UNIVERSITY OF MANITOBA

SENSORY REALITY OF ARCHITECTURE
IN THE URBAN ENVIRONMENT:
AN INVESTIGATION IN AUDITORY PERCEPTION

by

CHESTER C. ZWARYCH

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

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A dissertation submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of

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ABSTRACT

Title:

Sensory Reality of Architecture in the Urban Environment: An Investigation in Auditory Perception.

An academic architectural thesis in two parts:

Part I: "Experiential Reality and Research Methodology"--an investigation into how an urban environment is auditorilly experienced.

Part II: "Supporting Material--Intersensory Integration with the Urban Environment"--a study of sensory modalities focusing on man's capability of obtaining information about objects in the urban environment and how environmental stimuli affect the urban user.

ACKNOWLEDGEMENTS

My grateful thanks are due to my advisor and friend J. Collin, for his dedication and insight towards a humanistic architecture helped me to formulate an objective basis in developing this research paper. Thank you for expanding my perceptual boundaries, by goal of achieving a sensory equilibrium architecture now seems to have a threshold.

I am deeply in debt to Dean J. Anderson for his stimulating discussions, criticisms, suggestions and sympathetic interest, for the sensitivity spectrum of "Sensory Reality of Architecture" is a fragile one, one which can be destroyed by insentience.

Genuine appreciation is extended to B. Dexter for the wealth of resource information he provided during the writing of this paper. His keen contribution and scholarly attention has been invaluable.

Lastly, thanks to my parents for the sensory variety and comfort with which they have provided me over the years. Their understanding of 'optimal stimulation level' has given me the freedom to experience great diversification of stimulation. In time, the reality of my academic involvement will be transmuted into physical architecture, some of which they will sensorilly experience and hopefully appreciate.

TABLE OF CONTENTS

LIST OF FIGURES

Introduction:

The sensory environment: auditory sense will be studied within the human realm of experiencing the architectural reality of public urban space in order to assimilate new forms of architectural information. This graduate research paper will attempt to structure and identify sensory cues from the man-built environment. It is a preliminary exploration, and is intended to stimulate the sensitivity of sentient individuals in the architectural virtue. By carefully studying the auditory quality of the urban environment, architects will perhaps become more objective in designing responsive environments for clients and users.

> If the reliable findings of which we speak at first come trickling in slowly and in small numbers-compared with the formidable flood of full-page advertisements often so irresponsible as far as true life needs are concerned-they will nevertheless become in time a much more trustworthy guide in helping us toward sounder decisions of design and acceptance. [1]

Part I deals with the auditory experiential reality of Gastown, Vancouver, as perceived by a group of Blind people. The site itself has no particular significance or special interest to the author, other than that it is a sensory environment similar to the Ottawa Spark Street Mall, the Minneapolis Nicollet Mall and the Bastion Square project at Victoria, B.C. Gastown is a prototype sensory pedestrian urban environment, one which could be easily

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[1] Richard Neutra, Survival Through Design (New York: Oxford University Press, 1954), p. 333.

observed, measured and analyzed by the author due to its geographical accessibility.

Part II presents a discussion concerning integration of the human senses with the urban environment based on the premise that the architect has been traditionally concerned with only the primary visual aspects of space. Conversely the human perceives the environment through the amalgamation of all senses.

> Consider for a moment the difference between a Greek who garners information from the way people use their eyes and look at him, and the Navajo Indian whose eyes must never meet those of another person. Or consider the disparity between a German who must screen both sight and sound in order to have privacy, and the Italian who is involved with people visually or auditorily almost twenty-four hours a day. Compare the sensory world of the New England American, who must stay out of other people's olfactory range and who avoids breathing on anyone, and the Arab who has great difficulty interacting with others in any situation where he is not warly wrapped in the olfactory cloud of his companion. All the senses are involved in the perception of space; there is auditory, tactile, kinesthetic, and even thermal space....
>
> The kind of private and public spaces that should be created for people in towns and cities depends upon their position on the involvement scale. 2

A study that would generate the requisite tools for the control of the other perceptual aspects, such as the auditory sense, must therefore be predicated upon conditions of sensory equilibrium (an optimal level between sensory deprivation and sensory overload). A familiarity

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[2] Rene Dubos, So Human an Animal (New York: Charles Scribner's Sons, 1968), p. 93.

with the blind may provide us with an empirical basis for this control.

It is not the intention of this thesis to propose a totalitarian view of architectural values. Individual differences in terms of human needs and the means of satisfying them are in a constant state of dynamic sensory equilibrium (the comfort or neutral zone between sensory deprivation and sensory overload). Some spaces are soothing while others are uncomfortable. Identification of sensory stimulants therefore will objectify design problems by which basic responses can be synthesized into a form of architectural communication. Information communicated to the user by the sensory environment will elicit favorable or unfavorable behavioural patterns.[3]

> in a discotheque it may be wild to induce hallucinations through an optimal flicker response either by flashing lights or by viewing striped patterns, but in an office inhabited by the sedentary worker flicker from fluorescent luminaires, moving machinery, water reflections or striped wall paper is best avoided.

The goal of this study is to support a meaningful interaction within person-environment relationships. The knowledge systems of science and engineering that underly these relationships must interface with the behavioral and social psychological processes. Because technological progress is bringing the sounds of cities to the threshold of confusion and physiological stress, design must be predicated on more than simple visual appeal.

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[3] John F. Halldame, Psychophysical Synthesis of Environmental Systems (California: California Book Co. Ltd. 1968), pp. 1-3.

> Architecture is not for architects; it is for people, and whatever architects may think and whatever theories they may have, it is through the senses that people appreciate, that people feel architecture. [4]

The architecture that molds the sonic perception of the blind is indicative of direct personal interaction with, and obstacle perception of the urban sensory environment.

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[4] Bruce Allsopp, Towards a Humane Architecture London: Frederick Muller Limited, 1974), p. 3.

PART I

THE EXPERIENTIAL REALITY
AND
RESEARCH METHODOLOGY

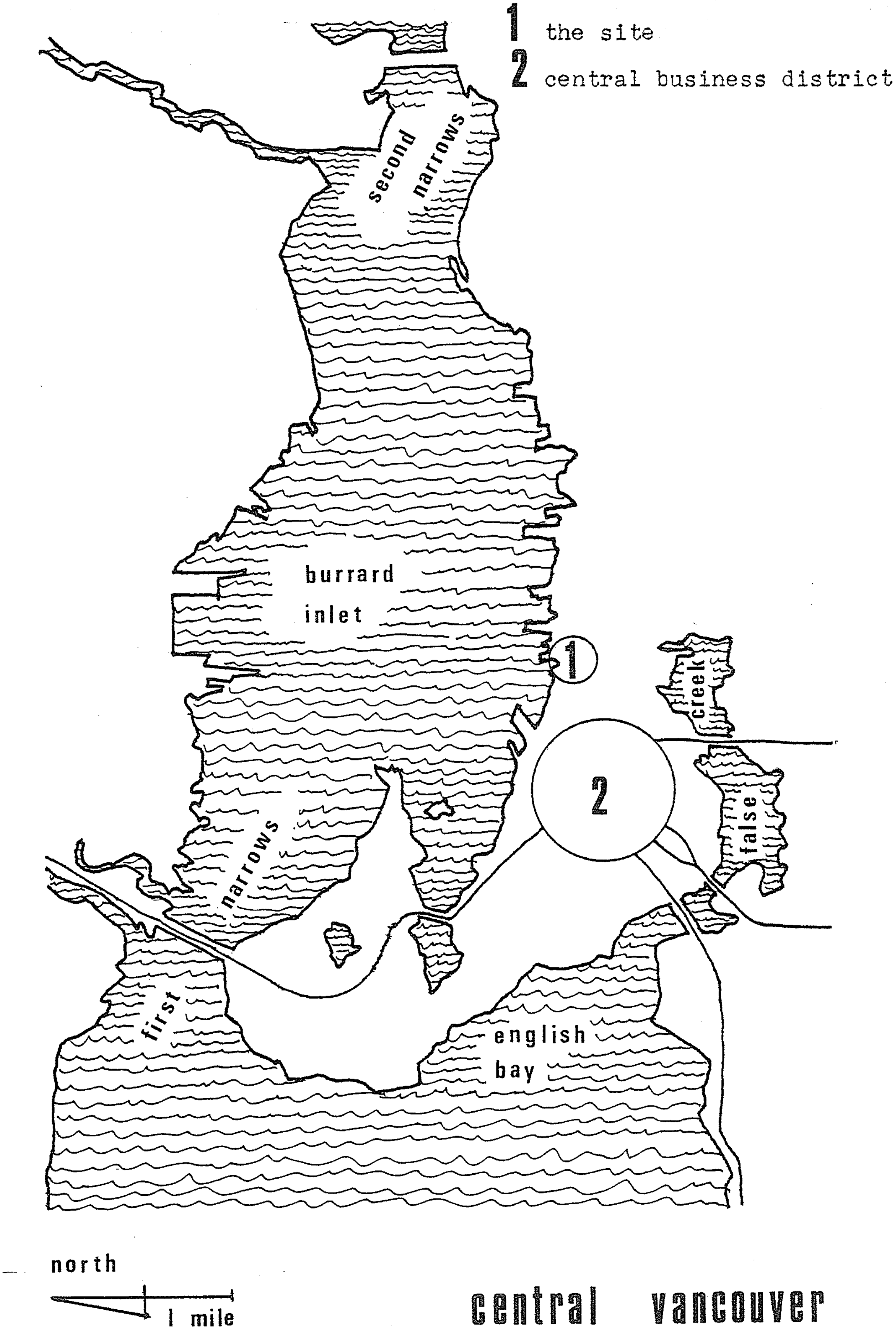
The following research of the auditory experiential reality of Gastown, Vancouver, as perceived by a group of Blind people is not a scientific experiment but an exploratory study of auditory awareness of the environment in which we live. It is a preliminary study that deserves more attention in later experimental research. This study explores three aspects of the problem:

1. How do sounds in the man-built environment influence perception?
2. What is the physical character of sounds in the Micro-Sonic Site?
3. Can sighted subjects perceive the quality of an actual soundscape in visual isolation?

A Walk with the Blind:

"When you take your ears for a soundwalk, you are both audience and performer in a concert of sound that occurs continually around you. By walking you are able to enter into a conversation with the landscape. Begin by listening to your feet. When you can hear your footsteps you are still in a human environment, but when you become separated from their sound by the ambient noise, you will know that the soundscape has been invaded and occupied."

THE
VANCOUVER
SOUNDSCAPE


1 the site
2 central business district
second narrows
burrard
inlet
1
creek
2
false
narrows
first
english
bay
north
1 mile
central vancouver

legend

1 Woodwards Parkade

2 Intersection - Abbott & Water Street

3 Mid-Street - Between Abbott & Carrall Street

4 The Garage - Courtyard

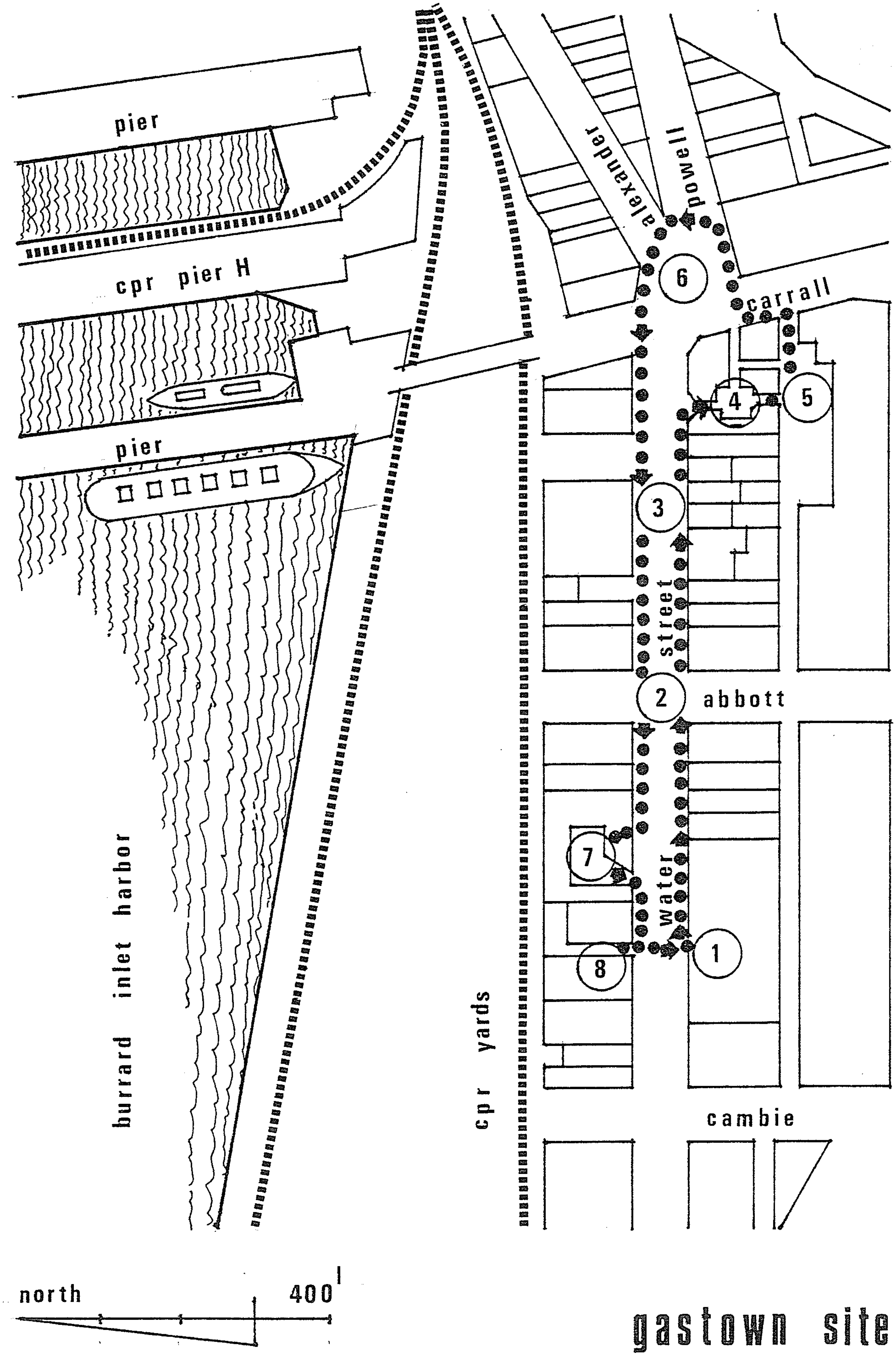
5 Blood Alley Square

6 Maple Tree Square

7 Gaslight Square

8 Gap - Space Between Two Buildings

THE SITE ITSELF: The dashed line indicates the course of the Blind Walk, starting at the Woodwards Parkade on Water Street.



gastown site

A Walk with the Blind*

The blind walk began at the northside of the Woodwards Parkade, facing Water Street between Cambie Street and Abbott Street. Water Street is the main street of Gastown, running East and West. The total time of the walk was 45 minutes, of which 20 minutes was primarily walking time, the other 25 minutes was used for discussion and rest breaks. The walk proceeded first along the south side of Water Street, parallel to the facades of nondescript Victorian and post-Victorian architecture. As we walked from the Parkade on the Italian-type brick paved sidewalk, one of the women expressed her annoyance of some music coming from a speaker set outside one of the store fronts.

> I hear some music. It's very loud, I don't like that noise.

As we continued the walk, a few cars and trucks roared past while an old man was playing an accordion, then a tourist bus arrived dominating the street sounds with more motor noise and air brakes, disorienting the majority of our walkers.

> If you were to walk here alone I think there would be so much noise it would be confusing-the noise confuses your direction.

One walker indicated that sounds have more clarity and identity at night, and that imagery is easier to construct.

> Passing doorways is another thing we can tell by sound very easily, if it's quiet enough to catch or detect. It's much easier to

*A group profile is presented on page , Experiment I- The Blind in the actual scene.

> travel at nights when the city is quiet, you know, because you can tell where things are, really by sound....late at night when there is nobody around, and you are walking down the street you can point out doorways, point out posts and everything, because the sound of your feet gives you the answers, like the sound acts like an echo back from objects and therefore you are building up in your mind from the sounds you hear a picture of all your surrounding and of course if it is quiet enough your picture is very, very clear.

Most of our walkers made comments on the raised cobble stone strips set into the roadway, indicating the pedestrian crossing at the Abbott-Water Street intersection. Some diverse comments followed:

> "I don't know whether I like that."

But to an older man it was a warning of something to happen or appear.

> The roughness isn't that bad. Under round lamp posts, the base of them should always have roughen cement sloped upwards towards the post because it would save ourself an awful lot of bumps. If you stepped on the slope you would instinctively know that there is a post or something there.

At approximately two-hundred and fifty feet from the Old Spaghetti Factory two-thirds of the walkers noticed a distinctive smell.

> "I can smell something"

While another commented.

> "smell that spaghetti!"

Yet it was interesting to note that when passing by the Dominion Hotel no comments were made of the aroma of beer, commonly surrounding such an establishment.

One individual was surprisingly sensitive to doorway depressions and entries leading into buildings from the sidewalk.

> "What's this, a doorway or a space over there?"

It happened to be a recessed vestibule approximately 4'-0" x 10'-0" x 20'-0" high.

> "That's right, you can tell by the sound changing. It automatically comes into your mental picture with things around you."

As we turned right, off Water Street into the Garage entrance, we walked immediately into a corridor approximately ten feet wide. The same gentleman said:

> "This is a lane isn't it? Well yes it is like a lane. You can feel the difference between the heights of the ceiling, like going through that narrow spot, it presses down on you."

When we arrived inside the Garage court, near the outdoor restaurant, surrounded by shops and domestic-looking offices, the elderly individual again expressed his conception of the spatial qualities:

> "Above our heads is open again. You see, you get your echo bounceback not only from the walls but from the ceiling. Your sound bounces back from ceilings and walls in there (he points to an enclosed space) but out here the space is open above."

The space above where he pointed was open with the exception of a few exposed concrete beams spanning across the opening. In fact, most of the walkers enjoyed this space, they felt at ease and comfortable with the surrounding sounds of furniture--chairs, tables and dishes moving. They began to talk more freely in a calm and relaxed manner.

> "It has atmosphere of its own, hasn't it."
>
> "Now that would be fun." (Referring to the outdoor restaurant)

Once we walked through the Mediterranean lane-type corridor, towards Blood Alley Square a general sense of freedom and pleasure was again observed in the faces of the blind walkers.

> There is definitely a roof over here, and the roof is getting lower and there is a wall there and there. We are outside again."
>
> "Here is Blood Alley Square should we start another riot-Ha, Ha you start it." (They all laugh).
>
> "This is like a street, I'm walking on the cobble stones. It is definitely much more open here than it was in there."

When asked, how high the buildings were in this area, we received some scattered comments. The spontaneous comments were:

> "Oh, I don't know."
>
> "Can't tell."

After some thought a woman remarked.

> "We're getting the sun quite well so the buildings can't be that high."

It might be noted here that this enclosed area is somewhat quiet as compared to the typical street soundscape. Spatially it is surrounded by painted brick buildings, standing three to four stories, in wall to wall cobblestone brick pavement, with a few maple trees and some dragon-headed street lamps.

Leaving the Alley and entering Carrall Street, on our way to Maple Tree Square, two of our walkers discussed the feeling and importance the wind plays, in terms of orientation clues.

> "You can feel the differences in the draft, like in that space you could feel a cool breeze coming on as soon as you knew the building was cut off."

> "Often you will be walking down the street and that's how you know you come to a corner, you'll feel the cross current winds suddenly hit you and so you don't have to start feeling around to find the curb."

Upon reaching Water Street and just before crossing Carrall and Powell Street, on our way to the Europe Hotel, we waited for a number of cars and loud trucks to pass. A sense of tension and irritation was experienced by some of our walkers. Referring to the traffic itself one woman remarked:

> "We don't want an argument with them. Traffic noise is very disturbing. That's all I can hear."

Standing in front of the 1909 built, Europe Hotel we asked our walkers if they could navigate by themselves here?

> "No, No way, nothing to navigate by, no I wouldn't like to. You would have to go just along the building. It's just too confusing."

Asked if it was any quieter in Blood Alley Square, one confused and irritated woman replied:

> "Ya, yes it was, I guess it was. I don't know."

However when the traffic noise died down the majority seemed almost spontaneously relaxed and behaved in a natural yet peaceful manner, joking and laughing (releasing tension). In describing the edge of the Europe Hotel, facing West between Powell and Alexander one male walker made the following comments:

> "It comes to a point, like a wedge, like a chunk of cheese. (Group laughs.) And it is a bit cheesy now." (Group laughs.)

During the crossing of Alexander, over to the Gassy Jack (Jack Deighton) Statue, no significant disruptive sounds appeared and once again it was quiet and free from traffic noise. The blind walkers were introduced to the statue and spontaneously began to touch and follow the contours of the statue, in an attempt to build up an image of it. From the expressions on their faces, one could see a positive yet pleasing and sensitive, almost delightful experience. It was a comfortable relief for the majority of our walkers, it was the first tactual experience of the walk, and they enjoyed it.

> "What's this?--That's his shoe. Boy he's got big feet." (They all laugh.)

A woman walker who previously was irritated and annoyed at the inhospitable sonic surrounding became engrossed with excitement.

> "Wouldn't you like to spend a day here and go into the shops-eat outside-that's fun, I'm going to do that some day."

From this point the walk continued on the North side of Water Street, across Abbott to Gaslight Square. The sun was high in the south-southwest as one woman walker remarked:

> "You can feel the heat reflect from the building."

While another man continued to point out detected depressions and gaps between buildings on the street front building facade, explaining that:

> "Glass is very similar to a wall, the only difference it would make is, if the glass was set in and then actually the space between you and it would give you the clue. Glass, brick and cement, are all hard materials-not much difference as far as sound goes."

> "Sound is to a blind person what fog is to a sighted person, because sounds around tend to confuse your directions, and you lose yourself to a certain extent, that is if you get too much sound like traffic, a lot of conversation, people all around, it gives you no sense of direction really, just the same as if you were in a fog, you would lose your directions.
>
> When travelling, you can get the sounding of objects, even if the traffic is going, but at the same time it's harder, it doesn't give you as clearly defined (information) as when it's very quiet. You would be surprised how clear the picture you can build in your mind of things around you, just by sound."

A sanitation worker was cleaning the street, scraping a rake over the brick pavers collecting trash and dropping it into a metal garbage can. This sound startled some of our walkers. "What's that?", they asked. And just as our walkers began to enjoy the sounds of an accordion and guitar playing in the distance, a large truck idled by, annoying most of our walkers. "Traffic drowns everything out!"

As we crossed the intersection at Abbott Street, once again frustration with the sonic environment was noticed as cars and a motorcycle dominated the immediate soundscape. In the distance to the north, CPR Box Cars also were squeaking for sound supremacy. Upon reaching the other side of the intersection, a sidewalk table protected under an umbrella, displayed some jewelry and leather goods. We stopped and our walkers were allowed to feel some of the trinkets. Most expressed real interest and made comments relevant to what stimulated them:

"That's leather, it smells beautiful."

A short time after this, we stopped for a coffee break. As we stood on the brick paved sidewalk, sipping our drinks, the discussion turned to the preference of dancing and walking on wooden surfaces, as opposed to concrete.

Walker: The moment you walk on wood you can tell the difference right away.
Author: Do you find that more comforting?
Walker: Oh yes, much more comfortable. (All agree.)
Author: Why is that?
Walkers: "There is more give to the wood, there is no give in cement."

"You get sore feet."

"It's a dream to walk or dance on a wood floor. If you could have spring sidewalks or things that would give a certain amount of give to them, I believe that it would be a lot easier on people's feet."

"Air cushioned sidewalks!" (Another remarked--all laugh.)

After the 10 minute coffee break we proceeded towards the east entrance of Gaslight Square. When our walkers were told that we will be turning to the right, into the Square, one male walker spontaneously responded: "Are the lights gas?" Unfortunately they were incandescent, and only some of the fixtures were made to appear like gaslights. It was a disappointment. We walked directly to the other side of the court, near the three maple trees and sat down on a wooden block bench. When we asked the walkers how this space felt relative to the one out on the street, most of their comments were uncomfortable:

> "I like getting back to the sun."

> "Well I always wanted to come here. This is a good way to find out about it. If there are any blind people living around here, I don't know how they get around."

> "If it were a high building (referring to the buildings surrounding the court itself) you would get more of an echo sound, but if they are low buildings-considering the amount of space inside, you say 70 ft. by 100 ft.-actually when compared to the height of the buildings, it doesn't leave you too much to make the echo sound like a cave or a cavern."

> "It's an enclosed sound here and that makes a difference from the street even if the street is open two ways, it doesn't hold down the sound. Traffic gives you the direction of the road and the line of a sidewalk and a line of buildings. You see, if the traffic turns the corner, then you know that you are coming to the curb."

When we asked our blind walkers, if the walls surrounding this square were constructed of wood such as cedar siding, rather than concrete, glass and brick, would that affect this space? One male blind walker commented:

> "You probably would get more of a resonance to it, the wood answers the sound. Hard dry wood is like an instrument, a piano or anything else. The dryness of the wood helps the strings to vibrate and carry the sound, and wood does exactly the same. If you get a porous wood wall and there's music playing to a certain extent the wood will amplify it-a little-you don't get that from stone or brick or anything like that. Wood does amplify because it acts as a resonant."

Just as the walk was coming to an end, after leaving Gaslight Square, we entered the sidewalk onto Water Street and then walked west approximately 30 feet and turned abruptly into a ten foot gap between two buildings. The building to the west was two stories and the one to the east was five stories. The alley-type gap was approximately 130 feet deep and open towards Water Street, as well as towards the CPR Yards. Visually one could see Burrard Inlet and the mountains to the north. The walking surface was composed of construction gravel near the entry although predominantly consisting of compacted soil, along with the normal candy paper wrappers that one associates with wind and alleys. This space seemed distinctively more quiet from other spaces experienced by our walkers on this tour. As they proceeded between the two buildings a deathlike silence dominated. Upon entry, one man was sensitive enough to notice the space--"This is like a lane." While the majority of our walkers by tone of voice and facial expression conveyed uncomfortable feelings to us:

"I feel kind of closed in now."

"Have we got time to do this? I don't like this."

"Oh let's not stop too long, I have to get going." (We asked her if she didn't like this area and she immediately replied) "No, I got to get home. Sorry but I have an appointment at three o'clock. But I've enjoyed it, sorry I haven't been much help--really the traffic does drown out an awful lot of noises."

When we came out of the spatially constricted gap, the same woman who was in a panic to get home was completely refreshed, the relief was amusing, she wanted to come back to Gastown, not during daylight but at night.

"I would like to be down here at night. (Oh yeh--others laugh) Oh yeh I would. The night life would be very interesting." (Another replied--maybe a little too interesting.)

Others were also delighted to be out of the gap.

"We found a curb, we're back home." (They all laugh.)

Before reaching the starting point (Woodwards Parkade) our blind walkers had to cross Water Street and then it was home free--into the cars. As they crossed the street no remarks were directed at the traffic noise, they were not conscious of it, however they did respond to the familiar, a moment of their past. Their remarks were natural and sincere.

Walker:	"What's that bell?"
Author:	It's a bicycle with a little bell.
Walker:	"I thought it was the ice cream man."
Author:	No.--they all laugh.

Walker: "I don't like ice cream, but they use to have it around, selling it, but now you don't hear it anymore."

The walk with the blind on Friday, September the nineteenth, nineteen hundred and seventy-five was an experiental reality the author shall not soon forget, for their sensitivity has provided an eternal insight into an individual's perception of the environment.

The Micro-Sonic Site:

The Micro-Sonic Site

Before the city was born, Vancouver's natural soundscape was like a symphony orchestra conducted by nature's two most experienced composers, the wind and the ocean. When at rest, silence steadily increased in clarity and brilliance. Perhaps the following poem by Emily Carr conveys the feeling of such a soundscape:

> The silence of our Western forests was so profound that our ears could scarcely comprehend it. If you spoke your voice came back to you as your face is thrown back to you in a mirror. It seemed as if the forest were so full of silence that there was no room for sounds. The birds who lived there were birds of prey--eagles, hawks, owls. Had a song bird loosed his throat the others would have pounced. Sober-coloured, silent little birds were the first to follow settlers into the West. Gulls there had always been; they began with the sea and had always cried over it. The vast sky spaces above, hungry for noise, steadily lapped up their cries. The forest was different--she brooded over silence and secrecy. [1]

As the city grew up the soundscape changed, nature's composers no longer conducted their symphony of silence and solitude, for the city audience had found a new soundscape-a man-made soundscape, the <u>ambient soundscape</u>:

> It is a low humming rumble, pitched below 80 cycles, a flat low E, usually. It is not loud, but continuous 24 hours a day with rare exceptions. This hum is very

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[1] Emily Carr quoted in Sonic Research Studio Communication Studies Department, <u>The Vancouver Soundscape</u>, World Soundscape Project-Document No. 5, Simon Fraser University, Burnaby 2, B.C., Canada, p. 7.

> irritating to me....It is very evident inside buildings, homes, etc. all over the South part of Vancouver. I believe it is caused by some machinery along the Fraser River or at the airport... This sound is a subtle and lethal torture, and the city of Vancouver should not allow it to continue. [2]

Today the world suffers from an overpopulation of unnecessary and boring sounds. These new and ugly sounds, dumped into our outdoor environment, lack quality and clarity, they are polluting the urban soundscape with too much acoustic information, making delicate sounds indiscriminate. Not only are natural sounds such as bird songs, ocean waves and sounds of rain drops on a roof being masked, but human speech sounds are now hardly audible in a contemporary urban soundscape.

Outdoor noise is generated by a number of sources, however it took the prospect of the sonic boom of supersonic aircraft to alert the general community to the problem of regular, repeated and predictable noise in our present environment. For years, industrial safety standards have limited noise in construction, manufacturing, mining, agricultural and other industrial settings where permanent damage to hearing could occur. But community noise has been largely ignored until recently. Perhaps, partly this apathy can be attributed to the fact that human beings living in a noisy environment soon become unaware of the ambient noise level and thus automatically attribute changes in their behavior to the noise which in-

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[2] Ibid., p. 21.

vades their body and mind. This state is often a result of habituation, where the brain simply loses its responsiveness to a noise which is repeated over and over again, thus diminishing its alerting function to the body. Fortunately, the ear adapts only to that specific frequency range of noise and does not dull our brain's responsiveness to all other auditory stimulation.[3]

Sonic brainwashing is slowly but effectively destroying the city-dwellers' physical and psychological well-being. Studies on sensory deprivation and sensory overload by Richard Held, Ph.D. of the Massachusetts Institute of Technology, have indicated "how noise, like silence, acts to disorient us who hear by removing sound cues which our ears could use to readily distinguish parts of our environment. By masking these cues, noise produces the same effects as silence."[4] With the steadily increasing number and level of noises in our cities, brought about by more powerful transportation modes, construction and associated powered equipment, man is losing his ability to listen discriminately. He is more prone to accept sounds of any quality that the "sound sewers" of the urban environment have to offer. This is partially due to habituation.

> The soundscape of the world is changing. Modern man is beginning to inhabit a world with an acoustic environment radically different from any he has

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[3]Theodore Berland. The Fight For Quiet (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1970), p. 52.

[4]*Ibid*., p. 45.

> hitherto known. These new sounds, which differ in quality and intensity from those of the past, have alerted many researches to the dangers of an indiscriminate and imperialistic spread of more and larger sounds into every corner of man's life. Noise pollution is now a world problem. [5]

Precisely how fast the noise level (ambient noise or noise climate) of the contemporary urban environment is rising is difficult to estimate. The figure of one decibel per year has frequently been used, however this seems a little high, since the decibel scale is logarithmic. (The actual sound pressure on the ear, increases 10 times with each 10 decibel increase). A study by Murry Schafer, as part of "The World Soundscape Project" analyzed sound levels of different fire engine sirens in Vancouver with the assumption that ambient noise would rise in proportion to social signals, revealing some startling evidence. Beginning with a 1912 La France device which measured 88-96 dBA and concluding with the newest siren measured 114 dBA, it revealed a rise of some 20 to 25 decibels in sixty years. This is nearly a half a decibel increase per year on the average.[6]

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[5] Murry Schafer, "The Tuning of the World" (unpublished works: as part of the World Soundscape Project, Simon Fraser University, 1975), p. 2.

[6] *Ibid.*, p. 309.

Bench mark:

It seems that all currently used noise rating scales are based on what the public as a group will put up with. That is, any requirements that are designed to deal with the problem of noise are based on the viewpoint of "reasonable" or "appropriateness", by the "average" person, irrespective of damages to the hearing mechanism, speech interferes, disturbances to sleep and rest or other forms of annoyance or irritations. A "bench mark" must be established then, in order to provide the basis against which data on the actual micro-sonic environment may be compared or assessed. One man's "auditory comfort" may be another man's "auditory discomfort." To disturb the public then means to disturb a significant portion of the public, and it is on this basis that an optimal sensory equilibrium environment must be achieved for all mankind (Refer to the chapter on Sensory Equilibrium, page). Since a person or a group of people consciously or unconsciously select to go to a "place", they do so for one basic reason, that is, to get sensory stimulated or sensory deprived. The spectrum of stimulation or deprivation required, rests on the dynamic psychological need of that particular person or group, since man seems to require diversified stimulation in order to maintain psychosomatic equilibrium.

> A leading authority says 'normal' city noises not only 'get on the nerves' but can do permanent damage to the auditory system, negatively affect the

> heart and blood pressure and eventually 'disturb every bodily function.' Loud blasts will send pulse and heartbeat skyrocketing, as will the effort to talk or be heard in presence of continuous, high-level noise. [7]

It must be remembered that the allotment of time devoted to a given "place" is consciously or unconsciously proportioned along with other divisions of "place" within the parameter of time. The exposure may be an hour, a day, a week or whatever. The sonic environment however does influence that decision. Therefore in terms of analyzing the micro-sonic site in Gastown we will establish speech interference and auditory information gathering interference as a deterrent to optimal well-being on the one hand and the need for auditory stimulation on the other.

Sound to the architect is like a building material, it is an integral, and vital part of any urban environment. Its emphasis however must largely be directed to its use in the ideal sonic urban climate. When sound becomes intrusive to speech and auditory information gathering, it then is considered as noise. It is undesirable due to its masking property. The American National Standards Institute defines noise as:[8]

1. any undesired sound
2. an erratic, intermittent, or statistically random oscillation.

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[7] James M. Fitch, American Building 2: The Environmental Forces That Shape It (Boston: Houghton Mifflin Company, 1972), p. 153.

[8] Robert A. Baron, The Tyranny of Noise (Toronto: The Macmillan Company of Canada, 1970), p. 39.

Although noise stimuli can provoke different degrees of annoyance reactions in individuals and groups depending on the "immediate state of mind, disposition, temperament, health or activities and the type, quality and intensity of noise"[9], there still are objective guides for predicting whether any noise will be annoying.

Man's hearing range extends roughly from 16 to 20,000 cycles per second and on the decibel scale from zero to 120 decibels. Man's optimal hearing is in the range of 250 to 4,000 cycles per second and most acute in the middle of the frequency range (around 1,000 cps or two C's above middle C on the piano). The optimal conversational level is approximately 60 decibels. (Refer to the "Auditory Sense" chapter, page 89). Continual exposure to sound levels greater than 80 decibels can cause hearing damage.[10]

A recent study on the problem of community noise in Manitoba revealed some quantitative evidence on speech interference levels which are applicable to the "ideal" noise climate in Gastown. Noise levels in residential areas are compatible with man's optimal auditory threshold. Gastown, being a micro-climate itself, similar to Nicollet Mall in downtown Minneapolis, Minn. visually possesses all the comfortable amenities associated with a stimulating

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[9] The National Bureau of Standards. A Guide to Airborne, Impact, and Structureborne Noise Control in Multifamily Dwellings. (Washington: U.S. Department of Housing and Urban Development, 1963), pp. 2-3.

[10] Noise and Hearing Conference at the University of Manitoba, Faculty of Engineering. November 15, 1974.

public urban space--Peoples place (boutiques, restaurants, nightclubs, book stores, art galleries, retail areas, Kiosks bus shelters, benches, lighting fixtures, flower planters, trees, sculptures, etc.). The scale of street furniture is appropriate to its image of being a place for lounging, browsing, eating and resting. One would assume therefore, that the microclimate in such an environment would possess similar pleasant sonic amenities corresponding to the visual amenities whereby low level, soothing, steady, unobtrusive sounds, typical of the natural undisturbed environment would be found.

