or noise. Noise is, therefore, an unwanted form of sound. Its definition does not depend on the intensity of the sound nor on its frequency but on the listener (his/her state of health, age, sex, social, cultural and economic position, tiredness, etc.) and on the time and place. Noise is thus something subjective, which has a negative effect on the health and comfort of people (and animals). Excessive noise causes damage of hearing, psychophysical disturbances, trauma, disturbances in blood circulation, tiredness, and can affect concentration for work, study and rest. Noise is caused by different kinds of machines and equipment, by transportation mean, and by people.

The human ear can perceive different kinds of tones, timbres, noises and their properties (level, duration, intensity, colour, etc.), but only in a certain range of frequency and sound pressure level. The ear of a young man is able to hear in the frequency range between 20 and 20000 Hz. Below 20 Hz is the field of inaudible infra - sound, and above 20000 Hz the field of inaudible ultra - sound. The human ear can hear only within the sound pressure level range of 0 dB (threshold of hearing) to 120 dB (threshold of pain). Hearing of the human ear is not uniform at all frequencies. Humans hear best in the frequency range between 1000 and 4000 Hz. Below 1000 Hz human hearing rapidly decreases. At 20 Hz, the hearing of the human



a) b)

Sl. 1. *Frekvenčno območje: a) spektra slišnega zvoka in b) spektra vidne svetlobe*
Fig. 1. *Frequency range: a) spectra of audible sound and b) spectra of visible light*

slišnost ušesa slabša od vrednosti izmerjenih z mikrofonom za skoraj 100 dB (sl. 1*a*). Odstopanje slišnosti ušesa od izmerjene vrednosti z mikrofonom ponazarjamo s krivuljo A-vrednoteno, ki prilagodi izmerjeno raven tisti, ki jo uho sliši.

Škodljivost hrupa je odvisna tudi od frekvenčnega spektra hrupa, ki je lahko širokopasoven, diskreten ali črtast in širokopasoven z izrazitimi diskretnimi toni. Najnevarnejši je slednji, ki je hkrati tudi najpogostejši. Škodljivost hrupa je odvisna tudi od tega, v katerem delu slišnega spektra se pojavlja. Hrup je najbolj škodljiv v najbolj slišnem področju zvočnega spektra, med 1000 in 4000 Hz. Žal večina strojev in naprav povzroča najbolj izrazit hrup prav v tem področju slišnega spektra.

Vpliv hrupa na počutje ljudi, na monotonijo dela, na storilnost, kakovost in moralo pri delu in v življenju sploh je vsestransko priznan, zato ga kot nezaželenega poskušamo zmanjšati, po možnosti na najnižjo raven. Pri tem ne gre pretiravati, saj se je človeško uho z razvojem prilagodilo določeni ravni hrupa. Najmanjša raven hrupa ni definirana, ker polje tišine še ni raziskano, vendar je znano da absolutna tišina deluje moreče (spomnimo se samo gluhe komore ali kaznilniške celice). V praksi so najmanjše vrednosti določene z dopustnimi vrednostmi ravni hrupa v bivalnem okolju, ki so različne ponoči in podnevi.

Raven hrupa navadno zmanjšujemo z različnimi tehničnimi metodami, npr. na mestu vira, na poti širjenja in na mestu sprejema, z optimiranjem dimenzij zvočnega vira, z ustreznimi obratovalnimi pogoji, s pasivnimi in aktivnimi glušniki, kabinami, ovirami in osebnimi zaščitnimi sredstvi ter s protizvokom (aktivno dušenje hrupa) [2].

Alternativni način zmanjševanja učinka hrupa je uporaba posebnih oblik, okrasja, uporaba arhitektonskih elementov, ki so brez svoje prvotne funkcije, izenačevanje oblike in vsebine v slikarstvu in kiparstvu z barvnimi vtisi in oblikami (figurativnost), s perspektivo, ki poglobi prostor itn. Poslikava prostora je lahko realistična, takšna kakršna je v resnici na fotografijah. Lahko pa prostor poslikamo tako, da ustvarimo vtis želenega. To dosežemo z barvo, oblikami in črtami, tako da izrazimo določene misli in občutke. To je tako imenovana moderna ali abstraktna poslikava. Ena od možnosti zmanjšanja učinka hrupa je sintetska glasba, ki združuje zvok, šum, hrup, elektrotone s toni instrumenta in glasu.

Pri alternativnih metodah se zvočna moč hrupa ne zmanjša kakor pri tehničnih metodah, spremeni se le občutek, zaznava (percepcija), ki odvrne pozornost poslušalca od hrupa. Tukaj nas zanima predvsem alternativna metoda zmanjšanja hrupa z barvnimi učinki.

ear is less than the sound which can be measured by a microphone, for nearly 100 dB (see Fig. 1*a)*. The difference between the level of sound heard by an ear and the level measured by a microphone is characterized by means of an A-weighted factor, which adapts the measured sound level to the level heard by an ear.

Harmfulness of noise also depends also on the frequency spectra of the noise, which can be broad band, discrete, linear, or broad band with pronounced discrete tones. The most dangerous is the last, which is also the most frequent. Harmfulness of noise also depends on the range of the audible noise spectra in which it appears. Noise is the most harmful in the most audible range of the sound spectra, among 1000 and 4000 Hz. Unfortunately, most of the machines and equipment cause the highest level of noise within this range of the audible spectra.

The effect of noise on people's comfort, on the monotony of work, on labor productivity, and on motivation at work and in life in general is universally recognized. Therefore efforts are made to reduce the undesirable noise to the lowest level possible. Here we need not exaggerate, since the human ear has adapted itself to a certain comfortable level of noise. The minimum level of noise has not been defined, because the field of silence has not been investigated yet, but it is well known that the absolutely peaceful place is annoying for the human being (for example the anechoic room or a jail cell). In practice the minimum comfort levels are defined by permissible levels of noise in our every day environment, which are different by night and by day.

