SPATIAL COMPLEXITY AS A FACTOR IN THE EXPERIENCE OF TIME DURATION

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(ABSTRACT)

The purpose of the study is to set forth a framework for the research of spatio-environmental factors on the experience of time duration. A literature survey considers the nature of the experience of time as well as the research that has been carried out on different factors in the experience of time duration. The survey also considers different categories of the spatio-environmental realm and how the realm is experienced through the sensory system. Particular attention is directed in the primary hypothesis toward the possible influence of the spatio-environmental factor of complexity, especially visual complexity. Exploratory testing of complexity used 24 college students performing duration estimates with the Production method viewing scale models of different complexity of wall surface and pattern.

A secondary aspect of the study is to find support for the possible application of the primary hypothesis to the field of architecture. One undesirable experience of time duration, boredom, is studied in greater detail. Literature support is found for the relationship between boredom and decreased sense input, with decreased perceived visual complexity an example of decreased sense input. The susceptibility of the elderly to decreased sense input is considered, pointing to a possible increased susceptibility of the elderly to certain types of boredom. The scale model testing was modified with a glass screen to simulate decreased visual input, and the relationship between decreased visual input and duration estimation was analyzed for support of the secondary hypothesis. Tests for both hypotheses failed to provide confirmation but offer helpful guidance for future tests.

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TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

TABLES

FIGURES

CHAPTER I

INTRODUCTION

RESEARCH QUESTION

Research on the experience of time duration has been conducted for a number of years. However, not enough has been undertaken on the impact of spatio-environmental factors on the experience of time. Studies of duration estimation have mainly focused on physiological and psychological factors. One exception was a significant set of studies on spatio-environmental factors undertaken by Alton DeLong. He demonstrated that the length of duration estimates is positively correlated to linear spatial scale (DeLong, 1981). This leads to the primary question of this study: Is there a possible significant role of other spatio-environmental factors such as complexity in the experience of time? A secondary question considers the potential application to the field of architecture: Does decreased perceived spatial complexity contribute to the experience of boredom among the elderly, a growing sector of the population who undergo a deterioration of their senses?

PURPOSE OF STUDY

The main purpose of this exploratory study is to set forth a framework for the research of spatio-environmental factors on the experience of time duration. A literature survey is used to study the nature of the experience of time as well as to distill the research that has been carried out on the experience of time duration. The survey also considers the spatio-environmental realm in terms of potential categories for study, the nature of the experience of the realm through the sensory system, as well as noting some research on the experience of different categories of the realm. In addition, an exploratory experiment was conducted to test the primary hypothesis that increases in spatial complexity result in shorter judgments of subjective time (in this experiment shorter judgment implies estimating longer intervals in the Production method - see definition of terms on p. 5). The dependent variable was time as measured by duration estimations and the independent variable was the change in complexity of an interior model of a room. For the exploratory experiment, complexity was narrowed to visual complexity. Rapoport and Kantor support this choice, claiming "again the findings firmly supported the idea that humans prefer complexity in their visual environment" (Rapoport and Kantor, 1967). Increased complexity involved increases in the number of spatial changes in the room surfaces, and, at a finer level, the introduction of patterns on the wall surfaces.

A secondary purpose is to establish support for a secondary hypothesis that boredom among the elderly is increased by decreased perceived spatial complexity due to the deterioration of their senses. Support is established through a literature review of boredom, decreased sense input, the elderly, and the links between them. Further support was sought from the exploratory experiment used in the primary hypothesis by modifying the experiment to consider the effect of perceived visual complexity, a form of sense input. The duration estimates used for the primary hypothesis were analyzed to determine whether a finer level of increased spatial complexity would fail to result in shorter judgments of subjective time (in this experiment shorter judgment implies estimating longer intervals in the Production method - see chart of terms on p. 7) among those subjects with decreased acuity. The dependent variable was time and the independent variables were the same complexity factors as with the primary hypothesis plus acuity as controlled by the type of glass through which the subjects viewed the model.

LIMITATIONS

The scope of the primary hypothesis and the secondary hypothesis are such that definitive findings cannot be established from this study. Favorable results from the tests would have provided greater confidence in reaching conclusions about the primary hypothesis since it is narrower than the secondary hypothesis. Even so, the tests of the primary hypothesis do not measure the impact of such factors as the scale of the models or the activity of the subjects during testing. A battery of tests would be required to reach more definitive conclusions, and suggestions for these are included in the conclusion section of this thesis. In terms of the secondary hypothesis a larger battery of tests would be required for support because additional factors such as acuity are introduced, and because several links must be established in the hypothesis. Since the test results from neither of the hypotheses could produce authoritative results, offering definitive guidelines for design would be presumptuous. However, possible design implications are raised for both hypotheses in the conclusion section for the purpose of suggesting future research.

SIGNIFICANCE OF STUDY

For the research community this study offers data for factors that have received limited attention in the area of duration estimation studies, along with suggestions for further research. A larger framework, the secondary hypothesis, is also suggested for research consideration. For the building design community, the study provides no immediate authoritative answers. However, if the hypotheses eventually find adequate support through research, guidelines concerning the complexity of building designs might be established in accordance with the demographics of the users of the projects. Directing attention to secondary hypothesis stems in part from the trend toward significant increases in the elderly population in the United States. By 1990 about 12% of the population will be over 65 years of age. That may increase to 18% by 2030. In addition, the number of the frail elderly are increasing at a faster rate than other groups of elderly (Urban Land Institute, 1983, pp. 3-4,8). That group is even more susceptible to the effects of sensory deterioration.

DEFINITIONS

Spatial Complexity. In this study "spatial complexity" refers to the types of complexity that are shaped or controlled by the built environment. "Spatial complexity" is related to the fuller term "spatio-environmental complexity" also used in the text which refers not only to intricacy of design but also to richness of sensory stimuli.

Experience of Time Duration. The expression refers to the subjective impression of the length of time that has elapsed between two specified events (Poppel, 1978). The experience of time duration is measured through duration estimation.

Duration Estimation. Obtaining an estimate of the elapsed time and comparing it to an objective standard such as a clock.

Methods of Obtaining Duration Estimates. Five basic methods of soliciting duration estimates are: 1) the Verbal Estimation method which involves receiving a verbal guess of time passed, 2) the Paired Comparison method which requires the subject to select which of a pair of intervals was the longest. It is also known as Just Noticeable Differences, Limits, Minimal Causes, Serial Exploration, Constant Stimuli, Constant Stimuli Differences, Right & Wrong Causes and Frequency, 3) the Reproduction method which calls for the subject to reproduce a given interval. Other names include Average Error, Equation, Adjustment, Production (an unfortunate source of confusion) and Successive Time Estimation, 4) the Production method which involves signalling when the subject thinks a given time interval has been reached, and 5) Chronometry, an additional method that involves the use of a measuring instrument. Combinations of these methods include Absolute Judgment, Single Stimuli, Limits-Verbal method, Rating Verbal method and Present-and-Past Time Estimation. In normal situations the method of Chronometry is used when a duration estimate is requested if possible. Reproduction and Production are used for short intervals (Doob, 1971, pp. 17-19, 25-26, 153). Allan distinguishes between duration scaling tasks (e.g. Verbal Estimation) and duration discrimination tasks (e.g. Paired Comparison) (Allan, 1983).

Over- and Underestimation. The use of the terms over- and underestimation in the study of duration estimation has produced a great deal of confusion. The confusion stems from the fact that the terms are meaningless unless related to a particular method of obtaining duration estimates. This connection is, unfortunately, often lacking in the literature on the subject. The result is a significant difficulty in comparing studies. In response to the problem, Doob developed a chart to aid the intersubjectivity and communication of the research. An abbreviated version of the chart is presented on page 7. Doob also distinguishes between primary and secondary judgment. Primary judgment refers to the immediate, spontaneous measure while secondary judgment applies to the reconsideration based on experience or the use of an objective standard (Doob, 1971, pp. 17-29, 33-46).

Table 1.

DURATION ESTIMATION METHODS AND TERMS

1. Timing	ACCELERATE	ACCELERATE	DECELERATE	ACCELERATE	DECELERATE	DECELERATE
2. Method	Comparison, Reproduction	Verbal (elapsed)	Production	Production	Verbal (elapsed)	Comparison, Reproduction
3. Primary judgment	II > I; II=I		adequate	adequate		II < I; II=I
a) length		long			short	
b) anticipation, hope		longer shorter			shorter, longer	
c) speed		slow fast			fast slow	
4. Objective time	II ≤ I; II < I	less	more	less	more	II ≥ I; II > I
5. Secondary or external judgment						
a) Subjective time	longer	longer	shorter	longer	shorter	shorter
b) Objective time						
i. length or subjective units	shorter	shorter	longer	shorter	longer	longer
ii. speed	slower	slower	faster	slower	faster	faster
c) Conclusion	OVER-ESTIMATE	OVER-ESTIMATE	OVER-ESTIMATE	UNDER-ESTIMATE	UNDER-ESTIMATE	UNDER-ESTIMATE

Doob, Leonard. *Patterning of Time*. New Haven: Yale Univ. Press, 1971, p. 42.

