Institute of Acoustics

SPECTRAL INFLUENCES ON THE PERCEPTION OF REPRODUCED SOUND

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THE RAINBOW EFFECT

Given the state of current knowledge about psychoacoustic phenomena, or rather the lack of non-proprietary hard data accumulated under this heading, it is possible to postulate almost anything. Given the prejudices and fancies of many hi-fi buffs and writers it is easy to see how 'subjective' considerations can become a covering blanket of pseudo-science underneath which all kinds of nasties may shelter. This experiment was set up to demonstrate (or otherwise) the inter-relation between what we see and what we hear, as a means of furthering our understanding of what we <u>think</u> we see and what we <u>think</u> we hear. The process of creating an illusion of presence at a live musical event has been a central obsession of the hi-fi and recording industries since their inception. A deeper understanding of the nature of the illusion we are seeking to create, and of the methods used to create it is seen as helpful therefore. Some of the guideposts we took in structuring the experiment were the following:

It is generally known that middle-to-high frequency sounds in the 3-5kHz range are capable of producing a marked 'go-away' response in the listener. This is very likely because they trigger certain protective/defensive and aggressive instincts or reflexes. They are sounds associated with danger or are alerting signals. The mechanisms by which these signals produce their responses are allied to those which produce the classic fright or flight syndrome.

It is also generally known that sounds around the 80Hz bass region are in some sense attractant, comforting 'come here' sounds, no doubt conditioned by the maternal heartbeat during our time in the womb.

It is also known that sounds can produce an emotional response and this is actively sought after in the playing, writing and auditioning of music. The calmative effects of music have been used therapeutically. The mechanisms in the brain which govern emotion are different from those referred to above. Much of this is true of the visual spectrum too .... there are colours which are alerting, exciting, calming and so on. As we will see, the pathways and mechanisms in the brain are in some ways closely related, so the question is asked, are the two spectra, sound and light inter-related, are they synergistic, antagonistic or just independent? Before going on to describe the experiment and give the results (because we did get some results) it is worth a scan around the cranium of homo sapiens.

As can be seen from the diagram, (diagram 1), the auditory centres are divisible into hearing and psychoauditory (a medical definition this, but not necessarily any less valid for that) and they lie in very close proximity to the limbic system, generally accepted as being the seat of emotion (diagram 2). It can be clearly seen that the visual centres of the brain are much further removed from this area, being at the back of the brain, but they too are sub-divided into a real and an interpretive zone.