Noise levels are usually reduced by different engineering methods (at the source, on the transmission path or at the receiver) by optimizing the geometry of the noise source, by appropriate operating conditions, by using passive or active silencers, cabins, barriers or personal protective means, and by active noise control [2].

Alternative ways of reducing the disturbing effects of noise are through the use of design, decoration, and architectural elements which exceed their primary function. In art, noise disturbance can also be soothed by equalizing forms and contents in paintings and sculpture, by means of colour impression and forms (figurativity), by perspective which deepens space, etc. A painting can be as realistic as a photographs, or it can be painted so that a desired impression is created. This can be achieved by colour, forms and lines so that certain ideas and feelings are expressed. These are called modern or abstract paintings. Another possibility for reducing the effects of noise is the use of synthetic music, which combines sound, noise, and electric tones with the tones of musical instruments and voice.

Alternative methods do not try to directly reduce noise power as is the case with engineering methods. They simply alter one's perception in an attempt to divert the attention of a listener from the present noise. In this paper, we discuss the use of colour as an alternative method for noise attenuation.

1.2 Lastnosti barve

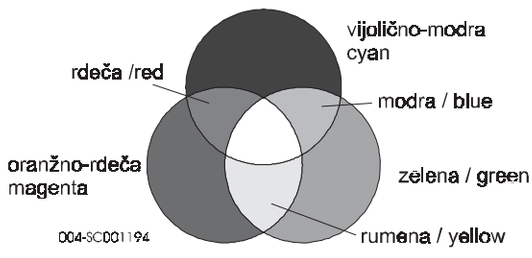
Barva se pojavi v našem očesu zaradi delovanja svetlobne energije oziroma svetlobnih žarkov z zelo visokimi frekvencami, ki se v nasprotju z zvokom kot elektromagnetno valovanje lahko širi tudi v vakuumu. Barva je lahko svetlobna, snovna in vizualna [8]. Svetlobna barva so barvni svetlobni žarki. Snovna barva pa je barvna snov, barvilo ali pigment, ki jo uporabljamo za pleskanje in slikanje. Ta nastane, če sončna (bela) svetloba, ki je uravnovešena zmes vseh valovnih dolžin vidnega spektra, prodre do predmeta (snovi). V tem primeru se del te vpadle svetlobe vsrka v snov, del odbije in en del svetlobe snov prepušča. Odbiti del svetlobe določene valovne dolžine vidimo kot barvo te snovi (snovna barva). Vizualna barva nastane zaradi sestavljanja barvnih vtisov na očesni mrežnici. Barvo z eno samo valovno dolžino imenujemo tonska monokromatska barva.

Z medsebojnim mešanjem osnovnih barv dobimo zmesne barve. Pri tem je treba upoštevati, da obstajajo različni barvni sistemi, ki so namenjeni za barvno orientacijo in sporazumevanje med ljudmi, ki se ukvarjajo z barvami. Tako ločimo mešanje s svetlobnimi in mešanje s snovnimi barvami. Pri snovnem mešanju mešamo barvno maso (pigmente), pri svetlobnem mešanju pa mešamo barvno luč. Mešanje svetlobnih barv poteka po seštevnem načelu, mešanje snovnih barv pa po odštevnem načelu. Rezultat tega je, da mešanica treh svetlobnih osnovnih barv (vijoličnomodre, zelene in oranžnordeče), oziroma dveh komplementarnih svetlobnih barv da belo svetlobo (sl. 2*a*), medtem ko mešanica treh osnovnih snovnih barv (rdeče, rumene in modre) ali dveh komplementarnih snovnih barv da črno barvo, (sl. 2*b*). Osnovne in zmesne barve pri svetlobnih in snovnih barvah so torej v nasprotnem sorazmerju. Osnovne in zmesne barve, ki jih naše oko dojema, imenujemo vizualne ali naravne barve. Naše oko dojema štiri osnovne barve: rumeno, rdečo, modro in zeleno. Pri vizualni barvi veljajo druga merila, po katerih mešanje osnovnih barv da v snovni in svetlobni mešanici sivo barvo, tako kakor pri mešanju bele in črne barve [8].

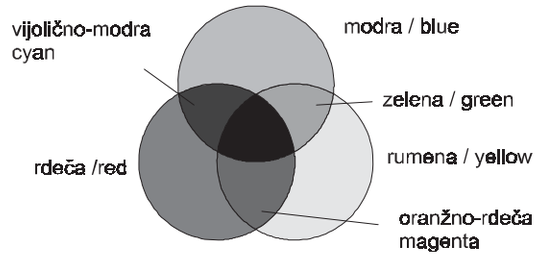
1.2 Property of colour

Colour is sensed by the eye as a consequence of light energy. Light rays are electromagnetic waves, which, in contrast to sound, can be transmitted in vacuum. Colour can be light, material (mass) or visual, [8]. Light-colour represents the colour of light rays. Material-colour represents the colour of a material, substance or pigment, which is natural or used or artistically. The material colour appears when sunlight (white light), which is a balanced mixture of all wavelengths within the visible spectra, strikes an object (material). Part of the light is absorbed by the material, and part is reflected. The remaining part of light is transmitted through the material. The reflected part of the light has a certain wavelength and is seen as the colour of the material (material colour). Visual-colour is the result of the interaction of light with the eye's retina. Visible light of a single wavelength is called tonal monochromatic colour.