CHAPTER II

LITERATURE REVIEW - PRIMARY HYPOTHESIS

TIME

The primary hypothesis of the study is that increases in spatial complexity result in shorter judgments of subjective time. The literature review on the primary hypothesis first considers the experience of time. A study of the history of philosophical thought on the subject is used to gain an understanding of the nature of the experience. The different experiential factors are considered with reference to the research that has been carried out for each factor. Factors other than spatio-environmental ones are considered to help future researchers, particularly by enabling them to indentify possible linking or influencing factors.

Philosophical Framework

> "Time travels in divers paces with divers persons.
> I'll tell you who Time ambles withal, who Time trots
> withal, who Time gallops withal, and who he stands withal."
>
> Shakespeare, As You Like It
> Act III, Scene II

In history the concept of time has been dealt with by a number of able minds. Plato's (428-347 B.C.) basic philosophy centered around the element of time. He viewed forms as eternal and absolute while particular objects were temporary and changeable, thus existing in the realm of time. Time was linked to being and change (Fraser, 1981, pp. 10-12). Aristotle (384-322 B.C.) defined time as the "number of motion in respect of 'before' and 'after'", thus tying it to motion and change. On the other hand, he excluded the connection with the motion of being. He viewed the measure of time as directional (related to motion) as well as durational (Fraser, 1981, pp. 12-15). The ancient Chinese brought together the concepts of space and time and related them to motion. Their expression for the universe, "yu-chou", essentially means space-time (Fraser, 1981, pp. 92-101). Augustine (353-430 A.D.) wrote a short but very insightful passage about time in his Confessions. In considering what it is we measure when we measure time, he replied, "It is in you, O my mind, that I measure time. I do not measure the things themselves whose passage produced the impress, it is the impress that I measure when I measure time. Thus either that is what time is, or I am not measuring time at all" (Fraser, 1981, p. 357). His ideas about subjective measurement of time are still respected today as seen by the similar views currently held by some researchers (Poppel, 1978).

John Locke (1632-1704) asserted that our idea of time includes the concept of succession and duration. He also asserted that our ideas come from either reflection or sensation. Succession relates to the reflection of the appearance of several ideas one after the other in our mind. Duration concerns the reflection on the distance between any part of the succession (Fraser, 1981, pp. 15-17). Isaac Newton, (1642-1727), unlike Locke, claimed the existence of absolute time while still recognizing relative time. Absolute time is independent of anything external while relative time is sensible, with its measure gained through the study of motion (Fraser, 1981, pp. 17-19). The philosopher Immanuel Kant (1724-1804) argued that we cannot consider phenomena as outside of time. He viewed time as a form of intuition entrenched in our minds so that we must see things as temporal just as someone with red glasses must see things as red (Fraser, 1981, pp. 21-23). The philosopher Henri Bergson (1859-1941) considered two different frameworks for perceiving time: linear (continuous and indivisible flow) versus spatial (atomic and divisible) (Cottle, 1976, pp. 10-17). One of the most comprehensive analyses of time ever made was by the philosopher Samuel Alexander (1859-1938). He asserted that "space is in its very nature temporal and time spatial". One way that he used to explain the relationship was that time is the mind of space and space the body of time. This analogy between body-mind and space-time relates to the spatial quality of the body and the fact that time is recognized through mental processes (Fraser, 1981, pp. 25-29).

More recently, the psychologist Herbert Woodrow (1951) claimed that time is not actually a thing that can be perceived in the same way an apple can be perceived (Poppel, 1978). The philosopher Martin Heidegger (1961) argued that our experience of the flow of time has a deeper base in the mental constitution of man. Both "physical" time used by science and "inborn" psychological time are inferred conceptual systems that relate to the "matters of being". On the other hand, the phenomenal world of man is concerned with the "matters in hand".

Duration estimation, part of the phenomenal world, would then relate to gauging progress toward one's aims (von Fieandt & Moustgaard, 1977, p. 444). The psychologist Robert Ornstein asserted that "real" time does not exist, but rather that even our clock time is simply a convention (Ornstein, 1969, pp. 25-36). The anthropologist Edward T. Hall viewed time as an unspoken language that communicates more clearly than words (Hall, 1959, p. 23). In addition, he observed that the clock is a cultural extension. Extensions are a kind of tool that not only aid in work but also separate people from their work. Since extensions tend to become confused with the reality they replace, they take on a life of their own (Hall, 1983, pp. 119-121). He developed a map of time and divided it into 8 categories: biological time (cycles), personal time (experiential), physical time (astronomical), metaphysical time, micro time (culture specific), sync time, sacred time (mythic, not in ordinary time), profane time (calendar and clock), and meta time (abstract) (Hall, 1983, pp. 13-26). The psychologist Thomas Cottle asserted that time gives meaning to private experience and public behavior (Cottle, 1976, p. 7).

Experiential Factors - General

A number of different factors have been investigated in terms of their influence on the experience of time. Most studies have focused on physiological and psychological factors because of the research orientation of psychology and similar disciplines. Research on spatio-environmental factors has received little attention. The design and construction fields, which are involved with these factors, are only slightly involved in non-technical research. This decreases the opportunity for a body of studies on the influence of spatio-environmental factors on the experience of time.

Spatio-Environmental Factors

Few studies of spatio-environmental factors have been carried out, with many potential factors open for further investigation. The research by DeLong on spatial scale has been significant and points to the reasonableness of further testing. Earlier research on the effect of travel distance produced less definite but still supportive results.

Spatial Scale. The most significant research on the influence of spatio-environmental factors on the experience of time has been carried out by DeLong. He tested the effect of linear (as opposed to volumetric) spatial scale on duration estimation and found an almost direct relationship between the compression of spatial scale and the compression of duration estimations. DeLong also considers the scale modifying properties of light as a possible factor in the experience of time. Sound may sometimes have the characteristic of being a temporal cuing device and as such should be controlled when studying other factors (DeLong, 1981).

Travel Distance. Another spatio-environmental factor that has received research attention is travel distance. The observed influences have been labeled the tau-effect (the distance will seem longer which is marked by a longer interval of travel time) and the kappa-effect (of two equidistant parts of a journey, that part which is travelled at a slower pace will seem longer). Though these relationships have statistical backing, not every subject followed that pattern (Cohen, Cooper & Ono, 1963).

Physiological Factors

Physiological factors received much of the early attention in time duration studies. One factor of particular interest to the secondary hypothesis is the effect of age. Much of the research on these factors has produced equivocal results.

Photoperiodism and Celestial Orientation. Photoperiodism was discovered by Garner and Allard (1920) who noticed the effect of the length of day on plant flowering. Later, other seasonal behaviors related to the length of day were considered including the autumn behavior of deciduous trees, some insect behavior, formation of winter pelt in animals and sexual behavior in many animals. Some research findings indicate that in some cases the length of the dark period is more important than the length of day. Celestial orientation and time sense has been demonstrated for bees and migratory birds (Fraser, 1981, pp. 281-295).

Biological Clock. Studies of the possible nature of the biological clock have focused on circadian (daily) rhythms. Plants and animals have exhibited rhythmic behavior even when placed in darkness for a period of time (Fraser, 1981, pp. 281-295). Human subjects were tested by the Fraisse group. They were placed in caves or shelter chambers for a period of weeks and kept records of their activities. Their estimation of "real" time was quite accurate, with errors in the 10-20% range. One of the subjects who had been inside for almost 6 months, however, recorded a 48 hour rhythm with a mid-day siesta that was as long as a normal night's sleep (von Fieandt and Moustgaard, 1977, p. 449). Some studies of internal clocks have focused on the ability of subjects to estimate time after being awakened from sleep or to spontaneously wake up at a specified time. Though ability varied between subjects, some studies have shown a noticeable degree of accuracy (Fraisse, 1963, pp. 43-47).

Age. Of special interest to the thesis are those studies on the effects of aging on duration estimation. One study of subjects from 6-87 years of age indicated differences in duration estimation based on age. Responses increased in magnitude with age for children and adolescents but were more varied among the adult subjects (Verrillo, 1982). Many studies focused on children and point to their relative inaccuracy, though this has been shown to be partially correctable through training (Fraisse, 1963, pp. 236-244). Fewer studies have included the elderly among the subjects. Accuracy was found to decrease among the elderly in a few studies (Doob, 1971, pp. 270-272).

One study in 1957 compared elderly World War I veterans (mean age - 67) to young Korean War veterans (mean age - 24) and found that the elderly group produced the shorter intervals (slower speed) for intervals of 30 and 300 seconds. Time was passing more slowly for them (Feifel, 1957). Another study of the impact of age on time experience compared 185 subjects from 10-90 years of age and measured both time orientation and duration estimation accuracy. For the estimation of 60 seconds by the production method the elderly showed decreased accuracy (comparable to the youngest subjects) and judged time as moving at a slower speed (LeBlanc, 1969).

Sex. Another key characteristic that has been studied frequently is the impact of the sex of the subject on duration estimation. Some authors have pointed to a greater accuracy for short intervals among men (von Fieandt & Moustgaard, 1977, p. 453). However, a number of American and foreign studies have found no differences (Doob, 1971, pp. 209-210).

Body Temperature. Two well known, independent studies by Francois (1927) and Hoagland (1933, 1935) indicated that changes in body temperature might have an important influence on the experience of time. Subjects with higher body temperature (e.g. because of fever) experienced time passing more slowly (von Fieandt & Moustgaard, 1977, pp. 446-447). More careful studies by Bell and Provins failed to confirm the hypothesis (Bell & Provins, 1963). Ornstein argued that even if such factors exist, they are not very useful in understanding time experience (Ornstein, 1969, pp. 32-35).