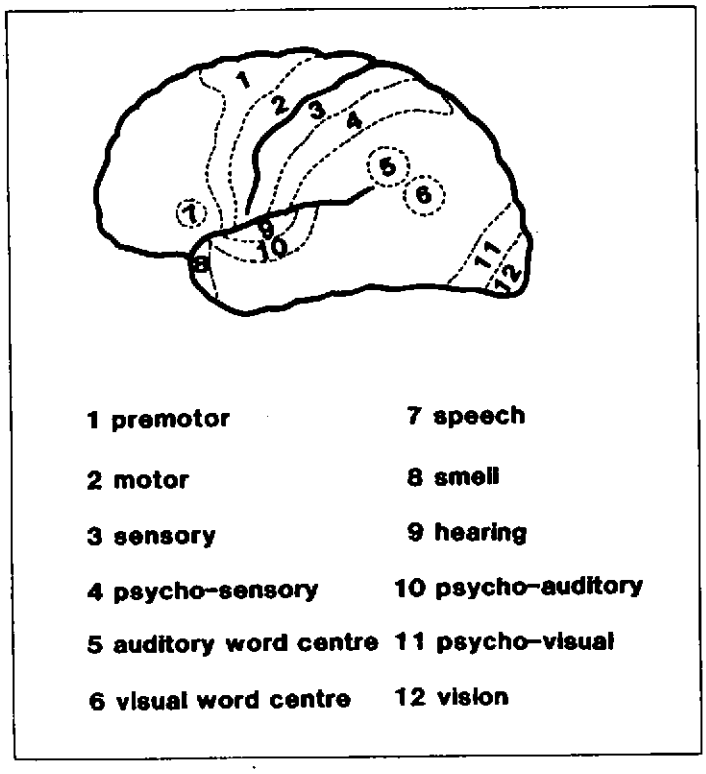

Diagram 1

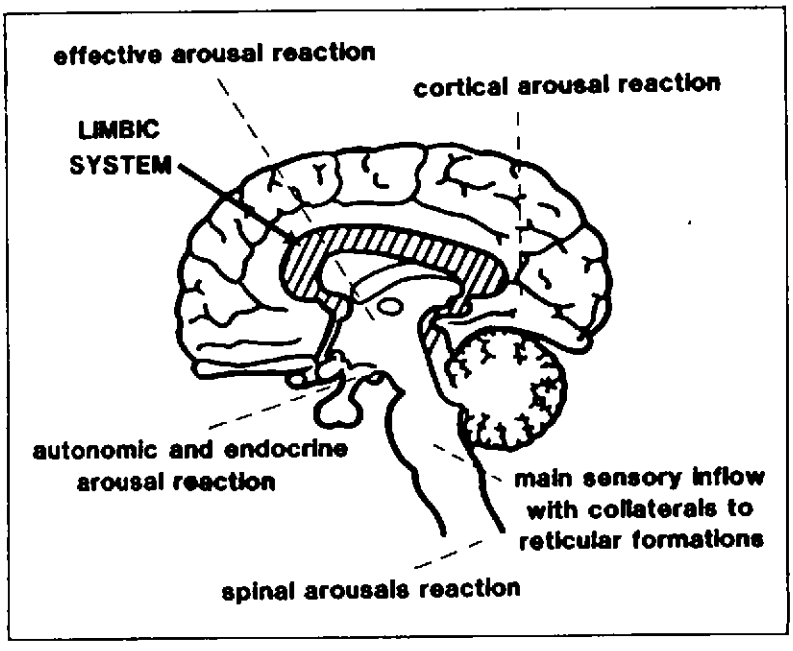

Diagram 2

It is not the function of this research to postulate what the mechanism of transfer between visual and auditory systems might be, and work undertaken on intelligibility may suggest that it is a matter of conditioning anyway, but we can demonstrate from the results here that there is a link. It logically follows that if colour can affect the way sound is perceived, the reverse might apply, and the second phase of our experiments will investigate this together with some further investigations into the precise areas of the sound spectrum which most influence our perception of reproduced sound. Much money and effort has been applied over the years into producing a 'good' or 'realistic' sound. We may be able to come closer to defining what exactly a good sound is.

Although the path may differ between the routes taken through the brain by sound stimuli as opposed to optical ones, there are structural similarities. Both pass via cranial nerves, II for sight and VIII for hearing and orientation. Sensory impulses travel along these nerves. The first neurone lies outside the brain but synapses with a second neurone which conveys the impulses of conscious sensations to the contralateral thalamic area. The site of the first synapse and the exact path to the thalamus varies with the sensation type.

There is a spatial representation of sensations within the thalamus and a certain amount of perception (especially of pain) occurs in that region, but for sight and sound a third neurone carries a sensory impulse to particular areas of the cerebral cortex for perception and interpretation. Two areas within the cerebral cortex have been identified as possibly involved with intelligibility and associated phenomena such as dyslexia. It is not known to the writers if there is a recognised medical condition for hearing which corresponds to dyselxia, but what is described as tone deafness would be a candidate, and this same area of the brain the likely site.

The closer proximity of the hearing centres to the limbic system and to the amygdaloid nucleus implies that interaction between sonic stimulus and emotional response may be close and pronounced whereas charting the collateral afferents of a visual stimulus suggests a priority response from cortical arousal reflexes and motor mechanisms, with the reticular formation playing a key role. This would explain the tendency of image to dominate sound from TV receivers and might also explain the difficulty encountered in defeating or exploting auditory phenomena such as Hass effect.

Spectral influence is an everyday practice, though hardly recognised as such. The potential value of colour and its theraputic effects can perhaps best be illustrated by imagining what it would be like to live in a room painted scarlet, mud colour or black, or any colour which you personally dislike, or cooking dinner in a bright red kitchen on a sweltering summer day or even waking up in a day glow orange bedroom. The converse then suggests itself. If the thought of a hideous colour can be depressing may not a colour that we like be used therapeutically, give us a lift or calm us down?