By mixing primary colours we get colour mixtures. Here we need to consider that different colour systems exist. They are used for colour orientation and communication among people who deal with colours. We must distinguish between mixing of light-colours and mixing of material-colours. In mixing material-colours material pigments are mixed, and in mixing light-colours light of different wavelengths are mixed. Mixing of light is based on the additive principle, while mixing of material-colour is based on the subtractive principle. The result of this is that the mixture of three basic light-colours (violet-blue, green and orange-red) or two complementary light-colours gives white light, (Fig. 2*a)*, whereas the mixture of three basic material-colours (red, yellow and blue) or two complementary material-colours give black colour, (Fig. 2*b)*. The basic and the intermediate colours of light- and material-colours are thus in opposite proportion. The basic and the mixed colours, which the eye perceives, are called visual or natural colours. The eye perceives four basic colours: yellow, red, blue and green. For the visual-colour other measures are valid, according to which the mixing of the basic colours gives gray colour, just as by mixing white and black colour [8].



a)



b)

Sl. 2. *Mešanje treh osnovnih svetlobnih barv (a) in treh osnovnih snovnih barv (b)*
Fig. 2. *Mixing of three basic light colours (a) and three basic material colours (b)*

Fizikalni pomen barve doseže svojo polno vrednost šele v naših očeh oziroma možganih, ker je barva samo ime za občutek, ki nastane, ko svetloba z določeno valovno dolžino razdraži oko. Barvni občutek je odvisen od zaznaval na mrežnici, ki se odzivajo na specifične svetlobne valove. Pri nastanku barve moramo ločiti barvni dražljaj, ki je vzrok, od barvnega občutka, ki je posledica dražljaja. Dražljaj lahko točno izmerimo s fotometrom ali spektrometrom, medtem ko občutka za zdaj ne znamo izmeriti. Človek lahko le približno pove, kdaj sta dva svetlobna občutka enako močna. Barva je torej v bistvu subjektivni pojav, ki je odvisen od fizioloških in psiholoških dejavnikov. Pri nastajanju barvnega občutka se razvijejo fizikalni in kemični procesi, ki imajo lastnost protiukrepanja na svetlobo (z določenim časovnim trajanjem), ki razdraži naše oko. Na tem pojavu temeljijo tako imenovane barvne iluzije ali premene, ki imajo pri barvni organizaciji odločilno vlogo.

Sprejeta slika se iz očesa prenese prek vidnih živcev v vidne centre velikih možganov, kjer so centri za vidne zaznave. Perceptivni center vida je v možganih povezan s percepcijo sluha in preostalih čutil ter s centrom spomina, kjer se nova percepcija povezuje s predstavami prejšnjih doživetij in nas tako determinirajo v času in prostoru [3].

Barvni pojav je odvisen od svetlobne energije, od ustroja naših oči, od barvnega občutka, od človekove duševnosti, od materiala ali pigmenta ter od estetsko-ustvarjalnih dejavnikov. Naše oko vidi samo barve v okviru barvnega spektra, od rdeče do vijoličaste barve, z valovno dolžino od približno 700 do 400 nanometrov (nm), oziroma v frekvenčnem obsegu od približno 4.10^{14} do 7.10^{14} Hz (sl. 1*b*), kar ustreza frekvenčnemu spektru bele svetlobe. Pri valovni dolžini pod približno 700 nm je nevidna infrardeča svetloba, nad okoli 400 nm pa je nevidna ultravijolična svetloba.

Oko ni enako občutljivo za vse barve. Največja občutljivost očesa je pri rumenozeleni svetlobi z valovno dolžino 560 nm, torej v srednjem delu vidnega spektra (sl. 1*b*). Energija ali moč posamezne barve v barvnem spektru ni enaka, saj ima vat rumeno zelene svetlobe veliko večji učinek kot vat rdeče ali modre svetlobe, kar s pridom izkoriščamo pri razsvetljavi.

Barve imajo fiziološki in psihološki učinek na ljudi, lahko so ti učinki subjektivni in objektivni, lahko vzbujajo v človeku različna čustva in so kot nekakšni psihični impulzi, ki nas lahko pripeljejo v različna psihofizična stanja, npr. da nas razveselijo ali razžalostijo, navdajajo z optimizmom ali pesimizmom, hrabrijo ali tolažijo, odpirajo ali tlačijo itn. Na podlagi teh učinkov vsaki barvi pripisujemo določene specifične fiziološke in psihološke lastnosti:

Colour achieves a physical meaning only in the eyes and in the brain, respectively, because colour is just a name for a feeling, which arises when light of a certain wave length stimulates the eye. Colour feeling depends on the receptors in the retina, which react to specific light waves. In examining the effects of colour we have to distinguish between the colour stimulus, which is the cause, and the feeling for the colour, which is the consequence. A stimulus can be measured by a photometer or by a spectrometer, whereas feeling cannot be measured yet. Person can only approximately tell when two light intensities have equal strength. Colour is thus a subjective phenomenon, depending upon physiological and psychological factors. In the generation of a colour feeling, physical and chemical processes develop which counterreact the light (with a certain time of duration), which stimulates the eye. This phenomenon is the basis for so-called colour illusion and transformation, which have a crucial role in colour organization.

The perceived picture is transferred from the eye via the visual nerve into the visual centers of the great brain, where the centers for visual perception lie. The perceptive center for sight is connected in the brain with that for hearing and for other feelings. It is also connected with the center for memory, where each new perception is connected with the ideas of previous experiences, thus determining us in time and space [3].