Physical Stress. Buchwald studied the effects of physical stress tasks in combination with some psychological factors. He found that the subjects significantly underestimated physical stress tasks for durations of 180 and 540 seconds (Buchwald, 1972).

Drugs. A number of studies have been carried out on the effect of drugs on the experience of time. Some support the hypothesis that stimulants and anti-depressants slow the speed of time while depressants and tranquilizers have the opposite effect. Results have been found for different drugs including LSD, marijuana, opium, alcohol and caffeine, though the results have sometimes been conflicting (Doob, 1971, pp. 312-316). Frankenhaeuser (1958, 1959, 1962, 1966) carried out a number of experiments with different drugs and found fairly similar results in terms of depressants and stimulants (von Fieandt & Moustgaard, 1977, pp. 455-457).

Mental Illness. A common symptom among mentally ill patients is a disturbance in the normal sense of time (Feifel, 1957). In connection to that, Fraisse conducted a study of mentally ill patients who were "temporally disoriented" in terms of calendar time and found that the patients still were able to estimate the time of day within 60 minutes (Fraisse, 1963, pp. 41-42).

Psychological Models

Several psychological models for duration judgment have been developed, including the storage size model, the processing effort model and the change model. In connection with the three models is the concept that filled intervals seem longer than empty intervals when retrospectively compared to each other. This has been labeled the filled-duration illusion (Thomas & Brown, 1974).

Storage Size Model. The storage size model focuses on the number and memorability (e.g. ease or difficulty of recalling a word) of items, often relating subsequent recall or recognition of the items to the estimates of duration. The tests usually were of relatively short intervals. Block (1974), Poynter (1979), Mulligan and Schiffman (1979) and Ornstein (1969) found support for this model (Poynter & Homa, 1983).

Processing Effort Model. The processing effort model relates duration estimation to the time required to process information. Tasks of different difficulty were given to the subjects. A difference has been found between short and long (greater than 10 seconds) intervals; longer intervals produced a sense of faster speed among those activities that required more processing. Investigation of this model was carried on by Avant et al (1975), Thomas and Weaver (1975), Burnside (1971), Hicks et al (1976) and Vroon (1970) (Poynter & Homa, 1983).

Change Model. The change model views the overall amount of change in cognitive context. Some studies that varied the way items were processed indicated estimate differences even though the processing effort was the same and the storage size model would have predicted opposite results. Fraisse (1963), Block and Reed (1978), Craik and Tulving (1975) and Poynter (1983) researched this model (Poynter & Homa, 1983).

Psychological Factors

Recent research into the experience of time has focused more on psychological factors than on physiological factors. Psychological factors have to be considered in the study of spatio-environmental factors. For example, variations in psychological stress tasks could affect the imagining task involved in estimating spatial scale, and variation in goals could affect the estimates of travel time.

Psychological Stress. A study on the effect of psychological stress tasks of 180 and 540 seconds indicate that they are related to an overestimation of time, while physical stress tasks had the opposite effect (Buchwald, 1972).

Goals. Goals may also have also been found to have an impact on time experience. In one study pleasant goals led to greater overestimation while unpleasant goals showed significantly less overestimation (Buchwald, 1972). In another study some subjects were given the opportunity to be relieved of uninteresting tasks while other subjects were not given the chance. Those with high motivation perceived time inversely to their rate of progress while those with low motivation showed no relationship between perceived time and rate of progress (Meade, 1956).

Attention. Research has also been carried out on the influence of attitude, and in particular, attention. Those intervals in which attention was focused appeared to be longer according to studies by Quasebarth (1924) and Woodrow (1933). During moments of extreme concentration the sense of time can be obliterated (Hall, 1983, pp. 126-127). Hart supports that hypothesis in her study of airline pilots. As workload increased time estimation was more frequently done retrospectively until it reached a point where the estimation task was forgotten altogther (Hart, 1978). This relates to Piaget's concept of perceptual centration in which he claimed a tendency for overestimation of the stimulus on which attention is focused in comparison to peripheral stimuli. In duration estimation this involves overestimating the intervals on which we center our attention (Fraisse, 1963, pp. 145-147). Hall has been intrigued by examples he has encountered of time compression and time expansion. Time often seems to compress in survival situations. This is recognized in the familiar phrase, "My whole life flashed before my eyes." The detail required to describe a few seconds of emergency action is sometimes amazing. On the other hand, time can seem to compress in large size tasks such as learning to land an airplane (Hall, 1983, pp. 125-126, 130-131).

Culture. Hall claims that culture is a factor in the experience of time. He asserts that some cultures experience polychrochronic time, carrying on simultaneous activities. Other cultures (e.g. the United States and Europe) experience monochronic time, focusing on one activity at a time. He hypothesizes that the experience of monochronic time by these cultures may be related to their love of clocks, which provide the standards for sensing the "flying" and "crawling" of time (Hall, 1983, pp. 41-54, 119). Little research has been carried out to test the effect of culture on duration estimation.

Personality. One personality trait that has been frequently studied is introversion-extroversion. The results have not been consistent, but extroverts tend to estimate intervals as being shorter than introverts (Doob, 1971, pp. 257-258; Buchwald, 1972; Pardes, 1965). Anxiety is another trait that has been often researched, though with conflicting results (Doob, 1971, p. 258). Individuals have carried out research on a number of other assorted traits such as dominance of parents (Doob, 1971, pp. 258-260).

Intelligence. Intelligence as a factor has received a bit of attention. Some studies have found a positive correlation between intelligence and accuracy for intervals under one minute but other studies failed to find such a correlation (Doob, 1971, pp. 255-257).

SPATIO-ENVIRONMENTAL REALM

The second component of the literature review on the primary hypothesis involves the consideration of the spatio-environmental realm. The purpose is to begin to identify other spatio-environmental factors and how they are experienced. Different categorization systems are considered with special attention on the system developed by Thiel since it is geared toward environment-behavior research which is closely allied to the field of architectural design.

Categorization

A variety of descriptive categorization systems of space and the environment have been set forth. Their differences reflect a variety in purpose and focus among those assembling or developing the systems.

Designers have their own language of space. One study collected a list of such terms and from a subgroup of the terms found that these descriptions were often good predictors of behavior (Collins, 1970).

Fitch, a respected Professor of Architecture at Columbia University, developed a set of categories for the physical environment. He tied these categories in with man's metabolic mechanism, perceptual systems and skeletal-muscular systems in order to argue for experiential bases for esthetic decisions. The categories for the physical environment include: thermal (radiant and ambient), atmospheric (temperature, humidity, movement, composition and pressure), aqueous (gaseous, fluid, and solid), luminous, sonic, world of objects (organic and inorganic), and spatio-gravitational (Fitch, 1972, p. 7).

Gibson approached the categorization as a psychologist considering the perceptual system. One set of descriptors focuses on the surface layout. Terms included surface medium, ground, open environment, enclosure, objects, place, as well as subcategories of those in a geometrical framework (Gibson, 1979, pp. 33-36). Another set of descriptors he used concerns affordances (i.e. what the environment affords man and animals). The divisions included the medium (e.g. air), substances, surfaces and their layouts, objects, other persons and animals, and places or hiding places (Gibson, 1979, pp. 127-137).

Olson and Bialystok approached the matter as psychologists interested in cognition. They studied the set of spatial terms in the English language. Several properties kept reappearing. The terms assumed a point of reference, were organized around a particular dimension, and come in contrasting pairs. Examples include: here/there (where), up/down (vertical), right/left (horizontal), front/back (frontal), long/short (length), far/near (distance), tall/short (height), wide/narrow (width), deep/shallow (depth) and thick/thin (thickness) (Olson & Bialystok, 1983, pp. 47-48).

Thiel established a system to act as an observational tool for environment-behavior researchers. He recognized a set of parameters including the subject, the physical environment, multilevel experience, space, furnishings, the presence of humanity, and motion. He then defined a set of motions and orientations, as well as a set of distance zones and scale of views. Notations were set up for space-establishing elements and their relationship, degree of explicitness, degree of enclosure, form quality, proportion, position, space connections, illumination, illumination modulation and scale (texture). Size was also recognized as a spatial factor (Thiel, 1970).

Experience Through the Senses

The spatio-environmental categories are not simply abstract but must be experienced through the senses. Fitch argues that the perceptual framework must be seen in relationship to the metabolic mechanisms. Before considering perception, the metabolic requirements must be met. He breaks down the metabolic mechanisms into three systems: the skin, the respiratory system and the digestive system. Fitch divides the perceptual system into categories and relates each to their contact with the physical environment. He further groups those systems according to their particular spatial focuses: the visual, auditory and olfactory systems are related to the middle and far environment, the tactile and gustatory systems to the near environment, and the proprioceptive system to the spatio-gravitational environment (Fitch, 1972, pp. 6-11).