The Manitoba study indicated that "to ensure that speech interference from intrusive noise be kept to a tolerable level in residential zones...should be limited to 50 dBA in summer, and 60 dBA in the winter,"[11] if good speech intelligibility* is to be achieved. The ambient noise level should then be kept low enough and of such character as to not interfere with desired sounds. If the sound pressure level is increased or reduced 3 db., a listener just notices the change in level, but if the change is 10 db., a doubling or halving of the apparent loudness occurs. A series of noise criterion curves

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[11] K.W. Yeow, "A Study on the Problem of Community Noise in Manitoba", Province of Manitoba Department of Mines Resources and Environment Management, p. 13.

* The intelligibility of the speech signal is quantified in terms of the articulation index (Al)-it is the percentage of words, rhymes, syllables or non sense syllables heard correctly by the listener in a standard intelligibility test.

developed by Leo Beranek and Newman on the basis of statistical studies of office workers in an enclosed space were plotted against speech interference levels and loudness levels, resulted in a permissible and acceptable noise level table.

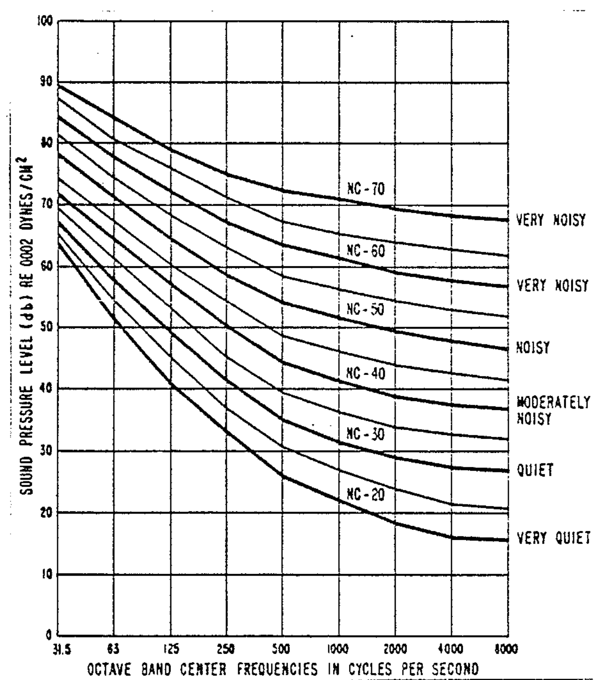

Figure 1. Noise Criterion Curves [11a]

The speech interference level and loudness level criteria were translated into a series of noise-criterion curves ranging from Nc-20 to NC-70, where the speech interference level (SIL) is the arithmetic average of the readings in decibels within the three-octave frequency bands most important to speech articulation-600-1,200, 1,200-2,400, and 2,400-4,800 cps. And a loudness level criteria re-

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[11a] "Noise Control in Architecture: More Engineering than Art." Architectural Record, (October 1967), p. 195.

lating to equal loudness depending on its decibel range relative to its cps range, thus a 20 db sound at 1,000 cps would be equal in loudness to a 40 db sound at 200 cps. This table, thus can act as a guide to speech interference caused by unwanted noise.[12] (Refer to Figure #1, page 30). Noise on the one hand differs from speech in that it is less ordered in nature, it is a "conglomeration of many frequencies and intensities without an ordered time sequence,"[13] unlike speech which has predictable rhythms, intensities and frequencies.

Until now, we have regarded speech interference as a basis for analyzing the micro-sonic site in Gastown, as it interfered with the optimal performance of the user and tended to elicit a negative response in its users. We now look at auditory information gathering interference, as another basis for predicting annoyance reaction in its users. Under normal circumstances we find that most people find sounds unpleasant, discordant, disturbing and painful if they are of the following nature.[14, 15]

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[12] "Noise Control in Architecture: More Engineering than Art." Architectural Record, (October 1967), p. 195.

[13] Helmer Myklebust, The Psychology of Deafness (New York: Grune and Stratton, Inc. 1971), p. 24.

[14] Theodore Berland, The Fight For Quiet (Englewood Cliffs, N.J.: Prentice-Hall, Inc. 1970), p. 46.

[15] The National Bureau of Standards. A Guide to Airborne, Impact and Structureborne Noise Control in Multifamily Dwellings. (Washington: U.S. Department of Housing and Urban Development, 1963), pp. 2-3.

1. The louder the noise the more likely it is to be annoying and disturbing, since it stimulates attention and increases response.

2. High pitched noises upwards from about 1,500 Hz are more disturbing than lower pitched ones.

3. Intermittent, irregular and random noises are more distracting than regular or steady-state ones.

4. Unexpected noises like sonic booms or sudden impact noises can startle.

5. Prolonged exposure to a disturbing noise will increase irritability until habituation develops.

6. Noises produced from a hidden or moving source where the person is uncertain where the noise is coming from, will produce annoyance.

7. Noise inappropriate to one's activity such as that created by others rather than self.

8. Uncontrolled use of distortion, high sound levels, echo, excessive reverberation, transmission and vibration will also cause annoyance, irritation and distraction.

Sounds which are distinct and undistorted such as pure tones which are replicated, communicate necessary and desirable information to the listener's ear. The use of the following factors contribute to good hearing when used discriminantly in designing for an ideal soundscape:[16]

Fidelity - The degree to which sounds are accurately reproduced as faithful a replica of the source as possible is important to good acoustics.

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[16] Published by United States Gypsum with the assistance of Bolt and Bernek and Newman, Acoustical Consultants, Sound Control in Design, 1959, p. 29.

Ample Loudness Level - The ideal situation is a level at any point in the room identical with the level of the source--no loss in distribution, no objectionable build-up from excessive reverberation.

Sound Distribution - Ample loudness level may be difficult to achieve at any point in a room, but proper use of room shape, reflective surfaces, absorption, and, when required, electronic amplification makes it possible to approach the ideal.

Optimum Reverberation - Reverberation, the persistence of sound within a room after the source has ceased, is not, in itself objectionable. A completely "dead" room is most oppressive. A certain amount of "liveness" is desirable. The pleasant "brilliance" of good concert halls and auditoriums is the result of just the right amount of reverberation (the "optimum reverberation" time).

Masking and Background (acoustic perfume) - The use of soft music in industrial and commercial spaces; the play of water from a small fountain in waiting rooms and lobbies, tends to "mask" annoying little distracting sounds. However if the sounds are too high, listening can become very fatiguing.

Sound Level Meter Study:

The experiential reality of the site as perceived by the blind throughout the field trip was one of a subjective nature, in which the blind responded purely to spontaneous stimuli. In order to provide an objective basis against which the behavioral response may be compared or assessed, a sound level meter was used to document the actual soundscape of the site. The measurement procedure consisted of walking through the prescribed "blind walk" with a sound meter and recording the sound levels at these selected locations. A Bruel and Kjaer precision sound level meter (SLM), type 2205 was used in the survey. The SLM was calibrated one month before its use so that the range of error was within acceptable limits. A one to two decibel error was measured, however Barry Truax a professor in the Department of Communication Studies at the Simon Fraser University who recorded the sound levels with the author assured the author that the meter was well within acceptable standards. The weather forecast for the day was for sunny skies, with a few early morning fog patches, with a low near 8^{o}F and a high of 20-24^{o}F and light winds 5 to 10 mph. At the actual time of the sound level recordings the sky was clear, no clouds whatsoever and the temperature was +20^{o}F--no winds. (A discussion on how wind and temperature may affect the nature of sounds perceived by the human ear is analyzed on page .

The sound level readings were recorded both in the dBA and dBC scale since the A-weighted scale closely corresponds to what the human ear hears, it covers a frequency range of 400 to 12,000 Hz, and like the ear it is more sensitive to the higher rather than the lower frequencies. This scale is widely used for measuring noise levels outdoors, such as in traffic noise surveys and surveys of noise in the community. The C scale corresponds to a frequency range of 25 to 10,000 Hz., thus the noise level measured on the A scale can be compared with that of the C scale to make a rough analysis. A "higher reading of the same noise on the C scale than on the A scale means that the noise has a heavy component of low frequencies which the ear would not perceive."[17] When this weighting network is used, the measurements are expressed in decibels both on the A and C-weighted scale. The B scale is seldom used, since it covers frequencies from 124 to 12,000 Hz and is somewhat more sensitive to higher frequencies.

The decibel, or dB, is a universally adopted unit for measuring sound intensity. The basic reference point is 0 decibels and it represents the threshold of audible sound for a healthy set of ears. The decibel is:

> not really a unit, but a ratio. Based on the dyne (a decibel is 0.000204 dyne per square centimeter), it is a logarithmic scale. It is related to the bel, which is named in honor of Alexander Graham Bell, who invented the telephone and worked with the deaf. Because it's logarithmic, the bel is not a constant unit as are inches and pounds, or centimeters and grams. It is more like the F stops on a camera lens. Thus, one bel is tenfold the power of a decibel and two bels means tenfold and tenfold again. If tenfold is 10 dB, a hundredfold is 20 dB. Double sound pressure is not 20 dB but 6 dB. Also when two sound sources impinge on you, the total decibels are not simply an addition of the two. If one source is 60 dB and the other is 60 dB, the total sound pressure is not 120 dB but 63 dB. [18]

The sound level meter study of Gastown (Refer to Figure #2, page 37) has revealed some interesting sound intensity differentials. An attempt therefore will be

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[17] Theodore Berland, The Fight For Quiet (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1970), p. 9.

[18] Ibid., p. 8.

made in the following section to analyze these variances in some objective terms and relate them specifically to the behavioral reactions of the blind subjects who participated in the field trip--'A Walk with the Blind', in Gastown.

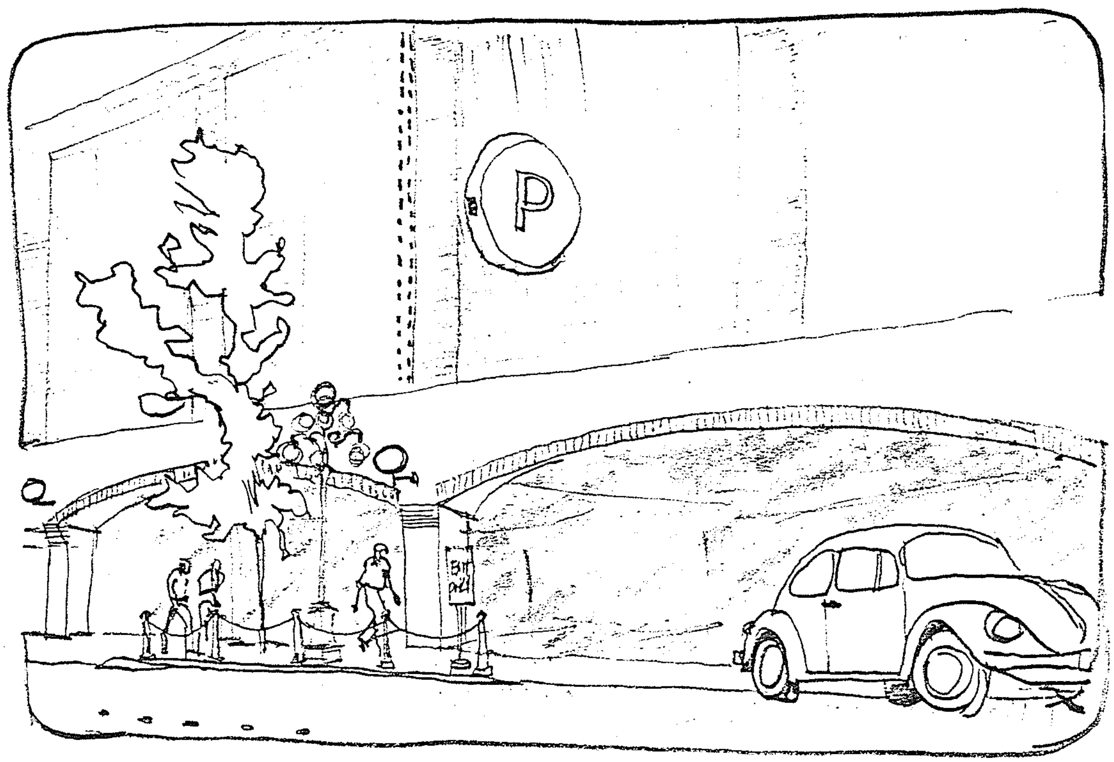
The measurable characteristic of sound in this research experiment has been primarily expressed as one value, that is the sound-pressure level (SPL) in decibels as registered by a simple sound level meter. When comparing different kinds of sounds, a knowledge of their 'sound spectrum' is necessary for making a precise sound quality judgment. For sound spectrum analysis, an instrument such as the Bruel and Kjaer (type 2203) is used. This combined instrument enables the user to measure the sound-pressure level in decibels and the sound frequencies in octave bands. In noise control practice both methods of measurement are used. As the author was unable to obtain an octave frequency analyzer, knowledge of frequency distribution is unavailable. Since certain groups of frequencies have greater intensity levels than others, a precise sound quality analysis therefore cannot be evaluated. "A sound which has a constant sound pressure level of, say, 60 dB, will appear to be quieter at a frequency of 100 Hz. than it will at 1000 Hz."[18a] Since the limitations of this research experiment are restricted to SPL's a further refinement in future research would merit the extension of this sound methodology.

[18a] C. Duerden, Noise Abatement (Toronto: Butterworth and Co. (Canada) Ltd., 1970), p. 15.

	AREA	ACTUAL	AVERAGE	NO TRAFFIC
1	Woodwards Parkade	69-74 dBA 79-83 dBC	72 dBA 80 dBC	Highest Traffic sound-90 dBC
2	Intersection	72-74 dBA 83-85 dBC	72 dBA 84 dBC	67 dBA 78 dBC
3	Mid-Street	68-74 dBA 80-84 dBC	70 dBA 82 dBC	66 dBA 77 dBC
4	The Garage	62-66 dBA 72-74 dBC	64 dBA 73 dBC	58 dBA 70 dBC
5	Blood Alley	59-62 dBA 72-74 dBC	60 dBA 73 dBC	57 dBA 70 dBC
6	Maple Tree Square	70-74 dBA 82-86 dBC	72 dBA 84 dBC	67 dBA 78 dBC
7	Gaslight Square	66-70 dBA 74-80 dBC	68 dBA 76 dBC	62 dBA 72 dBC
8	'Gap'	68-74 dBA 76-80 dBC	70 dBA 78 dBC	65 dBA 75 dBC

Fig. #2 - Sound Level Meter Study of Gastown

site decibel levels

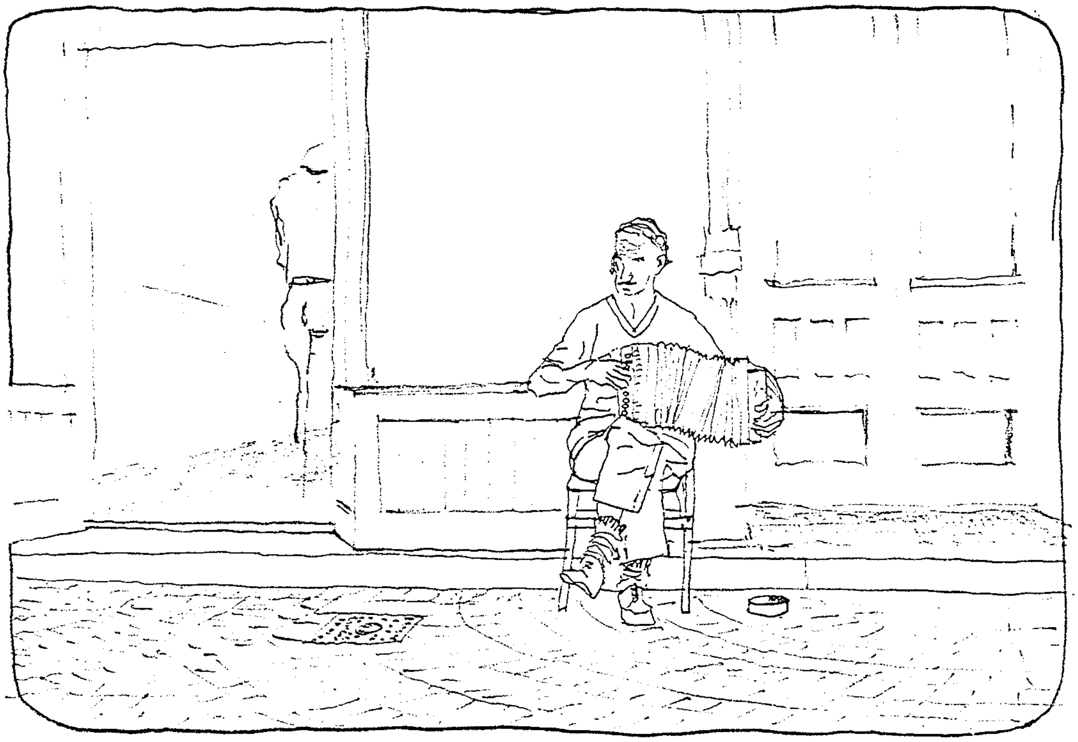


"If you were to walk here alone I think there would be so much noise it would be confusing- the noise confuses your direction."

woodwards parkade 72 dBA

"I don't know whether I like that."

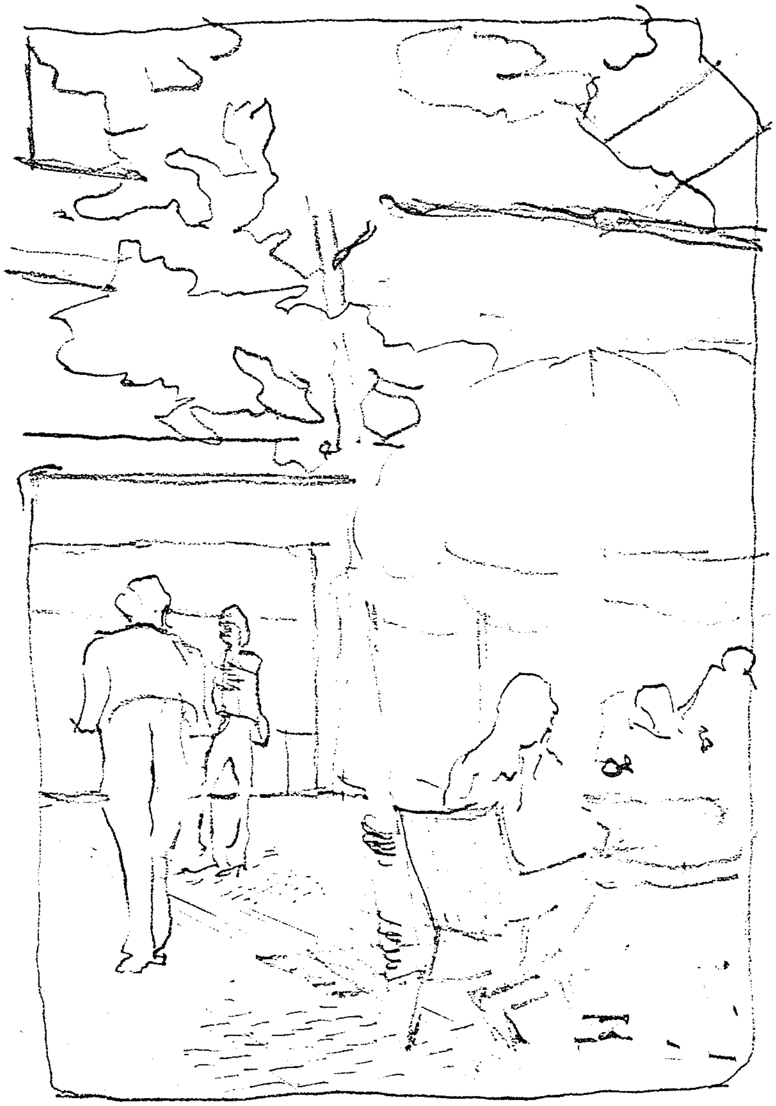
intersection 72 dBA



"The traffic drowns out almost everything."

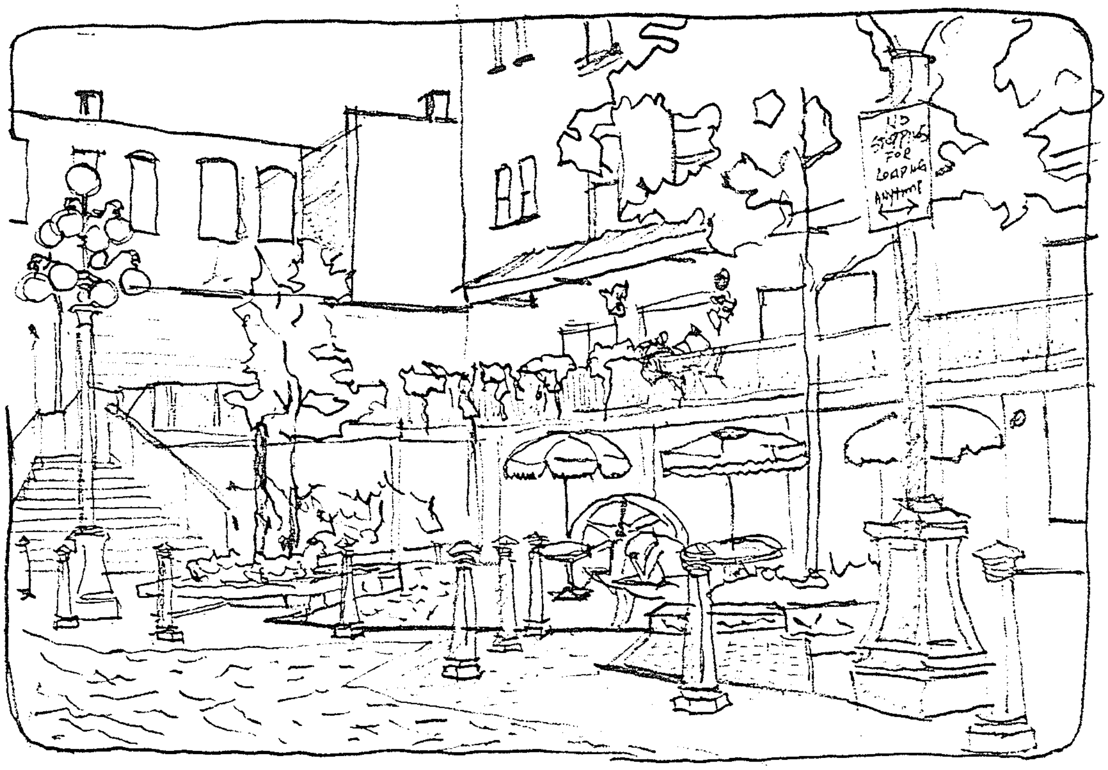
mid—street

70 dBA



"It has atmosphere of its own, hasn't it."

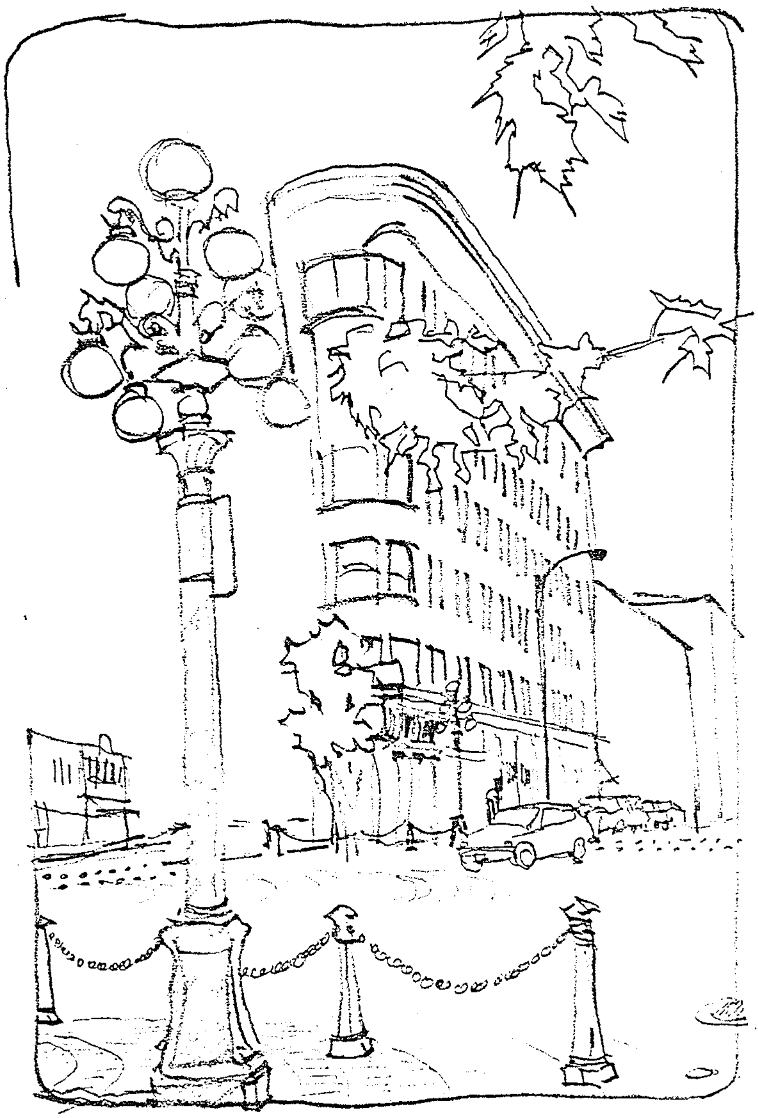
the garage - courtyard 64 dBA



"We're getting the sun quite well so the building can't be that high."

blood alley

60 dBA



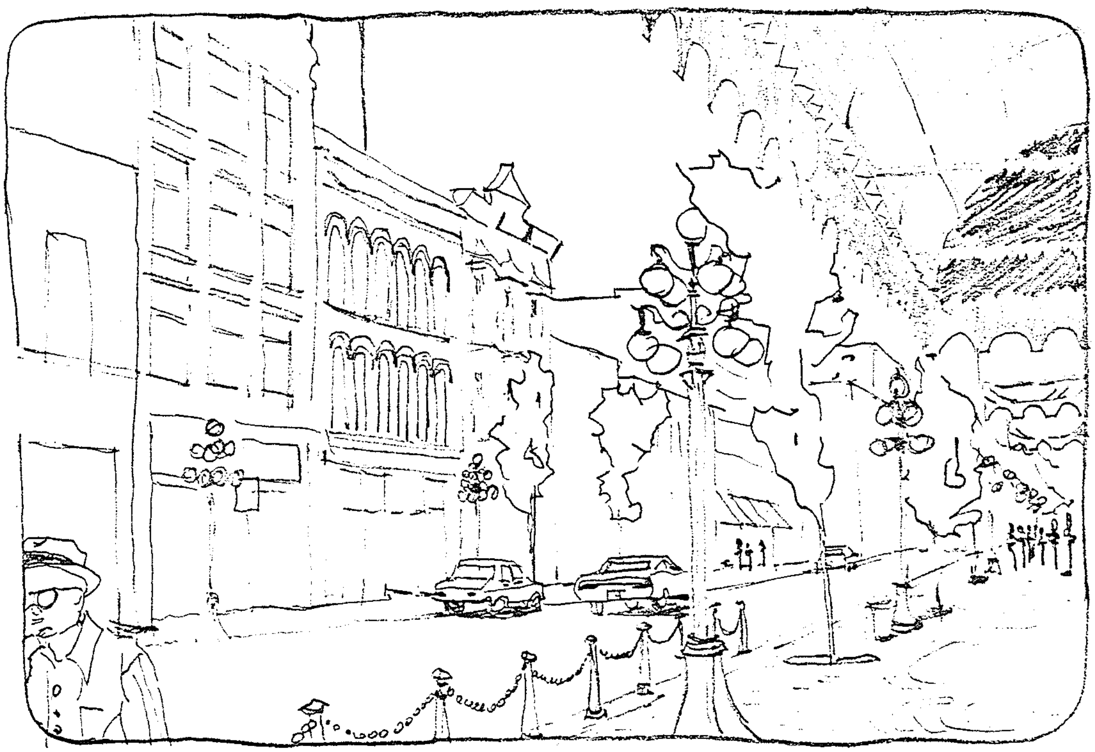
"Traffic noise is very disturbing. That's all I can hear."

"Nothing to navigate by."

maple tree square 72 dBA

"What's this?-That's his shoe. Boy
he's got big feet."

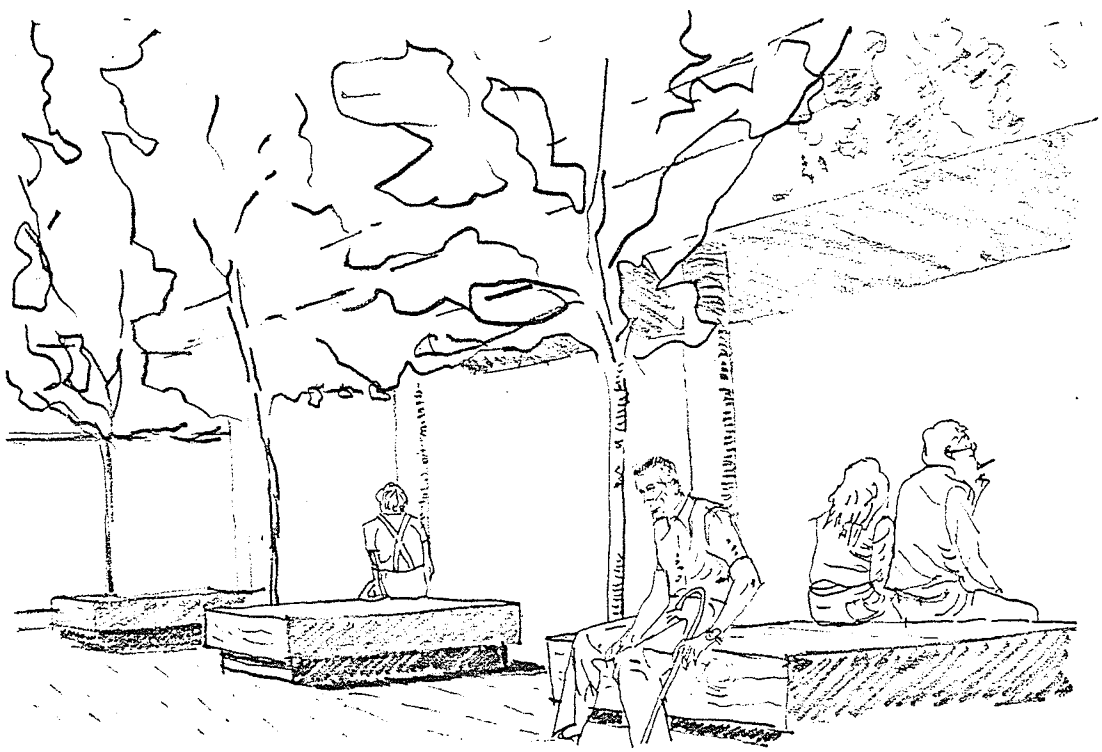
gassy jack statue **72 dBA**



"When travelling, you can get the sounding of objects, even if the traffic is going, but at the same time it's harder, it doesn't give you as clearly defined (information) as when it's very quiet. You would be surprised how clear the picture you can build in your mind of things around you, just by sound."

mid — street

70 dBA

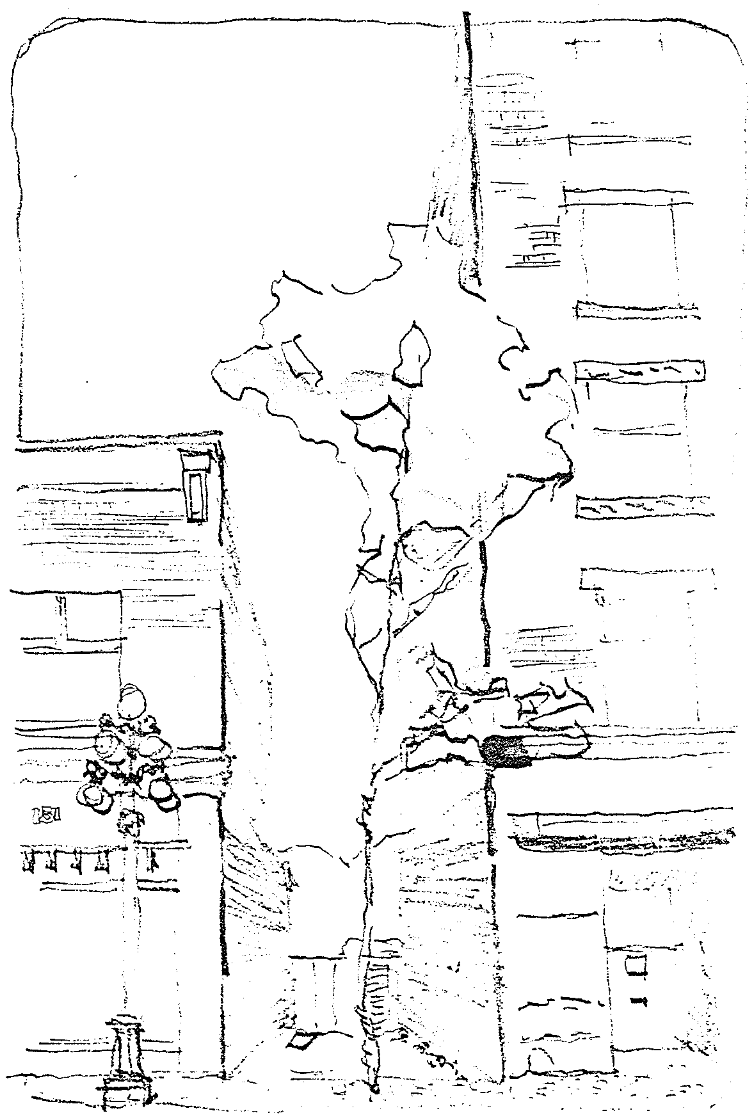


"I like getting back to the sun."

"Well I always wanted to come here. This is a good way to find out about it. If there are any blind people living around here, I don't know how they get around."

gaslight square

68 dBA

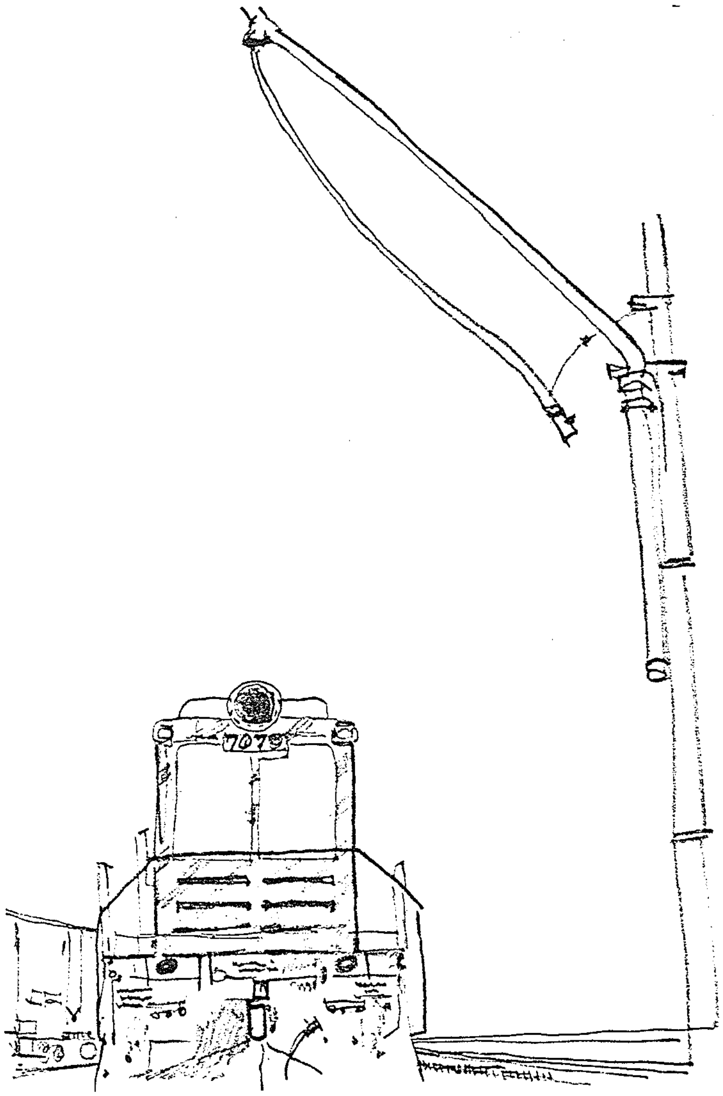


"I feel kind of closed in now."

"Have we got time to do this?
I don't like this."

gap

70 dBA



Sound spill:

cpr yards

90 dBA

Ambient Sound Spill:

Research on the soundscape surrounding the Gastown Site indicates a high ambient noise level. This can be accounted for by the sound spills caused by the construction activity immediately West of our site generated by the central business district, the manufacturing industry surrounding Burrard Inlet, the transportation system of the cities roadways as well as the ships docking in the harbor, aircraft taking off and landing, the CPR train station, and of course the sounds propagated by man in his daily routine-refuse collection, police and fire departments, etc. In terms of decibel levels this may account to an ambient noise level of well over 65 decibels. Based on the number of complaints registered by numerous officials in Vancouver as part of the Vancouver Soundscape Project, it is not surprising that the ambient noise level in Vancouver is rising. The following survey conducted by The World Soundscape Project lists the various categories of sound nuisance reported in Vancouver in 1969.[19]

Type of Noise	No. of Complaints
Trucks.	312
Motorcycles	298
Amplified Music/Radios.	230
Horns and Whistles.	186
Power Saws.	184
Power Lawnmowers.	175
Sirens.	174
Animals	155

[19]Murry Schafer, "The Tuning of the World" (unpublished works: as part of the World Soundscape Project, Simon Fraser University, 1975), p. 311.