The colour phenomenon depends on light energy, on the structure of the eye, on the feeling for colour, on human mentality, on material or pigment, and on the aesthetic-creative factors. The eye sees only light within the colour spectrum, from the red to violet colour, with wavelengths from approximately 700 to 400 nanometers (nm), or in the frequency range from approximately 4.10^{14} to 7.10^{14} Hz (Fig. 1*b)*. This range corresponds to the frequency spectrum of white light. Invisible infrared light is at wavelengths below approximately 700 nm, and above approximately 400 nm is invisible ultraviolet light.

An eye is not equally sensitive to all colours. The eye is most sensitive to yellow-green light with the wavelength of 560 nm, thus in the middle part of the visual spectrum (Fig. 1*b)*. The energy or power of a particular colour in the colour spectrum is not equal, but the watt of yellow-green light has a much bigger effect than the watt of the red or blue light, what is with great benefit exploited in illumination.

Colours have physiological and psychological effects on people, which can be subjective or objective. They can evoke different feelings in a human being and are like mental impulses, which can bring us into different psycho-physical states, e.g., into a state of joy or sadness. They can inspire us with optimism or pessimism, encourage or oppress, etc. On the basis of these effects we ascribe to each of the colours certain specific physiological and psychological properties:

Bela barva je bleščeča, zračna, nežna in svetla. Spominja na čistost, sramežljivost in resnico, je barva nedolžnosti, pravice in miroljubja. Bela barva je vidna na pigmentu, čigar masa ima lastnost, da odbija vse ali skoraj vse valovne dolžine (96%) barvnega spektra.

Črna barva je zamolkla, težka, slovesna in globoka. Spominja na žalost, mračnost in temo. Po Kandinskem je mrtvo nič, dokončen premor, brez možnosti, prihodnosti, upanja. Je brez zraka, toda na in ob njej vse druge barve zvenijo močneje. Črna barva nastane na pigmentu, čigar masa ima lastnost, da vsrka vse ali večino valovnih dolžin.

Siva barva je rezultat mešanja bele in črne barve, je barva tajnosti, zagonetnosti, groze in zla.

Rdeča barva z valovno dolžino od 700 do 630 nm je na spodnji meji vidnega spektra. Je med najbolj priljubljenimi barvami, z največjo vidno privlačnostjo. Je barva močnih elementarnih čustev in strasti. Povezujemo jo z jezo, borbo, hrabrostjo in ljubeznijo. Je stvarna polnokrvna temperamentna barva, ki žari znotraj lastne oblike in je statična, kar ji daje trdnost in moč. Je barva moči, aktivnosti in agresivnosti, je glasna in s stopnjevanjem bližine postaja vedno bolj "hrupna". *Škrlatna* barva vzbuja predstavo dostojanstva, bogastva in posvetne oblasti. Zviša krvni tlak, je vroča, pospešuje cirkulacijo krvi in dihanje, zato velja za duševni stimulus.

Oranžna barva z valovno dolžino od 630 do 550 nm je v zgornjem delu manj vidnega spektra. Je najtoplejša barva v barvnem krogu, deluje zelo živahno in dražilno, spominja na samozavest in odločnost, in najbolj sili v ospredje. Z modrozeleno barvo sestavlja največji toplo-hladni kontrast. Pospešuje prebavo in utrip srca, je emotivna, spravlja v dobro voljo, včasih tudi utruja.

Rumena barva z valovno dolžino od 580 do 550 nm je ena najbolj vidnih barv. Je povezana z zemljo, energijo, spominja na sonce in seva duhovno toplino in naravnanost k ljudem, vznemirja in daje moč, dviga človeka. Svetlo rumena barva deluje veselo in živahno, je duhovita in spodbudna in se razširja v prostor na žareč, intenziven način. Temno rumena barva povzroča neprijetne prispodobe in simbolizira bolezen, strahopetnost, ljubosumje, zavist, prevaro in izdajstvo. Z vijoličasto barvo sestavlja največji svetlo-temni kontrast. Je stimulans za oči in živce, pomirja živčna in psihonevrotična stanja. Velja za mentalni stimulus.

Zelena barva z valovno dolžino od 550 do 490 nm je tudi ena najbolj vidnih barv. Je uravnotežena barva, ki niha med duhovnostjo in rodovitnostjo. Je najbolj nevtralna med kromatičnimi barvami, zato pomirja in vzbuja občutek gotovosti. Izenačujeta jo lastnosti modre in rumene. V kombinaciji z modro in belo simbolizira pozitivne, v

White colour is glittering, airy, tender and light. It reminds us of purity, bashfulness and truth. It is the colour of innocence, justice and peace. White colour is visible on a pigment which reflects all or nearly all wavelengths (96 %) of the colour spectrum.

Black colour is dull, heavy, festive and deep. It reminds us of sadness and darkness. According to Kandinsky, it is the dead nothing, an endless pause, without possibility, future, hope. It is without air, but on it and next to it all other colours sound stronger. Black colour arises on a pigment which absorbs all or a greater part of visible light wavelengths.

Gray colour is a result of mixing the white and black colours. It is colour of secrets, mystery, horror and evil.

Red colour, with wavelengths from 700 to 630 nm, is on the lower border of the visible spectrum. It is among the most favored colours, with the highest visual attraction. It is also the colour of powerful elementary feelings and passions. It is connected with anger, fighting, courage and love. It is a full-blooded impulsive colour, radiating within its own form, and is static, which gives it steadiness and power. It is the colour of energy, activity and aggressiveness. Red colour is loud, and becomes with increasing nearness more and more "noisy". *Scarlet* colour evokes an idea of dignity, riches, and worldly authority. It increases blood pressure, is hot, and accelerates the circulation of blood and breathing; therefore, it can be used as a mental stimulus.