Visual System. The visual system provides about 90% of all the data received for a normal adult, a great imbalance in relation to data received through the other senses. It should be recognized that the visual understanding would have been impossible without the tactile and kinesthetic experience in the developing years of the individual. The habitats (i.e. the special conditions required for operation) of the visual system are wavelength, intensity and space. Interaction with the physical environment include the atmospheric (composition), aqueous, luminous, sonic, and world of objects. The principal function of the system is to "grab and not be grabbed", as Hans Blumenfeld claimed, not just to enjoy beauty. As a process, vision is very complex, involving physical, physiological and psychological phenomena. Generators/transmitters (light sources) interact with modifiers and retransmitters (natural and man-made objects of mediums), which are interfaced through receivers/encoders (eyes) and finally made intelligible through a decoder/interpreter (brain). Though the system operates over wide ranges, it chiefly was designed for middle and far vision, with a normal eye focusing from 15 feet to infinity. In addition, the system uses scanning (up to 10 times per second) to absorb a lot of information. Stress will result if the luminous environment offers too little or too much light intensity or contrast. Some investigators believe that visual fatigue can occur, perhaps in the muscles that control convergence and accommodation (Fitch, 1972, pp. 183-120).

Auditory System. The auditory system operates in a habitat of wavelength frequencies and energy input (decibels), reverberation period, and time. It interacts with the sonic and spatio-gravitational environments. The primary purpose of the system is not hearing but listening, a task critical in nature. The range of intensities sensible to the system is in the order of ten trillion times between the audible and painful ends. However, the system classifies the sounds into seven degrees of loudness and seven pitches. The system has no means of protection as the visual does, but individuals can listen selectively at a cost of fatigue. Noise pollution can lead to the gradual degeneration of the system. In terms of the sonic environment, sound attributes include period, frequency, wavelength and amplitude. The behaviors of sound in spaces include reflection, refraction, reverberation and resonance (Fitch, 1972, pp. 7, 131-139, 152-157).

Tactile System. The tactile system handles a range of information. One category is tactile information such as smooth/rough, blunt/sharp or wet/dry. Another is pressure information including hard/soft, elastic/plastic or pressure/suction. A third type is spatio-tactile information such as shape, volume, dimension or size. Haptic-muscular information considers weight and mass. One more class is thermal information dealing with heat/cold. The habitat of the system varies according to the information type: unperceptible to painful, too hot to too cold, gentle to crushing or soft to pricking, among others. Some properties have no zones of stress. The tactile system interfaces, obviously, with the world of objects. The system is indispensible for gaining information since we first learn about the environment through it. A range of neural sensors in the skin and muscles work in combination to allow the system to inform us (Fitch, 1972, pp. 7, 172-174).

Proprioceptive System. The proprioceptive system interacts with the spatio-gravitational environment, along with the skeletal-muscular system (not a perceptual system). The function of the prorioceptive system is to orient and discriminate movement (Fitch, 1982). Different kinds of movement are registered by the body: body framework movement through articular kinesthesis, skull movement through vestibular kinesthesis, movement of the skin against an object through cutaneous kinesthesis, and perspective transformations of the view through visual kinesthesis. Kinesthesis is different from the other systems in that it provides information without really being sensory (Gibson, 1966, p. 111).

Olfactory and Gustatory Systems. Two other systems are the olfactory and gustatory. The habitat of olfactory system includes the mixes of odors, their intensity and time. It interfaces with the atmospheric and aqueous environments and the world of objects. The problem is that messages of the system, particularly in terms of danger, are not always clear. Men do not depend on the system as much as many animal species do. The value of it for man is more experiential. Still, it possesses amazing sensitivity of great range.

For a substance to be perceived through the system it must be at least partially volatile to be supported by the atmosphere, and also soluble to penetrate the watery film over the mucous membrane of the nose (Fitch, 1972, pp. 7, 71-80). The gustatory system, of least interest to this study, interacts with the aqueous environment and world of objects (Fitch, 1972, p. 7).

Complexity and Other Categories

The experience of the spatio-environmental realm has received little research attention. One key set of references to this study are those supplied by Rapoport and Kantor on complexity. These references point strongly to the effect of complexity, including visual complexity, on our experience. Other factors for study are listed.

Complexity. One set of factors that seems potentially significant are the complexity, ambiguity and familiarity of the spatio-environmental realm. Rapoport and Kantor related various psychological studies to the field of design and concluded that complexity and ambiguity are desirable and preferred features. Complexity involves both spatial and temporal changes. A mixture of familiarity and novelty is also preferred. They also point to the support of Hall, Parr, Platt and Fitch in that conclusion. A body of psychological studies indicate that humans prefer complex visual environments to simple ones. In a study of 617 college studies, researchers found that people prefer a certain degree of ambiguity, a degree that they can cope with, and that the degree can increase. There seems to be an optimal perceptual rate. In another study, researchers suggested that a consensual point of visual preference for the rate of information input exists, though the significance of it is questionable. Rapoport and Kantor suggested some design aspects to consider, including allowing greater freedom of change in the environment and providing unspecialized settings for change of use. They pointed to some designers who have considered ambiguity including Venturi and Van Eyck (Rapoport & Kantor, 1967).

Quality. Quality is another factor that has been considered. Maslow and Mintz measured the effect of "beautiful", "average", and "ugly" rooms on subjects' assessment of the energy and well-being of faces in photographs. A significant difference was found in a positive direction (Maslow & Mintz, 1956).

Others. Besides the factors of scale, light, sound and distance referred to previously in connection with time, other spatio-environmental factors should also be recognized. Considering Thiel's system of categorization these would include texture, enclosure, objects, size, connections, color and proportion (Thiel, 1970).

SUMMARY

The study of spatial complexity and the experience of time requires a closer analysis of the spatio-environmental realm and time. Time has received significant attention over the centuries. Different factors have been considered in terms of their influence on the experience of time duration. These can be broken down into three categories: spatio-environmental, physiological and psychological. The spatio-environmental has been categorized in different ways depending on the purpose and focus of those developing or assembling the systems. The realm is experienced through the senses, and the different sense systems have been discussed. Research on some of the categories is discussed and other categories from Thiel's system are listed as a source for further study. See the summary of research on pages 30-32.

Table 2

RESEARCH ON TIME

Spatio-Environmental Factors	
Spatial Scale	DeLong (1981)
Travel Distance	Cohen, Cooper & Ono (1963)
Physiological Factors	
Photoperiodism	Fraser (1981) Garner & Allard (1920)
Biological Clock	von Fieandt & Moustgaard (1977) Fraisse (1963) Fraser (1981)
Age	Feifel (1957) Fraisse (1963) LeBlanc (1969) Verillo (1982)
Sex	Doob (1971) von Fieandt & Moustgaard (1977)
Body Temperature	Bell & Provins (1963) Francois (1927) Hoagland (1933, 1935)
Physical Stress	Buchwald (1972)
Drugs	Doob (1971) Frankenhaeuser (1958, 1959, 1962, 1966)
Mental Illness	Fraisse (1963)

Table 2 (continued)

Psychological Models	
Storage Size	Block (1974) Mulligan & Schiffman (1979) Ornstein (1969) Poynter (1979)
Processing Effort	Avant et al (1975) Burnside (1971) Hicks et al (1976) Thomas & Weaver (1975) Vroon (1970)
Change	Block & Reed (1978) Craik & Tulving (1975) Fraisse (1963) Poynter (1978)
Psychological Factors	
Psychological Stress	Buchwald (1972)
Goals	Buchwald (1972) Meade (1956)
Attention	Hall (1983) Hart (1978) Quasebarth (1924) Woodrow (1933)
Culture	Hall (1983)
Personality	Buchwald (1972) Doob (1971) Pardes (1965)
Intelligence	Doob (1971)

Table 3

RESEARCH ON SPACE

<u>Categorization</u>	Collins (1970) Fitch (1972) Gibson (1979) Olson & Bialystok (1983) Thiel (1970)
<u>Sense Systems</u>	
Visual	Fitch (1972)
Auditory	Fitch (1972)
Tactile	Fitch (1972)
Proprioceptive	Fitch (1972)
Olfactory & Gustatory	Fitch (1972)
<u>Categories of Spatio-Environmental Realm</u>	
Complexity	Rapoport & Kantor (1967)
Ambiguity	Rapoport & Kantor (1967)
Familiarity	Rapoport & Kantor (1967)
Quality	Maslow & Mintz (1956)
Scale	DeLong (1981)
Light	DeLong (1981) Thiel (1970)
Sound	DeLong (1981)
Travel Distance	Cohen, Cooper & Ono (1963) Thiel (1970)
Texture	Thiel (1970)
Enclosure	Thiel (1970)
Objects	Thiel (1970)
Size	Thiel (1970)
Connections	Thiel (1970)
Color	Thiel (1970)
Proportion	Thiel (1970)

CHAPTER III

LITERATURE REVIEW - SECONDARY HYPOTHESIS

The literature review for this section considers support for the secondary hypothesis which involves a three step argument. The first step is that boredom is related to the experience of time. Secondly, decreased sense input is linked as a source of boredom. Finally, the elderly are investigated as a group that is very susceptible to decreased sense input. The purpose of the linkage is to investigate a potentially significant application of the study of time duration. The application involves an experience of time, boredom, that is generally viewed as a problem. Boredom is then linked to the field of building design through the connection of boredom with decreased sense input. The elderly are singled out not only because of their susceptibility to decreased sense input but because of their large and growing numbers.

BOREDOM RELATED TO EXPERIENCE OF TIME

Definition of Boredom

The first step in considering boredom is to seek a definition of the term and to identify its types. The type of boredom of interest to this study can then be identified.