Type of Noise	No. of Complaints
Construction.	151
Automobiles.	138
Jet Aircraft.	136
Small Aircraft.	130
Industrial.	120
Hovercraft.	120
Domestic.	95
Foghorns.	88
Trains.	86
Children.	86
Office Noise.	81

In order to give the reader some indication of the sound intensity level these noise makers produce, a general list was composed by the author indicating the respective decibel levels usually associated with such sources.

CONSTRUCTION	dBA
Pneumatic hammer 50 ft.	85-108
6 ft.	110-120
Riveting machine	110
Generators	77
Impact Pile Driver	100-105
Chain saw (5-8Hp)	83
Large Transformers at 100'	50

MANUFACTURING	dBA
Milling Machine	85
Newspaper Press	97
Industrial Plant	100-110
Boiler Factory	125

TRANSPORTATION	dBA
Subway close at hand	90-100
Auto horn	110-120
Jet airplane	
-Jet takeoff	105
-(2000')	120
-200'	160
-50'	84
Trailer truck on highway-40mph.	90dB
Aircraft carrier decks	155
Freeway Traffic (50 feet)	70

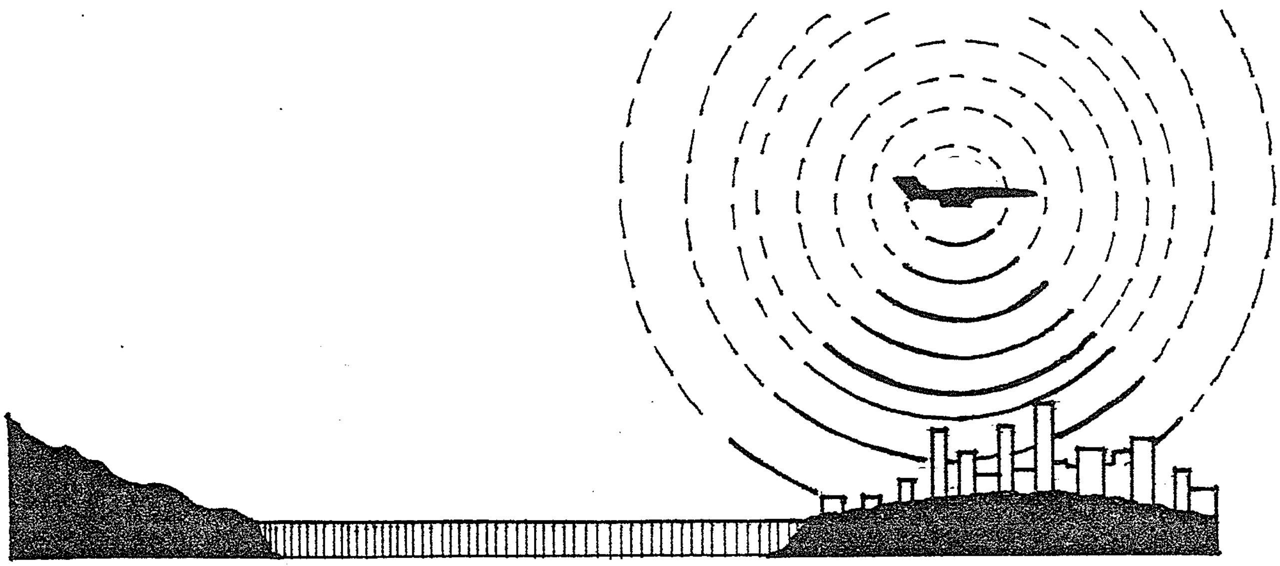
MAN-DAILY ROUTINE	dBA
Hum of small electric clock	40
Ambient noise, house kitchen	50
Piano	90-100
Quiet suburban residential	38
Normal suburban residential	42
Urban residential	46-50
Noisy urban residential	51-55
Very noisy urban residential	56-60

TRANSPORTATION	dBA
Freight Train (50 ft.)	76
N.Y. Subway Station	95
Prop. Plane Flyover-1000'	88
Car Wash-20'	89
Motorcycle 25'	90
Taxicab	72
Volkswagon	81
Pavement-sweeping machine	92
Inside an auto	84
Elevated Train	120-125
Inside an Air-plane	100
Snowmobiles	82
Boats inboard and outboard	80-95
Dune buggies	85-95
Dune bike	75
Model airplane	78
Busy street	70-80

NATURAL SOUNDS	dBA
Quiet rustle of leaves	10
Soft whisper	20-30
Normal conversa-tion	60
Dog bark (20')	40-46
Bird calls	44
Seagulls (dinner time)	74
Loud shout	80

MAN-DAILY ROUTINE	dBA
Library	35
Office	60
Bedroom	40
Living room	48
Discotheque	118
Power Mower	96
Dishwasher (Rinse) at 10'	60
Electric Type-writer at 10'	64
Cash Register 10'	65-70
T.V. Audio	70
Vacuum cleaner	70
Living room music	76
Garbage Disposal	80
Food Blender	88
Rock-N-Roll Band	108-114
Artillery Fire	130
Hi-Fi Addict (happy)	80-90
Empty theatre	30
Siren (10-15') Vancouver	114
Lawn mower	75
Snow blower	84
Leaf blower	76
Air conditioning unit at 20'	60

The sound-transmitting medium of ambient noise is almost always air. Unseen molecules of air are squeezed together in a very orderly way and because of the physical nature of air, they travel at about 1,100 feet per second or about 760 miles per hour. When the source of sound operates in a free field, that is, when no objects interfere with its path, it distributes its energy equally in all directions. Thus sound can travel great distances. This manifestation is experienced when aircraft pass over the city of Vancouver.



The further one is removed from the sound source however the less audible becomes the sound. This is due to the fact that the "intensity at any point is inversely proportional to the square of its distance from the source."[20] This is equivalent to a reduction of six decibels for every time the distance between the sound source and listener is doubled.

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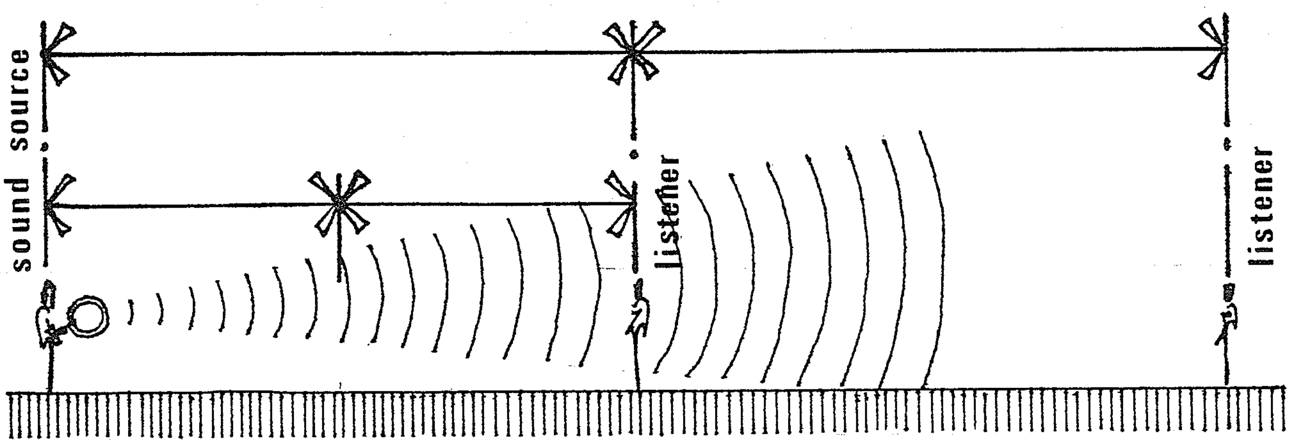
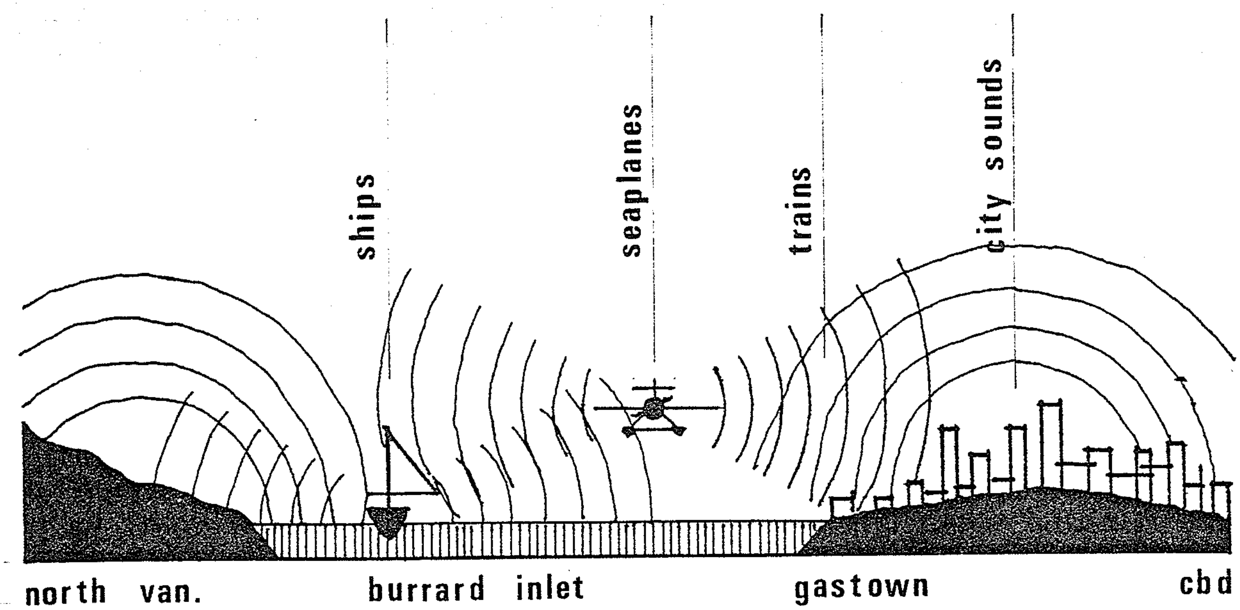
[20] Anita B. Lawrence, Architectural Acoustics (New York: Elsevier Publishing Company Ltd., 1970), p. 61.

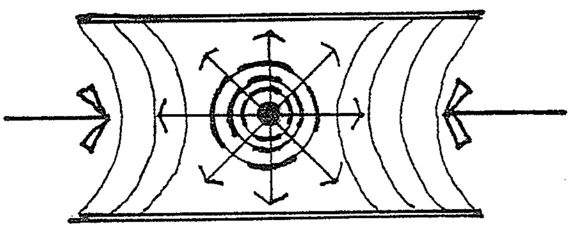


However the source of sound does not operate in a 'free field'. It is usually obstructed by nearby buildings or natural landscape, which cause the sound to reflect, thus the listener receives both the reflected as well as the direct sound. Some absorption or attenuation of the reflected sound will occur due to the properties of the reflective material. If we look at a cross section depicting sound sources surrounding Gastown we discover some interesting sound formations. Not only is Gastown bombarded by horizontal sound transmitted by the central business district but it is consumed spherically by a conglomeration of sound sources and intensities due to its juxtaposition in the city.

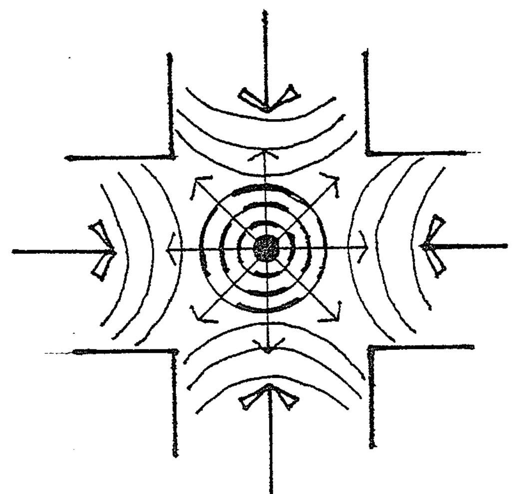


Micro-Sonic Street:

If it was possible to "play back" sound waves in slow motion at street level similar to what we see on television when football or hockey plays are re-run in slow motion, we would recognize some peculiar sound characteristics. For instance, we would see that sound has a directional characteristic in that it radiates more energy in some directions than in others, depending on the nature and intensity of the source. Consider the sound flow at street level where buildings line a relatively narrow street, such as is found on Water Street in Gastown. It is easier to identify a sound source in the mid-street than at the intersection due to its directional sound radiation. In the mid-street the sound waves are contained within the street cavity, they may travel in a direct path, reflecting off some of the building fascades, while absorped by others but basically the sound comes from either one or the other direction, since the street cavity is opened at both ends. Unlike that of the intersection where the listener is bombarded by sound waves from a number of directions. This may account for the lack of orientation experienced by our blind subjects when at the Abbott and Water Street intersection and at the Maple Tree Square intersection.

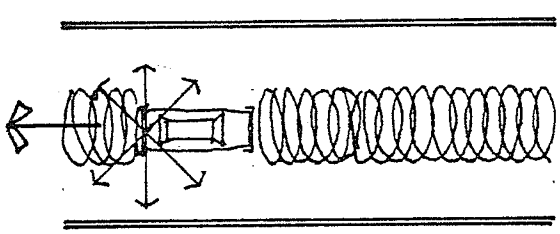


mid-street noise

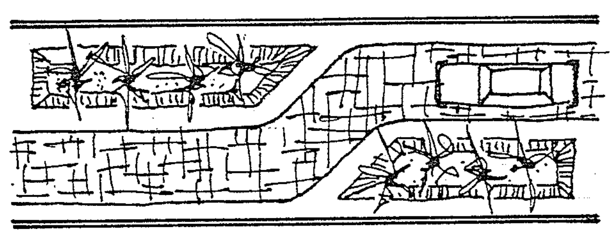


intersection noise

The sound level meter study indicated that at both these intersections, a high noise level existed--84 dBC. Due to the nature of the reflective surface and the lack of porous absorbers both on the building facades and on the roadway, the sound was allowed to take its own initiative in building the micro-sonic soundscape. Perhaps the greatest contributor of unwanted noise in Gastown apart from ambient noise is that produced by vehicular traffic. Since Water Street is used as a vehicular short-cut by industrial workers and others who are in a hurry to get to highway number 99 in order to cross the Lions Gate Bridge at the First Narrows. The noise generated by these vehicles, at times is substantially greater than the ambient noise level itself. This is due primarily to poor driving habits and lack of proper maintenance on the vehicles, something the architect or planner has no control of. Therefore by understanding the sound propagation behavior caused by the vehicles, a number of design alternatives may be suggested. Since the noise emitted by the stream of road traffic is radiated cylindrically from its line of travel, an obstruction in the nature of landscaping or offsetting the linearity of traffic movement may scatter and absorb some of the sound waves, and thus reduce the sound travel.[21]



cylindrical noise radiation



noise absorption and scatter

[21] *Ibid.*, p. 61.

The ultimate solution in reducing or preventing low frequency traffic noise from interfering with the sensory pedestrian is of course eliminating the metal vehicles from the symbolic pedestrian street, or at least making provisions to allow only service and emergency vehicles to enter. On the basis that Gastown is a historical focal point of Vancouver, it would be appropriate to preserve not only its architectural historical vitality but also its historical natural soundscape, since it was here in 1867 on the shores of Burrard Inlet that the community of Vancouver first developed. It appears that the design of the soundscape in Gastown was forgotten in the haste of historical restoration, which perhaps accounts for the lack of unique and informative sounds. The clip-clock-cobblestone-knock of the horses hooves and the wooden-wheel wagon walk is now but a visual facsimile mounted on some historical museum wall. Perhaps the criticism is premature at this time, for the City of Vancouver's beautification program in partnership with the City's Department of Social Planning and Community Development have indicated that the automobile traffic in Gastown is a critical problem which must be dealt with in order to provide a pleasant environment for both merchant and shopper.

Plants - may be used to assist in controlling some offensive traffic sound spills even though their effectiveness may not be considered significant, but together with their aesthetic value they will produce a sensory stimulation, one which only nature can provide. Trees which shed their foliage will be ineffective during the winter season. Therefore when selecting trees and shrubs for noise reduction, several factors should be considered.[22]

A. Sound:
- frequency
- decibel level
- intensity
- source

B. Planting:
- type
- height
- density
- location

C. Climatic factors:
- wind direction
- wind velocity
- temperature
- humidity

Plants seem to be effective in screening out some sound levels which are sensitive to the human ears. Tests have indicated that for dense homogeneous forests of either coniferous or deciduous trees a sound frequency of 200 to 3000 Hz. is reduced 7 decibels per 100 feet of forest, while a sound of 1000 Hz. is reduced by 2 decibels per 100 feet. However an amplification at 1000 Hz. in the order of 4 decibels was found within the first 100 feet of forest. This is due probably to resonance of the trunks and branches.[23] It appears that in order for plants to be

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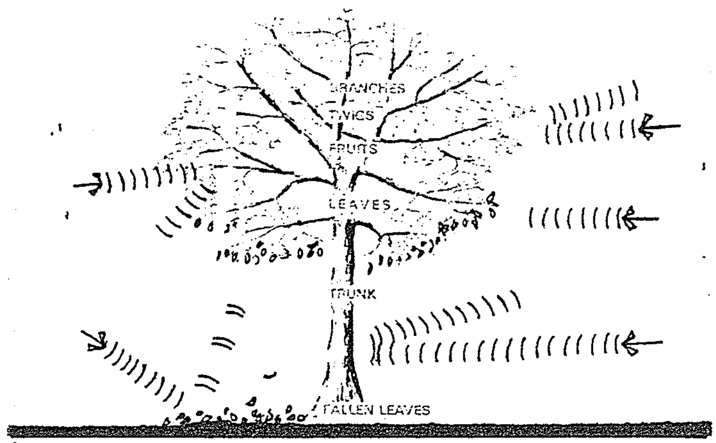
[22] Plants/People/and Environmental Quality, Engineering Uses of Plants: Published by the U.S. Department of the Interior, National Park Service, Washington, D.C. in collaboration with the American Society of Landscape Architects Foundation, p. 41.

[23] Anita B. Lawrence, Architectural Acoustics (New York: Elsevier Publishing Company Ltd., 1970), p. 65.

effective in absorbing unwanted noise, dense, pulpy leaves with flexible branches are desirable. Certainly a single row of trees or shrubs would have a negligible sound-attenuation effect, even though trunks and heavier branches would deflect some of the sound.[24]

PARTS THAT STOP SOUND



Trees planted in areas surrounded by soft surfaces, such as lawns and ground cover and located near the sound source would of course "absorb much of the external noise long before it reaches a building."[25] Since the maple trees in Gastown are sparely planted, they primarily add visual delight rather than attenuate or effectively mask the undesirable sounds.

> Plants, in addition to controlling sounds, in a sense make their own, and assist the wind in masking some offensive noises. The wind moving through pine needles, the

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[24] Plants/People/and Environmental Quality, Engineering Uses of Plants: Published by the U.S. Department of the Interior, National Park Service, Washington, D.C. in collaboration with the American Society of Landscape Architects Foundation, p. 42.

[25] Kevin Lynch, Site Planning (Cambridge: The MIT Press 1962), p. 80.

> rustle of oak leaves, either on the trees or on the ground, the sound of quaking aspen leaves, all constitute pleasant sounds which lessen the hearer's awareness of offensive noises. 26

Masking undesirable noise in this natural form is of course welcomed by the urban pedestrian.

Wind and Temperature - may also affect the nature of sounds perceived by the human ear in the micro-environment. A comment made by one of the blind subjects during the walk through Gastown pointed this out.

> It's much easier to travel at night when the city is quiet...because you can tell where things are just by the nature of the sound.

A further exploration on the effects of atmospheric conditions in relation to attenuation and propagation of sound, revealed some interesting information. There is usually a wind velocity gradient near the ground. This gradient may vary in height depending on the number of obstructions on the ground such as trees, buildings and ground elevation, relative to its surrounding. In the micro-environment, obstructions such as parked cars, pedestrians and shrubs form the equivalent. Wind velocities are usually greater in the higher altitudes due to the lack of these obstructions and conversely slower at ground level. Thus sound waves travelling up-wind would travel faster near the

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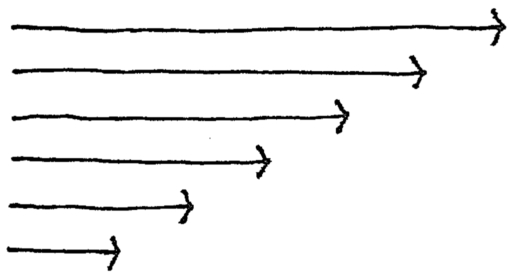
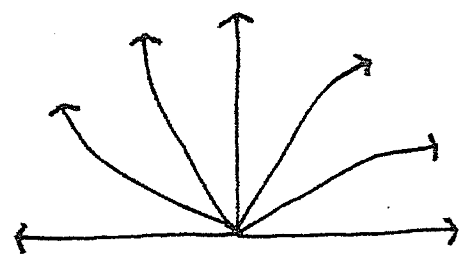
[26] Plants/People/and Environmental Quality, Engineering Uses of Plants: Published by the U.S. Department of the Interior, National Park Service, Washington, D.C. in collaboration with the American Society of Landscape Architects Foundation, p. 49.

ground and at progressively slower velocities as the height above ground increases. This causes sound waves to progressively bend upwards with altitude and therefore "less sound is received at a point up-wind than would be received if no wind were blowing."[27] Conversely more sound would be received down-wind.



wind velocity

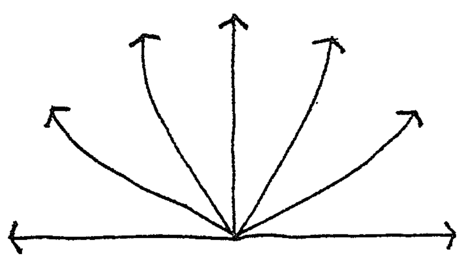


sound direction

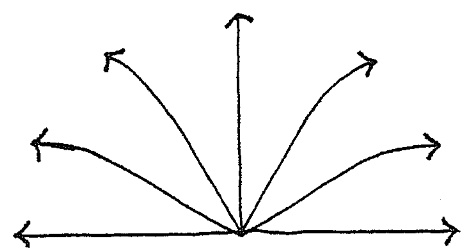
In the case of <u>temperature</u> gradients during the day, the air temperature near the ground is usually greater than that at altitude. In the normal lapse rate the temperature decreases approximately 3°F per 1000 feet of altitude. However in the micro-environment, where the streets are paved and surrounded by buildings the temperature fluctuation due to thermal activity will be marginally greater. The velocity of sound increases with increasing temperature, therefore when the sound waves reach colder temperatures

[27] Anita B. Lawrence, Architectural Acoustics (New York: Elsevier Publishing Company Ltd. 1970), p. 62.

they are bent upward, thus less sound is received than had no gradient existed. The opposite effect takes place at night when a temperature inversion exists. More sound is received at night due to the sound waves being bent downwards because the temperature is colder near the ground than that at altitude.[28]



normal daytime



night temp. inversion

This accounts for the fairly common experience of distant sounds being heard more distinctly at night. Along with the fact that the ambient noise level is lower at night, the blind as well as the sighted can enjoy 'night sound walks' in their environment.

Building Boundaries - should not be strictly thought of as 'visually articulated building envelopes,' enclosing man's specialized activities. The building profile as experienced from the outside has more respon-

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[28] Ibid., p. 63.

sibility than just pleasing the eye alone. It is a participant of the micro-sonic soundscape. Why is it then, that some architectural spaces are more micro-sonically pleasing than others? Judging from the sound level meter study in Gastown and relating it to the reaction of those who participated in the 'Blind Walk' a number of similarities can be associated. In terms of decibel levels and emotional levels of comfort a number of locations were preferred to others. For instance the courtyard in the Garage as experienced by the Blind was more desirable and likable than the constricted 'gap' between the two buildings. The respective comments were received from the blind when in these areas: "It has atmosphere of its own, hasn't it" while in the 'Gap' "Have we got time to do this? I don't like this." When compared with the recorded sound level meter we found that the reading in the Garage courtyard was 58 dBA as compared to 68 dBA in the 'Gap.' This was a 10 dBA level differential. In terms of physiological stress the sound pressure level experienced by the ears of the blind was over twice as loud as that as experienced in the Garage courtyard. The following table will indicate how some changes in sound level affect changes in perceived loudness.[29]

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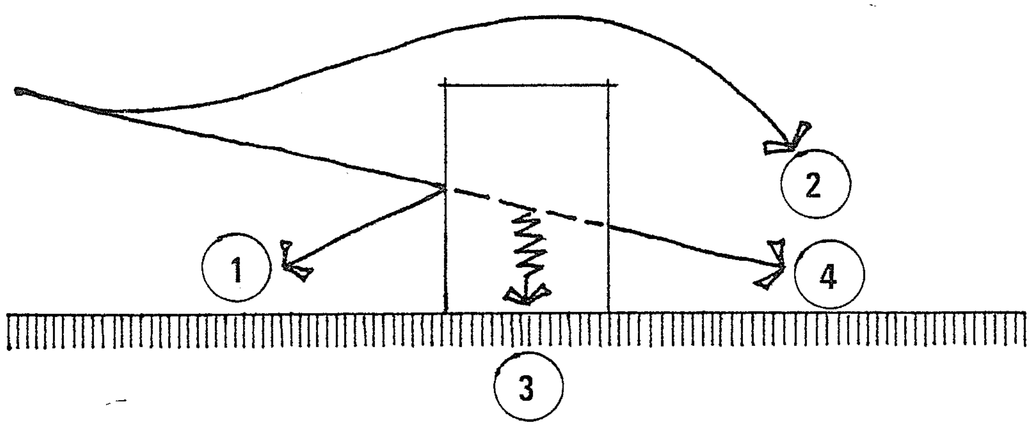
[29]Published by United States Gypsum with the assistance of Bolt and Bernek and Newman, Acoustical Consultants, Sound Control in Design, 1959, p. 15.

Change in Sound Level	Change in Apparent Loudness
3 db	- just perceptible
5 db	- clearly noticeable
10 db	- twice as loud (or ½)
15 db	- big change
20 db	- very much louder (or quieter)

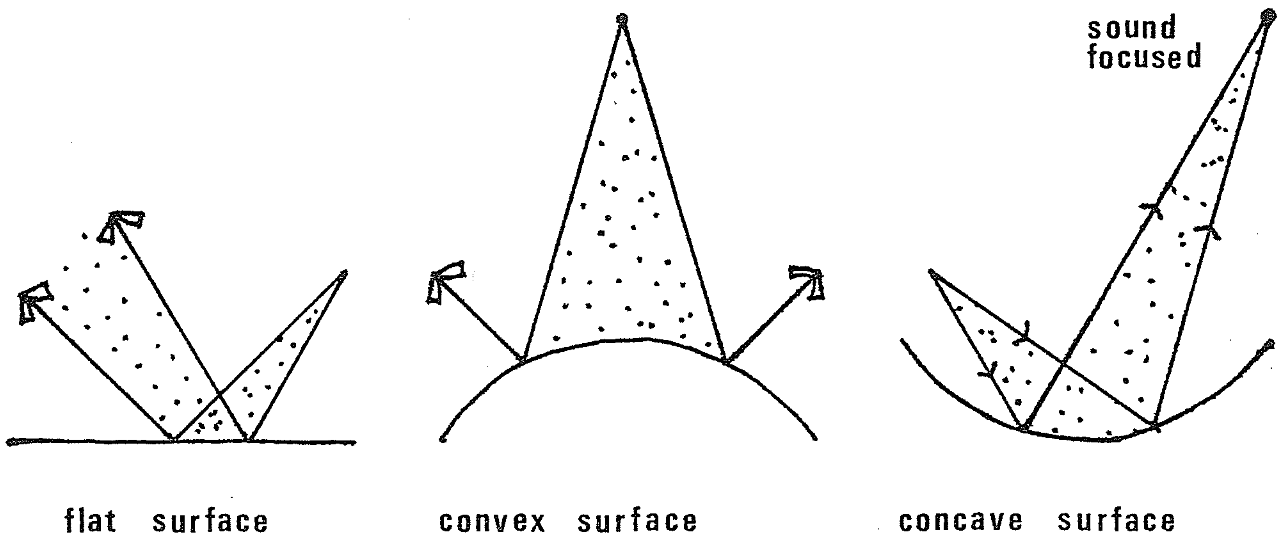
A closer look at how sounds behave in these two areas reveals some interesting architectural implications. Basically when sound waves strike a surface, they are either (1) reflected, (2) diffracted, (3) absorbed, or (4) transmitted.[30]



Reflected sounds have a number of properties depending on the nature of the surface. If the surface is hard and unyielding the sound will bounce away either in the direction of the source or in a direction less offensive to the listener. This usually is associated with the shape of the surface. The following are some diagrams of the gen-

[30] Arthur A. Williams, "Section 5 Sound," The Architects' Journal Information Library, (22 January, 1969), p. 262.

eralized characteristics of sound when it strikes a surface;[31] it must be remembered that these are general, and that they will vary depending on the texture and sound absorption quality.



Reflected sounds are usually experienced as echoes and hollow rumbles--reverberation. Once a sound is emitted, say by an individual, it is immediately heard as a direct sound, from lips to ears, however it can be heard again as distinct from the source. After the sound wave has reached a reflecting surface it is then reflected back to the individual's ear. "Echoes are caused when a strongly reflected sound is received after a time delay long enough to allow the sound to be heard separately from that received by the direct path."[32] If the time delay is more than 70 milliseconds, it will be experienced as an echo. Echoes may be

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[31] Ibid., p. 263.

[32] Ibid., p. 275.

heard in tunnels, in large empty rooms, and anywhere where hard surfaces reflect sound rather than absorb it.

Reverberation must not be confused with echo; it is, however, a form of echo-multiple echoes. That is sound waves persist for a considerable time after the sound source has stopped--until they are absorbed or converted to another form of energy. If the time interval between the direct and repeated sound is "less than approximately 1/7 of a second, a reverberation is produced, not an echo."[33] Reverberation can be reduced but if reduced to too low a level, a "deadness" to sound may occur.

Diffraction may occur according to the following: "when the smallest dimension of a reflecting surface is less than the wavelength of incident sound, sound waves are bent or diffracted around the edges of the surface and there is no significant reflection."[34] Sound may also be diffracted "as it passes through openings when the wavelength of the sound is large in relation to the size of the opening...thus sound is transmitted over the area of the opening and, due to diffraction, the opening acts effectively as a source radiating sound in all directions."[35]

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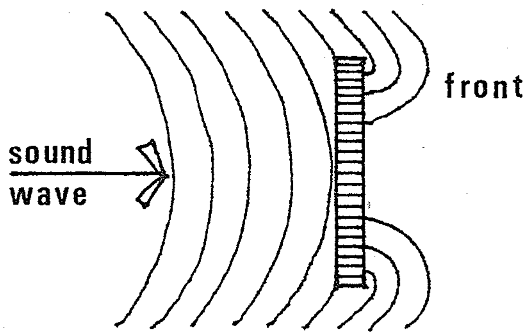
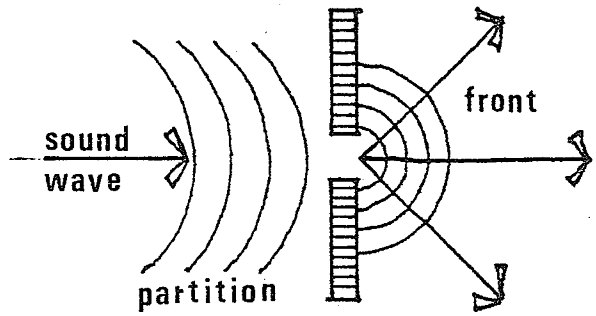
[33] Sven Hesselgren, The Language of Architecture, (Sweden: Studentlitteratur, 1969), p. 144.

[34] Arthur A. Williams, "Section 5 Sound," The Architects' Journal Information Library, (22 January, 1969), p. 264.

[35] Ibid.



wave fronts being bent around an object



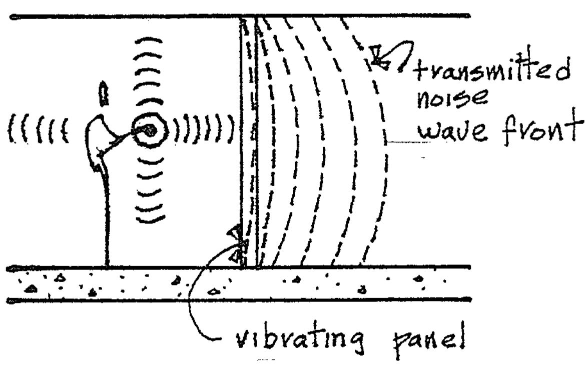
wave fronts being diffracted through a small opening

Objects like human bodies, and porous materials composed of organic or mineral fibers, fabric furnishings, of course absorb more sound than massive, stiff surfaces such as concrete and dense plaster. These porous absorbers are generally more efficient in dissipating sound energy in the high frequency range, however they may be "virtually ineffective if sealed with only one coat of paint."[36]

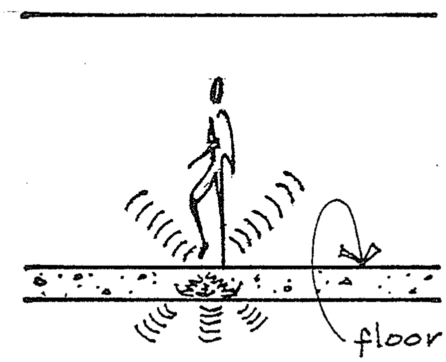
Another important aspect of sound control is that of sound transmission (the reduction of sound energy or intensity of sound, before it is allowed to be transmitted). Sound is usually transmitted in one of two forms: airborne transmission or structural-borne (impact transmission). The airborne sound is usually heard by the human ear, particularly since most of the sound waves generated are in the audible frequency range, while structural-borne sounds are usually felt as a sensation, since the soundwave

[36] Ibid.

causes the structure to vibrate. However, the vibration of the structure also causes airborne sound since the membrane or structure sets up sound waves on the side opposite the source similar to that of a drum.[37]



airborne noise



structural-borne noise

Generally speaking, the best way to prevent airborne sound transmission is by the use of mass. Heavy walls and dense floor structures will improve sound attenuation. There is only one way to prevent structure-borne sounds--by "introducing a discontinuity: if you break the pipe for example. (a plumbing stack) Another way...is to have pads: something that absorbs the impact and in fact avoids the noise altogether."[38] Structure-borne sounds travel generally further, at a higher speed, and are less attenuated than airborne sounds. "For example, in water the speed of sound is about 5000 feet per second, while in

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[37] Ibid., p. 265.

[38] Berry, "Noise in the Environment," A Panel Discussion Approaches to Noise Control, p. 80.

materials such as wood, metal or stone, the speed of sound may be as high as 12,000 to 20,000 feet per second."[39]

Alternative Soundscape:

The diagrams as depicted on the following pages are based on the preceding analysis of the soundscape in Gastown. The alternative soundscape plan is only a suggestion as to the direction soundscape design should take.