Orange colour, with wavelengths from 630 to 550 nm, is in the upper part of the less-visible spectrum. It is the warmest colour in the colour circle. It acts very lively and is stimulating. It reminds us of self-confidence and resoluteness, and stands out in the forefront. With blue-green it creates the strongest hot-cold contrast. It accelerates digestion and pulse, is emotive, and makes people happy or sometimes tired.

Yellow colour, with wavelengths from 580 to 550 nm, is one of the most visible colours. It is connected with the Earth and energy. It reminds us of the sun, and radiates spiritual warmth to people. It evokes and gives power, and lifts a human being. Light-yellow colour operates cheerfully and lively, is witty and stimulates, and is spread out in space in a glowing, intensive way. Dark-yellow colour causes unpleasant associations and symbolizes illness, cowardice, jealousy, envy, deception and treachery. With violet, yellow creates a light-dark contrast. It is the strongest colour stimulant for the eyes and nerves, and soothes one's mental state. It can be used as a mental stimulus.

Green colour, with wavelengths from 580 to 550 nm, is also one of the most visible colours. It is a well-balanced colour, which oscillates among spirituality and fertility. It is the most neutral among the chromatic colours, therefore it soothes and excites feelings of certainty. It is equalized by the properties of the blue and yellow colours. In combination with blue and white it symbolizes the positive, and

kombinaciji s črno, rumeno in vijoličasto pa negativne lastnosti. Vpliva na znižanje krvnega tlaka in razširjanje kapilar. Zelo je uporabna kot pomoč pri zdravljenju mentalnih bolezni, živčne utrujenosti, histeričnih nagnjenj, nespečnosti in podobno. Velja za sedativno in hipnotično sredstvo.

Modra barva z valovno dolžino od 490 do 450 nm je v zgornjem delu vidnega spektra. Je najbolj priljubljena, je izredno mehka, nežna, prostorska, kot barva neba beži v tretjo dimenzijo, je barva duhovnosti, poduhovljenosti, bolj abstraktna, hladna in zračna. Znižuje krvni in mišični tlak, pomirja utrip in zmanjšuje dihalni ritem. Velja za emotivni sedativ, živčna stanja bolje pomirja kot zelena.

Zelena in modra barva sta atmosferski, oddaljeni, breztelesni. Obe barvi učinkujeta sveže, lahkotno in zračno. Spominjata na odkritost, upanje in modrost. Zelena je v tem delovanju bolj umirjena, je barva socialnosti, pomoči, počitka, pomirjanja, samote, potrpežljivosti in razmišljanja.

Vijolična barva z valovno dolžino od 450 do 400 nm je na zgornji meji vidnega spektra (sl. 1*b*). Je odmaknjena, zamolkla in slovesna. Njen značaj je otožen in melanholičen. Spominja na žalost, vdanost, pokoro, upanje. Je najmanj priljubljena od vseh barv. Če jo zatemnimo, dobi značaj neke bolestne žalosti. Vpliva okrepčevalno na srce in pljuča ter poveča organsko odpornost.

Barve so lahko temne, svetle, težke in lahke. Temne barve nas tlačijo, svetle pa dvigajo, temne barve so spodaj v barvnem krogu, svetle zgoraj, temne znižujejo, svetle dvigujejo prostor, temne barve so težke, svetle lahke itn. Težke barve, to je težki pol barv v barvnem krogu, je v vijoličasti, lahki pol pa v rumeni barvi. Od prabarv silita rumena in bela navzven, rdeča se giblje na mestu, je trdna in je v tem gibanju nevtralna, modra in črna pa silita in se gibljeta navznoter.

Vse te lastnost barv izkoriščamo v vsakdanjem življenju, zlasti v delovnih in bivalnih prostorih, v propagandi, v prometni signalizaciji itn. Mešanje svetlobnih barv je značilno za ustvarjanje fotografskih učinkov na filmu, TV ali na zabavnih prireditvah, medtem ko se snovna barva uporablja pri barvanju sten prostorov ali izdelkov, v slikarstvu, za dekoracijo, pa tudi za zmanjšanje učinka hrupa v delovnem in bivalnem okolju.

Pri izbiri primerne barve lahko odloča več meril, npr.: reakcijski časi, dolgočasnost ali funkcionalnost barve, psihološki in fiziološki učinki in občutki itn. Ruski psihofiziolog Kravkov (1939) je prvi raziskoval avdiovizualne interakcije med vidnimi in slušnimi zaznavami. Ugotovil je, da občutljivost čepkov na mrežnici, se pravi zunanje zaznavanje barv, pod vplivom hkratnega poslušanja hrupa ali glasbe narašča z modro barvo, medtem ko pojema z oranžno.

in combination with black, yellow and violet it has negative properties. It influences blood pressure and widening of capillaries. It is very useful in medical treatment of mental illnesses, nerve fatigue, hysterical inclination, sleeplessness and the like. It can be used for sedative and hypnotic purposes.

Blue colour, with wavelengths from 490 to 450 nm, is in the upper part of the visible spectrum. It is the most popular colour, extraordinarily soft, delicate, spacious, and similar to the colour of the sky, thus escaping into the third dimension. It is the colour of spirituality, more abstract, cool and airy. It reduces blood and muscular pressure, soothes the pulse and reduces breathing rhythm. It can be used for emotive sedative purposes. It soothes nervousness better than green.

The green and blue colours are atmospheric, bodiless. The two colours act remotely, freshly, lightly and airily. They remindus of sincerity, hope and wisdom. Green colour is in this respect quieter; it is the colour of sociality, help, rest, calm, loneliness, patience and meditation.

Violet colour, with wavelengths from 450 to 400 nm, is on the upper limit of the visible spectrum (Fig. 1*b*). It is remote, dull and festive. Its character is sad and melancholic. It reminds us of gloom, loyalty, penitence, hope. It is least popular among all colours. If it is darkened it gets a character of painful sadness. Its influences are refreshing on the heart and lungs, and it increases organic resistance.