Boredom is a poorly defined scientific concept (O'Hanlon, 1980). Webster's Second Edition defines "to bore" as "to weary by tedious iteration or by dullness...", but does not indicate its source. Parallel terms in other languages and predecessors to the eighteenth century term include ennui, Langweile, spleen, melancholy and acedia (Esman, 1979). Two general categories have been recognized. The first is described as situational or transient and seems to be a reaction to external situations. This type appears to be an almost universal experience. A number of studies have focused on this type, especially in relation to industrial monotony (Turner, 1983). The duration tends to be relatively short and is highly responsive to external change (O'Hanlon, 1981). One study demonstrated that situational boredom is influenced noticeably by the arousal level, the constraint on the subject, the monotony or repetitiveness of the task and the unpleasantness of the task (Geiwitz, 1966). The other type is chronic boredom in which the state prevails in an individual most of the time. The cause seems to be more internal and its effects of longer duration (Turner, 1983). Since the design field can influence only the external factors, this study will focus on situational boredom.

Undesirability of Boredom

The study of boredom is not of significant interest unless it can be identified as a problem. The weight of the opinion of respected researchers, the findings of surveys and studies, and the study of language are considered to support the contention that boredom is a problem.

Selye, who has carried out more studies on stress than any other researcher, links sensory deprivation and boredom to stress. He ties it into a General Adaptation Syndrome concept which involves the nonspecific response of the body to any demand. In the case of boredom, effort would be required to adapt to the situation. He labels boredom as a pathogen and sees man as being made for work (Selye, 1976, pp. 55, 385-386). Lawton ties in boredom with the concept of environmental press which relates the demands of the environment to the competence of the individual. He views the direction toward increasing boredom as a source of anxiety and disorganization (Lawton, 1980, pp. 11-13). Hall points out that when time seems to drag, the external clock and the body clock are out of sync. He claims that "time dragging is a synonym for not having a good time." In addition, he asserts that when the gap is too wide, the strain of bringing the external clock and the body clock together makes people less happy and productive (Hall, 1983, p. 121). In a set of individual interviews of over 100 people of diverse backgrounds, the most frequent words used to describe boredom were negative - "restless", "hostile", "tired", "tense", "angry", "frustrated", "longing", "semi-conscious" and "miserable". The same researcher found that some employees who had been moved to a less stimulating environment complained of greater boredom and were found to be less productive than before even though their task had not changed. Those who had desks facing the wall seemed to be even more adversely affected (Brown, 1980, pp. 78-82, 97). In a couple of studies of confined situations, boredom was found to be one of the most annoying factors (Smith, 1969). Even without reference to the support of researchers, the undesirability of boredom is intuitively sensible. A common colloquial expression is to be "bored to death". A survey of literary sources over the ages also confirms this. Shakespeare, for example, substituted the term "weary" for a broad range of boredom (Healy, 1984, pp. 15-40).

Boredom and the Experience of Time

A crucial link in the secondary hypothesis is the connection between boredom and the experience of time. The opinion of researchers and findings of studies are analyzed to determine if support exists for the linkage and the degree to which the findings clarify the linkage.

The assertion that boredom is linked to the experiences of time has strong support. DeLong opened an article by flatly asserting that "the experience of time and temporal duration is central to mood, feeling and emotional states" (DeLong, 1981). Turner affirms that there is no question that the sense of time is disrupted during boredom. Research literature contains many articles supporting the link between boredom and the experience of time including Fraisse (1963), Hamilton (1981), Hartocollis (1976), Leckart and Weinberger (1980) and Wangh (1975) (Turner, 1983, pp. 2, 49). There have been indications that increased stimulation from the external world causes the objective time to seem to move faster (Feifel, 1957). Poppel referred to the sense of dragging time during boredom (Poppel, 1978). Brown found that in a set of interviews of over 100 people of diverse backgounds, one of the most frequent descriptions of boredom was "time goes by slowly" (Brown, 1980, p. 97). Doob speculates that boredom may in part involve a discrepancy between primary duration estimates (felt) and secondary (objective) in that time moves slower than desired (Doob, 1971, pp. 167-172). The trouble researchers have encountered is that experimental evidence is somewhat equivocal. Axel (1924) found that reduced task complexity made time seem to pass more slowly. Gullikson (1927) observed that resting people have the same experience. Loehlin (1959) concluded that boredom is a partial determinant in duration estimation. Others have found a U-shaped distribution with some overestimating and others underestimating duration (Pardes, 1965, pp. 9-11).

DECREASED SENSE INPUT LINKED TO BOREDOM

Even if boredom is found to be a problem, connections must be found with the experience of the spatio-environmental realm for boredom to be a concern for environment-behavior research. One link that has received significant direct and indirect attention is the relationship between decreased sense input and boredom. Much research has been carried out on different degrees of sensory deprivation, with this study interested in the less extreme cases.

Selye asserts that "a decrease in sensory input below the normal level is a common cause of boredom." As examples he included monotonous mass-production work and separation of infants from their mothers (Selye, 1976, p. 386). Fitch considered a spectrum of stress in which both ends are unhealthy. Too little stimulation hinders the full exercise of our critical facilities, and he linked boredom with the understimulation end of the stress spectrum (Fitch, 1972, pp. 12-14).

Lawton and Nahemow's model of environmental press also indicates that minimal interaction with the environment would lead to boredom. Lawton refers to Helson's adaptation-level theory (1964) that people normally adapt over time to non-intense stimulation so that their conscious awareness of it almost disappears. Lawton also asserted that with enough of a drop in environmental press, boredom would result (Lawton, 1980, p. 12-13). Rapoport and Kantor consider the range of perceptual input, with one end being sensory deprivation which they relate to monotony. Referring to the work of McReynolds and Kessen-Munsinger they claim that stimuli which is too simple leads to boredom (Rapoport & Kantor, 1967). Heron argues that a changing sensory environment is a basic need of humans. Without it, the brain may stop functioning properly and behavioral abnormalities may develop (Heron, 1957). Schultz also suggests that there is a need or drive for sensory stimulation and labels it "sensoristasis". He relates it to the concept of homeostasis (maintenance of internal equilibrium developed by Cannon) (Schultz, 1955). Brown contends that "when boredom occurs there is generally an unmet need for a change in sensory stimulation" (Brown, 1980, p. 102). Studies of situations where groups were confined indicated that monotonous situations over time spur a desire for change to relieve boredom. The authors recorded these observations of boredom in a survey of research on sensory deprivation (Smith, 1969). Orme notes that sensory deprivation does not require a long time to occur but can be produced, to some extent, in half an hour (Orme, 1969, p. 66). Studer notes that most analyses of environmental stimulus assume the need for greater stimulation. He asserts, however, that the question is "not how can stimuli be arranged to stimulate, but how can stimuli be arranged to bring about a requisite state of behavioral affairs" (Studer, 1970).

ELDERLY DECREASE IN SENSORY INPUT

The elderly are one group that is especially susceptible to decreased sensory input. Sensory motor deficits, with their inherent sensory loss, have been seen to increase with age. These losses with their long term mixture and often acute effects cause elderly people to experience a form of sensory deprivation (Breines, 1981, p. 128). Lawton noted this reduction in competency in dealing with the environment. One study of deterioration among nursing home residents found, in order of frequency (65-11%): impaired mobility, senility, impaired vision, agitation or nervousness, depression, arthritis, heart trouble, impaired hearing, impaired speech, diabetes, and paralysis due to stroke (Lawton, 1980, pp. 14-15, 110). Sensory deprivation among the elderly has received increasing attention among such groups as geriatric nurses (Burnside, 1976, p. 380). Different types of sensory loss have been investigated by researchers.

Lens. A gradual accumulation of inert tissue forms at the center of the crystalline lens. The lens also becomes less transparent as the nuclei and cell membranes of the old fibers compress, lose water and shrink. In addition, the thickness and size of the lens increases with age, and the capsule becomes thicker and less permeable. As a result of deterioration in the lens, the transmission and refraction of light are affected with a resulting increase in the absolute threshold for vision. While transparency for the entire visible spectrum of light is affected, opacity occurs even more strongly in shorter wavelengths. The quantity and spectral quality of light are altered because of this yellowing of the lens. The ability to match color reduces with age. The ability to discriminate blue and green is poorer than for red and yellow at all ages, and the declines occur faster for blue and green (Corso, 1971).

Pupil and Retina. Besides the lens, the pupil is also affected. The size of it reduces with age, further reducing the quantity of light reaching the retina. The amount of light reaching the retina has been shown to decrease linearly from 20-60 years. Visual acuity deteriorates at an accelerated rate after about 50 years. Some speculation is that loss in acuity is more likely due to the changes in the crystalline lens and the vitreous humor rather than retinal degeneration (Corso, 1971).

Accommodation. Accommodation, the ability to alter focal length, is reduced in amplitude as the cortex of the lens forms a smaller fraction of the total lens volume. The decreases occur steadily until 60 years and then usually stops. Presbyopia is arbitrarily assumed to occur when the amplitude reduces to a particular size (Corso, 1971).

Other Visual Problems. Dark adaptation has been shown to decrease with age, although the effect on rate of adaptation is not clear (Corso, 1971). Additional problems of the elderly include "misty eyes" (tearing), acute glare problems and wear from fluorescent flicker characterized by tearing, headaches, and general inattentiveness (Hiatt, 1978).