> In many situations design of the soundscape alone may be a way of making the city less stressful, but more delightful and informative to its users. Sonic planning would be more economical than massive and costly face-liftings or total redevelopment. Visually dull sections of the city might become vital if a new dimension of sound were overlaid, or a chaotic setting may become more orderly when paired with harmonious rather than raucous sounds .....The addition of new sounds will not increase the perceived noise level of the city in most cases, in fact it may reduce annoyance, if the character of the new sound is carefully designed. [40]

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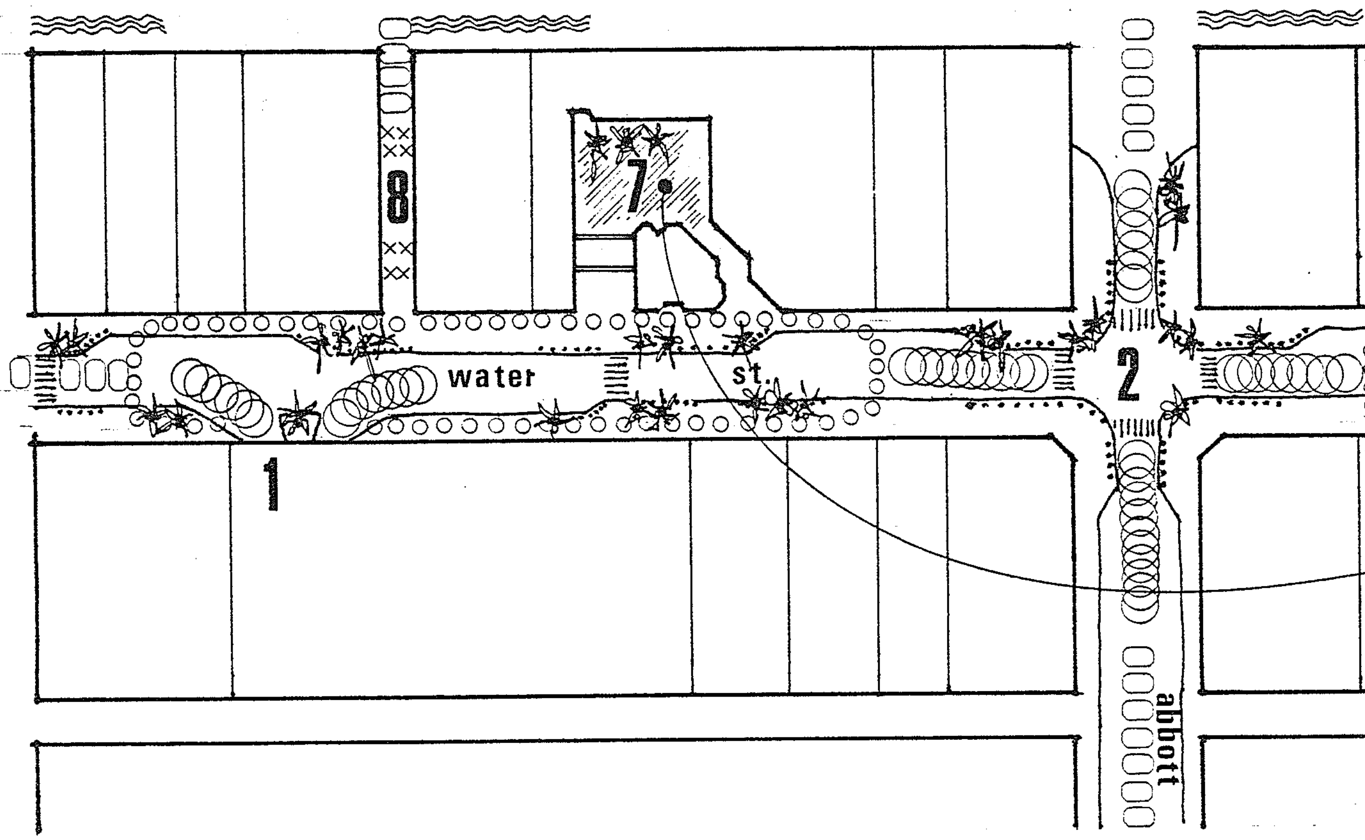
[39] The National Bureau of Standards, A Guide to Airborne, Impact and Structureborne Noise Control in Multifamily Dwellings (Washington: U.S. Department of Housing and Urban Development, 1963), p. iv.

[40] Michael Southworth, "The Sonic Environment of Cities," Environment and Behaviour. Vol. 1, No. 1 (June 1969), p. 67.



actual soundscape:

confusing & uninformative sounds

responsive & informative sound space

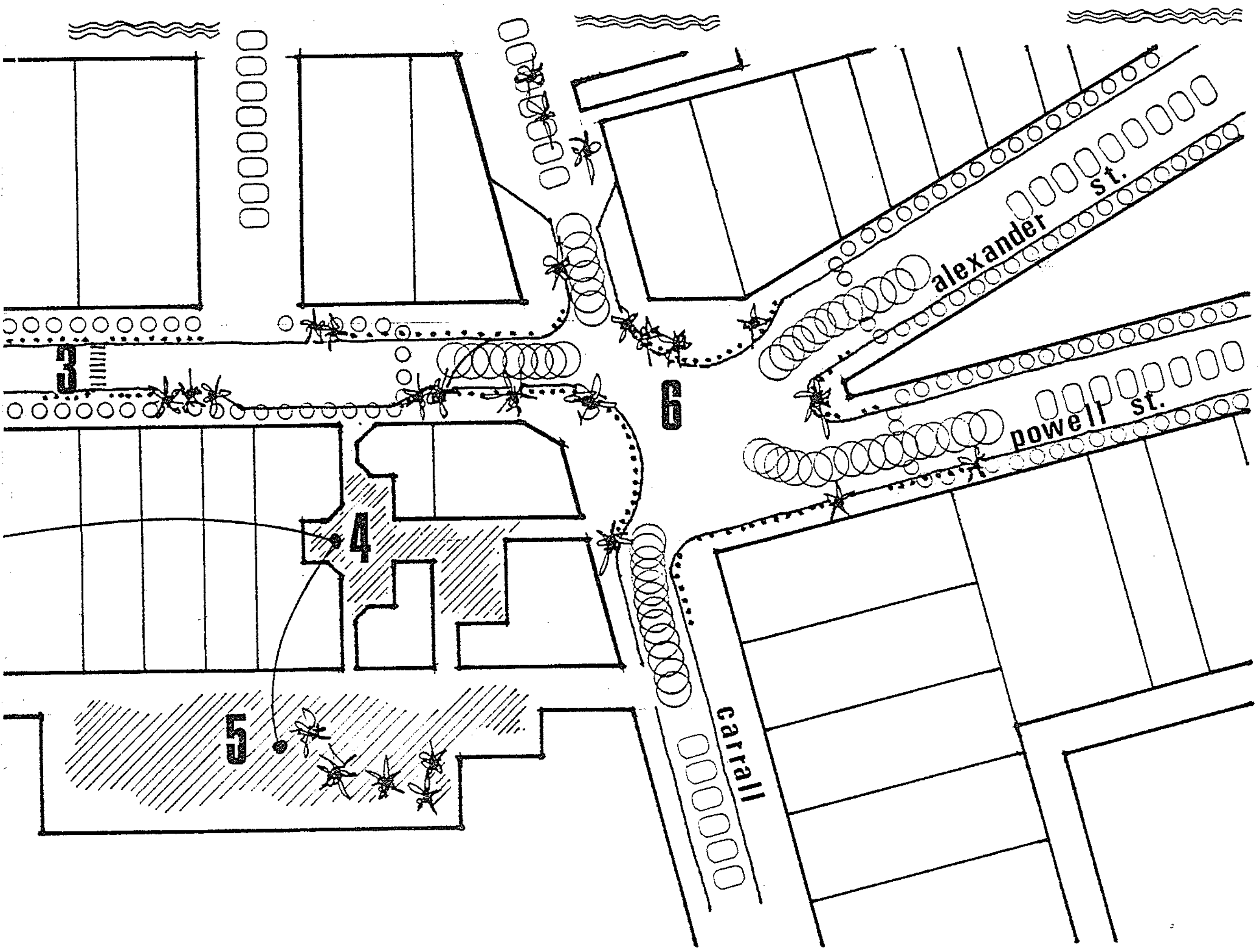
annoying & attention-demanding sounds when vehicular traffic active otherwise quiet and informative

distracting high frequency sounds

ambient sound spill

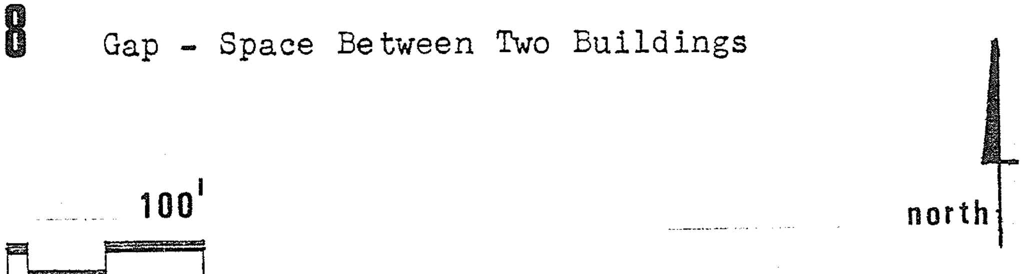
dead sound

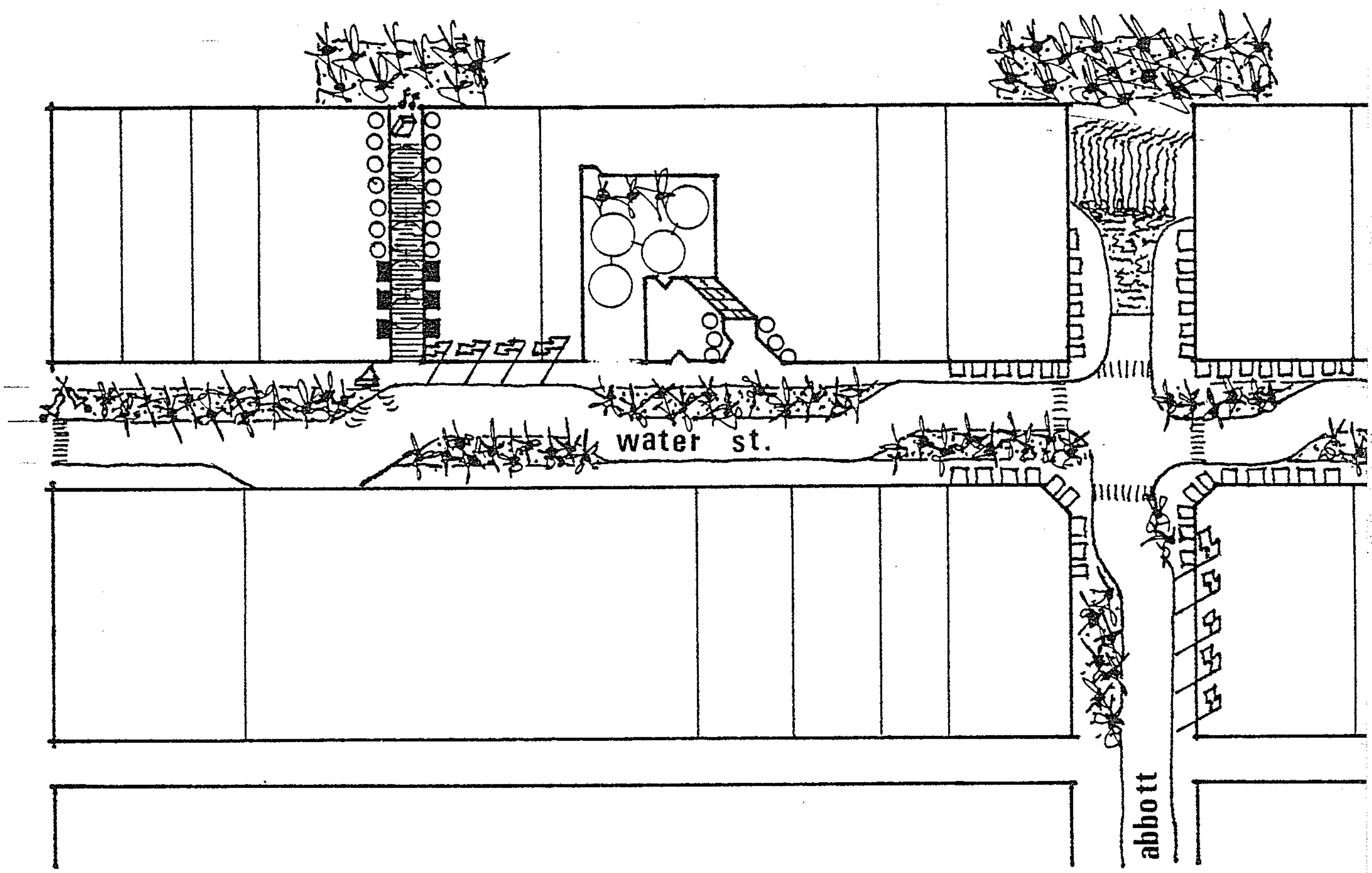
passive micro-sonic involvement



LEGEND

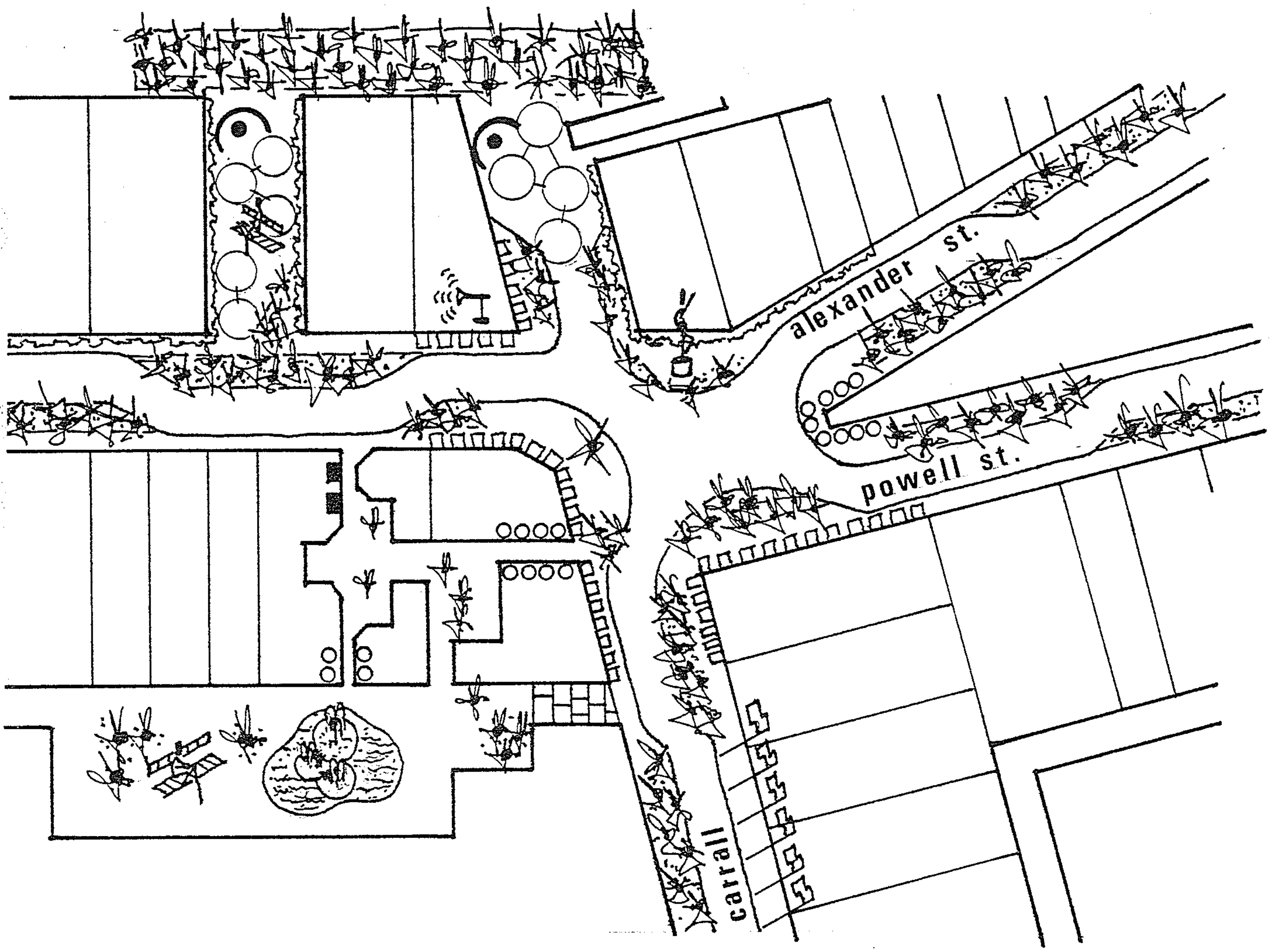
1 Woodwards Parkade
2 Intersection - Abbott & Water Street
3 Mid-Street - Between Abbott & Carrall Street
4 The Garage - Courtyard
5 Blood Alley
6 Maple Tree Square
7 Gaslight Square
8 Gap - Space Between Two Buildings





alternative soundscape:

- hand bells
- sound absorption panels
- wind velocity whistle
- musical sidewalk
- tress and ground barrier
- street waterfall
- water fountain
- reflecting pool
- flags - sound masking
- musical canopy - rain activated



wooden sidewalk

loudspeakers

ivy on building

sound absorbing awnings

music box

sonic sculpture

musical lights - photoelectric cells

acrylic sound deflectors (suspended)

musical bench

street musician kiosk

north

Comparative Analysis:

Comparative Analysis:

This section is intended to characterize personal feelings of sensory comfort in terms of positive and negative evaluation of the sonic environment found in Gastown. As architects, we are so familiar with ordinary sounds that we are not accustomed to being aware of how profoundly they stimulate us.

> We have become so photocentric that we pay no attention to the loud blasts of traffic and machine noise which cause all hearing men to cringe, and which deny the blind the ability to navigate, thus enforcing their blindness as a curse. [1]

Hopefully the results of the following experiments will enable architects to understand and perhaps develop greater levels of sensitivity in designing responsive environments for clients and users. In order to achieve experimental validity, the architectural descriptors used in judgment of personal feelings of auditory sensory comfort will be correlated with the Sound Level Meter study of the previous section. The analysis will be based on two experiments.

1. The Blind, in the actual scene, and
2. The Sighted, viewing color-slides of the actual scene.

By comparing the reactions of the Blind in the actual scene with the reactions of the sighted in a comprehensive simulated scene, architects may in time be more able to comprehend and predict how users perceive and respond to the environment designed for them.

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[1] Howard Broomfield, "A Vision of Blindness" (unpublished works, A manual for playing it by Ear, Simon Fraser University, 1974).

Experiment I - The Blind in the actual scene.

Subjects: Eight adult subjects from the Canadian National Institute for the Blind (CNIB) in Vancouver, British Columbia. The sample consisted of three female subjects and five male subjects ranging in age from 50 to 70 years, with a mean age of 62. All subjects were volunteers who received no financial renumeration for participating in this experiment. All subjects were registered by an ophthalmologist as legally blind. The CNIB defines blindness as the inability to see (even after correction) at twenty feet or less what can be normally seen at two hundred feet. The above subjects were selected on the basis that they had independent mobility both in the internal and external environment. Hence they were not likely to feel restricted in an unfamiliar environment.

Procedure: The eight experimental subjects were divided into two groups of four. The plan was simply to walk along the proposed route in Gastown and have the respondents make personal comments on various auditory qualities based on the underlying dimension of comfortable versus uncomfortable. The subjects were permitted to stop as they wished and encouraged to describe the nature of their sensations within the total sequence of events. At several points during the field trip, disorientation and irritation caused some subjects to hesitate in expressing their natural feelings.

The total field trip took 45 minutes per group.

Eight distinct areas were of interest to the author due to the nature of their soundscape and thus were used as key areas for observations.

1. Woodwards Parkade
2. Intersection - Abbott and Water Street
3. Mid-Street - Between Abbott and Carall Street
4. The Garage - Courtyard
5. Blood Alley
6. Maple Tree Square
7. Gaslight Square
8. Gap - Space between two buildings

In order to provide the subjects with a natural starting point, the course of the field trip started at the Woodwards Parkade. At the end of the field trip the blind subjects were driven home. On the following day, individual blind subjects were requested to record their personal feelings (an expression of auditory comfort) about the actual scene, on a fifty bi-polar, seven-step adjective scale (Refer to figures 3 to 8, pages 81 to 86). Upon consideration of the lists composed by Canter (1968), Kasmar (1970), Hershberger (1969), and Osgood (1971) and in conjunction with research on sensory integration in this thesis, a list of bi-polar descriptors hence was assembled. Such descriptors on adjective scales are commonly referred to by social-psychologists as 'semantic differentials.' It is a preliminary exploration since some of the research results are purely qualitative in nature and therefore can only be regarded as suggestive. In this experiment the Blind subjects were requested to rate the auditory environment of Gastown in terms of two separate experiences:

1. General Public Urban Space, and
2. Enclosed Micro-Spaces/Space focusing on:
   a) The Garage--Courtyard
   b) Blood Alley
   c) Gaslight Square.

<u>Evaluation</u>: The objective of this experiment is to determine whether, in terms of semantic differential, evaluative judgments of auditory comfort correspond or differ significantly to the sound level meter study in the previous chapter. A semantic differential scale utilizing a dynamic sensory equilibrium loading (Refer to chapter on sensory equilibrium page 179) will also be attempted in order to determine whether or not the soundscape environment in Gastown is too stimulating in terms of sensory overload or too dull in terms of sensory deprivation. A graphic analysis of the data therefore is provided. Refer to Figures #3, 4, 5, 6, 7, 8, pages, 81, 82, 83, 84, 85, 86. The above Figures show the statistical mean distribution of data collected from both groups, the blind and the sighted. Results of the analysis characterized in terms of positive and negative evaluation of auditory comfort level of the sonic environment in the General Public Urban Space indicate that our Blind subjects felt this space to be a <u>negative</u> one. Seventy-two per cent of the scales were judged as more negative, that is the Blind subjects judged them to be more fatiguing, distracting, artificial, monumental and public. While only 28% were judged as more pleasant, lively, sensitive and identifiable. When we compare the 'feeling state' of the Blind subjects to the decibel level in this space we notice that the mean decibel level is 68.5 dBA and 78.8 dBC. As noted in the previous chapter, man's optimal conversational level is 60 dBA, hence a significant level of distraction in terms of speech

interference resulted.

When statistical mean judgments of the Enclosed Micro-Spaces were analyzed it was found that the Blind subjects rated these spaces as positive, conducive to their 'feeling state'. This accounted for 73% of the scales being judged as more positive--that is, inviting, sociable, restful, soothing and informative; only 27% were judged as unrhythmic, disruptive, public and as undefined space. The Sound Level Meter study indicated a mean decibel level of 64 dBA and 74 dBC, with the lowest reading being 58 dBA. The decibel level in these spaces are significantly lower than those found in the General Public Urban Space, hence this may account for the change in 'feeling state' by our Blind subjects.

Upon evaluating the results of the dynamic sensory equilibrium scale a statistical mean judgment analysis indicated that 80% of the scales were judged on the basis that the General Public Urban Space exerted a feeling state of sensory overload. On the other hand, 64% of the scales indicated that the Enclosed Micro-Spaces imposed a feeling state of sensory deprivation. Surprisingly the implication of these results suggest that the Blind subjects in our experiment preferred the Enclosed Spaces over the General Space because they were more sonically comforting and less sensory demanding (auditory-sensory deprivation). The General Public Urban Space was found to be more sonically uncomfortable and too sensory demanding (auditory sensory overload).

Experiment II - The Sighted viewing color slides of the actual scene.

Subjects: The experimental subjects were university students drawn from the faculty of Architecture at the University of Manitoba. The sample consisted of 2 female subjects and 5 male subjects ranging in age from 22 to 29 years, and with a mean age of 25. All subjects were volunteers who received no financial renumeration for participating in this experiment. Pre-Master Qualifying students were selected rather than senior students of the faculty on the basis that students entering the architectural program are less likely to be influenced by their professional education.

Procedure: The seven experimental subjects viewed 35 mm color slide projections of the actual scenes of Gastown. Eighty different scenes were used in the study. The selection of slides was based on adequately depicting the variety, composition and quality of the outdoor soundscape environment. The color slide presentation attempted to simulate the same route that was taken by the Blind subjects in the actual scene. The subjects were allowed a viewing time of twenty seconds per slide. As in the previous experiment (Experiment I), the sighted subjects were requested to rate the auditory environment of Gastown as conveyed in the above color slides on the same fifty bipolar adjective scale as used by the blind subjects.

Evaluation: The objective of this experiment is to determine whether in terms of semantic differential, evaluative judgment patterns produced after viewing color slides differ significantly from those of the Blind in the actual scene. In other words, the sighted subjects simulated the auditory soundscape of Gastown in visual terms, that is by viewing color slides. They subsequently recorded the perceived sounds in terms of personal feelings on the semantic differential scale.

Results of the analysis indicated that the Sighted subjects' reaction patterns to the General Public Urban Space differed astonishingly with those of the Blind. 93% of the scales indicated this space to be sonically positive. The Blind subjects judged this space to be 72% negative. The differential between the two evaluations was remarkable. Expressed in opposite magnitude, this is a 177% differential. Refer to Figure 3, 4, page 81, 82. Results of this analysis indicate that the soundscape of Gastown as imagined by the Sighted subjects while viewing color slides is incompatible with the 'feeling state' of the Blind in the actual scene.

When the Enclosed Micro-spaces were analyzed, the response patterns of the Sighted subjects revealed a somewhat similar feeling state across the media. The Sighted subjects judged this space to be 96% positive as opposed to 93% positive by the Blind subjects. The magnitude of the differences however, tended to be judged as more positive by the Sighted subjects. This was somewhat of a surprise to the author since the reaction patterns of the

Sighted to the General space varied quite differently from the blind in the actual scene. It seems that the Sighted subjects in this experiment are more capable of imagining the soundscape to Enclosed Micro-spaces than they are to General Public Urban spaces.

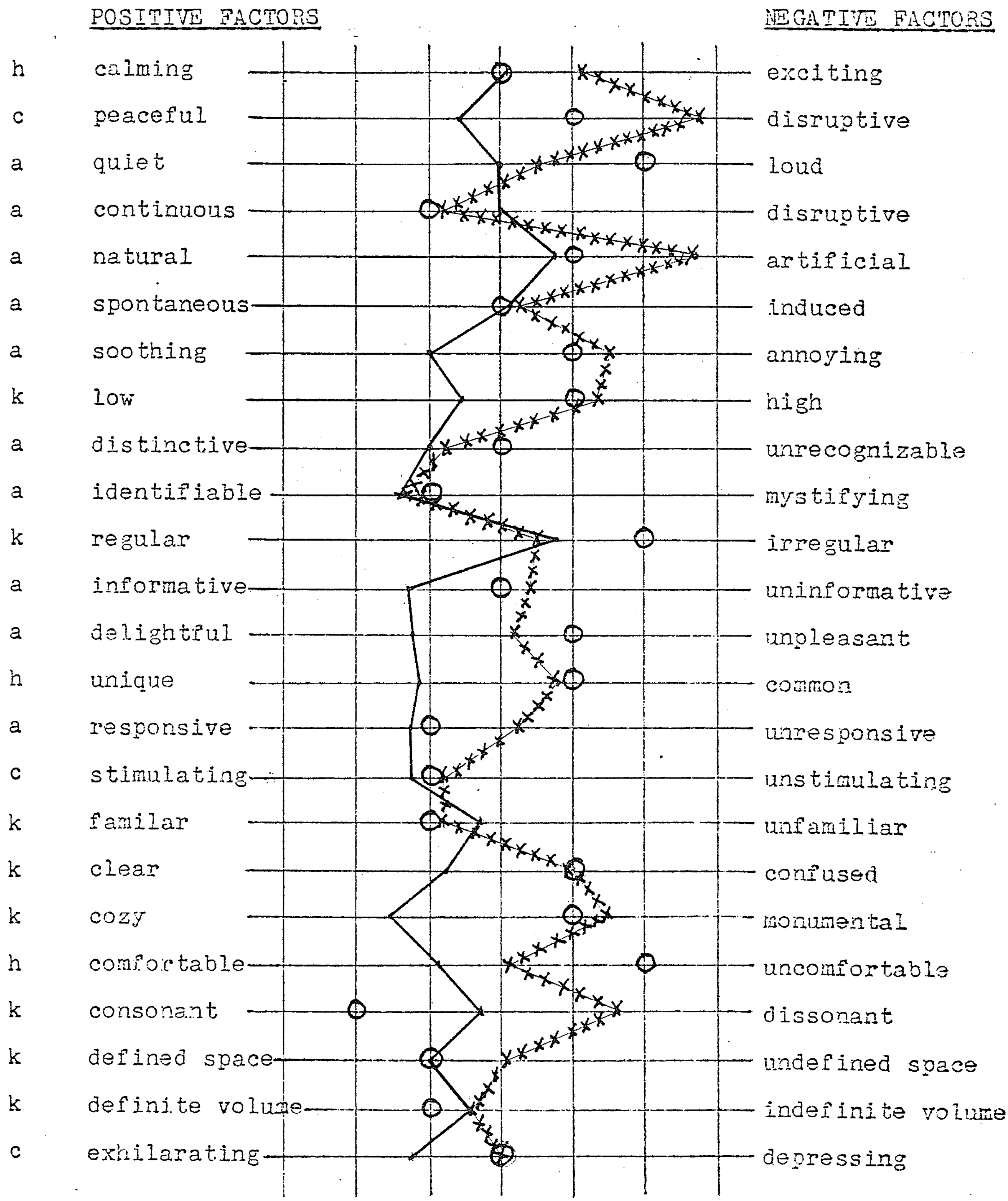
Reaction patterns in terms of the dynamic sensory equilibrium scale indicated that the Sighted subjects felt the General Public Urban Space to be sensory overloading, yet they found this space to be positive despite of the high decibel reading. The sensory overload mean judgment was 73%, even though it behaved erratically across the media. When the Enclosed Micro-Spaces were analyzed, the Sighted subjects' reaction patterns indicated a mean judgment of 55% in favor of sensory overload. Once again this judgment was incompatible with the feeling state of the Blind subjects in the actual scene. The Blind subjects judged these spaces to be sensory depriving, accounting for a mean judgment of 64%.

Overall, the comparative analysis indicated that both groups were consistent in their judgments of the soundscape in Gastown. The Blind subjects consistently evaluated the spaces as negative and sensory overloading or positive and sensory depriving. The Sighted subjects consistently evaluated the spaces as only positive and sensory overloading. The Sighted subjects were exposed to a visual facsimile of the actual scene (color slides-auditory deprivation). Their reaction patterns in terms of perceiving the actual soundscape consistently varied from that of the Blind subjects. Perhaps not surprisingly, because the designed environment is contemplated in visual terms and repeatedly conceived in isolation. The inability of the Sighted subjects to prognosticate the actual soundscape environment in Gastown further supports the above probability. The glorification of the visual environment must be elevated in parity with that of the other sensory modalities. Perhaps sensory equality in the designed environment is too vigorous a concept to command. As designers and architects, however, we must not demean the influence of these sensory modalities, for the experiential reality will not conceal this insentience.

On the following pages, a graphic analysis of the data is presented. The bi-polar descriptors assembled are from lists composed by Canter, Kasmar, Hershberger, Osgood and the author, and are designated as such:

c = Canter
k = Kasmar
h = Hershberger
o = Osgood
a = Author

RATING THE AUDITORY SENSORY ENVIRONMENT: 'General Public Urban Space



Blind Subjects xxxxx Sighted Subjects _____ Author ooooo

Fig.# 3 Statistical Mean Distribution
(Bi-polar Adjective Scale)

General Public Urban Space

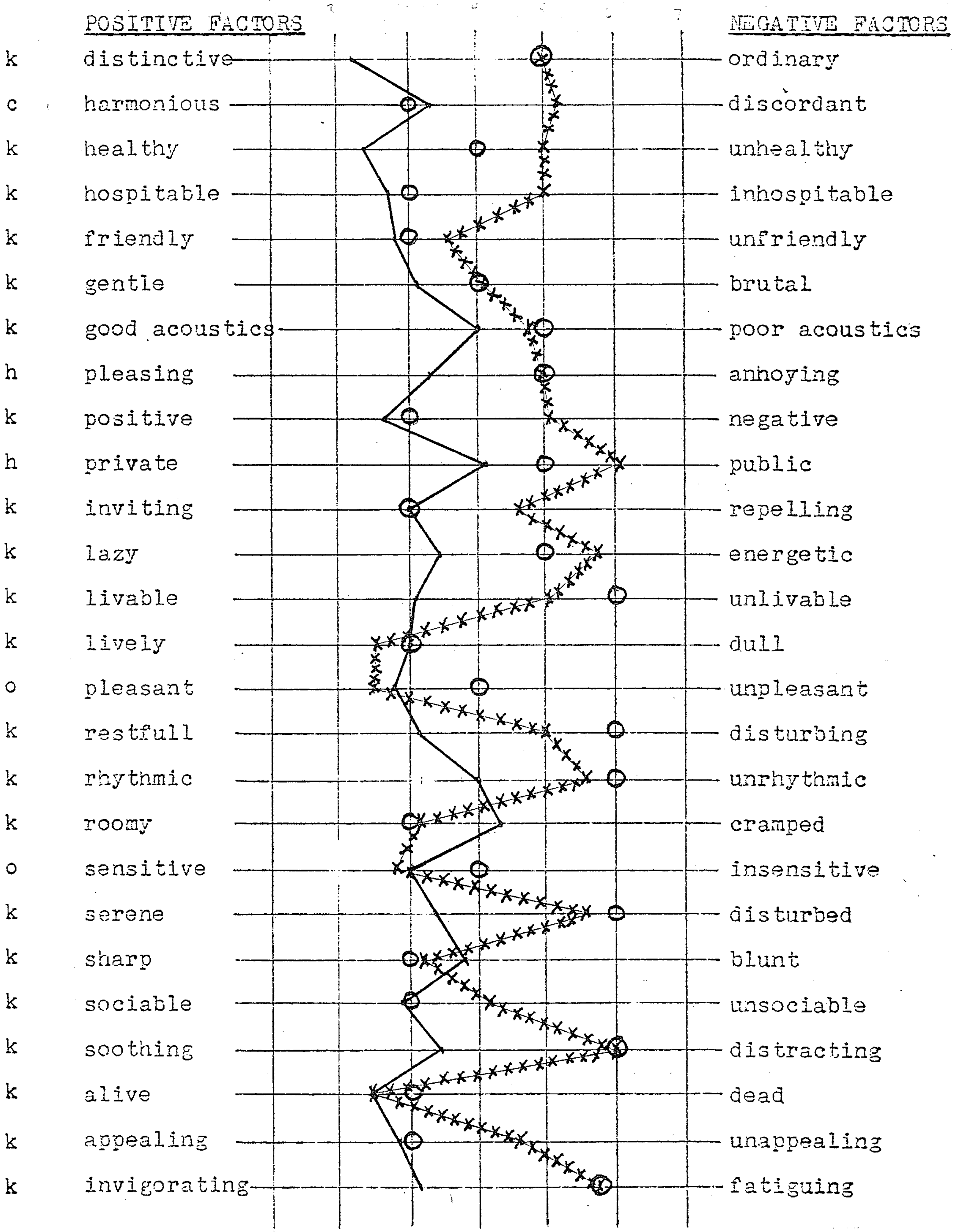


Fig. #4 Bi-polar Adjective Scale.