Experiments have shown that most of us find central colours stimulating and others tranquillising. Different colours are also known to affect our perception of temperature, e.g. a Norwegian study recorded that people in a blue room set a thermostat three degrees higher than people in a red room. This is consistent with the view that large field of red light induce physiological

symptoms of emotional arousal - the speeding up of heart and respiration rates, the raising of blood pressure and the electrical activity of the brain. Red is therefore "exciting" in its effect on the nervous system, especially on the sypathetic branch of the autonomic nervous system. Blue light conversely has a calming effect, reducing heart rate, respiration and blood pressure. Its calming effect operating chiefly through the para-sympathetic branch of the autonomic on the nervous system.

The origin of colour significance can be traced to the beginning of mans' life dictated as it was by night and day - darkness and light. Night meant trying to keep warm and going to sleep therefore passivity and a general slowing down of metabolic and glandular activity. Day light meant working hard and hunting and therefore high activity with the consequential increase in metabolic rate and glandular secretion thus providing man with both energy and incentive. Man was regulated by those two environments and their associated colours, dark blue for night and bright yellow for day light. They are heteronomous colours and regulate from the outside. The self-regulating or autonomous colours of red and green can also be traced to primitive man. The actions of attack and conquest are universally associated with the colour red whereas self-presentation and defending are associated with green.

Environmentally, colour effects our physiological responses. Many institutions decorated with toned down colour schemes are designed to create an inoffensive, neutral environment. Studies though have shown that long periods spent in these environments are actually very depressing. Institutions are now more often being decorated with lively colours to boost morale. Airlines carefully select the correct colours for the interior decoration of their cabins to ensure that the tension often associated with flying are relaxed to some degree.

Marketing has made use of the developments in the field of colour psychology. For example a sugar manufacturer knows not to sell his product in green packaging. It must be packaged in a blue container or have the colour blue somewhere on the package. This is because the physiological sensation associated with the colour blue is "sweetness" and green is "astringence".

The following colours provide these associations:

Colour Associations

Grey - restful for short periods but depressing over long periods.
Blue - calming, cool, sometimes used to create an environment for meditation.
Red - strong, warm, red attracts attention, warns, also raises blood pressure. Speeds up the heart and respiration. Rarely used in large, unrelieved areas.
Yellow - bright, cheerful. Impure mixtures of yellow can seem harsh, unhealthy or repulsive (murky yellow).
Green - has been called the colour of "elastic tension" conveys qualities of both energy and evenness.
Violet - environmentally it is the colour of increasing distance and space.
Brown - can seem earthy, cosy, fertile or dirty and dull.
Black - Negative, void, mystery, warm, engulfing and comforting.

What effect then is colour or the lack of it having upon the illusion we are seeking to create? The final piece of equipment in the chain which creates the illusion and enables the reproduced sound to be heard is the loudspeaker. How much thought though has been given to the shape, form, balance of colour and aesthetic appreciation of the actual enclosures? They are universally the same proportions and universally dark in colour.

The majority of living rooms in this country have some form of sound reproduction system but in many cases all our efforts to provide accurate reproduced sound are wasted as the loudspeakers are "hidden". You will generally find them on the floor so that the sound is masked by the room furnishings or high up on a wall above the line where again the reproduced sound is not being fully appreciated.

How do we overcome this problem? A question we asked ourselves. Perhaps colour might provide part of the answer. The easiest colour to change was that of the speaker grills and we therefore established a means whereby we could test peoples reactions to a piece of music reproduced through three different sets of speakers, each with different coloured speaker grills.

The experiment was conducted in the studio of a multi-track studio of Sandwell College in the Midlands. Three pairs of Wharfedale Diamonds were fed with a piece of music from the control room of the studio. In each case there was no increase in volume to each set of speakers and the equipment remained constant.

The only stimuli we wished the participants to have were those of sound and colour from the speakers and so a system was devised to enable each set of speakers to be illuminated when it was being used. The visual stimulus was enhanced by the participants sitting in a darkened studio.

After the participants had partaken in the experiment they were taken to another location and asked to complete a questionnaire which did not refer to colour. In fact at no time were any of the participants informed that they were partaking in a colour experiment. Each coloured grill was referred to as speaker 1, 2 or 3.

The results of the experiment proved interesting as will be described.