Auditory. The auditory senses also experience deterioration with age. Presbycusis, the loss of auditory acuity due to age apart from factors such as disease and noise exposure, has been measured in a number of studies. Men tend to suffer greater losses than women. The loss of sensitivity has been attributed to four kinds of presbycusis: sensory, neural, metabolic and mechanical. The elderly also have reduced speech discrimination, with younger people having 9-20% better range in one study. The loss was greater than would be expected from audiograms. Difficulty is increased if speech is accelerated. Discrimination is hardest for those components with highest frequencies. Noisy environments further hinder the task. The elderly have a decreased capacity for short-term auditory retention (Corso, 1971).

Other Senses. Other senses are also affected by age-related deterioration. In studies of tactile sensitivity, elderly people required greater stimulation to reach the thresholds of perception. Vibratory sensitivity shows significant decrease only after 80 years, with lower extremities more affected. Gustatory, olfactory and pain senses also show decreases (Corso, 1971).

Sensory Inflexibility and Cognition. Other factors also contribute to a decrease in sensory input among the elderly. One factor is increased sensory inflexibility. A return to tactual/ kinesthetic sensory mechanisms, the basis of early development, tends to occur. Comfort and security are sought. There is a tendency to rely on the expected perception and a difficulty in reorganizing input. Sensory motor performance and cognitive assessment are not always in synch (Breines, 1981, pp. 135-136). One study of perception of different spatial abilities indicated a decline in spatial visualization ability, though the mechanism was not clear (Doyle, 1982).

Limited Movement. Elderly people are also more likely to be incapacitated for periods in prone or supine positions. This form of deprivation will affect their perception of the spatial realm. In fact, lack of body movement inhibits the best source of sensory information since movement would have allowed all the sensors to function in concert. Secondary effects of illnesses and accident may include the reduction of sensory input due to the lack of movement (Breines, 1981, pp. 130-131). One researcher studied 180 young healthy adults who were restricted to bed for almost 3 hours in a simulated neutral hospital room. They were allowed to move freely in bed and required to stay awake. Almost 30 of the subjects experienced "indeterminate stimulus experiences" (ISE's) such as hallucinations, which are peculiar sensory disturbances under conditions of sensory deprivation. This is in spite of the fact that the deprivation was not as severe as in many sensory deprivation studies (Downs, 1974). In addition, institutional settings often provide sensory reduced environments resulting in a chronic sensory deprivation. Experiments involving increasing the sensory input showed significant improvement in well-being (Mitchell, 1977, pp. 282-284).

Social Relationships. Changes in social relationships have an important impact. Social isolation has been shown to produce effects similar to sensory stimulus reduction (Suedfeld, 1969). Social isolation and "ageism" are forms of social deprivation which are experienced as reductions in competencies (Lawton, 1980, p. 15). Selye includes the relocation and separation of the elderly among a list of daily stressors in life (Selye, 1976, p. 390). In addition, one survey of over 600 elderly housing residents indicated a marked tendency toward insularity (Howell, 1980, p. 7).

SUMMARY

Literary support for the secondary hypothesis is considered. Three steps are involved in the argument. First, boredom is related to the experience of time. Second, decreased sense input (of which less perceived visual complexity is a type) is considered as a source of situational boredom. Finally, the elderly decrease in sensory input is discussed. The net result of the linkage is support for the secondary hypotheses that boredom (and in particular, situational boredom) among the elderly is increased by decreased perceived spatial complexity due to the deterioration of the senses. See the Argument Flowchart and the summary of research on pages 44-45.

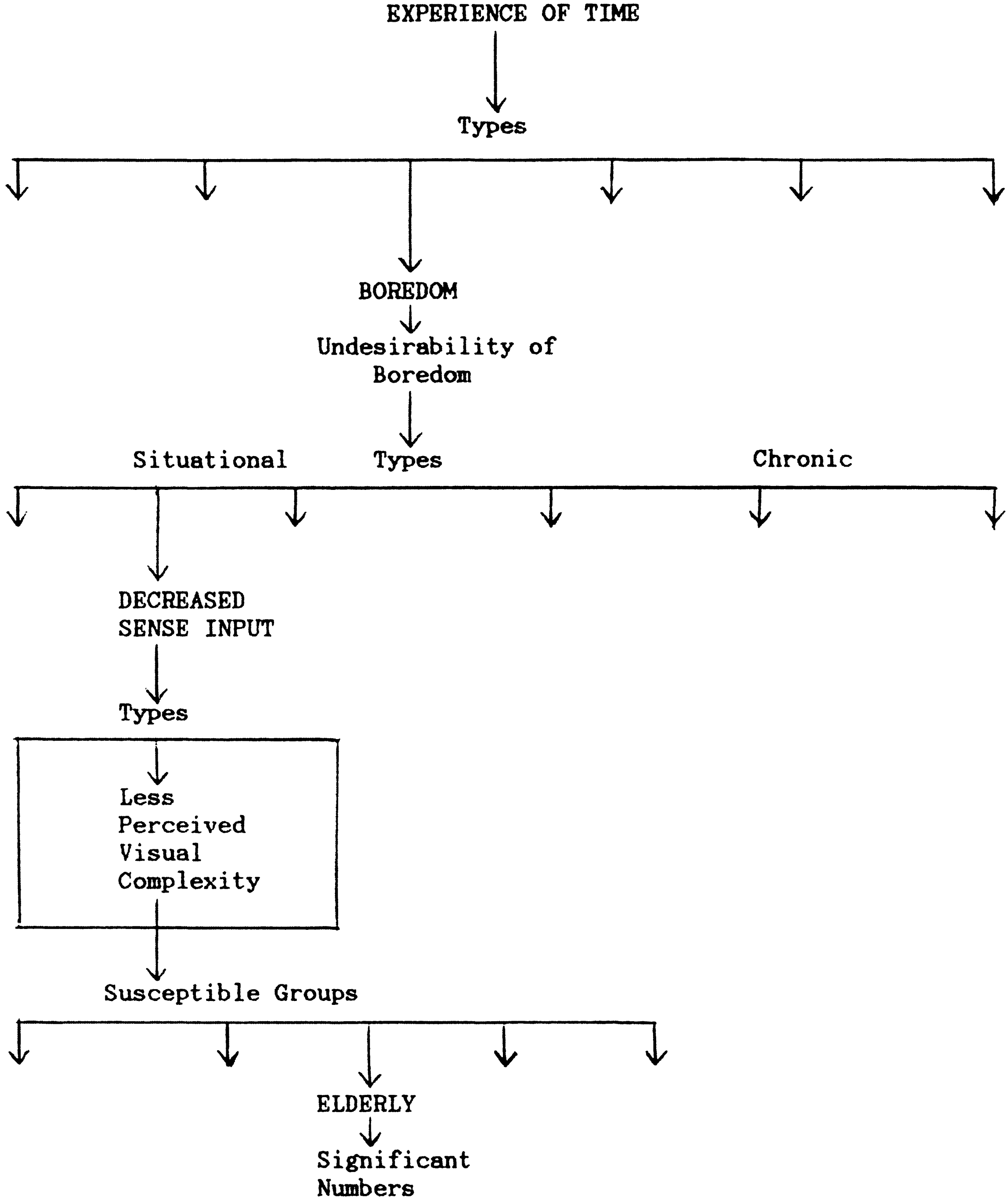

Figure 1

ARGUMENT FLOWCHART

Table 4.

RESEARCH ON BOREDOM

Definition of Boredom	
	Geiwitz (1966)
	O'Hanlon (1980)
	Turner (1983)
Undesirability of Boredom	
	Brown (1980)
	Hall (1983)
	Lawton (1980)
	Selye (1976)
	Smith (1969)
Boredom and the Experience of Time	
	Axel (1924)
	DeLong (1981)
	Doob (1971)
	Feifel (1957)
	Fraisse (1963)
	Gullikson (1927)
	Hamilton (1981)
	Hartocollis (1976)
	Leckart & Weinberger (1980)
	Loehlin (1959)
	Pardes (1965)
	Poppel (1978)
	Wangh (1975)
Decreased Sense Input as a Source of Boredom	
	Fitch (1972)
	Heron (1957)
	Lawton (1980)
	Rapoport & Kantor (1967)
	Seyle (1976)
	Smith (1969)

CHAPTER IV

MATERIALS AND METHODS

In this section general methodological matters are first considered. Previous research on duration estimation is studied with a focus on the methods used. This is followed by a description of the methodology used in the thesis experiment.

METHODOLOGICAL BACKGROUND

A review of previous research on duration estimation methodology provides a source of information to guide future research. The four basic methods of duration estimation are evaluated. Factors that influence experiments are listed. Guidelines for improving intersubjectivity of research on duration estimated are set forth. In addition, examples of research techniques are included which served to guide the thesis experiment methodology and which offer clues for future research methodology.