DYNAMIC SENSORY EQUILIBRIUM

'General Public Urban Space'

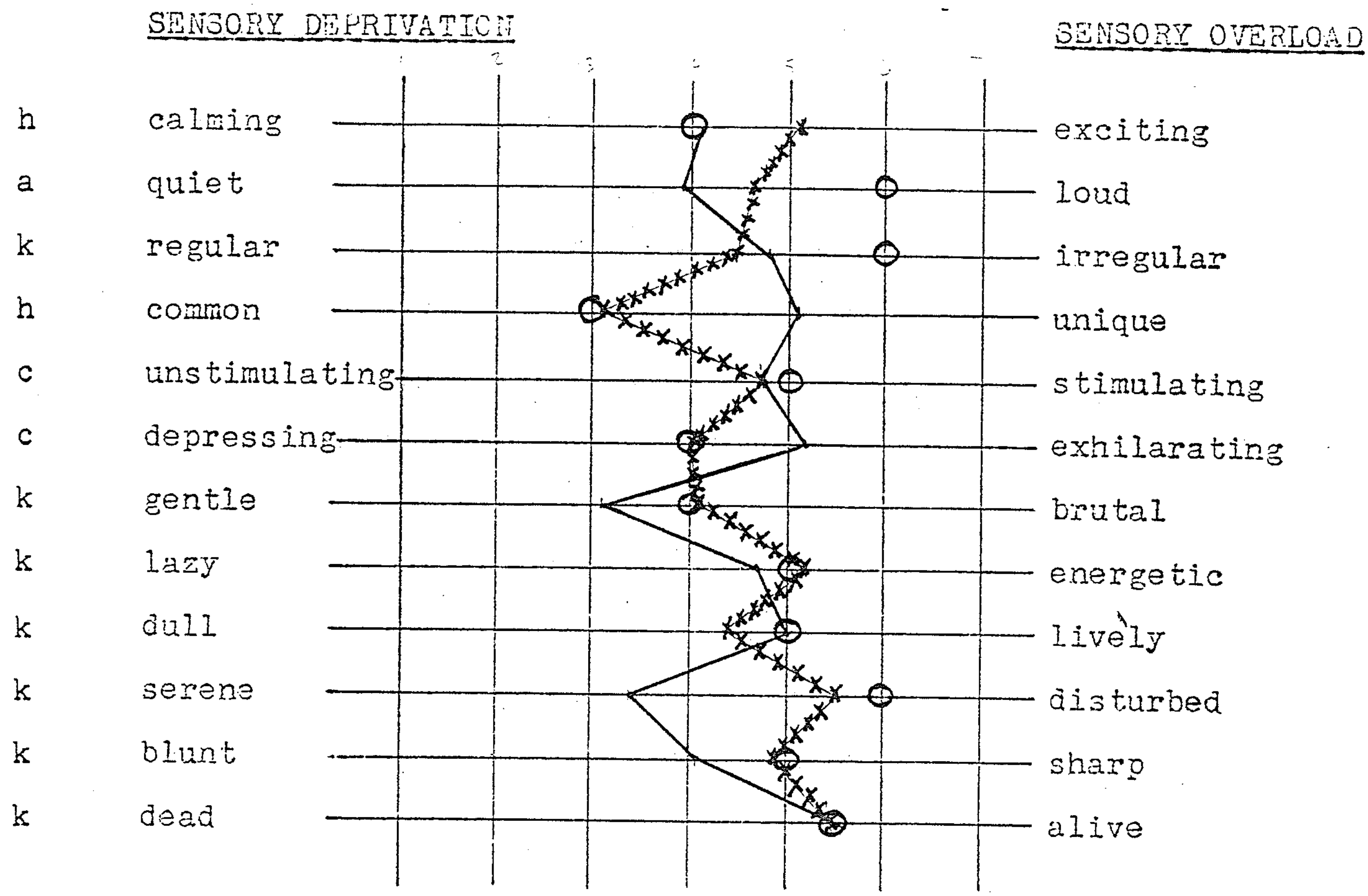
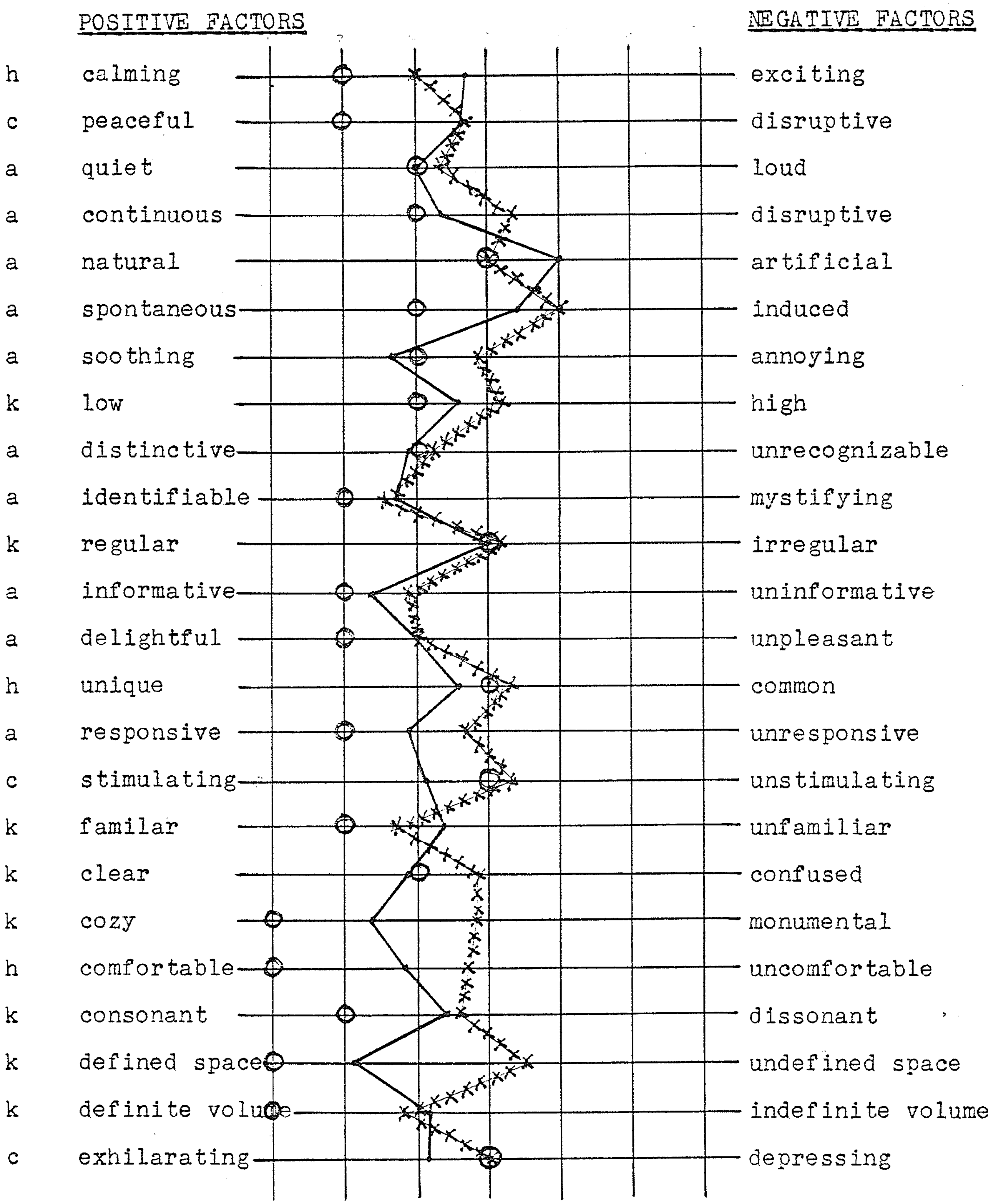


Fig. #5 Bi-polar Adjective Scale

RATING THE AUDITORY SENSORY ENVIRONMENT:'Enclosed Space'



Blind Subjects xxxxx   Sighted Subjects ______   Author oooo

Fig.#6 Statistical Mean Distribution

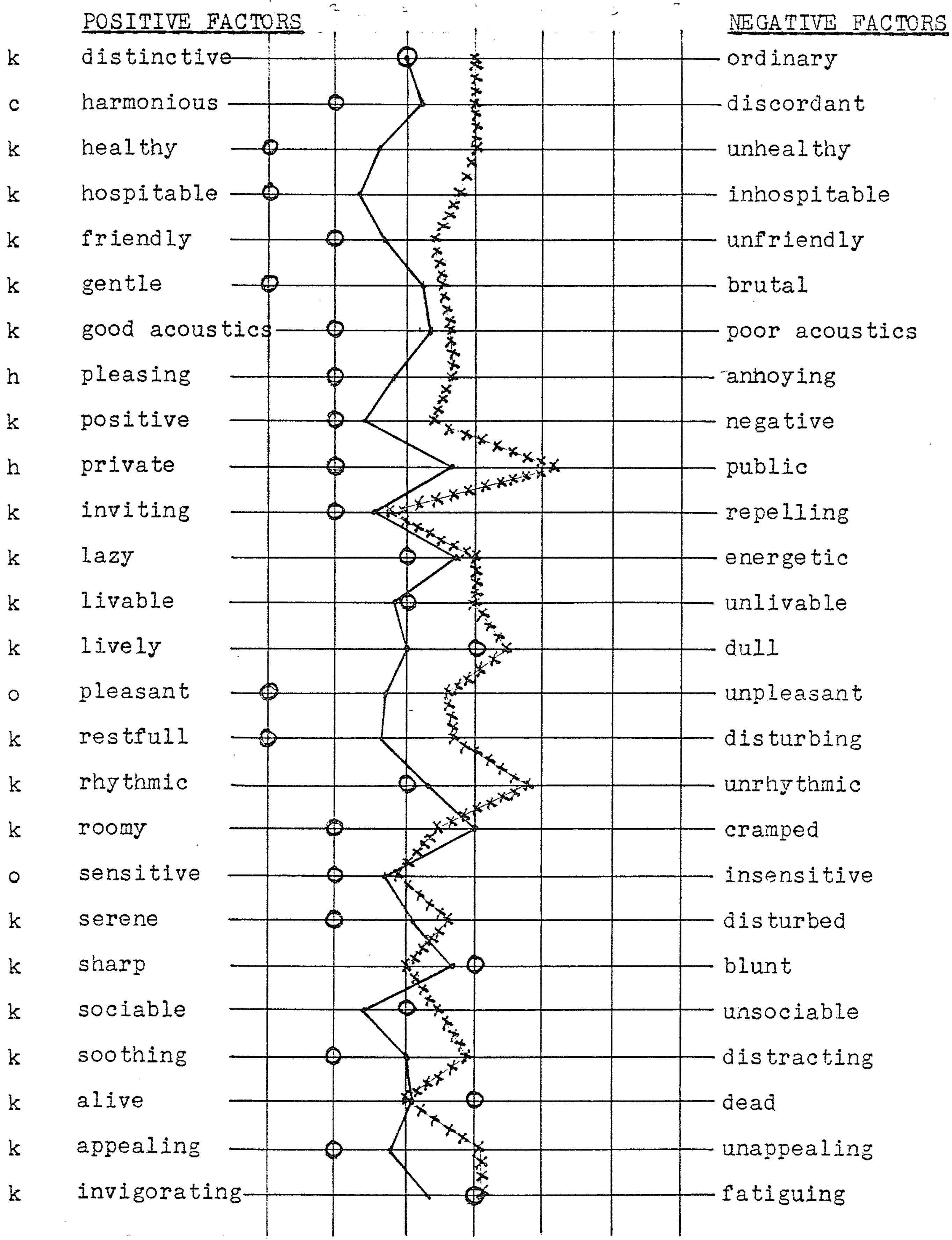


Fig. #7 Bi-polar Adjective Scale

DYNAMIC SENSORY EQUILIBRIUM

'Enclosed Micro-Spaces'

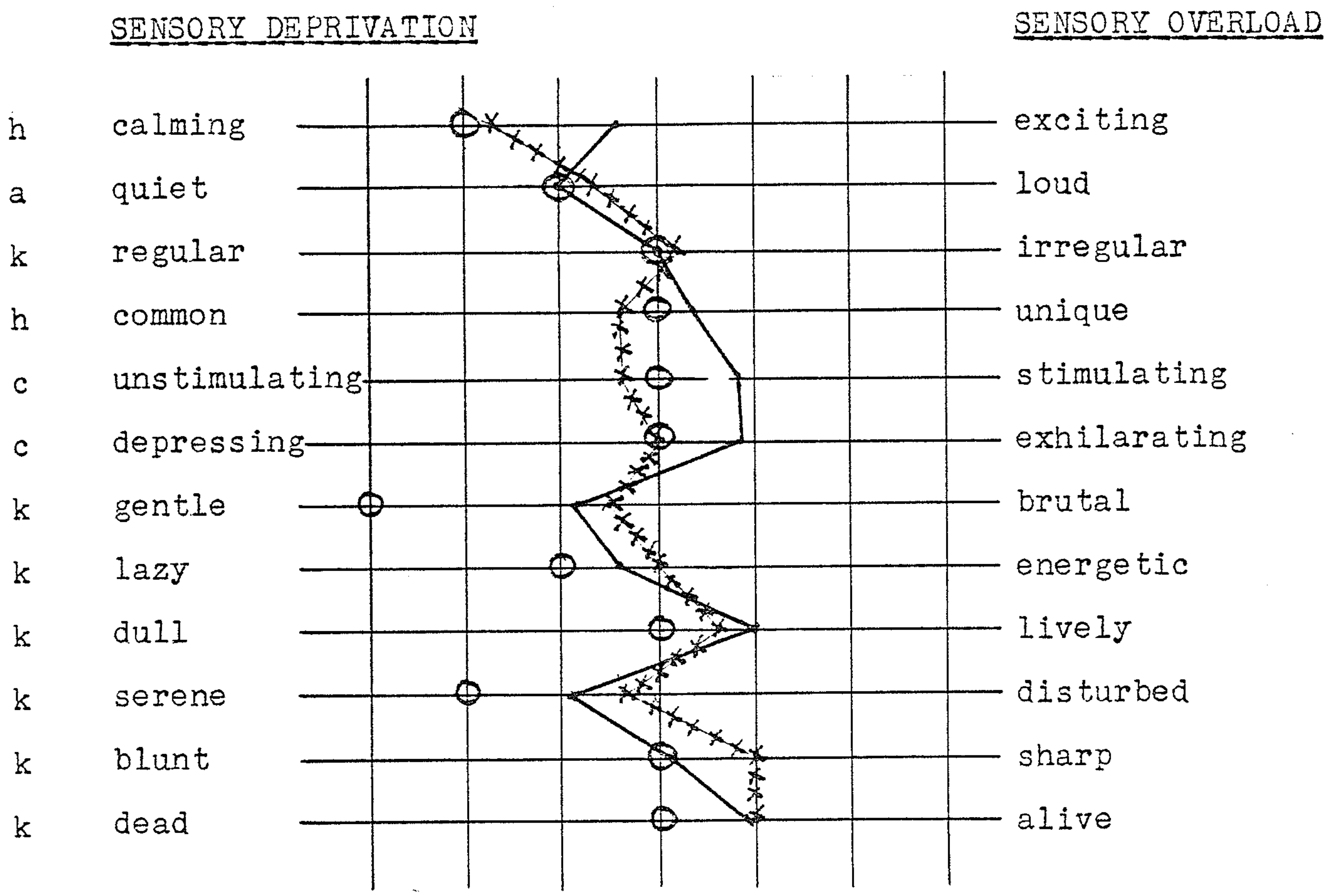


Fig. #8 Bi-polar Adjective Scale

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PART II

SUPPORTING MATERIAL

INTERSENSORY INTEGRATION

WITH

THE URBAN ENVIRONMENT

The primary focus of Part II deals with the re-examination of man's sensory modalities in terms of Intersensory Integration with the Urban Environment. To generate the requisite understanding of this sensory integration we will firstly examine the sensory modalities in isolation, particularly with reference to physiological tolerances, then attempt to balance these together in order to achieve a state of Dynamic Sensory Equilibrium. Visual architecture conceived as an isolate can never be experienced as intended. Design must employ complementary sensory modalities to be truly successful. One of the goals of the architect should therefore be to strive towards designing an architectural environment within the spectrum of Dynamic Sensory Equilibrium.

Auditory Sense:

Auditory Sense:

As a point of departure from "pure architecture" (that which pleases primarily the visual sense) we must first establish some basic knowledge of the primary auditory mechanism, the ear.

> The modern architect is designing for the deaf. His ears are stuffed with bacon. Until they can be unplugged with Ear cleaning exercises, modern architecture may be expected to continue its same rotten course. The only subjects which architecture schools have bothered to teach their students have been isolation, absorption and sound reduction. [1]

By carefully studying the auditory sense within the realm of architecture, architects may become more sensitive and objective when designing environments which will inevitably elicit human reactions.

The audiologist who is mainly concerned with the psychophysiology and psychoacoustics of hearing can contribute some insight into the fundamental knowledge of the hearing mechanism. Hearing is one of man's major sensory modalities. Sensory modalities are those parts of the body which serve as receivers of stimulation from outside the body. They are called sensory receptors. These sensory receptors are considered as end-organs. The ear in this case is the end-organ for hearing. Similarly then are the eyes, nose, and hands respectively for vision,

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[1] Murry Schafer, "The Tuning of the World" (unpublished works: as part of the World Soundscape Project, Simon Fraser University, 1975), p. 360.

smell and touch. Stimuli in the environment activate the end-organ where by it is converted into nerve impulses. These nerve impulses are transmitted to the brain where they are then interpreted and hence transformed into a meaningful experience.

For purposes of clarity, the human ear can be divided into three parts: the outer ear, the middle ear, and the inner ear. The outer ear or the external ear consists of two Parts: the pinna and the auditory canal. Some forms of animal life, such as the dog, can move their pinnas and focus them toward the source of sound and thereby hear better.[2] Humans must turn their heads around in order to catch environmental sounds more effectively because they cannot move their pinnas. The middle ear is the conductive mechanism, since its function is to conduct the sound vibrations to the inner ear. Since the vibratory type of energy cannot be transmitted via the nervous system it must be converted into another form. The cochlea is the vital organ in the chain of structures comprising the hearing mechanism. It is the movement of cilia on the cochlea which constitutes the specific conversion of vibratory energy into nerve impulses. These nerve impulses now reach the brain by way of the eighth nerve.[3] This pro-

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[2] Helmer Myklebust, The Psychology of Deafness (New York: Grune and Stratton, Inc. 1971), p. 13.

[3] Dr. V. Magian, Lecturer, Department of Otolarynology, Faculty of Medicine, The University of Manitoba, Noise and Hearing Conference. Feb. 15, 1975.

cess is not yet fully understood by otolaryngologists, and audiologists but much has been learned about it in recent years through the contributions of scientists such as Stevens, Davis, Wever, and Bekesy. Ronchi (1957) hence views sound as a subjective phenomenon:[4]

> ....Outside the mind there are vibrations. These, however, are not sound or noise, but a silent motion. Only when these vibrations have been received by an ear, transformed into nerve impulses and carried to the brain and mind, only then, internally is the sound created that corresponds to the external vibrations, and it is created to represent this stimulus as it reached the mind.

Sound is a constant life companion. Our human organism repeatedly emits sound through the larynx, diaphragm, nasal passage, oral cavity and so on. We are bombarded by the sounds of others around us, and by the sounds of the world of objects. We cannot close our ears as we can our eyes. We are vulnerable to sounds other than those created by nature. The sound of birds, the sigh of wind in the trees or tall grass, the pelting of rain against leaves, the whirring of a rattlesnake, even the roll of thunder is not physiologically stressful, for these sounds fall within the natural threshold of the hearing mechanism. Man-made pollution of the sonic environment constitutes a real and rising threat: radios, televisions, vacuum cleaners, power lawn mowers, air

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[4] Ray H. Barsch, Achieving Perceptual-Motor Efficiency (Washington: Special Child Publications, 1968), p. 235.

conditioners, office machines, jet aircraft and the cacophony of industrial plants.

The auditory mechanism is confronted with the immense complexity of the sound world. The human organism must be able to scan the physical space and identify and evaluate the direction and distance of the sound source. By the localizing process we become aware of the space of sound, assigning it to some position relative to ourself. We then build a perception of the auditory world as a dimension of our cognitive space. This is the region of symbols, thoughts, ideas and conceptualizations. It is this domain in which personal image, ego, self-realization, self-actualization and self-concept are formed, as studied by Ames, Ittelson, Titchener, Hebb, Gardner and Piaget.[5] In the realm of man's survival, audition functions in two ways; it acts as a warning system, and as a scanning system. It alerts the organism to possible danger, records changes in the acoustic environment and scans for sound which may have meaningful messages to its own value system. Audition also activates the visual mode to inspect the auditory reflex for detail of its relevance, be it an imminent threat to survival. Spatial orientation is another important facet of audition, since it is regarded as a distance sense spanning the six fields of space and noting the four zones

[5] Ibid., p. 72.

[6] Ibid., p. 73.

The six fields of space are:
(Based on Harmon and Getman, the coordinate system of the organism. The fields of space are geometric and based upon the concept of ordinates.)

1. Right space
2. Left space
3. Front space
4. Back space
5. Up space
6. Down space

The four zones of space from an ontogenetic viewpoint are:[7]
(The "inbetweeness" of two points act as a constant variant in the human being of no fixed position in space.)

1. Near space zone - distance of reach
2. Mid space zone - two to 16 feet in all directions
3. Far space zone - 17 to 30 feet
4. Remote space zone - 30 feet to infinity

Some similarity in distance can be seen in comparing E.T. Hall's studies of social distance to the ontogenetic four zones of space. Both studies associate a sensory experience of distance from space immediately outside themselves. From an auditory communication viewpoint we observe that different voice levels are employed at various distances.

Table I

Social Distances (from Hall, 1966)[8]

1. Intimate distance. close phase--up to 6 in. far phase--6 in. to 18 in.	audible whisper intimate utterance

[7] *Ibid.*, p. 75.

[8] Geoffrey Broadbent, *Design in Architecture* (New York: John Wiley & Sons 1973), p. 162.

2.	Personal distance close phase--18 in. to 30 in. far phase--$2\frac{1}{2}$ ft. to 4 ft.	moderate voice personal involvement
3.	Social distance close phase--4 ft. to 7 ft. far phase--7 ft. to 12 ft.	impersonal business formal business
4.	Public distance close phase--12 ft. to 25 ft. far phase--25 ft. and over	loud voice planned formal discourse public utterance political expression

A brief reference should be made to the subject of auditory masking, since it is often indiscriminantly used in architectural environments. If it is too attention-demanding, it influences our ability to concentrate. Two or more different auditory perceptions can be experienced simultaneously, due to the mind's ability to control foreground and background sounds. Even though the sounds around us may enter our hearing mechanism we cannot manage to hear every sound. We must learn to differentiate and localize the source and direction of foregound and background sound, speech or noise in the auditory space. A person speaking to another at a cocktail party, no matter how engrossed he may be, can suppress his auditory exchange and immediately shift to a background social interest. As his world of demand may dictate his auditory organism must acquire a flexibility of moving from one to another. This complex facet of auditory behavior tends to be possible only if both ears and both hemispheres of the brain are functioning simultaneously.[9]

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[9] Sven Hesselgren, The Language of Architecture (Sweden: Studentlitteratur, 1969), p. 142.

The significance of auditory masking may be made clearer by differentiating between hearing and listening. Hearing may be designated as a physical procedure whereby sound waves are transmitted to the ear and activate the hearing mechanism. Listening is the percepto-cognitive function of converting raw sound into a symbolically meaningful information. Warren Brodey, a psychiatrist who has been working with the blind, confirms this by stating:[10]

> A blind man is familiar with the echo of his footsteps as they rebound from the boundaries of his room from walls and draperies, from rug and ceiling. He knows where an obstacle has interfered with this rebound. He knows the room where higher frequencies resonate and breath sounds seems more rasping. The sound of your breathing is one way the blind man knows you and where you are in relation to the objects of the room. He listens to hear sound as it is altered by the response of the physical environment.

It is the perceiving mechanism that determines the amount of data necessary for a meaning to occur. The blind, being visually handicapped, tend to be auditory efficient perceivers for they can process less data into more meaningful patterns; conversely inefficient perceivers require more data.

The average young human's hearing range extends roughly from 16 to 20,000 cycles per second (cps)* and on the decibel scale from zero to 120 db's. Refer to Figure #9, page 96, and Figure #10, page .

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[10] Warren Brodey M.D., "Sound and Space", <u>AIA Journal</u>, (July, 1964), p. 58.

*The term Herz, designated by Hz, has been adopted in place of cycles per second. For example 16 Hz is used

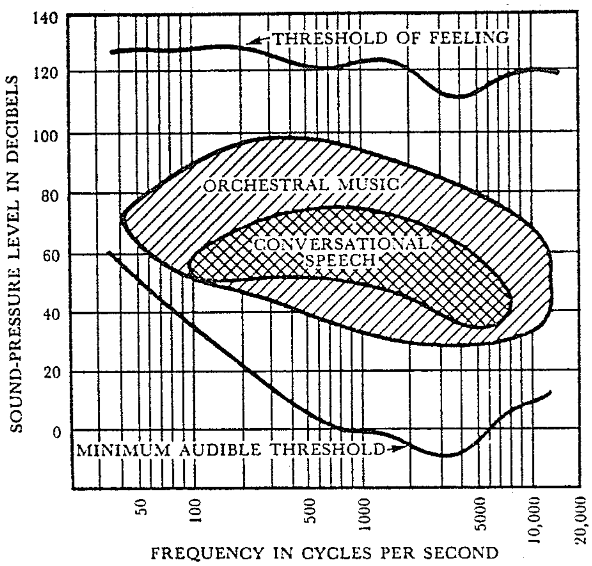

Figure 9, Human's Hearing Range[10a]

The upper frequency limit for a normal adult is approximately 12,000 to 15,000 cycles per second. The threshold of a whisper being at a range of 20 to 30 decibels and the threshold of discomfort and pain being at the top of the scale of 120 decibels. Sound waves which are below 20 Hz are experienced as vibrations and are called infrasonic; sound waves above 20,000 Hz which are inaudible are called ultrasonic.

[10a]Sven Hesselgren, The Language of Architecture (Sweden: Studentlitteratur, 1969), p. 102.

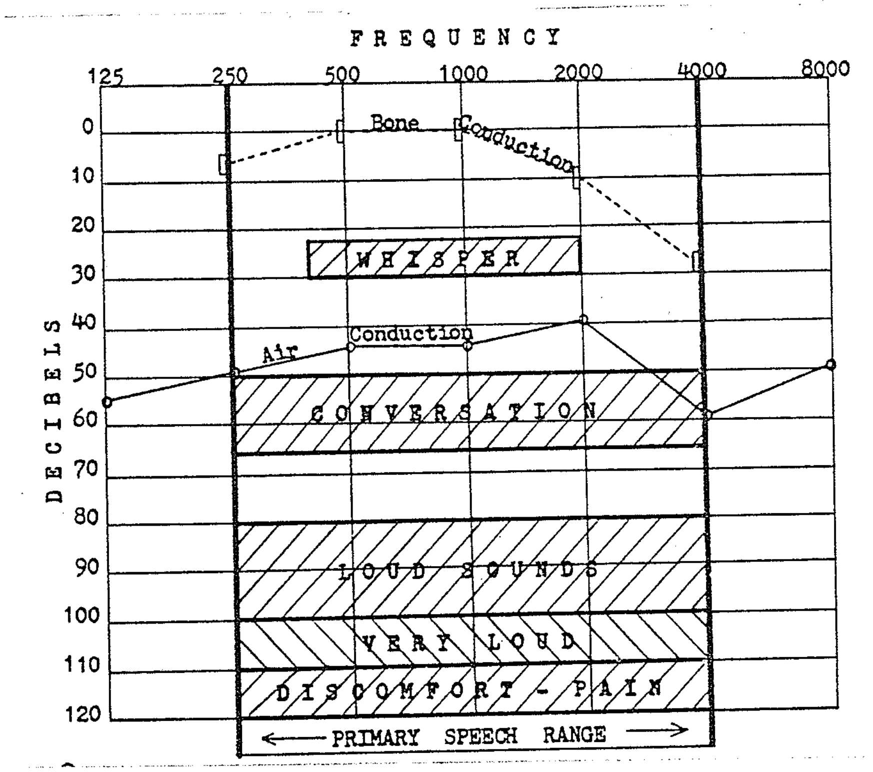

Figure 10, Audiogram showing hearing test results for bone and air conduction, speech range and sound levels. 10b

In terms of the absolute threshold, the human ear is most sensitive within the range of 250 - 4,000 Hz. According to calculations made by Sivian and White (1933), if the most sensitive human ear were about 5 decibels more sensitive than it is, then the thermal agitation of the air molecules would be heard as noise.[11]

[10b] Helmer Myklebust, The Psychology of Deafness (New York: Grune and Stratton, Inc. 1971), p. 23.

[11] Roland Harper, Human Senses in Action (London: Longman Group Ltd. 1972), p. 171.

Also if a person were sensitive to a pitch lower than 16 Hz he would suffer from the annoyance of hearing his own heartbeat. The human ear appears to be most sensitive to sound at a pitch corresponding to a child's or woman's cry since "the auditory receptors are tuned to frequencies that have adaptive significance for the species."[12]

A closer analysis of the speech range (the band of frequencies found in the spoken word) reveals that they extend from 250 to 400 Hz. Vowel sounds are found in the low frequency band, 500 Hz. and consonants in the high frequency band, 3000 Hz., however the majority of the speech sounds fall in the 500 to 2000 Hz. frequency.[13]

Studies on the maturation of the auditory processes conducted by Carmichael, Froeschels and Wedenberg reveal that auditory development of a child begins as early as the fetal stage. Although the auditory mechanism is fully developed at the time of birth, the infant's capacity to respond to sound seems to be limited to reflex or to startle reactions. As the infant develops after birth, changes in the auditory capacity differ in several respects. Piaget demonstrates that after the second month the infant first acquires auditory responses, he attends

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[12]Rene Dubos, <u>So Human an Animal</u> (New York: Charles Scribner's Sons, 1968), p. 125.

[13]Helmer Myklebust, <u>The Psychology of Deafness</u> (New York: Grune and Stratton, Inc. 1971), p. 25.

to voices and gives evidence of listening behavior. By the third month the infant begins to turn its head in the direction of sound, a scanning behavior that shows evidence that sight and hearing is becoming coordinated. As the child matures, voluntary behavior rather than reflex or startle movements become of more significance to him, since listening behavior is acquired by learning and maturation. Spenser, after investigating the maturation of auditory perception in normal children age two to six, revealed that hearing, like vision has a number of dimensions psychologically. Not all dimensions have been studied, however it was apparent that factors such as "rhythm, auditory memory span and auditory discrimination are directly dependent on maturation."[14] The age of full maturity has not been determined yet, but by comparison some visual processes such as stereoscopic vision are known not to mature until approximately eight years of age. Studies by Spencer, Myklebust and Birch and Mathews suggest that full auditory maturity does not occur until approximately seven years of age and that auditory memory span continues to mature well beyond this age. Since blind people use the auditory sense as a lead sense they tend to depend on auditory memory far more than the sighted.

> Blind people tell in vivid detail how some rooms have a kind of sound that is exciting and yet not too sharp;

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[14] _Ibid._, p. 19.

> while other rooms have a sound that is soothing and yet not dull. I am aware that they measure sound in a way I have not learned. They talk of and remember the sound in a room as if they were talking of color. [15]

To be able to understand the dimensions of the listening process it is to our benefit to view the works of two men who have exemplified perceptive cognitive theories in the efficiency of listening and learning. Fessenden presents seven levels of listening:[16]

- Isolating the auditory stimuli
- Identifying the auditory stimuli
- Integrating the auditory stimuli with what was experienced in the past
- Inspecting the auditory stimulus
- Interpretation
- Interpolation
- Introspection

Brown described five basic skills required for efficient learnings:[17]

- Discover the central idea of what was heard and synthesize it into component parts.
- Distinguish relevant from irrelevant material.
- Make logical inference of what was heard.
- Make use of contextual clues.
- Follow without confusion a fairly complex thought unit.

Studies made by Rankin reveal that approximately 70% of an adult's waking day is spent in verbal communica-

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[15]Warren Brodey M.D., "Sound and Space," AIA Journal, (July, 1964), p. 60.

[16]Ray H. Barsch, Achieving Perceptual-Motor Efficiency (Washington: Special Child Publications, 1968), p. 243.

[17]Ibid.

tion. According to Nichols, 40% of the white collar collar workers receive their salary for listening. Studies conducted by Brown, on college freshmen revealed however that only 40% of what was heard was comprehended.[18] The development of good listening skills is vitally important to all people particularly architects, for it is primarily through this process that architects communicate to prospective clients, investors, contractors, realtors, engineers, economists, etcetera. Rarely is the architect's client or environmental user able to express his feelings in graphical terms. The auditory sense hence must serve as that communication vehicle, since people appreciate or feel architecture through their own senses. As architects we must learn to listen, then we must analyze, for the user knows what he wants.[19]

> People want architecture which is warm and comforting to the senses, architecture which is pleasant to live with, which caters for man as he is and not for man as an abstraction, architecture which is seen to be appropriate to its purpose, bearing in mind the habitual attitudes and responses of people who have been brought up in a living society, not processed in a laboratory. The supreme fallacy of modern architectural thought is that if the architect designs what he knows, by his own introverted standards of pure architecture to be best, the public ought to grow to like it. Why the hell should they?

Furthermore architect's auditory involvement should not be necessarily restricted to people-interaction, for buildings also have an ability of their own to com-

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[18] Ibid., p. 241.

[19] Bruce Allsopp, Towards a Humane Architecture (London: Frederick Muller Limited, 1974), p. 4.

municate:[20]

> Listen to the sounds a building makes when no one is in it. It breathes with a life of its own. Floors creak, timber snaps, radiators crack, furnaces groan. But although buildings of the past made characteristic sounds, they cannot compete with modern buildings for the strength and persistence of sound emitted. Modern ventilation, lighting, elevators and heating systems create strong internal sounds; and fans and exhaust systems disgorge staggering amounts of noise into the streets and onto the sidewalks around the buildings themselves.

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[20]Murry Schafer, "The Tuning of the World" (unpublished works: as part of the World Soundscape Project, Simon Fraser University, 1975), p. 361.

Visual Sense:

Visual Sense:

As this thesis is primarily concerned with the auditory sense, aspects of the visual sense will be dealt with in a limited form. Since the architect has been traditionally concerned with the visual aspects of both space and aesthetics, the experience of the visual phenomenon needs some explanation. Of the traditional five senses man is more consciously dependent on sight as an information collector for the perception of the outside world than on the other sensory systems (hearing, smell, taste, and touch). Sight, like hearing, is a "distance receptor" and is regarded as the most valued faculty. The blind must develop an awareness of environmental situations through the remaining senses. Through sensory training or rehabilitation the blind can function efficiently in a world predominantly designed for the sighted.

By comparing the distance senses, vision and hearing, one will find some variance in their integrated functions. But first it is important to mention that the optic nerve contains roughly eighteen times as many neurons as the cochlear nerve and therefore it is probable to assume that it transmits that much more information.[1] Both, the visual and auditory sense are directional in nature

[1] Edward T. Hall, The Hidden Dimension (New York: Doubleday & Company, Inc. 1969), p. 42.

whereby they focus on a stimuli source. Vision is directed in the area immediately in front of the person whereas hearing encompasses all the directions. Vision then, can be considered as primarily a foreground sense since it usually focuses on an experience after it has been identified through the hearing organism. In contrast, hearing is considered as a background sense, even while drawing on a drafting board or while viewing a light at an intersection to change. Audition continues to scan the background and calls attention to changes in the surrounding environment. Conversely there are many instances where this event reverses. When listening intently to some beautiful music, the eyes may be directed away aimlessly or even closed, to focus auditory experience into the foreground as much as possible. Both distance senses also perform in a reciprocal manner, however, the majority of time, hearing serves more as a background sense and vision more as a foreground sense.

According to Cobb, it is only characteristic of man that both these distance senses are developed. He describes the dog as an animal that has only one well developed distance sense, that being hearing. The dog primarily depends on hearing and olfaction and not on vision since it is relatively undeveloped.[2] When we discover faculties which exceed our own it is no wonder to us, since each species is endowed with senses which aid it to

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[2]Helmer Myklebust, The Psychology of Deafness (New York: Grune and Stratton, Inc. 1971), p. 47.

perceive its outside world. Birds for example enjoy a vision almost eight times that of the human being, but in their tree life environment, sharp distance vision is essential. Some snakes, including the rattle-snake, when compared to other vertebrates have no marked difference in visual capacities. Nevertheless the rattle-snake can strike prey in complete darkness by the aid of infrared radiation receptors. These receptors do not respond to light waves in the visual range but respond to infrared rays (warmth). The rattle-snake thus detects the rays emitted by its prey (mouse or rat), then strikes and captures it.[3]

Human vision today is studied by a wide range of specialists, opthamologists, psychologists, engineers and others. Since vision plays a large role in the experiencing of architecture and architectural aspects such as shape, size, location and the physical characteristics of the world of objects, its complexity suggests further inspection, especially by architects and designers. For instance, unlike the rattle-snake, the human visible spectrum of the electromagnetic range of light waves is only about 1/70th of the total and includes light with wavelengths extending over 390-700 mμ (a millimicron (mμ) is a millionth of a millimetre).[*] The total electromagnetic

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[3] R.H. Day, Human Perception (Toronto: John Wiley and Sons, Inc., 1969), p. 4.

[*] Recently the term nanometre (10^{-9} metre) has been adopted in place of millimicron.

spectrum ranges from cosmic rays with wavelengths in the vicinity of 10^{-3} mμ to electromagnetic waves of wavelengths around 10^{12} mμ. Within the visible portion of the spectrum, neural stimulation is highest in the yellow-green wavelengths (approx. 5700 angstrom units),** and lowest in the violet band (3800 au) or above the red (7200 au). Refer to Figure 11 and 12, page 107. The range of energies to which the naked eye responds to is enormous as James Fitch states: "from that of a lighted candle 14 miles away to a landscape flooded by 8000 foot-candles (fc) of sunshine."[4] To accommodate itself to such a range of stimuli, the eye has a series of modulating devices designated as "physiological optics," the muscular and neurologic aspects of the eyeball and its multiple components and processes, cornea, lens, pupil, retina, extracular muscles, fovea, and the optic nerve. In any discussion of vision it is necessary to distinguish between physiologic optics (retinal image) and visual perception (what man perceives). James Gibson, a psychologist, labeled them respectively as the "visual field" and "visual world". The perceptual viewpoint on vision has been the subject of much investigation. Gibson described the visual field as that made up of constantly shifting light patterns as recorded by the retina in which

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[4]James M. Fitch, American Building 2: The Environmental Forces That Shape It (Boston: Houghton Mifflin Company, 1972), p. 93.