Colours can be dark, bright, light, and heavy. The dark colours depress us, while the light ones lift us. The dark colours are at the bottom in the colour circle, the light ones are on top. The dark colours lower and the bright ones rise space, the dark are heavy and the bright are light, etc. The heaviest colour in the colour circle is violet, the lightest is yellow. From the elementary colours yellow and white stand out, the red colour moving in the place, it is solid and in this movement neutral, the blue and black colours tend to move inwards.

All these properties of colours are exploited in everyday life, particularly in working and dwelling places, in adventising, in traffic signals, etc. Mixing of light colours is characteristic for establishing the photographic effects of film, TV or in show business. Mixing of material colours is used in painting the walls of rooms and products, in art paintings, for decoration, and also for attenuation of the effect of noise in working and dwelling places.

The choice of appropriate colours is influenced by several factors (e.g., the reaction time, dullness or functionality of colour, psychological and physiological effects and feelings, etc). Russian psychophysiologist Kravkov (1939) was the first who investigated interactions between the visible and audible perceptions. He discovered that the sensitivity of cones in the retina (i.e. the periphery perception of colours),while under the influence of simultaneously listening to noise or music, increases with blue colour, whereas it decreases with orange colour.

Profesor Trstenjak je proučeval vpliv funkcionalnosti barv na področju psihologije dela, v šoli in klinični psihologiji in ugotovil, da sta rumena in njej podobna rjava barva najbolj kratkočasni, siva in zelena pa najbolj dolgočasni [7]. Ugotovil je, da je vsaka takšna raziskava nepopolna, saj pri ocenjevanju igra pomembno vlogo tudi osebni občutek, ker ima vsak človek svojo barvo, ima torej določeno simpatijo do določene barve. Ljudem je namreč "simpatična" barva najmanj dolgočasna. Zato zahtevi funkcionalne barve v njeni uporabi na posameznih delovnih in življenjskih področjih zadostimo le, če upoštevamo vpliv različnih barvnih tonov na subjektivno počutje človeka, ne glede na njegove individualne simpatije za določene barve.

Iskanje "funkcionalne barve" je zelo zahtevno opravilo, saj barve vplivajo na počutje človeka, na njegovo storilnost in kakovost dela, kakor tudi na učinkovitost propagande. Zato se dandanes z barvnim raziskovanjem ukvarjajo fiziki, fiziologi, arhitekti, psihologi, tehniki, pedagogi, filozofi, zdravniki, kemiki, barvni oblikovalci in likovni umetniki. Barva je namreč funkcionalna če je lepa, da pa je lepa, mora biti funkcionalna. Iz tega izhaja, da je pri iskanju funkcionalne barve nujno sodelovanje med zgoraj naštetimi strokovnjaki, ki upoštevajo različne vidike in lastnosti barve.

Priljubljenost barve se razlikuje glede na spol in geografsko poreklo, ni enaka pri moških in ženskah, pri otrocih in starejših osebah, pri Afričanih, Azijcih ali Evropejcih itn. Pri Evropejcih (pretežno odraslih in moških) je najbolj priljubljena barva modra, sledi ji rdeča (za katero se navdušuje večina žensk). Med najmanj priljubljenimi barvami pa je vijolična, sledijo ji oranžna, zelena in rumena barva [7].

2 UČINKI BARVE NA ZMANJŠANJE HRUPA

V prejšnjem poglavju smo ugotovili vse mogoče škodljive učinke hrupa na ljudi, od različnih psihofizičnih motenj do zmanjšanja delovne storilnosti in duševne uravnovešenosti. Da bi zmanjšali hrup s pomočjo barv, je na prvi pogled protislovna in prav neverjetna zamisel, saj sta zvok in barva prav toliko vsaksebi kakor tip in okus. Pa vendar je praksa pokazala, da barva vpliva na človeka in na zmanjšanje nezaželenega učinka hrupa. Ker barva jakosti zvoka ne more zmanjšati, mora pri blažitvi hrupa učinkovati na človeka le posredno, tako da zmanjša njegovo občutljivost za dojemanje hrupa. To pomeni, da vodijo barve do fizioloških in psiholoških sprememb v človeku, ki zmanjšajo njegovo utrujenost in občutljivost za hrup in hkrati zboljšajo njegovo razpoloženje in delovno storilnost.

Professor Trstenjak has investigated the functional effects of colours in the field of work psychology, in schools, and in clinical psychology, and has found that yellow and brown are the most entertaining colours, while gray and green colours are the most boring [7]. He has established that any such investigation is bound to be incomplete, since subjective feelings play an important role, and each person has a certain inclination for a certain colour. To people the colour they like (their favorite colour) is the least boring. Therefore, the requirements of a functional colour in a particular working or dwelling place can be satisfied only if we consider the influence of different colour tones on the subjective feelings of a person, regardless of his/her individual inclination for certain colours.

Looking for the "functional colour" is a very demanding business, since it influences a person's feelings, productivity and quality of work, as well as the effectiveness of commercial advertising. Therefore current colour research is being performed by physicists, physiologists, architects, psychologists, engineers, pedagogues, philosophers, doctors, chemists, colour designers and artists. Colour is functional if it is beautiful, and vice versa. It follows that in seeking for a functional colour it is necessary that all of the above experts cooperate, considering different viewpoints and properties of colours.

Popularity of colour differs according to sex and geographic provenance. It is not equal between men and women, children and elder people, Africans, Asians or Europeans, etc. For Europeans (mainly adult men), blue is the most popular colour, then red follows (especially liked by women). Among the least popular colours is violet, followed by orange, green and yellow [7].