Evaluation of Duration Estimation Methods

Of the different methods used to obtain duration estimates, no agreement has been reached as to which is superior. Doob includes four criteria for superiority. These include accuracy of judgment, variability from person to person under similar conditions, reliability of an individual's judgment (constancy) and objectivity of method. He assumes a strong objectivity for the method since it is usually not a sensitive issue. Few methodological studies have been made of duration estimation. Reproduction has most often produced the most accurate estimates. Reliability information is extensive because investigators usually provide the data. However, comparisons of reliability among methods have produced inconclusive results. Correlations have been found to be highest between Verbal Estimation and Production, high between Production and Reproduction, but negative between Verbal Estimation and Reproduction (Doob, 1971, pp. 19-21, 27-29). Evidence indicates the tendency to overestimate with the Reproduction method and underestimate with the Production method if the duration is filled with input (Thomas & Brown, 1974). Hart claims that the Production & Verbal Estimation methods are superior because they involve less ambiguity in the interpretation of the cognitive processes involved in duration estimation (Hart, 1976).

Factors Influencing Duration Estimation Methodology

Different factors influence experimental effectiveness. One key factor is the time at which the motive for temporal estimation is aroused: there can be prior arousal (before the interval), interim arousal, and delayed subsequent arousal. In addition, there is a tendency to round out guesses. Another concern is the need to warn subjects against checking heartbeat, pulse or respiration, or using counting. Counting often increases accuracy, especially on repeated and corrected estimations. Length of the measured duration also effects accuracy. In addition, the estimates have to be translated into response, and this involves memory. Estimates vary inversely as lapse before judgment increases (Doob, 1971, pp. 22, 60, 115, 164, 172-174, 181).

Intersubjectivity

In order to increase the intersubjectivity of different duration estimation studies, Doob recommends that each researcher note the country of the study, the status of the subjects, the method of measurement, and the time at which the temporal motive was aroused (Doob, 1971, pp. 22-23).

Examples of Previous Experiments

DeLong tested the effect of linear spatial scale on duration estimation. He used three scale models of small lounges built at 1/6, 1/12, and 1/24 scale. Scale furnishings and people were incorporated into the models. Over 100 adult subjects were used in the first experiment and over 50 in each of the second and third, though the subjects were divided into smaller groups. They were to imagine themselves in the space and imagine moving the figures around. After being familiarized with the room, they were told to say when they felt (not thought) that 30 minutes was up (Production method). They were not, however, told the goal of the study. Cross checks were included such as having one group view models of two different scales and using a number of different investigators to reduce investigator bias. A similar second experiment was run with side blinders to prevent peripheral views of the normal scale environment, which did not prove significant. Another similar experiment was performed with the subjects divided into those who felt they were being tested or who reported acoustical distractions and into those who thought their timing was based on feelings. Subjects varied in viewing one, two or three models (the order was randomized). The results reflected little difference occurring after previous exposure. The first group produced estimations three to four times higher than the second and not proportionately linked to scale, though they still underestimated noticeably. On the other hand, the second group and the subjects of the other experiments produced estimates that were directly proportional to scale. Subjects were also tested in the normal scale world performing normal tasks for intervals ranging from 2 minutes to 3-1/2 hours. In that experiment elapsed time and estimated time were roughly equal. DeLong suggested some modifying factors including the subject's height and light (DeLong, 1981).

Edney studied the effects of prior exposure to a space on the perception of its size, on the subject's interpersonal distancing and on his/her evaluation of the place. Subjects were 96 undergraduate students using a 2 x 2 x 2 factorial design combining exposure to room, anticipation of future exposure and presence of another person. They were evenly divided in several ways including those receiving prior exposure or not, those expecting to return to that room or to another room, and those alone or with a planted worker. The differences stemmed, in part at least, from the use of auditory cuing by some subjects. This cuing involved listening to sounds in the environment or imagining conversations in the scale room. Prior exposure involved 25 minutes of filling out a questionnaire related to the physical nature of the room. Results from the experiments indicate that subjects exposed to a room for the first time estimated it to be significantly larger (Edney, 1972).

Feifel researched the effect of age on the judgment of time. He compared two groups of war veterans, one with a mean age of 67 and the other a mean age of 24. The Production method of estimation was used. Both groups were asked operatively to estimate 30, 60, 180, and 300 second intervals. Three readings were taken for each interval and the mean established. Counting was not discouraged. The elderly group significantly underestimated the time interval (Feifel, 1957).

LeBlanc tested for a chronological development of concern for the future and for a parallel increase in accuracy of duration estimation. One test involved looking at slides and making up short stories. The second test used 185 subjects from 10-90 years of age to estimate duration. They used the Production method by pressing a bar for an estimated 16 seconds and for one minute. The experimenter read the actual time from a digital clock. Counting was discouraged. Accuracy decreased toward middle-age, and there was a greater degree of underestimation. He suggested that it might be worth measuring longer periods since Postman (1944) found overestimating among collegiate students in the 3-7 minute range (LeBlanc, 1969).

Ornstein performed a variety of tests to evaluate a cognitive model of the perception of time. One study involved 24 university students each listening to three 9 minute-20 second tapes. Each tape had stimuli recorded at one of three different rates, and with regular and irregular intervals. A bogus use of an instrument to measure physiological reactions provided an excuse for asking that all jewelry (particularly watches) be removed. After each test, a questionnaire with 11 questions was provided, with the middle question asking the duration length in minutes from 1-20 minutes, a form of the Verbal Estimation method. The results showed a greater underestimation when stimulus was given at a slower rate. Another study involved 110 students viewing geometric shapes of varied complexity. In groups of 4-6 the subjects would look at the third most complex shape (from a set of 6 shapes of increasing complexity) for 30 seconds, and were told to be ready to answer questions. Then they would see one of the other five for 30 seconds. Afterwards, using the Comparison method, they were shown a line representing the length of the first interval and asked to draw a line representing the relative length of the second. Since the room was dark during the test and instructions were given after viewing, no attempt was made to remove watches. The simplest two shapes produced underestimation, but further complexity produced no significant change (Ornstein, 1969).

Pardes attempted to investigate two deductions made from Eysenck's theory of personality. In particular, this involved studying the relationship of introversion-extroversion, boredom, and time estimation. Sixty subjects were used from two Veteran Administration Hospitals. The subjects were selected from 195 participants who were screened through questionnaires to produce groups of introverts and extroverts. They were each given 4-minute practice tasks twice and asked to estimate the duration, how long it felt, and how fast it seemed to pass. Then they had a 2-minute period of sitting after which they were told of its length. Then the 4-minute task was performed again 3 times, followed by another 4-minute task performed 3 times. The last intervals were of 30 second length, and 3 of those intervals were presented. Duration estimates were made after each interval, using the Verbal Estimation method (except for the 30 second intervals which also used the Reproduction method), and after the subjects had been seated 20 minutes for the session they were asked for the duration of the session to that point. A second session was administered 6 weeks later and the retest reliability indicated values over .70 except for the initial practice intervals and the verbal estimates of the 30 second intervals. After each set of 3 intervals (the 2 using 4-minute intervals and the one using 30-second intervals) the subjects were requested to respond to several items. These included an Adjective Checklist (for marking words that described the subject's feelings about the task), a Boredom Scale (1-10) and a Rate Scale (1-7) of the speed of time were given, though the results were not significant. The investigator suggested the use of longer intervals to induce more boredom (Pardes, 1965, pp. 1-3, 29-30, 32, 48).

RESEARCH METHODOLOGY

The methodology used in the thesis experiment is presented in this section. Description of the models, subjects, setting and models, procedure and pretests are included.

Models

Three different 1/12 scale models of rooms were used in the experiment. They were designed and constructed by the researcher. The models represented living rooms with approximate dimensions of 18 feet wide by 15 feet deep by 10 feet high in scale and were constructed with cardboard. Two 6 foot wide by 4 foot high windows were located in the side walls and were represented by opaque mylar sheets. The simplest model was the standard model and had no changes in the wall surface. In addition, the 2 side windows were flush with the inside surface and no molding was represented at the top and bottom of the walls (see Figure 2). A complex model contained dimensional changes in the wall surface: a shallow but long projection of the rear portion of the left wall, a narrower but deeper recess in the left part of the rear wall, a 2 foot wide by 4 foot high recessed shelf in the rear wall, a narrow but deep projection of a column in the right part of the rear wall, and a deep project at the top of the rear wall that ran the length of the

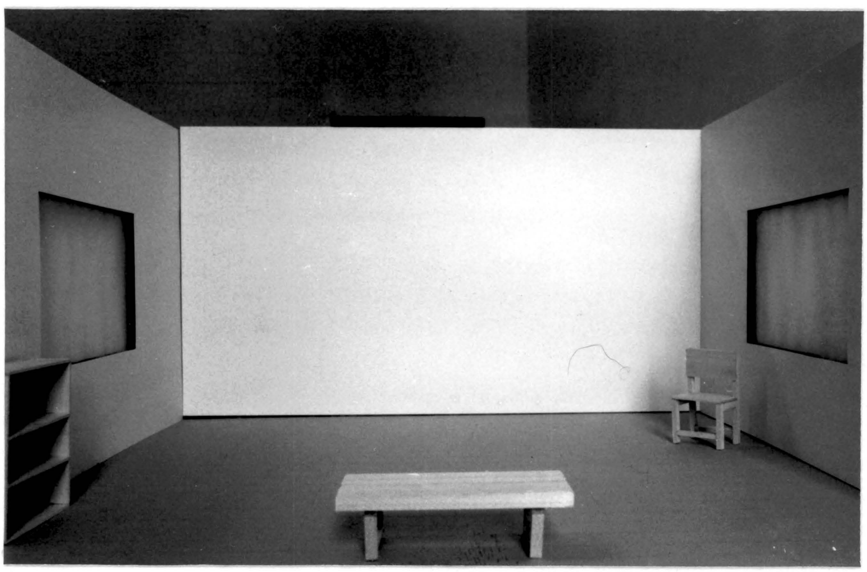

Figure 2.