**Angstrom is a unit of wavelength of light equal to one ten-billionth of a meter.

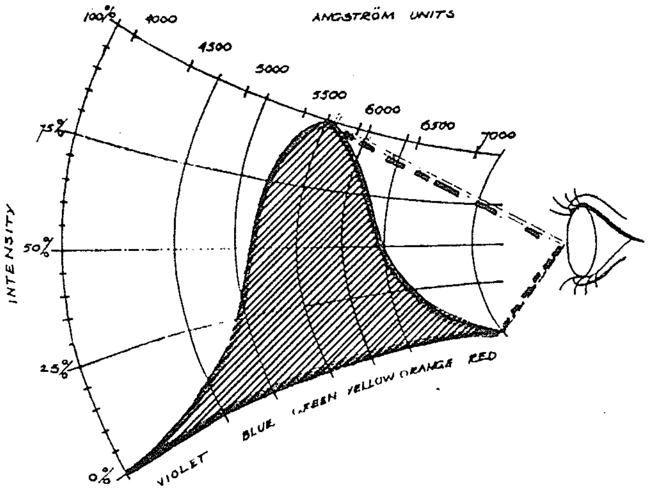

Figure 11, Man's Visible Spectrum[4a]

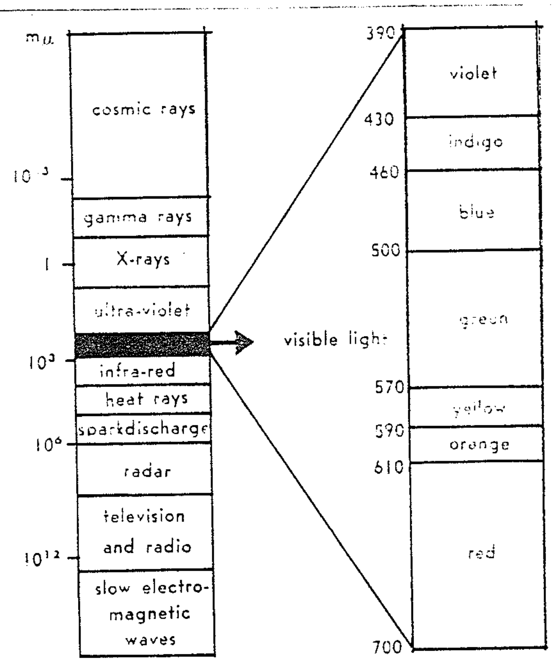

Figure 12, The Electromagnetic Spectrum[4b]

[4a]James M. Fitch, American Building 2: The Environmental Forces That Shape It (Boston: Houghton Mifflin Company, 1972), p. 92.

[4b]R.H. Day, Human Perception (Toronto: John Wiley and Sons, Inc., 1969), p.3.

man uses to construct his visual world. And the visual world as "...extending in distance and depth, being upright, stable and without boundaries, colored, shadowed, illuminated and textured, composed of surfaces, edges, shapes and interspaces--and most significant--as containing things that have meaning."[5]

Gibson further divided the perception of the visual world into two types:[6]

1. The "literal world"
   That composed of color, textures, surfaces, edges, slopes, shapes, and interspaces that form a more or less constant background for experience which provide a "fundamental repertory of impressions to guide present and future perceptions."

2. The "significant things"
   That composed of objects, places, people, signals and written symbols.

For graphic and more detailed description of the above distinctions the author suggests that the reader refer to Kevin Lynch's work, The Image of The City.

The architect conventionally expresses his concepts of spatial phenomena in visual terms, however vision-based estimates of shape, size, and relation of objects would be impossible without previous tactile and kinesthetic explorations. The importance of being able to integrate visual and kinesthetic experiences has been demonstrated

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[5] Ray H. Barsch, <u>Achieving Perceptual-Motor Efficiency</u> (Washington: Special Child Publications, 1968), p. 260.

[6] <u>Ibid</u>.

by two psychologists, Held and Heim. Two sets of kittens were used in the experiment. One set was carried through a maze and the other set was allowed to walk along the same track. The one that was carried did not develop "normal visual spatial capacities" as those that were allowed to walk since they did not learn the mazes nearly as well.[7] In the same token, man sees distances and dimensions, but our original understanding of distances, and of the friction and gravity to be overcome in exploring it comes originally from the kinesthetic experience:[8]

> Architects talk of balance, rhythm, symmetry as though they were purely visual qualities, but our perception of them rests on complex factors of heartbeat, vestibular apparatus and sensors in skin and muscle.

Gibson has also shown that there are purely visual cues to the perception of space. As you move toward an object, the visual field expands; as you move away, it contracts. On the other hand there are many important aspects of human experience that cannot be visually perceived at all, for example, electric shock, the smell of roses or the taste of wine, symphonic music or the sexual organs.

The concept that no two people see exactly the same thing when actively using their eyes in a natural situation is shocking to some people because it implies that not all men relate to the world around them in the same

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[7] Edward T. Hall, The Hidden Dimension (New York: Doubleday & Company, Inc. 1969), p. 66.

[8] James M. Fitch, American Building 2: The Environmental Forces That Shape It (Boston: Houghton Mifflin Company 1972), p. 84.

way. As Cantril pointed out, "...a person sees what is significant with significance defined in terms of one's relationship to what he is looking at."[9] Murphy and Solley in their investigations in the field of visual perception emphasized that the viewer perceives "as he wishes to perceive." It can be said then, that man sees what he wants to see and by looking at something he does so by his own choice. However we never look at just one thing, we are always looking at the relation between things and ourselves. Our vision is continually active, continually moving, continually holding things in a circle around itself, constituting what is present to us as we are.

The differences in the visual world arise when two people view the same object through the medium of the retina (the light-sensitive part of the eye), since it's composed of at least three different parts: the fovea, the macula and the region where peripheral vision occurs. All three parts perform different visual functions therefore man sees in three distinct different ways. Although they act in a simultaneous way, blending into each other producing a single image:[10]

1. Fovea (near-vision)

   This is the area which involves critical seeing tasks, concentration on a visual field

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[9] Ray H. Barsch, Achieving Perceptual-Motor Efficiency (Washington: Special Child Publications, 1968), p. 261.

[10] Edward T. Hall, The Hidden Dimension (New York: Doubleday & Company, Inc. 1969), p. 70.

rarely farther from the eye than the arm's reach. The fovea is described in the following passage:

> It is a small circular pit in the center of the retina which contains roughly 25,000 closely packed color-sensitive cones, each with its own nerve fiber. The fovea contains cells at the unbelievable concentration of 160,000 cells per square millimeter (an area the size of the head of a pin). The fovea enables the average person to see most sharply a small circle ranging in size from 1/96 of an inch to ¼ of an inch (estimates differ) at a distance of twelve inches from the eye.

Without this activity of the fovea man would be unable to do detail work such as viewing microscopes, telescopes, doing needle-threading, seeing the details of a mother's face, viewing pictures, engraving and other such close work.

2. Macula (middle-vision)

   This is the region surrounding the fovea, an oval, yellow body of color-sensitive cells. It is not as clear and sharp as the fovea. The spatial parameters cover a visual angle of 3 degrees in the vertical plane and 12 to 15 degrees in the horizontal plane. Man uses the macula vision for such things as looking at flowers, seeing a friend, watching television programs, observing demonstrations by his teachers, reading and drafting.

3. Peripheral vision (far-vision)

   The spatial parameters of peripheral vision

> is approximately 180 degrees, that is 90 degrees on each side of a line extending through the middle of the skull. The perception of movement is enhanced by this vision, but detail sight is reduced. Watching cloud formations, sunsets, viewing speeding cars, watching children play in school yards, seeing airplanes fly, walking and viewing store front windows, and watching activities on a construction site are some of the many activities made possible by peripheral vision.

Genuine understanding of the various dimensions of the seeing mechanism is of dominant importance to the architect in visually experiencing architectural design. Architects still persist in discussing architecture as though its esthetic impact upon us were an exclusively visual phenomenon. According to Fitch who presented a lecture at the University of Manitoba, the tendency to base important design decisions on narrowly visual criteria seems to have steadily increased with literacy.[11] He further expands:

> The more books and magazines he reads, the more TV and cinema he scans, the more apt is the architect to rely largely or wholly upon visually acquired data, divorced from its matrix of multi-dimensional sensual reality. This failure to recognize the enormous significance of the nonvisual impact of architecture leads to the impoverishment of all perceptual experience--including even, ironically, that of vision

[11] James M. Fitch, American Building 2: The Environmental Forces That Shape It (Boston: Houghton Mifflin Company 1972), p. 84.

ifself.

Assigning purely visual qualities in the design of spaces in architecture is historically unsuccessful, to perceive of a building design on the drawing board the architect must visualize the full range of multi-dimensional totality of the sensory experience. Especially when moving in the flesh through a space. Architecture is unlike that of other visual arts, in architecture we are completely submerged in the sensory experience of the building form. We are participants and not observers. When viewing glossy photographs of "novel form architecture" or well rendered architectural perspectives we must remember that it is only a visual facsimile of the building and not the total sensuous behavior that really takes place in what is visually presented. This type of graphic display has visible and invisible limitations of great consequences. The dehumanization of man and buildings is represented in visual form. Graphic perspectives of buildings and urban spaces are cast in ideal climatic settings, mid-summer with the sun's angle at its optimum lowest shadow line, where the building is isolated and its features are emphasized rather than displaying it in its true environmental decaying setting. An example of this is Wright's house at Bear Run, where the photograph has become more famous than the house itself. Architects must explore the other than visual media in presenting architectural concepts and compositions. Design must employ complementary sensory modalities to be truly successful.

Olfactory Sense:

Olfactory Sense:

It is generally thought that smell has nothing to do with the experience of architecture however every building has its characteristic smell.

> All buildings generate their own olfactory environment, whether or not the architect has anticipated the fact in his consideration. Too often in the modern world, he has not. Hence, as in other aspects of the design process, purely visual criteria will often tend to dominate design decisions, to the detriment of other avenues of sensory perception. 1

The sensuous impact on the olfactory sense is very powerful. It is a distance receptor similar to the role played by the eyes and ears. Even though we are less frequently aware of its information capacity, its sensitivity is astounding to chemists. "The olfactory process is basically a chemical one with complex absorption and diffusion gradients along with receptor specificity, which accounts for the discriminatory responses to odors." (Pieron, 1952).[2] The smelling organ of the human being is able to detect the smell of 1/1,000,000 of one milligram of vanillin in one liter of air. The ability of the nose to distinguish such stimuli reveals the significance of its role in experiencing the built environment, one which architects should bear in mind when making major design decisions.

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1 James M. Fitch, American Building 2:The Environmental Forces That Shape It. (Boston: Houghton Mifflin Company, 1972), p. 78.

2 Ray H. Barsch, Achieving Perceptual-Motor Efficiency. (Washington: Special Child Publications, 1968), p. 197.

> Every act of the architect has olfactory consequences: at the very least he should be able to anticipate them. This becomes especially important in buildings like schools and hospitals where centralized air-conditioning systems introduce the hazards of accidentally distributing obnoxious odors across the whole building. [3]

Olfactory responses are distinguished through their particular odor-(odor being the quality of something that stimulates the olfactory organ)[4] whereas the stimulus is a chemical composition which activates smell. Since stimulus has no response attribute, we may talk of an agreeable odor but not an agreeable smell.[5] Smell thus is the mechanical product of the sensory apparatus. The smelling organ has more than 13 kinds of end organs where each one responds to a different kind of elementary odor. These receptors are located in the cleft at the top of the nasal cavity in each nostril. (Amoore Johnston and Rubin 1964, Haagen-Smit 1952, Geldard 1953, Stevens 1951).

Surprisingly it is interesting to note that man has only one quarter of a square inch of olfactory nerve endings. A dog has 10 square inches and a shark has 24 square feet.[6]

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[3] James M. Fitch, American Building 2: The Environmental Forces That Shape It. (Boston: Houghton Mifflin Company, 1972), p. 78.

[4] Webster's New Collegiate Dictionary.

[5] John F. Halldame, Psychophysical Synthesis of Environmental Systems. (California: California Book Co. Ltd., 1968), p. 50.

[6] John F. Young, Cybernetics. (New York: American Elsevier Pub. Co., 1969), p. 7.

In order for any substance to affect the olfactory nerve endings it must have two physical properties:

1. it must be volatile (in order for the atmosphere to support it)
2. it must be soluble in both water and lipids (in order to penetrate the watery film that covers the mucous membrane of the nose).[7]

There exists an enormous gap between the limited knowledge of the mechanism of olfaction on one hand and the fairly advanced knowledge of optics and acoustics on the other. Sound and color can be accurately linked with frequency in cycles per second, decibels or electromagnetic energy, but no one knows with any degree of certainty what distinguishes the various olficients from each other. This is expressed in fact that there is not yet an objective, quantitative unit of measurement for odor.[8]

The most elaborate attempt to classify and systematize the sensation of smell was made by Henning (1915). According to him only six different basic smells can be distinguished, all other smells can be adequately considered in reference to them.[9]

1. fragrant
2. putrid

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[7] John F. Halldame, Psychophysical Synthesis of Environmental Systems (California: California Book Co. Ltd., 1968), p. 50.

[8] W. Buddenbrock, The Senses (Toronto: Ambassador Books Ltd., 1958), p. 118.

[9] Sven Hesselgren, The Language of Architecture (Sweden: Studentlitteratur, 1969), p. 145.

3. ethereal
4. spicy
5. burned
6. resinous

Compound smells may be considered as those experienced when any two different stimuli for smells are mixed in such a way that affect the nose simultaneously. John Halldame, postulated the existence of seven primary odors that may be recognized:[10]

1. camphoraceous
2. musky
3. floral
4. pepperminty
5. ethereal
6. pungent
7. putrid.

The search for a unit of measurement of odoriferous categories is a continual one for experimental psychologist. Even with practice the layman can construct his own classification of odors.[11]

1. alliaceous
2. ambrosiac
3. pepperminty
4. aromatic
5. ethereal
6. foul
7. fragrant
8. goaty
9. nauseous

James M. Fitch categorizes odors as having three properties

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[10] John F. Halldame, Psychophysical Synthesis of Environmental Systems. (California: California Book Co. Ltd., 1968), pp. 50-2.

[11] Yi-Fu Tuan, Topophilia. (New Jersey: Prentice Hall Inc., 1974), p. 10.

in order for them to be experienced by man.[12]

1. Pleasant-unattractive/repellent
2. Intensity
3. Time

Without explaining the items in the lists it can be seen that there are many possibilities. In terms of what has actually been done, it is evident that odor plays an important experiential role in our environment, one which architects should capitalize on. Examples depicting con-

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[12] James M. Fitch, American Building 2: The Environmental Forces That Shape It. (Boston: Houghton Mifflin Company, 1972), p. 80.

scious use of the olfactory sense by architects as a design tool are rare, Le Corbusier for one, "advised that one should place the kitchen at the top of a building, so that its smells would not permeate the rest."[13]

Odor control within an environment may be achieved through some of the following parameters:

dilution / adaptation

masking / concentration

removal / reduction

Some explanation of the above terms follows:

<u>dilution</u> This method involves bringing outside air and mixing it with the used air in a given space by use of increased fan movement, duct and conditioner capacities.

<u>adaptation</u> is basically olfactory monotony which occurs with time. The persons in a given space once exposed to a steady concentration of a given substance over a continued period of time will gradually lose their capacity to perceive its odor.

<u>masking</u> is the modification of odors by superimposing a stronger concentration such as deodorants and reodorants. This technique is commonly applied to bathrooms, kitchens, hospitals, bedding and people, in lieu of more adequate ventilation.

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[13]Geoffrey Broadbent, <u>Design in Architecture</u>. (New York: John Wiley & Sons, 1973), p. 142.

<u>concentration</u> is achieved by increasing the areas of exposure, air movement, temperature, and moisture in a confined area.

<u>removal</u> is basically filtering odor by chemical adsorption, through thin filters of activated charcoal or vapor neutralization or catalytic combustion.

<u>reduction</u> is generally dumping foul odors from bathrooms, kitchens or industrial processes by way of ventilation.

Man in the Western World partially because of neglect and of technological progress has subjected himself to environmental pollution of great consequences.

> ...We are dumping our garbage into the sky. "This 'garbage' includes solid particles such as ashes and bits of stone and carbon; microscopic droplets of oily and tarry matter; and especially many kinds of gases, some of which are obvious because they are pigmented, smelly, or irritating to the mucous membranes, while others of equal importance remain unnoticed." 14

Almost to the point where olfactory blandness and sameness has anesthetized perception itself, not excluding the other senses as well.

> Our cities lack both olfactory and visual variety. Anyone who has walked along the streets of almost any European village or town knows what is nearby. In the typical French town one may savor the smell of coffee, spices, vegetables, freshly plucked fowl, clean laundry, and the characteristic

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[14] Rene Dubos, <u>So Human an Animal</u>. (New York: Charles Scribner's Sons, 1968), p. 203.

> odor of outdoor cafes. Olfactions of this type can provide a sense of life; the shifts and the transitions not only help to locate one in space but add zest to daily living. 15

Man's loss of acuity may indeed be evolutionary and the loss of the olfactory sense may be a quality to be enjoyed with the growth of atmospheric pollution but the consequences are not only dangerous to our health alone but to the richness and variety of our daily life.

Fortunately we are not all anosmic; we still have the ability to perceive and recognize smells in our environment in the same manner as children do. Perhaps with maturity we become more discriminant and leary of differentiating more complex olfactory information, since memories of past events and scenes are easily recalled.

> Books read near high-school library shelving retain olfactory accents which remain emotionally associated with these early experiences in literature. As a matter of fact, odors of school environment, as of many others, are most intimately held in memory and more quickly recognized again in later years than are visual impressions of the architecture involved. 16

These memory images together with the immediate sensory impressions act as co-determinants of our present actions. They lend more weight to our immediate sensory impression.

If we are to continue to enjoy our sensory environment we must design for it, keeping in mind all the rele-

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[15] Edward T. Hall, The Hidden Dimension (New York: Doubleday & Company, Inc. 1969), p. 50.

[16] Richard Neutra, Survival Through Design (New York: Oxford University Press, 1954), p. 146.

vant senses for they are the details that point to greater wholesomeness in the setting for life. Remember?

> The interior of the little red schoolhouse, with its cast-iron stove glowing in an unventilated room, and the classrooms of its great successor, the monumental brick box of a metropolitan school district, with its wood-trimmed blackboards and oiled or waxed floors, all had a peculiar sour smell.... the lockers loaded with rain-drenched overcoats, and the lunch kit scented by cheese sandwiches. 17

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17 Richard Neutra, Survival Through Design. (New York: Oxford University Press, 1954), p. 145.

Tactile Sense:

Tactile Sense:

It seems that few architects have grasped the deep significance of touch, (the use of texture in architecture) particularly in the transmutation of tactile information into visual constructs.

> The tendency to base important design decisions on narrowly visual criteria seems to have steadily increased with literacy....this failure to recognize the enormous significance of the non-visual impact of architecture leads to the impoverishment of all perceptual experience-including even, ironically, that of vision itself. [1]

Tactuality is both physical and psychological, it is a vital component in human behavior. It as as old as life itself and indeed, the ability to respond to stimuli is one of the basic criteria of life.

In the early development of the human nervous system cutaneous stimulation is of prime importance, since it initiates body awareness and thus holds a major role in the achievement of identity. Insufficient tactile stimulation (sensory deprivation) will produce deleterious consequences to the infant's cognitive and psychological future. Institutionalized infants receive extra stimulation as it is beneficial to their development and critical in the formation of a lifelong identity. Stimulation has been regarded as a "booster" for perceptual functioning in other modes.

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[1] James M. Fitch, American Building 2: The Environmental Forces That Shape It (Boston: Houghton Mifflin Company, 1972), p. 85.

The acquisition of tactual sophistication originates in the gestational period and through cutaneous variations in uterine transport. (Carmichael, 1954).[2]

The shape and form and space of the outerworld of reality gradually emerges by the infants building blocks of experience, acquired through all its senses yet always contingent, correlated and evaluated by the criterion of touch.

The infant at birth is bombarded with different tactile stimulations, it is held in feeding positions, covered in soft blankets, rubbed with baby oils, powdered, sponged with warm water, carried from place to place, etc., the infant develops a "feeling" of comfort in this tactual ministration. Since the sensory modalities are all skin receptors of different types, the eyes, ears, nose and certainly the tongue, at first "feel" rather than see, hear, smell and taste. When the infant is able it will put to the test whatever it can, by "putting it into his mouth, and what he there feels with hand and mouth will tell him what he desires to know."[3]

The manipulation of objects in this manner by the infant reveals some unique qualities. Gibson (1963) discussed these qualities obtained through manual inspection to include the following:

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[2] Ray H. Barsch, Achieving Perceptual-Motor Efficiency (Washington: Special Child Publications, 1968), p. 215.

[3] Ashley Montagu, Touching-The Human Significance of the Skin (New York: Harper & Row, Publishers, 1972), p. 226.

rigidity
unity
stability
weight
shape
thickness
texture [7]

Gradually the child will develop a distance between what he tactually feels and what he experiences using other senses. Touch does not become perceptual for the infant until awareness of difference becomes a part of his ongoing behavior. Once the infant recognizes each experience or object as a separate and distinct class, it is on the road of tactual sophistication development.

In 1883, Rousseau detected this desire in children to touch and handle everything as a necessary part of a child's training:

> It is by looking, fingering and hearing and above all, by comparing sight and touch that he learns to feel the heat and cold, the hardness and softness, the heaviness and lightness of bodies and to judge of their size and form and all of their physical properties. [4]

Tactuality then is defined as the ability of the cutaneous surface of the body to gain <u>information</u> by means of active or passive <u>contact</u> thus channeling the data to a higher control center for information processing. The term tactuality is preferred to touch "to convey the composite idea of a reception, transmission, transduction into

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[7] Bryant J. Cratty, <u>Movement and Spatial Awareness in Blind Children and Youth</u> (Illinois: Charles C. Thomas Publisher, 1971), p. 42.

[4] Ray H. Barsch, <u>Achieving Perceptual-Motor Efficiency</u> (Washington: Special Child Publications, 1968), p. 204.

percepts, cognition and feedback-correlation and to convey the idea of a processing entity in a constant state of energization."[5]

Tactile stimuli have always been associated with producing responses to architectural environments but few are consciously specified by architects to produce an implied sensory experience, especially when touched by the user.

> Rough masonry on the front of a fireplace, crude-surfaced, porous softwood, homespun upholstery goods, coarsely woven rugs and blankets-apart from all associations with rusticity--will yield effects profoundly different from smooth, evenly polished surfaces. [18]

The primary characteristic in touch is contact. The sequence of tactual sophistication rests on touching and being touched, bit by bit, allowing the body to build a resource of tactual information. The foundation of tactual organization is developed in the early stages of life. The child's early environment is one of "texture." As the child crawls and walks on carpeting, linoleum, concrete, wood, grass it develops an awareness of difference. The wool sweater, the cap on his head, the leather shoes, the melting chocolate in his hands, the feel of tears running down his cheeks, the cold snow, the round door knob, the bruised knee, all this tactuality has a meaning for him

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[5] Ibid., p. 211.

[18] Richard Neutra, Survival Through Design (New York: Oxford University Press, 1954), p. 149.

which is mentally registered. Some are pleasurable others are not, he later develops an approach-avoidance reaction.

Man's relationship to his environment is directed by his perceptions, as Edward T. Hall states:

> Man's sense of space is closely related to his sense of self, which is in an intimate transaction with his environment. Man can be viewed as having visual, kinesthetic, tactile, and thermal aspects of his self which may be either inhibited or encouraged to develop by his environment. [6]

If tactuality has meaning for man, he will obtain significant information from it and utilize it to expland his knowledge such as the applied use of texture in architecture.

It appears that the use of "texture" in architecture is seldom used consciously by architects. The ability to see other than with the mind's eye is in a state of retrogression.

> ...without the ingredients of sensuous enjoyment the practice of architecture must inevitably degenerate into little more than a sordid routine, or at the most the exercise of mere intellectual cleverness. [8]

The use of texture in architecture is not necessarily restricted to actual physical contact. It is also experienced as a visual phenomenon, however it still must be:

> ...appriased and appreciated almost by touch, even when it is visually presented. With few exceptions it is the memory of tactile experiences that enables us to appreciate texture. So far, only a few designers have paid much attention to the importance of texture,

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[6] Edward T. Hall, The Hidden Dimension (New York: Doubleday & Company, Inc., 1969), p. 63.

[8] Gordon Cullen, The Concise Townscape (London: The Architectural Press, 1968), p. 93.

> and its use in architecture is largely haphazard and informal. In other words, textures on and in buildings are seldom used consciously and with psychological or social awareness. [9]

Some terminology of tactual sensitivity must be established in order to describe the attributes of a given surface. Sven Hesselgren mentions three such classifications:[10]

Texture: referred originally more particularly to textiles but has gradually come to designate certain attributes connected with the visual perception of a surface.

Grain: is the only term referring exclusively to a sense of contact and is used to describe certain sensations of touch in connection with surfaces.

Structure: refers particularly to the construction of a body or a process which can therefore be hidden from the senses.

According to Katz, the attributes of grain may vary in two ways:[11]

hard - soft

smooth - rough

The sensation of elasticity is an attribute other than grain which may be sensed in the range of:

elasticity - plasticity

Man depends to a very large extent upon the tactile stimulation of the external world, for by nature, he is a

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[9] Edward T. Hall, The Hidden Dimension. (New York: Doubleday & Company, Inc., 1969), p. 62.

[10] Sven Hesselgran, The Language of Architecture. (Sweden: Studentlitteratur, 1969), p. 119.

[11] Ibid.

creature of the surface of the earth. His body has grown accustomed to the resistance and pressures beneath his feet, as he has always been in contact with different surfaces. This is of great practical importance to the architect as he may create spaces shaped by real and implied surfaces. "Architecture begins with the floor, the point of man's contact with the earth to which he belongs."[12]

We recognize the nature of a surface before we let our feet touch it, we recognize the difference in sensations felt between walking on concrete or wooden floors or between grass and sand, even though we wear hard soled shoes and the sense of temperature is lost, the sensory receptors are still able to make enormous distinctions. We respond to surface enrichment.

> Much of the reason for success or failure of any space lies in impact of its bounding surfaces....Surfaces which appear smooth, polished or velvety to the eye will often lead us to stroke them, as if to confirm the tactile pleasure they promise. Very rough surfaces, on the one hand, cause us to shy away from them irrespective of how handsome they may be in purely formal (i.e. visual) terms. [13]

The approach-avoidance reaction to surface enrichment is a significant one for architects to understand and experience. An example of this is to be found in Wright's old Imperial Hotel in Tokyo.

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[12] Bruce Allsopp, Towards a Humane Architecture (Great Britain: Frederick Muller Limited, 1974), p. 3.

[13] James M. Fitch, American Building 2: The Environmental Forces That Shape It (Boston: Houghton Mifflin Company, 1972), p. 175.

> Wright, an artist in the use of texture, used the roughest of bricks, then separated them by smooth, gilded mortar set in from the surface a full half-inch. Walking down these halls the guest is almost compelled to run his fingers along the grooves. But Wright did not intend that people run their fingers along the grooves. The brick is so rough that to obey this impulse would be to risk mangling a finger. With this advice Wright enhances the experience of space by personally involving people with the surfaces of the building. 14

Another example of reactions to surface enrichment may be found at the School of Architecture at Yale University:

> the corrugated, bush-hammered concrete walls...are very handsome indeed when experienced from a safe distance. But their rough texture is too obviously hostile to the human epidermis to make a person feel safe at close quarters. The natural tendency of persons moving along them is to maintain a safety zone of empty air between the wall and themselves. 15

Much of what we experience through sight has been perceived through other sensory receptors, consequently information is abstracted and synthesized into visual constructs. Considering that the surface area of the skin is the largest organ system of the body, approximately 2,500 square centimeters in the newborn and approximately 18,000 square centimeters in the average male and constitutes about 17 percent of the total body weight. This sense organ has

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[14] Edward T. Hall, The Hidden Dimension. (New York: Doubleday & Company, Inc., 1969), p. 51.

[15] James M. Fitch, American Building 2: The Environment Forces That Shape It. (Boston: Houghton Mifflin Company, 1972), p. 175.

the capacity to distinguish texture (grain) between a smooth glass surface to one etched in grooves 1/2,500 of an inch deep. In physiological terms the human skin is estimated to have some 50 receptors per 100 square millimeters. It is no wonder that the skin is very sensitive to touch. The human skin is the oldest of all the sensory modalities and is the earliest to develop in the human embryo. Its physiological functions are:[16]

1. to protect underlying parts from mechanical and radiation injuries as well as foreign substances and organisms.
2. to act as a sense organ.
3. to act as a temperature regulator.
4. to act as a metabolic organ in the metabolism and storage of fat, as well as water and salt metabolism by perspiration.

Body skin is not to be taken for granted as it is an efficient facade covering a complex range of living systems which human performance depends on. A human being can spend his life blind and deaf, deprived of the sense of smell and taste, but cannot survive at all without the functions performed by the skin. Helen Keller who was blind and deaf at infancy, literally developed her mind through the stimulation of her skin. Information received from the external environment by our skin is a continuous process, one which we may not be aware of at all times, however the blind continually depend on. The blind are a good source

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[16] Ashley Montagu, Touching-The Human Significance of the Skin (New York: Harper & Row, Publishers, 1972), p. 4.

of sensory data. The complex system of sensors in the skin enable them to perceive temperature, humidity, pressure, shape, texture and weight of objects.

> ...A brick wall on the north side of a given street was identified as a landmark to the blind because it radiated heat over the total width of the sidewalk. 17

The blind compensate for their deficiencies by using other sensory systems, why is it then that architects conventionally express their concepts of spatial phenomena in visual terms when human mankind has all these other sensory receptors to measure his environment? Is it that architects have become evolutionary "cognitively sophisticated", withdrawn from human sensory realities? Perhaps a study of architecture without architects is in order, for sensory bombardment is not to be isolated to specific senses, it must be integrated with all the senses, especially if we are to realize a steady improvement in our man-made environment.

> Treated as a perceptual system the haptic incorporates all those sensations (pressure, warmth, cold, pain and kinesthetics) which previously divided up the sense of touch, and thus it includes all those aspects of sensual detection which involve physical contact both inside and outside the body. 18

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[17] Edward T. Hall, The Hidden Dimension (New York: Doubleday & Company, Inc., 1969), p. 59.

[18] Kent C. Bloomer and Charles W. Moore, Body Memory, and Architecture (New Haven: Yale University Press, 1977), p. 34.

Gustatory Sense:

Gustatory Sense:

To contend that the gustatory sense generates joy in architecture is to insist that the fruit flies in the architectural trailers at the University of Manitoba generate a voracious appetite for the academic hungry students. Architecture is not to be eaten, it is to be digested intellectually and sensorilly experienced.

"The gustatory mode is a primitive allegiance to physical and cognitive development"...its mechanical functioning embraces a number of factors in addition to the usual senses of taste, the organism processes nutritional information by use of the tongue, digestive system, food preference and the manner of chewing it.[1] As an infant develops in its physical environment it learns to differentiate between what is edible and inedible, between what "tastes good" and "tastes bad", since it is critical to the digestive tract and to the human's total survival.

For simplification, in general terms the gustatory sense as well as the other senses has been incorporated into a percepto-cognitive survival sequence which consists basically of four stages of activity:[2]

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[1] Ray H. Barsch, <u>Achieving Perceptual-Motor Efficiency</u> (Washington: Special Child Publications, 1968), p. 179.

[2] <u>Ibid</u>., p. 45.

1. sensitizing - receiving a particular stimuli
2. perceiving - converting it into meaning
3. symbolizing - transformation of meaning into symbols
4. conceiving - reduction of symbolic complexity similar to abstraction.

As man is exposed to a diversified sphere of experience throughout life, intersensory integration incorporates with the cognitive domain of various symbols and the effect produced is that of cognitive duality.

> We refer to ideas or notions as being 'palatable,' to certain behaviors as being 'in good taste' or 'poor taste'. Choice of color combinations in clothing and furniture (architecture) are also evaluated as being in 'good or poor taste.' Appreciation of painting and sculpture, selection of books, choice of automobile--all may be considered as representative of the 'taste' of the individual. Thoughts may be expressed 'with tongue in cheek.' We may 'digest' an idea, be 'nauseated' by a notion, find a particular comment 'hard to swallow' and 'regurgitate' facts in a collegiate quiz. As man has developed language to symbolize his experiences, his personal function and structure have provided a source of dual representation. Again, using his own experiencing as a referent, he has elevated the physical terminology to the cognitive terrain to be intellectually useful in his mental explorations. [3]

In actual fact "the sense of taste is a means of exploring the near environment,"[4] the tongue is a good tool in differentiating chemical stimulus, mediating the responses of sweet, bitter, sour and saline.[5] But the "sensation" experi-

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[3] Ray H. Barsch, Achieving Perceptual-Motor Efficiency (Washington: Special Child Publications, 1968), p. 189.

[4] James M. Fitch, American Building 2: The Environmental Forces That Shape It (Boston: Houghton Mifflin Company, 1972), p. 11.

[5] John F. Halldame, Psychophysical Synthesis of Environmental Systems (California: California Book Co. Ltd., 1968), p. 5G-1.

enced does not originate in the receptor area, it is only sensitized there, from which it must be processed to the conceiving stage where cognitive duality may take place. Such as associating pleasurable or unpleasurable sensations. "By studying our use of language we can see how fundamental this evaluation is. Everything that generates joy is called sweet: love, sleep, a child, or a beautiful woman; while anything unpleasant, such as death or pain, is described as bitter."[6]

Apart from cognitive duality, it is generally thought that the gustatory sense has nothing to do with the experience of architecture.

> An appalling amount of untreated or inadequately treated urban sewage houses, chemical factories, and metallurgical plants. In many cases, the river water is then used for public consumption by communities downstream after a so-called purifying process, which often does not go beyond filtration and chlorination.... Drinking water increasingly contains a variety of detergents, bleaches, dyes, chemical and metallurgical wastes, herbicides and insecticides, etc., which have resisted purification process. [7]

It would be naive to think of architects as chemists or conversely, chemists as architects. In quantifiable terms, both disciplines deal with properties of composition and structure. Yet both architects and chemists are vulnerable to the imperfections of their creations, especially when combined with precarious elements. Fashionable, stylistic,

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[6] W. Von Buddenbrock, The Senses (Toronto: Ambassador Books Ltd., 1958), p. 122.

[7] Rene Dubos, So Human an Animal (New York: Charles Scribner's Sons, 1968), p. 199.

modernistic and technological architecture is ubiquitious; it is the stimuli of the 'now generation.' Similarly, the cola we drink is part of the pepsi generation. Both the 'cola' we drink and the 'architectural vogue' we design, are immediate gratifications only. The transmutation of gustatory information into visual and physical constructs is not structurally feasible nor socially demanding. Perhaps as children we were delighted in consuming ginger bread houses but as architects we must concern ourselves with the idea of the stimulus in a wholly active way and hence integrate it with all the sensory modalities. If we as architects are to retain our public image of creating natural healthy environments then we must learn not only to discriminatingly taste with our tongues but with an enlightened mind.

Kinesthetic Sense:

Kinesthetic Sense:

It seems that few architects have seriously confronted the kinesthetic sense in the design process. As children, we have subconsciously experienced the dimensions of the Kinesthetic sense. Those of us who have climbed monkey bars in playgrounds, crawled up teeter-totters, ascended and descended ladders, stairs, ramps and travelled in elevators understand the feelings created by these spatial movements.

As part of our own actions we need to recognize and understand the kinesthetic sense in its complete range of feeling and what it is like in terms of muscles, joints and tendons. We as architects need to recognize the kinesthetic feelings, and sensations set up within our bodies in response to observation of the movement skills of others.

Charles Bell (1826) who has been credited with the discovery of the kinesthetic sense (deep sense) or the muscular sense stated:[1]

> The organs of sensing for kinesthesis are located in the muscles, tendons, and joints receiving a continuous supply of information about the movements made by the individual and the pressures or tensions produced in various parts of the body from all centers.

A comprehensive definition of kinesthetic stimuli as

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[1] Ray H. Barsch, Achieving Perceptual-Motor Efficiency (Washington: Special Child Publications, 1968), p. 219.

described by the American Physiologic Society follows:[2]

> ...pressing upon or displacing without injury the connective tissue underneath the skin, periosteum, bone sheaths of the joints leading to sensations often referred to as a deep sensibility. Under physiological conditions, of course, it is the contraction of muscles which act as a major kinesthetic stimulus.

Like other sensory experiences kinesthetic feedback is based upon previous learned experience. It requires a remembering process which enables perceptions of spatial extensions to take place. It follows logically that _learning_ about movement must emphasize the physical, sensory self-experience, but the _doing_ must stress the discipline of conscious efforts of the mind to fully comprehend the whole.

Kinesthesia on the other hand, is regarded as a _cognitive emergent_, since it depends on sensory feedback. The cognitive component is essential to kinesthesia. _Kinesthesia, then, is the technical label which implies that movement by the performer is perceived along with its action_. _It is the cognitive employment of position and patterned muscular effort that resolves a task_. Kinesthesia provides the basis of our awareness of the position and movement of the limbs, the feelings involved in operating levers and controls and in manipulating and exploring a wide variety of natural and synthetic materials. However, there is the danger of too much thinking at the time of doing, which can break the _natural flow and spontaneity_

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[2] _Ibid_.

and freedom and the rightness of the movement. For the experience of movement to be real, complete, and alive, the feeling of the movement must be stressed and not the thinking of how it is performed.