2 EFFECT OF COLOUR ON NOISE ATTENUATION

In the previous section we discussed many different harmful effects of noise on people, from the different psychophysical disturbances to smaller working productivity and mental balance. To reduce noise by means of colours seems, at first, a paradoxical and incredible idea, but sound and colour are just as different as touch and taste. However, practice has shown that colour influences human feeling and can attenuate the undesirable effect of noise. Although colour cannot reduce the intensity of sound, it can, in soothing the noise, have an influence on man indirectly, so that it reduces his sensitivity to the perception of noise. This means that colours cause physiological and psychological changes in people, which decrease his tiredness and sensitivity to noise, while at the same time improving his humour and working productivity.

Človek sprejema največ informacij prek oči (87 %), saj je vid osrednji čut, ki ga napačne ali negativno delujoče barve kaj hitro utrudijo. Znano je namreč, da se človek zelo pogosto utrudi "prek oči". Ko se utrudijo oči, postane utrujeno celotno telo. Barve namreč vsebujejo "ozračje značilnega razpoloženja" in so "nosilke objektivnega občutka" [1]. Utrujenemu in živčnemu človeku postane ropot (strojev, otrok, prometa) neznosen. Duševno svež in spočit človek ga domala prezre. Če želimo, da barve ublažijo hrup, morajo postati osrednji vodilni predmet, hrup pa precej zakrito ozadje. Da to dosežemo, moramo poskrbeti, da z aktivnimi barvami tako močno osvežimo človeka, da ne občuti več hrupa kot nadležni pojav ali bolečino. Na ta način dosežemo razbremenitev tudi drugih čutov.

Hrup zmanjšamo z izrazitimi barvami, ki so daleč od preveč opaznih ali kričečih barvnih tonov [1]. Vendar niso samo gole barve tiste, ki lahko zmanjšajo hrup. Lahko so tudi umetniške slike, ki ustvarjajo še močnejši vtis. Zato slike vse pogosteje postajajo inventar pisarn in hodnikov upravnih poslopij. Pričakovati je mogoče, da bodo v bližnji prihodnosti krasile tudi industrijske dvorane in delavnice. Umetniška slika lahko pomeni več kakor samo kulturno potrebo nekega okolja.

Z barvo in obliko, torej estetiko prostora, orodja in strojev, lahko dosežemo ublažitev negativnih učinkov hrupa. Dobra izbira barve ni preprosto opravilo, ker je ni mogoče meriti do najmanjših nadrobnosti, do zadnjih razločkov, ki jih še lahko odkrijemo z občutkom (intuitivno). Zato pri izbiri barve odloča predvsem občutek oblikovalca ali umetnika, razum je večkrat drugotnega pomena. Če nas poslušanje nezaželenega zvoka (hrupa) v prisotnosti barve ali slike zapelje v svet prijetnih misli, je namen dosežen. Z interakcijo slišnega in vidnega v določenih razmerah si uho in oko prilagodita zunanje pojave svojim fiziološkim potrebam.

Rezultati raziskav prof. Trstenjaka so pokazali, da se subjektivna motorična reaktivnost na barvne dražljaje giblje v zakoniti povezavi s fizikalnimi lastnostmi barve [7]. Na sliki 1*b* so prikazani s črtkano premico reakcijski časi pri posameznih barvnih tonih, kar pomeni, da se reakcijski časi posameznih barvnih tonov gibljejo v nasprotnem sorazmerju z njihovimi valovnimi dolžinami. Reakcijski časi pri dnevni svetlobi so krajši kakor v mraku ali temi. Barve, ki povzročajo krajši reakcijski čas, nas hitreje vznemirijo, medtem ko nas barve z daljšimi reakcijskimi časi pomirjajo. Učinke različnih reakcijskih časov barv izkoriščamo v prometni signalizaciji. Interakcijski vplivi pri vseh barvah so pod vplivom glasbe nižji kakor pod vplivom hrupa. Zaradi tega je treba upoštevati tudi na tem področju tako imenovane funkcionalne barve, avdiovizualno interakcijo, če hočemo priti do dobrih rezultatov [7].

A human being accepts the most information through the eyes (87 %), sight being the central sense. One's vision may get tired quickly by wrong or negative colours. It is well known that a human being very often gets tired "over the eyes". When the eyes are tired then the whole body becomes tired. Colours contain "the atmosphere of characteristic humour" and they are "supporters of the objective feeling" [3]. For a tired and nervous man, noise (of machines, children, traffic etc.) becomes intolerable, whereas a mentally fresh and rested person overlooks it. If we want colours to soothe a noise then they have to become the central sensory object, and the noise must be rather hidden in the background. In order to achieve this, we have to take care that active colours are used to refresh a person so strongly that he does not feel the noise as an undesirable phenomenon or pain. In this way we achieve a feeling of relaxation.

Noise can be attenuated by pronounced colours, which are far from the too much noticed or crying colour tones, [3]. But it is not just the colours that can attenuate noise; paintings can create an even stronger impression. Therefore, paintings are becoming very frequent decorations in offices and corridors of administrative buildings. We can expect that paintings will in the near future decorate industrial halls and workshops as well. The art of painting can mean much more than just a cultural need of a certain environment.

With colour and form, and aesthetics of space, tools, and machines, we can achieve a soothing of the negative effects of noise. Good choice of colour is not a simple business. It is not possible to directly measure the benefits of colour, which can be still discovered through feelings (intuitively). Therefore decisions on colour should be entrusted to the designer's or artist's intuition, the intellect playing a minor role. If, when hearing an undesirable sound (noise) in the presence of a colour or a picture, we are seduced into a world of pleasant associations, the desired effect is achieved. With the interaction of audible and visible signals under certain conditions the ear and eye adapt the outer phenomena to their own physiological demands.