For the architect it is the thinking aspect that should be stressed. Since the design he creates on paper will inevitably elicit a spontaneous movement (kinesthetic) or a conscious movement (kinesthesia) in the real physical environment. The architect can effectively control the true nature of movement according to the sensory effect he may wish to achieve.

Let us consider the free, natural, spontaneous, unsophisticated character of movement displayed in children. Children require and see basic truths and essential meanings through their senses. Their questions are directed toward a variety of sensory impressions. They express their feelings spontaneously through their movements. "Children are inquisitive, puzzled, always wondering-and they begin to understand by what they see, hear, taste, smell and feel."[3] A child's way of trying to find out about things for himself as to what is real is characterized by his movements in examining, exploring, investigating and identifying with all the new things in his world. In the child's movement, we see the natural spontaneity and freedom, the buoyancy of the body, and the feeling of excite-

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[3]Alice Gates, A New Look at Movement, A Dancer's View (Minneapolis: Burgess Publishing Company, 1968), p. 15.

ment expressed by the movement:[4]

> In movements which are largely involuntary, as in the case of patterns of gestures, we are able to see certain movement qualities which reflect inner states of feeling or emotion. The child jumping up and down with excitement is an example of such evidences of feeling, as is someone pacing up and down, or tapping the foot with impatience, fidgeting, drumming his fingers on a table, or any of a number of other things. Other movements in this category are the gestures commonly used as symbolic of meanings, such as gestures of greeting, or farewell, nodding, shaking the head, shrugging the shoulders, and others. These gestures take on fine shades of quality differences characteristic of the individual's movement habits.

It is apparent that children will do spontaneously what their bodies are ready to do and what feels right to them, in their free activities of play, and their attempts to duplicate the activities and body skills of their peer groups. The basis of the "rightness of the feeling" of their movements is essentially a matter of bodily attitudes toward the movement elements (of shape and space, rhythm and time factors, weight and energy), which are appropriate to the body needs for its growth. These attitudes and natural preferences will change, as different stages in the child's growth are reached and the needs change.[5]

Unlike the kinesthetic component in the behavioral composite of every human, perception of body movement is not regarded as an automatic association. A basic example of the kinesthetic component being present in effort is

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[4] Ibid., p. 79.

[5] Ibid., p. 150.

when the young infant purposefully moves a body part, such as learning to walk and cognitively directs that movement. Once it achieves a reasonably adequate stride where walking becomes automatic then it can be said that it is a kinesthetic process:[6]

> ...movements and actions are preceded by a conscious decision to perform the definite task. Many movements are, however, done involuntarily-that means, without the investigation and guidance of a conscious decision. In the automatic repetitive movements used so frequently in industry, man does not think of the motive, or even the effect of his movements, he simply performs them in the right order after having taken the initial decision to do the work.

However when cognition is returned to the act of walking such as on uneven terrain, wandering through the countryside, side stepping pools of water, climbing variable stair treads, kicking a football, accelerating or decelerating gait, then kinesthesia is the product. This conscious awareness of knowing more of the reality of movement, of positioning one's body in space by introducing novelty (that which is different from the customary or usual) into habituated performance generates the kinesthesis component to action. Often children's activities are pressured by parents, schools and society in the western culture in general to the point of restricted refinement and discipline in the learning of specific game skills. (hockey, football, baseball etc.) One can sometimes

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[6] Rudolf Laban and F.C. Lawrence, Effort (London: MacDonald & Evans, 1947), p. 5.

observe children who have had too few opportunities for free expressive play activities, and see the results of this lack in their poor coordination or inability to use the body easily and naturally in many situations.

We have already observed that the cultivation of sensory awareness and sensitivity is not all of the process of perception, but for our purposes it is a vital and necessary point of departure to which to give our attentions next. To practice the fine art of perception, that is, to recognize the true significance of our own sensory experiences of movement and what we know because of them, requires that we think about them for ourselves. Some people appear to move easily and effectively in all situations, with an individual and special quality of grace which is associated with their personalities. This voluntary order of movement may be referred to as kinesthesia, where the individual begins to move through space with a purpose, general and specific, constantly reducing the number of movement errors as he develops. Kinesthesia allows him to refine and sharpen his gross patterns of movement into delicately complex patterns of fine performance. The child refines his crawling movements to walking, to running, to racing with other children. Through the usual course of development a large repertoire of motor skills are generated, to the point where the child is expected to swim, ride a bicycle, throw a ball with accuracy, dance with a partner, figure skate and countless other actions. All of these stages rely upon the sophistication of his kinesthetic organization at the time he is expected to conform to such events in life. If he has a low order of kinesthesia then he must stumble through or devise some other comforting escape route. If he is a good kinesthicizer then he comfortably experiences satisfaction and moves into the next performance echelon:[7]

> The child who kinesthicizes readily in the learning of the usual childhood skills becomes generally more proficient in any motor learning. Once he discovers the utility of feedback, he can rely upon it to support his learning at any age. A good child kinesthicizer becomes a good adult kinesthicizer.

This is evident in what we will refer to as the "highly sophisticated kinesthicizers", such as the ballerina, the gymnast and other disciplined structured performers. A performer may repeat an action many times before he kinesthicizes it. That is before he can "get the hang of it", to the point where he can synchronize his muscular movement patterns smoothly and efficiently. We must recognize the similarities in the characteristics of human movement and the differences which constitute the uniqueness of each individual both in his body and in his movement. In the gymnast's performance we see a pattern of synchronized coordinated movements of the whole body, where we may feel the enjoyment and satisfaction experienced by the performer. Whether the performer's body adjustments are physical or mechanical in nature in relation to gravity and momentum they must be directed towards main-

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[7] Ray H. Barsch, Achieving Perceptual-Motor Efficiency (Washington: Special Child Publications, 1968), p. 229.

taining the dynamic balance of the body parts and the body mass, or weight, in relation to the gravital forces constantly acting upon them. Sometimes the body is able to feel the needed adjustments in terms of changes in spatial, rhythmic or energy elements, thus making them easily, and without apparent effort. Human movement is seldom observed as single movements in isolation except of course in slow motion photography. We are most likely to see movement in a context, as a sequence of actions. Our reactions to equilibrium may be better described by Laban's movements of opposition. "When one side of the body tends to go into one direction, the other side will almost automatically tend towards the contrary direction."[8 *] This voluntary or involuntary need to establish bodily equilibrium is depicted in Fig. #13, page 144.

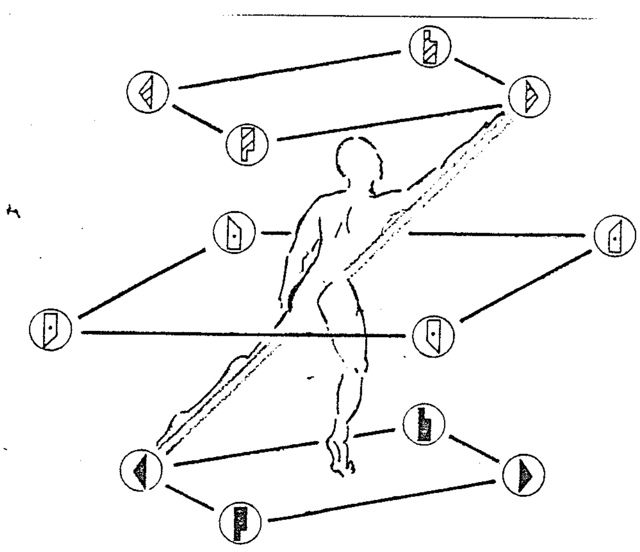

Figure 13, Naturally Equilibrated Bodily Attitude[8]
left arm and leg right arm

[8] Rudolf Laban, Choreutics (London: MacDonald and Evans, 1966), p. 89.

* Choreutics, is defined by Webster's New Collegiate Dictionary as "the art or the science, dealing with the analysis and synthesis of movement."

The extensions of the body limbs during extreme body equilibrium form a spatial position, that is the space occupied or surrounded within the reach of the body. This range or dimension of movement in space is referred to by Laban as "personal space" or the "kinesphere."[9] That is the sphere or area covered by the body in its movement, while never losing its reference to the body size and the extent of movement possible in the body and its parts. Outside the kinesphere lies the rest of space, space in general. We experience general space by entering into it with our original kinesphere, since we always carry it with us. As Arnold Koerte* describes in his article, The Road to Auribeau:[10]

> In our built environment then, motion is being provided by the viewer, not by the object. Man, unlike the camera, is in constant motion and will therefore experience stationary space as anything but stationary. In addition, even when he is walking in a straight line across a room, his eyes will always remain an extremely agile instrument-ever ready to perceive impressions from left, right, above, below and even from the back. Simultaneously, the other senses (<u>audio</u>,** olfactory,

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[9] *Ibid.*, p. 10.

[10] Arnold Koerte, "The Road to Auribeau", *The Canadian Architect*, (July, 1973), p. 36.

* Arnold Koerte was a professor in Architecture at the University of Manitoba (1964-1973) who stimulated my sensitivity towards a sensory architecture.

** Emphasized by the author, as the quality of sound will change with movement.

> kinetic) are actually designed to transmit supplementary messages received from all directions, not only in the walking direction.

Since man has a memory he will retain a sensory image or experience an "after effect" of preceding space when in the presence of new space stimulus. (an environmental change). Rudolf Laban states in his book Choreutics:[11]

> Movement is, so to speak, living architecture-living in the sense of changing emplacements as well as changing cohesion. This architecture is created by human movements and is made up of pathways tracing shapes in space, and these we may call "trace-forms".

Understanding mobility restrictions in the physically handicapped, such as the blind and comparing them with the "highly sophisticated kinesthicizers", we as architects can determine a maximum and optimum level of spatial movements within the sensory built environment. The physically handicapped such as the legally blind experience movement primarily through the auditory sense. Equally as important is the kinesthetic sense, since it supplements their other sensory information collectors to the point where they may pursue an active independent life. This is a major objective of rehabilitation programs in restoring mobility in the blind. Dependence upon other people for travel is one of the most acutely felt problems

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[11] Rudolf Laban, Choreutics (London: MacDonald and Evans, 1966), p. 5.

on the part of newly blinded adults. This dependence is one of the primary ways in which blind children are different and begin to feel different from their sighted companions. The blind must be taught to move with confidence when confronted with street noises, textures and other general conditions encountered when attempting to move from one environment to another. Hence they receive training to help them overcome their handicap. This is achieved usually by the following:[12]

Use of a sighted person as a guide
Familiarization
Hand and forearm protection
Trailing
Direction taking
Squaring off
Sensory training
Cane techniques

As soon as the blind develop an awareness of their environment, they achieve a sense of confidence, hence they are encouraged to explore and to adapt physically to other more demanding environments. As Bryant observed in studies with blind children:[13]

> I have seen children of 4 and 5 run up and down stairs, steer tricycles, motor cars and perambulators around the garden, swing on high swings, climb up camouflage nets and jungle gyms, jump and splash in a paddling pool and dance to music quite freely.

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[12] Bryant J. Cratty, Movement and Spatial Awareness in Blind Children and Youth (Illinois: Charles C. Thomas Publisher, 1971), p. 207.

[13] Ibid., p. 146.

The blind as well as the sighted experience movement through the sensation of tension in their own body, through bodily vibrations, displacements of blood in the body, accompanying noises, and so on. However the blind seem to have developed a much more sophisticated acute conscious sense of its presence. They learn to appreciate the sensory experience more. As revealed in a poem composed by Malcolm, who is aged 5 years 8 months:[14]

> Snow, snow, cold, cold snow,
> When the sun shines away you go.
> Where do you go?
> Well I don't know-
> Snow, snow, cold, cold snow.

As architects it is imperative that we too learn to develop an acute sensitivity to the physical environment, for the buildings we design will undoubtedly influence the behavior of those who use them. By consciously and deliberately observing, examing and thinking of movement as it occurs in our environment, we as architects will be able to define and perhaps predict desirable body movement patterns in the environments we design.

> Vestibular Kinesthesis determines our behavior on ramps and stairs. The spiral-ramped galleries of the Guggenheim Museum, for example, force a continuous disequilibrium on the visitor which stresses his vestibular apparatus. 15

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[14] A.H. Bowley and Leslie Gardner, The Handicapped Child, Educational and Psychological Guidance for the Organically Handicapped (London: Churchill Livingstone, 1972), p. 56.

[15] James M. Fitch, American Building 2: The Environmental Forces That Shape It (Boston: Houghton Mifflin Company 1972), p. 162.

The human being is an ever changing man-made environment is constantly exposed to Kinesthetic sensations. Some of which produce more desirable inner feelings than others. Studies conducted on blind people to determine their sensitivity to gradients revealed that about fifty percent of the subjects reported sensitivity to one degree of decline and about fifty percent reported sensitivity to two degrees of incline. The following analysis expressed their sensitivity or perception to gradients:[16]

Declines		Inclines	
Sensitive to 1^o	good	Sensitive to 1^o	excellent
2^o	fair	2^o	good
4^o	poor	4^o	fair
6^o	extremely poor	6^o	poor

People experience space in many different ways. Every time the designer or architect designs a wall or floor he intervenes in the behavioral character of those who use the space. In other words if the architect expresses empathy towards the kinesthetic modality in his design process, the experience as perceived by the user will be enhanced:[17]

> The main debating chamber of the United Nations Building in New York has walls which seem to be caving inwards-the symbolic implications were noted with glee by early critics of the design-

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[16] Bryant J. Cratty, Movement and Spatial Awareness in Blind Children and Youth (Illinois: Charles C. Thomas Publisher, 1971), p. 232.

[17] G. Broadbent, Design in Architecture (Toronto: John Wiley & Sons, 1973), p. 145.

but so has Le Corbusier's chapel at Ronchamp and, what is more, its floor is dished too. The experience of walking across a slightly dished floor is an extraordinarily subtle one. It is, of course multi-modal: in addition to the sense of equili-orium it also stimulates with a subtle frisson the kinesthetic senses and the sense of sight.
In other words, if we take into account a sense which is usually neglected, it leads us to new and creative conclusions as to how we might design.

Sensory Deprivation:

Sensory Deprivation

The architect's function in designing built-environments for man's sensory and social stimulation is often truncated. The individual patron of the architect is being replaced by "the social client" at an accelerated rate, isolating him from the "real client", man, who's basic needs of sensory arousal are essential for maintaining life. The prevalence of social-technological architecture is increasingly isolating man from his natural environment. Technology has provided the architect with a range of building possibilities which often contribute to the manipulation of the natural environment, resulting in formal, abstract and platitudinous architecture and urban design.

> Less and less able to encompass the complexity of modern technology, the architect's function is truncated. His designing becomes more and more a process of assemblage, more removed from functional necessity and therefore more susceptible to the pressures of fad and fashion. [1]

If we consider something to be in fashion, we must predicate it on having a limited "time span." The duration of stimulation a particular "fashion" may possess is relative to the monotony or boredom it produces, thus a change in fashion results.

> The utopian element in architectural thinking has disappeared; theory itself is disrepute. The men whose polemics

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[1]James M. Fitch, American Building 2: The Environmental Forces That Shape It (Boston: Houghton Mifflin Company, 1972), p. 322.

> (whether in print or in stone) once galvanized the Western World-Wright, Mies van der Rohe, Le Corbusier and Gropius-are gone. Few younger men aspire to their prophetic role. The dominant attitude is one of complacent laissez faire whose esthetic expression is genial eclecticism. [2]

Monotony and boredom are synonymous with sensory deprivation. For sensory deprivation is the feeling of unreality or detachment, confusion and apprehension, a lost contact with surrounding stimulation. Edward T. Hall cites that the technological development of the automobile has insulated man not only from his environment but from other human contact, to the point where interaction usually becomes competitive, aggressive and destructive. We who drive cars to work or school on a daily basis must experience this feeling of sensory deprivation from the natural environment. Once the car door is closed the space we inhabit is artificial, (a man made micro-environment). The ear is tuned to the local radio station, eliminating auditory contact with the external soundscape (auditory deprivation), the nose is over-stimulated by the cigarette butts in the ash tray (olfactory deprivation) and, the body has little feeling of the road due to the well cushioned seats (kinesthetic deprivation). The experience is primarily visual; even at that, "near vision is blurred by the speed of the automobile as man's entire organism was designed to move through the environment at less than five miles per hour."[3] The experience of sensory deprivation is not only posed by the

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[2] Ibid., p. 318.

[3] Edward T. Hall, The Hidden Dimension (New York: Doubleday & Company, Inc., 1969), p. 176.

automobile, it is prevalent in every closet of architecture: hospitals, waiting rooms, elevators, corridors, dormatories, classrooms. All are cold and indifferent spaces. Prolonged exposure to a monotonous environment has deleterious effects, yet some architects fail to understand man's relation to his environment and repeatedly design the same environment over and over again.

> Buckminister Fuller, one of the most creative of our designers, has proposed that we build gargantuan geodesic domes over cities. These great greenhouses would enclose a mechanized, man-controlled climate: the stars, the seasons, and the sun would be walled out in a triumph of technology. Air pollution and weather would disappear; yet these domes would deny the instinct of man to co-exist with nature. [4]

Some fundamental solutions must be found to problems posed by man-made environments. Studies on perceptual deprivation at McGill University by Dr. Hebb have shed some light on man's ability to endure long periods in a confined environment. Architects, through extraction, can benefit from studies such as those of Dr. Hebb.

In his experiments, male adult subjects were confined to a small lighted semi-soundproof cubicle, one at a time, for 24 hours. During confinement, subjects wore translucent goggles that admitted diffuse light but prevented patterned vision. A U-shaped foam rubber pillow, the walls of the cubicle, and the masking noise of the thermostatically regulated air-conditioner restricted auditory perception. At no time during the experiment were subjects

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[4] Rene Dubos, <u>So Human An Animal</u>. (New York: Charles Scribner's Sons, 1968), p. 212.

informed as to what time of day it was.

In general, the subjects at first spent some time in organized thought, reviewing their studies and making attempts to solve personal problems. After a while they began to reminisce about past incidents, their families, their friends; some tried to remember in detail a motion picture they had seen, some counted numbers steadily into the thousands. Similar experiences have been reported by persons in solitary confinement for long periods. As time wore on, however, this type of activity became more difficult because of diminishing ability to concentrate, and subjects became "content to let the mind drift." Finally, blank periods during which they could think of nothing would frequently occur. During isolation there were frequent reports of confusion, inability to concentrate, and inability to "think about anything to think about." After a long period of isolation many subjects began to see images. In addition, feelings of exceptional emotional liability were often reported.[5]

> Now, investigations of the effects of sensory deprivation indicate that too little stress is as deleterious to the body as too much. Volunteer subjects for such experiments were reduced to gibbering incoherence in a matter of hours by being isolated from all visual, sonic, haptic and thermal stimulation. One investigator of the effects of sensory deprivation concludes: Prolonged exposure

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[5] Woodburn Heron, "The Pathology of Boredom," Frontiers of Psychological Research, ed. S. Coopersmith. (San Francisco: W.H. Freeman and Company, 1966), p. 84.

> to a monotonous environment, then has definitely deleterious effects. The individual's thinking is impaired; he shows childish emotional responses; his visual perception becomes disturbed; he suffers from hallucinations; his brain-pattern changes. [6]

Marked subjective states and behavioral disturbances are frequently associated with persistent conditions of sensory deprivation, to a point that if a person were so deprived his brain would cease to function normally. Sensory stimulation, in addition to having its normal function of bringing information to the individual, serves to keep the brain active, alert and alive.

> ...with exceptional conditions of sensory, deprivation literally a void would be created with vigorous striving for necessary stimulation to keep the ARAS and, in turn, the cortex, going on an activated basis so that one's past or present may be reviewed. Without such stimulation, boredom, inactivity, and, ultimately, sleep, prevail. [7]

Mild boredom can produce listlessness and a lack of direction or motivation while intense boredom as was shown in the McGill University study creates anxiety and irritability, somatic complaints, temporal and spatial disorientation and a visual phenomenon described as hallucination. During sensory deprivation a point is reached where any activity will suffice just so long as some kind of behaviour output can be achieved. Sensory deprivation is damaging

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[6] James M. Fitch, American Building 2: The Environmental Forces That Shape It. (Boston: Houghton Mifflin Company, 1972), p. 13.

[7] Philip Solomon and Philip E. Kubzansky, Sensory Deprivation. (Cambridge: Harvard University Press, 1961), p. 176.

to the nervous system and the brain does its utmost to protect itself, at the expense of man's physical well being--a nervous breakdown.

> What we perceive and respond to constitutes the world we factually inhabit....Man may differ from animals in being more independent of external impressions, but that this independence is not absolute is shown by the fact that his mental equilibrium and intellectual ability rapidly deteriorate when his senses are kept inactive. [8]

A boring or monotonous sensory stimulation produces a disruption of the capacity to learn or even to think. We as architects must recognize this. Man-built environments are initially designed to elicit a conditioned response; if it turns out to be a negative one then it must be evaluated as such and the cause must be determined.

Sensory systems are particularly sensitive to change:[9]

> The sort of variation that we often demand instinctively on esthetic grounds, has a sound physiological and psychological basis. A change in environment stimulates our built-in devices to perceive and respond rapidly to significant events and efficiency is thereby increased. His worth paying for variety.

We as environmental builders must strive to create as many diversified sensory environments as is necessary to achieve a "dynamic environmental balance."

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[8] Rene Dubos, So Human An Animal. (New York: Charles Scribner's Sons, 1968), p. 125.

[9] Geoffrey Broadbent, Design in Architecture. (New York: John Wiley & Sons, 1973), p. 141.

Sensory Overload:

Sensory Overload

Just as there can be sensory deprivation, so can there be sensory overload in man's built-environment. Architects designing new stimulating environments, facilitating man's behavioral responses, must consider the consequences of their creations in light of sensory overload. Equally as important they must develop "priority systems" whereby unimportant information may be filtered out, transmitting only critical information to the user. Overstimulation is synonomous with environmental conditions that undisciplined technology has created.

> The exhaustion of natural resources and the erosion of the land; the chemical pollution of air and water; the high levels of noise, light and other stimuli; the pervasive ugliness and inescapable pressures resulting from high-population densities and mechanized life; all these phenomena and many others which threaten the life of modern man have become critical only during recent decades. [1]

Consequences of architectural and environmental creations become realities of man's immediate usage. They are permanent, and they surround our presence on a daily basis. They influence all human beings, irrespective of genetic constitution. "They are not inherent in man's nature but are the products of his responses to social and technological innovations."[2]

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[1] Rene Dubos, So Human An Animal. (New York: Charles Scribner's Sons, 1968), p. 229.

[2] Ibid., p. 219.

Architects must vocalize their knowledge of architectural consequences and provide leadership to the general public at large, for feedback is important. The result of this will lead to the development of "filtration systems", whereby overstimulation will be controlled and held in psychosomatic equilibrium.

> Proper screening can reduce both the disruption and overstimulation, and permits much higher concentrations of populations. Screening is what we get from rooms, apartments, and buildings in cities. Such screening works until several individuals are crowded into one room; then a drastic change occurs. The walls no longer shield and protect, but instead press inward on the inhabitants. [3]

There is a widespread impulse to withdraw from an overstimulating life we know to be inhuman. Many people "use their homes to escape from the stresses of the outside world and practice social withdrawal as a form of self-protection."[4] Withdrawal becomes a conditioned response, a habit, a familiar act--one that is friendly, comfortable, and without obstruction, one which serves to calm the shattered nerves. The more automatic the withdrawal, the better the adaptation. When the human's channel capacities are operating at their maximum rate they require rest. When the human's reticular system is overloaded it can no

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[3] Edward T. Hall, The Hidden Dimension. (New York: Doubleday & Company, Inc., 1969), p. 185.

[4] Rene Dubos, So Human An Animal. (New York: Charles Scribner's Sons, 1968), p. 158.

longer transmit coherent information, hence the withdrawal or "cut-off principle" results.

> If the inmate of the human zoo becomes grossly overstimulated, he too falls back on the cut-off principle. When many different stimuli are blaring away and conflicting with one another, the situation becomes unbearable. If we can run and hide, then all is well, but our complex commitments to super-tribal living usually prevent this. We can shut our eyes and cover our ears, but something more than blindfolds and ear-plugs are needed. [5]

The human animal cannot tolerate prolonged strains of excessive over-activity for they are damaging to his mental and physical well being. Extreme consequences of too much stress are behavioural immobilization, general confusion, excessive sleeping and finally a nervous breakdown.

Alcohol, tranquilizers, sleeping pills and Dexedrine (dextroamphetamine sulphate) all help to increase an individual's information processing capacity but only delay the point of sensory overload.

Sensory Overload then can be defined as the point where information input from two or more sensory modalities reaches levels greater than normal, thus contributing to extreme stress. Stress is also experienced when less than adequate inputs or stimulation are experienced as in Sensory Deprivation. These concepts play an important role in many architectural and environmental experiences. People

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[5] Desmond Morris, The Human Zoo (Toronto: Bantam Books of Canada Ltd., 1969), p. 190.

interact with their environment in addition to reacting to it. Knowledge of simple relationships between constancy and contrast, while at the same time understanding the causes and correlations of these relationships should provide designers with greater spectrums in design decision making.

Current technology is providing architects with vast fields of options, not only in the western world but abroad. New frontiers of space travel and colonization are becoming more than just realities. Minimal and haphazard designs are invalid and insulting, sarcastic and hypocritical. Design consequences and their implications are the very roots of environmental design planning. It is through research and experimentation of man's encompassing underlying dimensions, that we, as architects, will create optimal balanced environments.

Aerospace psychologists, physiologists and chemists concerned with lengthy space flights are advancing research in the field of man's behavioural performance in terms of establishing maximum and optimum channel capacities of sensory information input versus rate of output. This is of significance to architects.

> It is possible that critical situations in space flight may overload a man in space with the necessity of responding simultaneously to information from multiple dial readings, auditory signals, and other sensory input. As a result of this overload he might be unable to process information adequately, and a serious breakdown in performance might result. It is therefore important to know what are the maximum and optimum channel capacities of individual,

> what processes of adjustment do they use to compensate for information input overload, and if possible, what are the respective costs to a person of forced performance at various rates of information input, as well as the cost of the respective adjustment processes to overload.[6]

For the purpose of their study Aerospace psychologists selected five behaving systems: cell, organ, individual, group and social institution. These were then exposed to information input overload (sensory stresses). These living systems were selected on the basis that they fundamentally share comparable problems. They all exist in an environment based fundamentally upon the chemistry of water, they are exposed to pressures, temperatures, radiations and hydrations. They are composed of protoplasm (proteins and amino acids), and they are basically of the same genetic inheritance that existed in the original forms of life. The study revealed some interesting similarities and formal identities among them. The rate of information input and rate of information output was similar in all five levels. If the rate of information input in terms of "bits" per second is increased, the rate of output follows exactly as a linear function for a period of time. It eventually levels off when it reaches the channel capacity or maximum rate of output. This state may be maintained for a period of time even though the input rate increases. However, "as the input rate speeds up even faster, the output falls drastic-

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[6] James G. Miller, "Sensory Overloading", Symposium on Psychophysiological Aspects of Space Flight, Brooks Air Force Base, Texas, 1960 (New York: Columbia U. Press, 1961), p. 215.

ally, sometimes to zero. The system is "overloaded" and can no longer transmit information."[7]

An IOTA apparatus (Information Overload Testing Aid) was used to measure the channel capacity of various living systems. Some interesting results followed: man's information processing capacity is fairly low in comparison to that of a frog and a rat.

Frog's maximum channel capacity	=	4,000	bits per second
Rat's maximum channel capacity	=	50	bits per second
Man's maximum channel capacity	=	6	bits per second
Group (4 men) channel capacity	=	3	bits per second

This should be of some interest to architects, and designers for man's attention span is severely limited--usually to six discrete entities. That is man's maximum channel capacity.

> Designers sometimes act as if the bird's-eye view they have of a building from its plan is somehow transmitted to the users, and hence there is a need to make that plan look as neat and formal as possible. The mere fast of attention suggests that this is a spurious exercise as no user of the building can ever be aware at a given moment in time of all the aspects which make up the plan. At a more specific level, any designer using a coding system for identifying parts of his building or routes within it, which had more than six or seven elements should not be surprised if many of his building users are confused on their first attempts to use the code. [8]

Man's ability to be aware of the total environment at any

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[7] Ibid., p. 219.

[8] David Canter, Psychology for Architects (London: Applied Science Publishers Ltd., 1974), p. 41.

given point in time depends on his efficiency and channel capacity to process such stimulation. As this is generally limited to 6 bits per second, it is no wonder that man's awareness of his environment is constructed from bits and pieces that are selectively recorded. This is possibly a preventive measure to keep the central nervous system from being overloaded. On the other hand, when the nervous system is bombarded with excessive information input from a number of "sensory modalities such that the channel capacities of the central decision-making mechanisms of the nervous system are exceeded," the RS (reticular system) appears to limit input, by selectively filtering out excessive amounts of input that can cause stress to the system. This has traditionally been referred to as a central mechanism, called attention.[9] The reticular system plays an important part in controlling sensory overload. Its role is to respond and limit the quantity of input information (sensory stimulation) coming in through all the sensory pathways (nervous system).

Man, including other living systems, has developed some fundamental adjustment and defense mechanisms, against the stresses of information input overload. These appear to be the following:[10]

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[9] James G. Miller, "Sensory Overloading," Symposium on Psychophysiological Aspects of Space Flight, Brooks Air Force Base, Texas, 1960 (New York: Columbia U. Press, 1961), p. 221.

[10] Ibid., p. 222.

omission	- whenever there is extreme overload, information processing is stopped.
error	- processing incorrectly and then not making necessary adjustment.
queuing	- delaying responses during peak load periods, then catching up during lulls.
filtering	- systematic omission of certain categories of information relative to some sort of priority scheme.
approximation	- an output mechanism whereby a less precise or accurate response is given because there is no time to be precise.
multiple channels	- parallel transmission subsystems that can do comparable tasks at the same time and as a result can handle more information than a single channel can transmit alone.
decentralization	- is a special case of adjustment and defense mechanism.
escape	- leaving a situation entirely or taking any other steps that effectively cut off the flow of information.

It is of interest to know that once individuals and groups learn about all of the adjustment processes, they tended to use various ones as is shown below.

Rates of information input	Type used
Slow	non are used
Medium	all are attempted wherever possible
High	Filtering and omission
Very Rapid	Omission (approx. 98% of information transmitted into the system was omitted).

With the use of these mechanisms the human body is able to keep operating, although at a very low performance level due to the loss of input information transmission.

> Smogs, unpleasant odors, and other forms of environmental pollution, noise from street and air traffic, crowding and excessive stimuli are but a few among the common manifestations of modern life that are extremely objectionable when first experienced, then progressively escape conscious awareness. Few are the urban dwellers, even among the sensitive, who realize that they hardly ever experience fragrant air or a starry night. Most of us become oblivious to the filth, visual confusion, dirt, and outright ugliness that we encounter morning and night on our way to and from the office. [11]

There is a certain rate of information transmission at which the living system is most efficient, however the optimal strategy for utilizing the system is still under research. We know basically that the "comfort zone" of sensory stimulation rests in some dynamic threshold between sensory deprivation and sensory overload. These sensory polarities are in essence the threshold against which man operates. As architects, we must deal with the "sensitivity spectrum of this equilibrium," when placing new pieces of "architecture" in juxtaposition within relationship to the surroundings, in order to achieve "sensory compatible environments" that are alive and active.

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[11] Rene Dubos, <u>So Human An Animal</u> (New York: Charles Scribner's Sons, 1968), p. 157.

Sensory Handicapped:

Sensory Handicapped

To be able to design sensory environments, one must be sentient to individual differences and limitations. To lose contact with the outside world, to be isolated from other people, and to be uncertain about the integrity of the self is to be sensory handicapped. Yet most buildings designed by architects proceed as if everyone responds to them in more or less the same way.

> As we have seen, amongst the many users of a building some will have very frequent contact with it, others will visit it very rarely. Thus some will have the opportunity to find their way about it and to discover ways of dealing with any intricacies in it, whilst others will be coming to it fresh with little opportunity for having learnt about it. Many buildings, however, seem to be designed as if the users come to them with a standard set of reactions which remain throughout their contact with the building. [1]

Let us consider some of the bases of being sensory handicapped, for these differences and limitations may teach us what we have overlooked in our designs. It is difficult for those with normal capacities to understand the implications of being sensory handicapped. Imagine a city without sound, or a landscape without visual depth of field. The deaf and the blind learn to operate in such an isolated and detached environment by shifting

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[1] David Canter, Psychology for Architects (London: Applied Science Publishers Ltd., 1974), p. 6.

the roles of their remaining senses. Being impaired or deprived of a given sense limits man's homeostatic equilibrium with the environment. Myklebust further describes how a reduction in "perceptual reciprocation" results when there is a loss of information from a given sensory channel, since the specific sensory experience is interpreted on the basis of what has been learned from all sensory experience.

> A sensory deprivation limits the world of experience. It deprives the organism of some of the material resources from which the mind develops. Because total experience is reduced, there is an imposition on the balance and equilibrium of all psychological processes. When one type of sensation is lacking, it alters the integration and function of all of the others. Experience is now constituted differently; the world of perception, conception, imagination, and thought has an altered foundation, a new configuration. Such alteration occurs naturally and unknowingly, because unless the individual is organized and attuned differently, survival itself may be in jeopardy. [2]

When discussing sensory behavior it is common to consider the five basic senses as classified into two groups. Since "it is chiefly through the senses that man mediates between inner needs and external circumstances."[3] The close senses are olfaction, gustation and taction whereas the distance senses are hearing and vision. Both hearing and vision play a lead role in maintaining man's contact

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[2] Helmer Myklebust, The Psychology of Deafness. (New York: Grune and Stratton, Inc., 1971), p. 1.

[3] Ibid., pp. 46, 48.

with the external environment: vision being considered as directional, focusing only in front of a person, (foreground) and hearing encompassing all directions (background). When a person becomes deaf, the visual sense must take on a different role. It serves a dual role, fulfilling both foreground and background. When a person becomes blind, hearing becomes the lead sense. In both the deaf and the blind the close senses also shift their roles, becoming more supplementary and critical to the individual's needs and adjustment.

> Many people lose their sight after long years of seeing people, and places, and things. After learning to be relaxed with their blindness, they begin to pay attention to their remaining senses. Smells, sounds, and feelings call up images of the past, and they reconstruct the world as conscious dream visualizations. [4]

Figure 14, page 169 illustrates the shift in roles of the remaining senses when the "Sensory Handicapped" loses one or both distance senses.

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[4] Howard Broomfield, "A Vision of Blindness." (unpublished works, Simon Fraser University, 1974), p. 2.

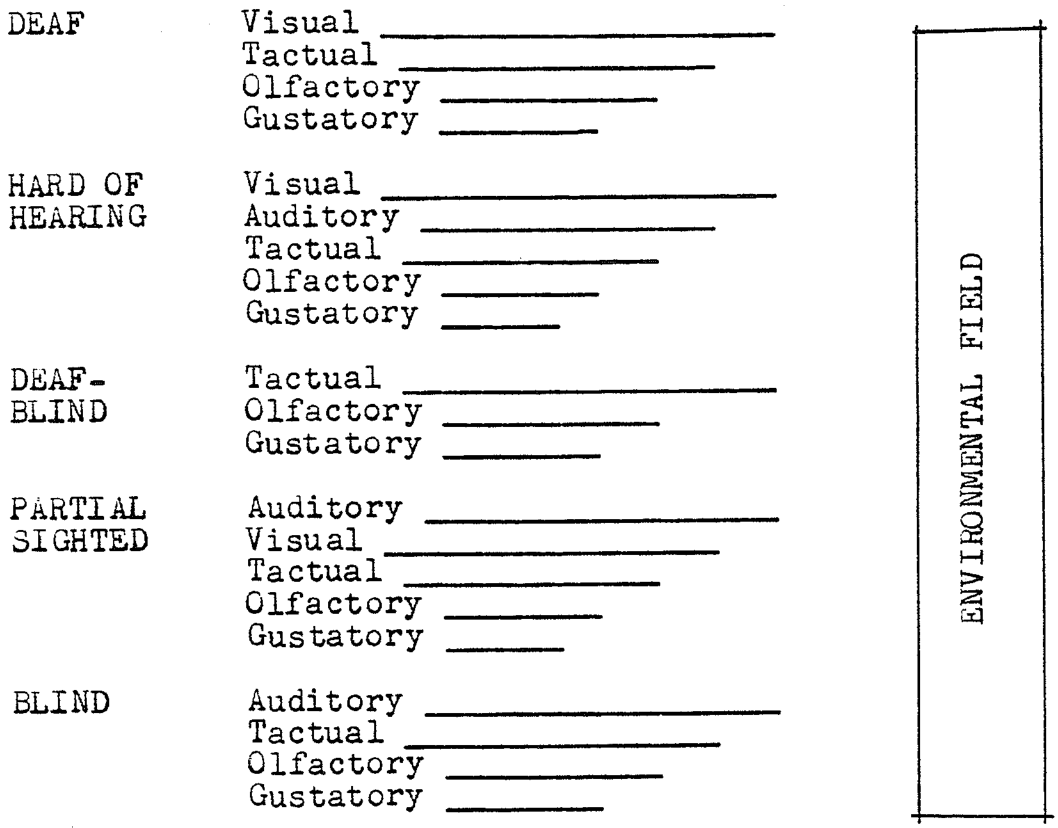

Figure 14. The hierarchy of sensory organization resulting when distance senses are impaired. 4a

[4a] Helmer Myklebust, The Psychology of Deafness (New York: Grune and Stratton, Inc., 1971), p. 51.

A closer look at the world in which the Deaf operate will lead us to a greater recognition that the small things in life, the essential bits that make us complete operative beings have either been abused or taken for granted and often ignored by production designers. The deaf are often misunderstood because their handicap is less obvious. They appear to have no physical limitations. Yet the psychological effects of sudden deafness (auditory deprivation) are more severe than visual deprivation caused by sudden blindness, to the blind.

> Deep depression resulted, characterized by undefined feelings of loss, lack of alertness, sadness, loneliness, and paranoid tendencies. The tension of perpetual silence created severe headaches in many. It was hard to grasp the passage of time and patients frequently fall asleep because life had few contrasts. [5]

It appears that sound provides an important link with life and the feeling of well-being. Man requires constant auditory contact with the outside world. Without sound the world seems dead, static and unchangeable, to the point where even "visual perception is different, less contrastful, less attention-demanding, and less informative--a fact discovered decades ago by the film industry when sound was added to silent movies."[6] Peter Knapp (1948)

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[5] Michael Southworth, "The Sonic Environment of Cities," Environment and Behavior, Vol. 1, No. 1 (June 1969), p. 51.

[6] Ibid., p. 52.

noticed deaf people experienced great anxiety in crowds or traffic because the scanning and alerting function of hearing was absent, thus limiting danger cues only to the visual field. According to Ramsdell, this basic signaling is a warning role of hearing which constantly keeps man in contact with the total environment and warns him of its stability and friendliness.[7] This function of hearing is developed early in life. "The deaf child learns through startling, frightening experiences early in life that environmental changes occur that cannot be monitored visually"[8] and because of such experience the child develops a unique dependence on the close senses. The shifting of the senses to the tactual sense thus provides vibratory contact with the surrounding space. If the child finds this to be uninformative then manual inspection, smelling and even tasting will follow. Again, the basic implication here is that when a distance sense is impaired, a shift in lead senses follows and a dependency on a close sense is established.

From this study of the Deaf we can draw some implications for architectural thinkers to utilize. We know that total absence of sound is psychologically unhealthy, yet, over stimulating sounds produce similar stressful conditions. "In many situations design of the

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[7] Hlemer Myklebust, The Psychology of Deafness (New York: Grune and Stratton, Inc., 1971), p. 46.

[8] Ibid., p. 52.

soundscape alone may be a way of making the city less stressful but more delightful and informative to its users.[9]" Sonic design by sonic planners is a possibility, however more extensive and controlled research is required; perhaps isolated urban micro-environments should be designated as experimental environments which would be most suited for public responses.

> ...sequences of sonically differentiated floor materials which squeak, rumble, squish, or pop when walked upon would be fun and could be used to provide interest or distraction in dull or ugly visual settings. Large animated sculptures which make sound when people move around them would also be attractive. [10]

The lead role of man's distance senses is vision, which is accompanied by hearing, while both interact when another under given conflicting circumstances. In architectural terms it sounds like this:

> A place which seems pleasing must do much more than appeal to the eye, a fact which designers often ignore. Spaces of a grand scale that have closet sounds, which are visually animated but sonically dead, or spatially attractive but saturated with noise, lack much for hearing people and could be better appreciated by the deaf. [11]

The world of the Blind is similar in some respects to the world of the Deaf, both use one of the remaining

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[9] Michael Southworth, "The Sonic Environment of Cities," Environment and Behavior. Vol. 1, No. 1 (June 1969), p. 65.

[10] Ibid., p. 68.

[11] Ibid., p. 52.

distance senses. For the Blind hearing becomes the important means of obtaining information from the environment. Because of necessity the Blind hear things which most sighted persons learn to ignore. Despite the attention the Blind may give to the sonic environment, their mental images of that environment are much more generalized than those constructed by the sighted, "for the sonic environment is less informative and the ear is far less effective than the eye in gathering information."[12] Research by E.T. Hall indicates that the Blind are restricted to a radius outdoors of 20 to 100 feet in gathering information. This of course depends on the type of information received.[13]

Use of sound is the chief way in which the blind judge spaces. The more responsive and informative it is the more they can personally interact with the man-environment. Communication is a simple example.

> In order for the blind...to express feeling with any degree of comfort, he must be quite aware of the manner, in which his communication is received. As the sighted person offers some indication of his emotions, he receives permission to proceed from the smiles, sympathetic faces, nods, etc. of his listener....The communicator must receive constant stimuli from the communicant in order to proceed with the communication. [14]

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[12] Ibid., p. 50.

[13] Edward T. Hall, The Hidden Dimension (New York: Doubleday & Company, Inc., 1969), p. 65.

[14] Louis S. Cholden, A Psychiatrist Works with Blindness (New York: American Foundation for the Blind, 1972), p. 36.

Since the blind experience limited sensory contact with the environment, such sonic involvement is necessary for their well-being.

Studies indicate that the Blind prefer some sounds to others, for example, generally they preferred sounds in the low to middle frequency and intensity, novel sounds, transparent nonrepetitive sounds such as the trickle of water, or the rustle of leaves in the wind, human voices, also informative and culturally approved sounds, such as birds and bells. Snow and rain also are welcomed by the blind for they "shrink the apparent sonic spaciousness of the city, eliminate many high frequencies, and make the city quieter."[15]

Less pleasing sounds usually lie within the high frequency (512+Hz) and higher intensity (90+db). They are most annoying because they are less informative and more attention-demanding. The worst sounds are those of the jack hammer and the siren for they are disorienting, since they cover a large territory of the soundscape.

> Sounds of moving cars and trucks particularly annoyed the auditory subjects.... These sounds are usually loud, close and uninformative, and also cover a large territory and have high masking effects. Unfortunately they invade most city experiences and blanket large districts from which there is little escape. [16]

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[15] Michael Southworth, "The Sonic Environment of Cities," Environment and Behavior. Vol. 1, No. 1 (June 1969), p. 58.

[16] *Ibid*., p. 60.

Unlike the Deaf, the Blind handicaps are physically obvious. Psychologically perhaps, not as traumatically effected but, like the Deaf, experience certain consequences once vision is impaired or deprived. According to Adams the newly Blind experience a number of losses.[17]

loss of mobility
loss of ability to communicate (reading and writing)
loss of immediate contact
loss of earning power and income
changes in personal relationships
loss of independence
increased loneliness
frustration and depression

Apparently congenitally blind suffer no "transitional problems" from the world of sight but do realize and learn to accept that there is a normal experience for others beyond their reach. For some, this becomes a reality when eye sight is restored in later life by operation. An interesting phenomena exists: when the sighted opens his eyelids, he takes for granted that he can see--objects, colors, distance, movement, etc.; when the newly sighted views the world for the first time, he is "barely able to recognize objects, far less to see them three-dimensionally."[18]

> When Roger found himself confronted for the first time with a landscape, he saw nothing but a confusion of forms and colours. 18a

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[17] G.R. Adams, "The Blind and the Partially Sighted," Designing for the Handicapped (edited by K.Bayes & S. Francklin), p. 47.

[18] Yi Fu Tuan, Topophilia (New Jersey: Prentice-Hall Inc., 1974), p. 7.

[18a] M. Von Sendon, Space and Sight. The perception of space and shape in the congenitally Blind Before and after Operation. (London: Methuen & Co. Ltd., 1960), p. 132.

Through time and experience they will learn to see as the sighted do, but first they must learn the significance of sight through the use of all their senses. They must touch objects to coordinate vision with feeling, reach out or walk through spaces to establish depth of field, and hopefully integrate intersensory control in some hierarchy of sensory organization.

To be sensory handicapped and relaxed with the handicap itself is to be inferior, subservient and out of the running, especially when surrounded and absorbed by an overbearing and domineering man-built environment. Since man first walked the earth, survival was one of his basic instincts. Survival of the weak, including the old, the sick and the disabled were all inevitably threatened. The dominent were primarily responsible for their protection, providing food and shelter. As man developed he became more educated and comfortable with his fire, tools, technology and progress. He also became detached from the sick, the weak and the handicapped, specializing in his own interest and development, creating environments of his own likes and images and ignoring the fact that the physically disabled, the mentally retarded, the synesthete, the blind and partially sighted, the deaf and hard of hearing and the elderly, must as the dominant, respond and interact with the built environment with the same efficiency yet with impaired senses.

> As the cycle of a person's life draws
> to its end, the sensory powers gradually

> desert the tired body like withered leaves shaken off a tree by the autumn winds. Eyes and ears become dim and weak, no longer capable of noticing the beauty of this world. But the world of the imagination--the shadow of the world of the sense--permits us to enjoy again all the beauty that was ever ours in life. 19

Perhaps it is difficult for some architects to withdraw from their own academia and allow themselves to develop empathy towards the handicapped. Possibly it is because the architect's clients are well fed, neatly dressed, medically fit, stable and without any noticeable sensory handicap. The architect's social life is composed of people who are active and alive, representing large corporations and syndicates, focusing on the future. Continued exposure to such clients suppresses the architect's reality of the real users of the architectural-man-built environment. The users of the environment are not all perfect specimens of mankind. They are all handicapped or impaired to some extent, experiencing some perceptual or conceptual side effects. It is normal for man to have a cold or fever, take medication, wear glasses or a hearing aid, and it is normal for him to be kinesthetically clumsy or mentally fatigued or depressed, yet generally this behaviour is not associated with sensory impairment or with being handicapped. Most architects accept or take for granted that the architecture created by their pen

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[19] W. Von Buddenbrock, The Senses (Toronto: Ambassador Books Ltd., 1958), p. 161.

will be experienced by healthy, normal users. Architecture in general should not be designed for "Spartan Users."

Unfortunately economic pro-formas do however influence what is built and architects seem to bend like weeping willow trees at their command. Even though the final judgment rests with the architect's own consciousness and the sense of right or wrong exists as a consequence, the handicapped are still threatened and are at a disadvantage when it comes to relating to man's inhuman progress with the environment.

The experiential reality of our environment must be predicated on our sensory involvement. Our ability to interact with it under various emotional and physical dimensions must stem from intersensory integration and stimulation. Limiting design to a specific sense, (such as vision) is nonsense. It is like designing for "architectural bird watchers," ignoring the common user, the one who seldom notices or understands architects and/or architecture.

Sensory Equilibrium:

Sensory Equilibrium:

Many architects understandably are expected to perform services in the shortest imaginable period of time. The constraints of design time and budget allowance, are predominant to the profession, leaving very little time for research exploration. Present architecture is seen as technologically efficient, sufficient, and attractive, at least from the architect's point of view. This contented and complacent attitude is very slowly but surely destroying the very sensitive dynamic environmental balance which the user biologically and socially responds with.

> Cities, dwellings, and the ways of life in them cannot be designed or imagined merely on the basis of available technology. Each decision concerning them must take into consideration not only human needs in the present but also long-range consequences. [1]

Man responds to a variety of sensory stimulation in a variety of ways, some of which are patterned and predictable. Perhaps a better knowledge of how man perceives and responds to his physical environment would help architectural designers to improve their ability to make better and effective predictions which are essential to man's achievement of "sensory equilibrium."

This chapter will attempt to construct a "Sensory Equilibrium Scale," depicting man's sensory boundaries

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[1] Rene Dubos, So Human an Animal (New York: Charles Scribner's Sons, 1968), p. 214.

with respect to the stimulus exerted by the natural and man-built environment. Refer to figure #16, page 185. Since "all men have always had the same sensory apparatus for perceiving changes in the qualities and dimensions of their environment,"[2] it must be possible to establish a mean range of sensory comfort by identifying and selecting the properties which produce positive response.

> Physical comfort cannot be mechanically equated with esthetic satisfaction, however. For while all human standards of beauty and ugliness stand ultimately upon a bedrock of material existence, the standards themselves vary astonishingly....All men have always had the same central nervous system for analyzing and responding to the stimuli thus perceived. Moreover, the physiological limits of this experience are absolute and intractable. Ultimately, physiology, and not culture, establishes the levels at which sensory stimuli become traumatic. [3]

Sensory equilibrium, psychosomatic equilibrium and optimal level of stimulation are all characteristic of reactions to extreme environments which produce overstimulation or understimulation. McReynolds (1956) expressed a similar idea in his concept of rate of perceptualization, "monotonous conditions provide too low a rate, with boredom, excessive stimulation produces too high a rate, with disruptive excitement; the <u>optimal rate yields the</u>

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[2] James M. Fitch, *American Building 2: The Environmental Forces That Shape It* (Boston: Houghton Mifflin Company, 1972), p. 14.

[3] *Ibid.*

experience of pleasure.[4]"

Leuba (1955), who has developed the concept of optimal stimulation and who used it in resolving some of the problems of learning theory states, "that there is an optimal level of stimulation, subject to variations at different times, and that learning is associated with movement toward this optimal level, downward when stimulation is too high and upward when it is too low.[5]"

What is apparent in the above findings is that a fluctuation exists within the boundaries of sensory equilibrium or "sensory comfort." It is a "dynamic zone" between sensory overload and sensory deprivation, between what is experienced as pleasant and what is experienced as unpleasant. We know that sensory overstimulation or understimulation can cause abnormalities in feeling states, perceptual distortions and deterioration of the ability to think.

> In each of these conditions, sensory deprivation and sensory overload, there is a circumstance which upsets the balance of the regulating system, namely the ARAS. When this happens persistently, perception is disrupted, attention gives way to distractability, and interest to boredom. Behavioral performance is either held in abeyance or becomes highly stereotyped and not adaptive. [6]

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[4] Robert W. White, "Excerpts from Motivation Reconsidered: The Concept of Competence," Environmental Psychology: Men and His Physical Setting. ed. H.M. Proshansky, W.H. Ittelson, L.G. Rivlin, (New York: Holt, Rinehart & Winston, Inc. 1970), p. 126.

[5] Ibid.

[6] Philip Solomon and Philip E. Kubzansky, Sensory Deprivation (Cambridge: Harvard University Press 1961), p. 177.

Within the context of recent surveys of anatomy and physiology, the role of the ascending reticular activating system (ARAS) suggests its function is a regulating mechanism: "because of its strategic location at the crossroads for incoming and outgoing messages and its apparent ability to sample all such activity and to develop from it a more lasting influence in a form of alerting and attention, the reticular system appears to provide a common mechanism for the foregoing sensory conditions and their effects."[7] If we conceive of the ARAS as controlling and monitoring both input and output information to the point of maintaining stimulation satisfaction, we then must recognize the importance a multiplicity of environmental stimuli has on maintaining psychological development and health in human beings.

> ...a changing sensory environment seems essential for human beings. Without it, the brain ceases to function in an adequate way, and abnormalities of behavior develop. In fact...variety is not the spice of life: it is the very stuff of it. [8]

Sensory variety plays an important role in achieving sensory equilibrium both in the physical and social environment. Since man seems to require diversified stimulation in order to maintain psychosomatic equilibrium, man's sensory threshold in response to stimulus in his natural and man-built

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[7] Philip Solomon and Philip E. Kubzansky, Sensory Deprivation (Cambridge: Harvard University Press 1961), p. 175.

[8] James M. Fitch, American Building 2: The Environmental Forces That Shape It (Boston: Houghton Mifflin Company 1972), p. 14.

environment is <u>physiologically quantitative</u>. That is, all men are affected by a particular stimuli (e.g. heat, cold or noise) in a similar way and respond in a similar pattern. Man's sensory modalities are designed to certain physiological tolerances. Refer to figure #15, page 184, (<u>Physiological Sensory Range Scale</u>) and to earlier chapters on sensory modalities.

Physiological tolerances are basic in man, yet are often ill conceived or abused by designers and architects. Stressful or comfortable environments are often the result of accidental design.

Sensory variety is often predicated on the function of time and arousal capacity, since "constant exposure to a steady stimulation at some fixed level will ultimately deaden the capacity to perceive it,"[9] hence the need for variable stimuli.

Sensory modalities are particularly sensitive to change and have a tendency to vary with individuals, depending on their adaptation level. The observations of McClelland (1953) suggest:

> ...affective arousal occurs when a stimulus pattern produces a discrepancy from the existing adaptation level. Small discrepancies produce <u>pleasant</u> affect and a tendency to approach; large ones produce <u>unpleasantness</u> and a tendency toward avoidance. The child at play...needs frequent <u>novelty</u> in the stimulus field in order to keep up his interest-in order to maintain

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[9] <u>Ibid</u>.

Sensory Modalities	Minimal	Optimal	Maximal
Auditory	16 cps 0 db.	250-4000 cps 50-70 db.	20,000 cps 120 db.
Visual	800 angstrom units	5500 angstrom units	7200 angstrom units
Olfactory	1/1,000,000 of one milligram of vanillin in 1 liter of air	meaningful odor variation	adaptation: constant exposure
Tactile	passive contact	cutaneous variations	active contact
Gustatory	chemical sensitization	appropriate variety	cognitive symbolization
Kinesthetic	passive	individual requirements	active

Figure 15. Physiological Sensory Range Scale (Sensory Modalities)

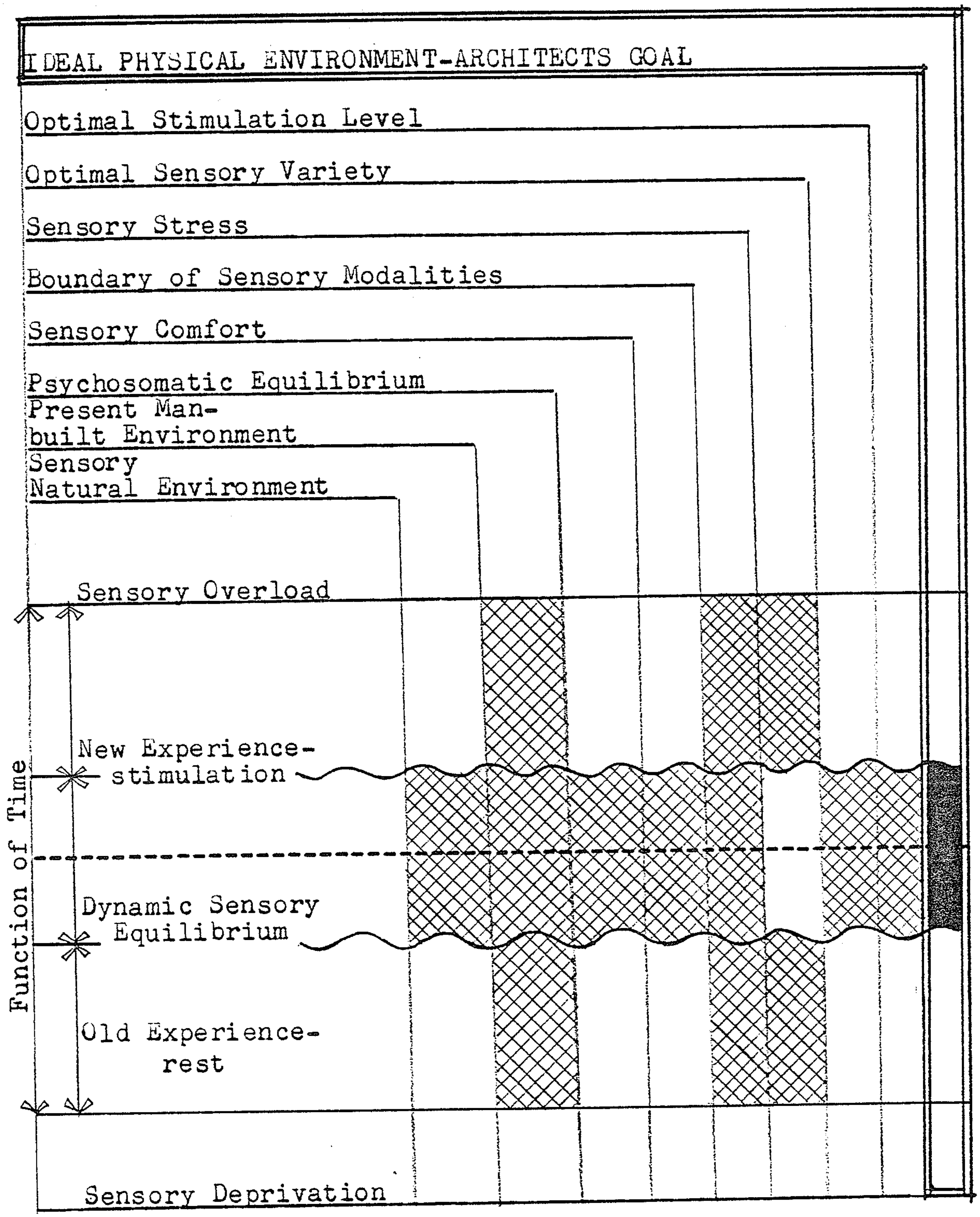

Figure 16. Sensory Equilibrium Scale.

pleasant discrepancies from whatever adaptation level he has reached. [10]

The need for novelty or new experiences on the one hand is often dependent on the boredom and monotony experienced from familiarity or old experiences on the other hand. The tendency to vary behavior rather than to repeat it is an inescapable fact of human behavior. Only recently has attention been given to developing a scale or index to measure the need for variety. This hopefully will help quantify the construct of "optimal stimulation level"--the need for extremes of sensations, such as: new, unfamiliar, irregularity, enjoyment of danger and thrill seeking. Refer to Figure #17, page 187, Sensory Variety Index Figure.

The Change Seeker Index, CST by Garlington and Shimota, (1964) and the Sensation Seeking Scale, SSS by Zuckerman, Kolin, Price and Zoob (1964) are two such developmental studies. Related studies, tentatively labeled Sociability, Cognitive Complexity, Thrill Seeking, Worry, and Vigor by the U.S. Navy still remain unpublished.[11]

Studies on "sensory variety" and "optimal stimulation level" seem to be camouflaged under secrecy, similar to early studies on brain washing (forceful indoctrination and behavior alteration) conducted at McGill University by

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[10] Robert W. White, "Excerpts from Motivation Reconsidered: The Concept of Competence," Environmental Psychology: Men and His Physical Setting. ed. H.M. Proshansky, W.H. Ittelson, L.G. Rivlin, (New York: Holt, Rinehart & Winston, Inc. 1970), p. 126.

[11] John P. Zubek, Sensory Deprivation: Fifteen Years of Research (New York: Appleton-Century-Crofts 1969), pp. 319-22.

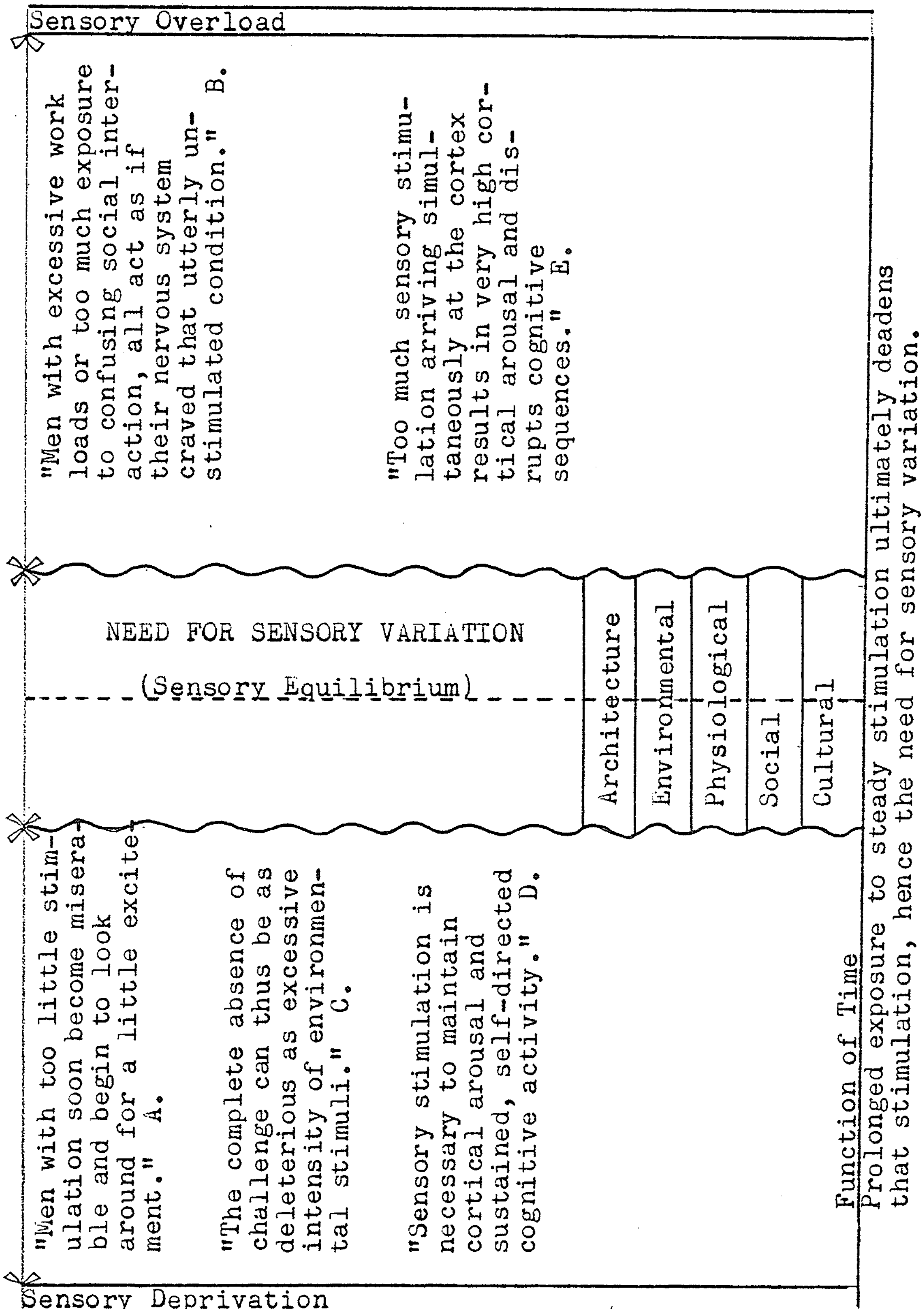

Figure #17. Sensory Variety Index

A & B.- Robert W. White, "Excerpts from Motivation Reconsidered: The Concept of Competence," Environmental Psychology: Men and His Physical Setting ed. H.M. Proshansky, W.H. Ittelson, L.G. Rivlin, (New York: Holt, Rinehart and Winston, Inc. 1970), p. 126.

C. - Rene Dubos, So Human an Animal (New York: Charles Scribner's Sons, 1968), p. 271.

D & E.- John P. Zubek, Sensory Deprivation: Fifteen Years of Research (New York: Appleton-Century-Crofts 1969), p. 431.

Dr. Hebb (1951-54). They were disguised as sensory deprivation studies.[12] Whatever the motives behind the secrecy, we as humans do recognize and experience the basic need for "sensory variety" on a daily basis.

> We may seek rest and minimal stimulation at the end of the day, but that is not what we are looking for the next morning. Even when its primary needs are satisfied and its homeostatic chores are done, an organism is alive, active and up to something. 13

Hopefully the architectural experiental reality of "optimal stimulation level" will be achieved, once the "sensitivity spectrum" of "sensory equilibrium" is understood and put into practice. Given the freedom of choice of any man-built environment designed within the "physiological sensory threshold", man will continue to enhance his humanness, his dignity, and his freedom of being a fulfilled individual.

> We must strive instead to create as many diversified environments as possible. Richness and diversity of physical and social environments constitute an essential criteria of functionalism, whether in the planning of cities, the design of dwellings, or the management of individual life. 14

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[12] Philip Solomon and Philip E. Kubzansky, "Woodburn, Heron, Cognitive and Physiological Effects of Perceptual Isolation," Sensory Deprivation (Cambridge: Harvard University Press 1961), p. 6.

[13] Robert W. White, "Excerpts from Motivation Reconsidered: The Concept of Competence," Environmental Psychology: Men and His Physical Setting. ed. H.M. Proshansky, W.H. Ittelson, L.G. Rivlin, (New York: Holt, Rinehart and Winston, Inc. 1970), p. 127.

[14] Rene Dubos, So Human an Animal (New York: Charles Scribner's Sons, 1968), p. 175.

Sensory Stress:

It seems contradictory that just by the nature of its soundscape, a pleasant visual environment can elicit the uncomfortable feelings of fatigue and stress. On the other hand, noxious smelling rooms filled with cigarette smoke, cigar butts, filthy old beer stained carpets, illuminated by poor and arbitrary lighting, (such as found in most "Pubs") can produce pleasant and unstressful feelings. Such non visual environments attract people on the basis of other sensory stimulations. Beer and beer-nuts are known to excite one's gustatory sense and the vibrations of a live band will stimulate the auditory sense of even the hard of hearing.

Through experience we have found that prolonged exposure to any man-built environment will eventually deaden the novel feeling of the stimulation, causing man to become tired and bored with it to the point where he eventually learns to ignore it or to adapt to it:

> Such adaptability is obviously an asset for survival and seems to assure the continued biological success of the human race. Paradoxically, however, the very fact that man readily achieves biological and sociocultural adjustments to so many different kinds of stress and undesirable conditions is dangerous for his welfare and his future. [15]

The significant element of adaptation appears to be the acceptance of this discomfort or stress without any willing-

[15] Ibid., p. 94.

ness to act to change the situation, until physical and mental health are affected. Man's ability to conceal the impatience, irritation and hostile feelings generated by the physical environment are potentially dangerous to his emotional health since accumulated tensions and emotional stresses destroy the dynamic threshold of sensory equilibrium. Too much or too little environmental stimuli will produce stress. Over crowding can be as deleterious as the lack of human contact, such as experienced in solitary confinement. Extreme situations of sensory overloading will result in the need for sensory underloading (the need for privacy, withdrawal or sleep) and too much sensory deprivation will develop a craving for sensory stimulation. Former prisoners who have served long sentences in prison have experienced some of these affects:

> they found it impossible to sleep during the first week following release because they revelled too much in hearing, seeing, tasting and feeling....The noise on Market Street distressed me, and besides, my eyes pained. They were so unused to see rapidly moving vehicles and so many strange faces.
>
> The world was strange and a little frightening; the traffic roared and pounced, the colors of women's dresses, flowers, and neon signs jabbed the nerves of my eyes, and music had a rich, new texture as tangible as fur or silk. I wake at dawn, and began to long for bed at dinner time. 16

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[16] Robert Sommer, Tight Spaces-Hard Architecture and How to Humanize It (Englewood Cliffs, New Jersey: Prentice-Hall, Inc. 1974), p. 33.

It appears that "Biological man requires a dynamic environmental balance, a golden mean between extremes"[17] of Sensory deprivation and sensory overload.

Sensory Comfort:

> People want architecture which is warm and comforting to the senses, architecture which is pleasant to live with, which caters for man as he is and not for man as an abstraction, architecture which is seen to be appropriate to its purpose, bearing in mind the habitual attitudes and responses of people who have been brought up in a living society, not processed in a laboratory. [18]

The ideal sensory environment tends to be one in which man is physiologically and psychologically comfortable, one which enables him to carry out his daily activities in an easy and satisfying way. Such pleasurable environments experienced in their duality however are rarely predictable and controllable, especially in physical, social, cultural and aesthetic terms, since they do not lend themselves to scientific quantification. They are still highly subjective and socially conditioned. The gap of quantification is becoming more measurable with the increased knowledge of what human beings biologically require and culturally desire. New physical environments are being designed, constructed, and changed by man on the basis of a continual-

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[17] James M. Fitch, American Building 2: The Environmental Forces That Shape It (Boston: Houghton Mifflin Company 1972), p. 18.

[18] Bruce Allsopp, Towards a Humane Architecture (Great Britain: Frederick Muller Limited, 1974), p. 4.

ly evolving scientific technology where scientists of all persuasions are being asked to reexamine the physical world that they have in part created. The concern with solving problems of a man-built environment has increasingly led to the more fundamental question of why did it happen and what can be done to prevent new problems from developing. What has emerged is an emphasis on predicting and understanding the consequences of the physical environment for the behavior of the individual, and this emphasis in turn has called attention to the social scientist, one who can interface systems of psychology with engineering knowledge.

Although man is capable of adapting to second-rate environments, it is often at the cost of blunted sensitivities, as we see in the following passage by Rene Dubos:

> Millions upon millions of human beings are so well adjusted to the urban and industrial environment that they no longer mind the stench of automobile exhausts, or the ugliness generated by the urban sprawl; they regard it as normal to be trapped in automobile traffic, to spend much of a sunny afternoon on concrete highways among the dreariness of anonymous and amorphous streams of motor cars. Life in the modern city has become a symbol of the fact that man can become adapted to starless skies, treeless avenues, shapeless buildings, tasteless bread, joyless celebrations, spiritless pleasures--to a life without reverence for the past, love for the present, or hope for the future. [19]

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[19] Rene Dubos, So Human an Animal (New York: Charles Scribner's Sons, 1968), p. 279.

It appears that man's feelings are affected directly by his physical environment, as studies on the effects of physical environment on people's judgement by Maslow and Mintz (1956) have revealed.[20] Destructive environments confine, depress, irritate and denigrate human aspirations. They destroy the sensitive person's emotional balance, whereby feelings of pleasure and pain become less sensory discriminating. Emotional value judgements on what is beautiful or ugly, comfortable or uncomfortable, repugnant or curious, become obscure when conditioning occurs, as environmental stimuli have excitatory as well as inhibitory effects.

To achieve a harmonious accord with nature and the man-built environment, all environmental forces must be held within comfortable physiological tolerances, (sensory stimulation which is neither too great nor too little for the body as a whole). Sensory equilibrium--sensory comfort is summarized by Richard Neutra in the following way:

> ...the human organism reacts as a whole and responds to the environment as a fused totality, in which any one stimulus is hardly separable from the rest. Design is perceived and specifically planned not as a sum of design elements or of separate stimuli but as an integration of such stimuli. At the same time, recognition of this fact and of the great need for skilled integration should not deter us from analytical exploration as far as the current state of information permits.[21]

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[20] Geoffrey Broadbent, Design in Architecture (New York: John Wiley & Sons 1973), p. 160.

[21] Richard J. Neutra, Survival Through Design (New York: Oxford University Press 1954), p. 335.

Synthesis:

The lessons of this research lead the author to ask "Have architects lost their senses?" Are they remaining cognizant of their potential in the use of sensory modalities in the design process? What essence of creativity is missing in the aspiration of creating a humane architecture? Sir Henry Wotton once stated that buildings must possess three conditions, commodity, firmness and delight--as evidence that architectural creativity is cross-cultural in nature.[1] It appears that the conditions of commodity and firmness have been resolved but that the condition of delight is still languorous.

In many situations, design of the nonvisual factors (such as the soundscape environment) appears to be the least emphasized among the decision-making priorities. Admittedly, visual conception of the actual environment does not readily lend itself to olfactory images. The visual use of texture and of tactile-oriented materials are much more easily applied to experienced feelings.

The human eyes perceive, but they do not directly feel--they are more abstract receptors than those of the other senses. The blind are well aware of the immense potential available through the integrated use of all the non-visual senses.

Visual architecture conceived as an isolate can

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[1] H. Wotton, (1624), <u>The Elements of Architecture Collected from the Best Sources and Examples</u> (London: Reprinted Gregg Press, 1969).

never be experienced as intended. Design must employ complementary sensory modality to be truly successful. Each modality must reinforce the complementary modalities. The human appraisal of the environment is predicated on this integration of sensory modalities.

To encourage healthy responses by the users of designed space, the architect must understand deletion, preservation or the encouragement of certain sensory stimuli. Architects must think of people as individuals, not as groups, classes or corporations. They must contrive to give people what is sensorially stimulating and informative within the spectrum of dynamic sensory equilibrium.

> The designer will be most useful to his consumership if he does not let himself be side-tracked into reduced sub-human, merely sensory aesthetics. To aim at mere impressionism is by no means normal. On the contrary, it is abnormal and artificial to relegate oneself to a sort of primary perceptual abstraction. It takes self-denying exercise to do it. To be all eye for light and color and bring them onto the canvas was just such an abstraction and was, for a time, a wonderfully refreshing theory. The common man never went along with it, in spite of its superb accomplishments. It may be dangerous to let such interesting indulgence in sophisticated primitivism lead us astray. It cannot do so for any length of time. Nature cannot be overcome. [2]

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[2] Richard Neutra, Survival Through Design (New York: Oxford University Press, 1954), p. 245.

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