Trstenjak's research results have shown that the subjective motor- reactivity to colour stimuli moves in correlation with the physical properties of colour [7]. The dashed line in Fig. 1*b* shows human response times for particular colour tones, and illustrates that the reaction times to particular colour tones move in an inverse proportion with their wavelengths. Human reaction times by daylight are shorter than those in darkness. The colours which cause a shorter reaction time, excite us faster, whereas the colours with longer reaction times quiet us down. Effects of the different reaction times to colours are exploited in traffic signalization. The effects of all colours are less under the influence of music than under the influence of noise. Owing to this, we should also consider so-called functional colour and audio-visual interaction, if we want to achieve good results in this field of research [7].

3 SKLEP

Barve imajo psihofizični vpliv na ljudi, lahko delujejo pomirjevalno ali dražeče, stimulativno ali zaviralno, povečujejo storilnosti ali jo zmanjšujejo itn. Prizadevamo si za njihov pozitivni učinek. Barve se morajo prilagoditi tako individualnim kakor kolektivnim potrebam ljudi. Če želimo doseči vizualno blažitev hrupa z uporabo barve, moramo doseči dinamično ravnotežje med zvočnim segmentom in barvo določenega spektra, ob upoštevanju velikosti prostora in subjeka (ov) v njem. Napačno izbrana barva lahko negativno vpliva na človeka.

Avdiovizualna interakcija zvoka in barvne svetlobe ima dandanes pomembno vlogo v zabavnih prireditvah, v kinematografiji, TV in v šolski psihologiji, kjer se barvna svetloba in glasba medsebojno dopolnjujeta. Svetlobne barve niso primerne za zmanjšanje hrupa, ker ga s tem kvečjemu okrepimo. Za zmanjšanje hrupa so bolj primerne snovne barve ali umetniške slike, ki lahko ustvarijo v možganih vtis manjše hrupnosti. Večkrat je problem v tem, da so ti učinki subjektivnega značaja, ki se s časom lahko spremenijo ali celo izničijo. V tem primeru je občutek tisti, ki vodi možgane. Ta občutek ne temelji na čistem razumu, zato zlasti v umetnosti ne moremo zaupati čistemu razumu, saj bi s tem sledili nevarni poti logike. Seštevanje v umetnosti je nedoumljivo, saj je znano, da seštevanje, npr. rumena in rumena in rumena dajo sivo. Oko se utrudi od preveč rumenih, kar pripelje do fiziološke omejitve. Fiziološko omejitev je dobro upoštevati tudi pri eksaktnih vedah.

3 CONCLUSION

Colours have a psycho-physical influence on people. They can soothe or excite, stimulate or depress. They can increase productivity or decrease it. Efforts have been made to enhance their positive effects. Colours must be adapted to individuals as well as to the collective needs of people. If we want to achieve soothing of noise by visual means through colour, we have to achieve a dynamic equilibrium between sound and colour within an environment, by considering both the size of the space and the subject(s) in it. Wrongly chosen colours can have negative influences on people.

Audio-visual interaction between sound and colour has an important role in show business, in cinematography, in TV and in school psychology, where coloured light and music complement one another. Light colours are not suitable for the attenuation of noise, because in fact they exacerbate it. More suitable for the reduction of noise are material colours or paintings that can create a perception of a less noise. The problem, however, is that these effects are of a subjective nature. They can change over time or even lose their character. In this case, feelings control the brain. Thess feelings are not based on pure intellect, therefore we cannot trust the pure intellect, since in doing so we will follow the dangerous way of logic, particularly in art. Summation in art is inconceivable, since it is known that addition, e.g., yellow plus yellow plus yellow, give gray colour. The eye becomes tired of too much yellow, which leads to a physiological restriction. The physiological restriction should also be considered in exact sciences.

4 LITERATURA
4 REFERENCES

[1] Adlešič, M. (1957) Svet svetlobe in barv. *Mladinska knjiga, Ljubljana*.
[2] Čudina, M. (1997) Tehnična akustika. *Zapiski predavanj, Fakulteta za strojništvo, Ljubljana.*
[3] Itten, J. (1972) Kunst der Farbe. Studienausgabe, *Otto Meier Verlag, Ravensburg.*
[4] Kandinsky, W. (1914) Concerning the Spiritual in Art. *London, Constable*.
[5] Kuret, P.(1997) Glasba in likovna umetnost. *Zbornik referatov*, *Festival Ljubljana, Ljubljana.*
[6] Skrjabin, A. N. (1984) Skrjabin und die Skrjabinisten. *München.*
[7] Trstenjak, A. (1978) Človek in barve. *Dopisna delavska univerza Univerzum, Ljubljana.*
[8] Zornik, K. (1968) Teorija likovne umetnosti. *Akademija za likovno umetnost, Ljubljana.*
[9] Pušlar-Čudina, M., M. Čudina (1998) Barva in hrup. *Zbornik referatov Prvega kongresa Slovenskega društva za akustiko, Portorož.*

Naslova avtorjev:
Milena Pušlar-Čudina
Pod bukvami 18
1000 Ljubljana

prof.dr. Mirko Čudina, dipl.inž.
Fakulteta za strojništvo
Univerze v Ljubljani
Aškerčeva 6
1000 Ljubljana

Author's Address:
Milena Pušlar-Čudina
Pod bukvami 18
1000 Ljubljana, Slovenia

Prof.Dr. Mirko Čudina, Dipl.Ing.
Faculty of Mechanical Engineering
University of Ljubljana
Aškerčeva 6
1000 Ljubljana, Slovenia

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