Standard model without ceiling.

rear wall. In addition, the 2 side windows were recessed deeply, and moldings were represented at the base and top of all of the walls using balsa wood (see Figure 3). A very complex model contained the same dimensional changes as the complex model plus three patterns on the back wall (Zipatone 228, 309 and 461) (see Figure 4). The room colors were neutral and similar for each model and the finishing materials were represented as wallboard walls and wood board floors and ceilings. A scale coffee table, chair and bookshelf were included (the same furnishing and position for each model) in order to help the subjects to identify the scale of the model. No scale figures were included so that the subjects would not imagine engaging themselves in conversation or acivity with the scale figure. Side blinders were used, just as Delong did in some of his tests in order to reduce distractions.

Only the model tested by the subjectwas viewable at a time. The effect of using scale models has already been tested by DeLong, and the relationship between scale and time has been established. In addition, only relative differences and not absolute values need to be measured to test the hypotheses.

Subjects

The subjects included 24 college-aged students from 19 to 41 years of age. The criteria for selection were age and status as a student. The sex and the subject of origin of the subjects were not controlled. Roughly two-thirds of the subjects were American and the same proportion were males. They were divided into two groups: one viewed

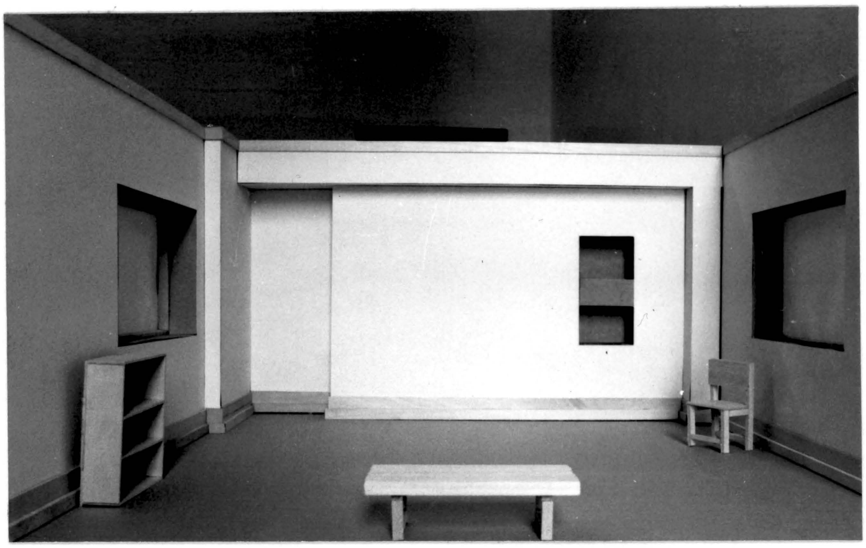

Figure 3.

Complex model without ceiling.

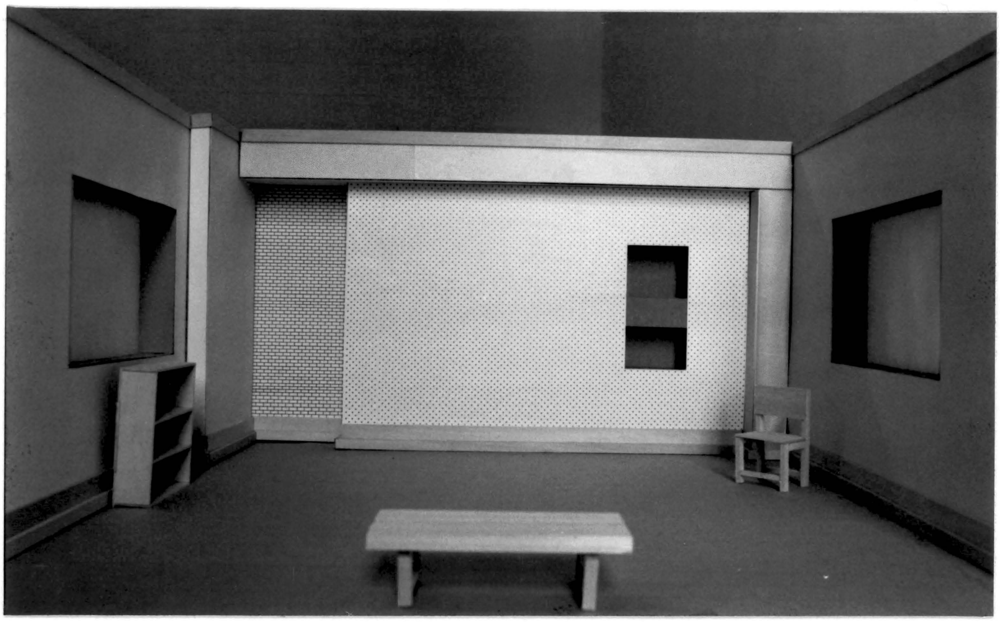

Figure 4.

Very complex model without ceiling.

a model through clear glass (PPG, single-strength window glass) and the other through a glass that caused objects beyond a couple of inches to appear fuzzy (PPG, non-glare picture glass) (see Figure 5). In effect, the second group were those with a loss of acuity. The two groups were then each divided into three subgroups with each subgroup viewing one of the three different models described on page 53. A random number chart was used to assign subjects to the groups and subgroups.

Setting

A portable setting was used to allow testing in different locations by minimizing the effect of the differences. This will allow closer duplication of the setting for future tests in different locations. The models were set on a flat surface of table height and subjects observed them from a reasonably comfortable desk-type chair. The eye level of the model was adjusted to the eye level of the subject when he/she was seated comfortably and upright (see Figure 6). The flat surface was surrounded on three sides by a 5 foot high barrier that was 6 feet wide and 6 feet long, open only on the subject's backside (see Figure 7). Two incandescent bulbs were placed inside the barrier on either side of the model and at about model height. This helped to even the lighting between different locations.

Figure 5

Very complex model viewed through fuzzy glass with ceiling
and side lights.

Figure 6

Subject viewing model with hands over ears.

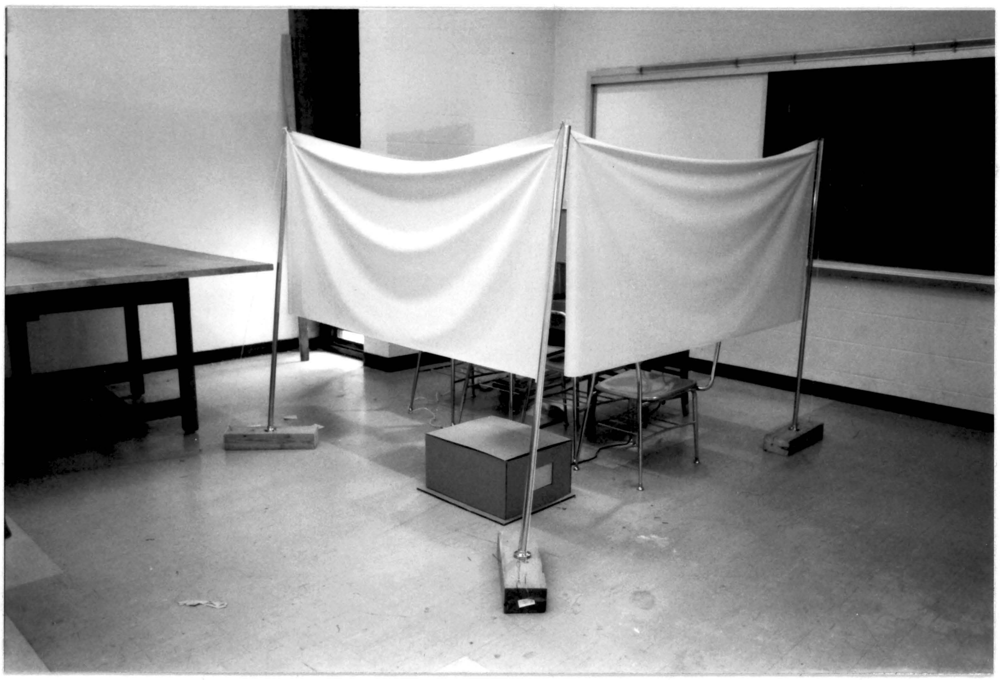

Figure 7

Portable setting viewed from rear side.

Procedure

Subjects were told that the purpose of the experiment was to determine how changes in the complexity of rooms and in the ability to see clearly affect their impression of rooms. The subjects were seated before the model and asked to remove their watches to eliminate distractions. The age of the subject was recorded along with their sex. Their first task was to imagine themselves in the scale room, walking around and trying to make some quick impressions of it. They were told that detailed information would not be sought later, only impressions. In addition, they were asked to stop when they felt (not thought) 5 minutes was up, and told that their impressions would be sought. The subjects were instructed not to count and not to be concerned with the accuracy of their estimate. They were then instructed to place their elbows on the surface in front of the model and asked to place their hands over their ears in order to help reduce the auditory cuing that DeLong noted and to help bring their vision right up to the model to aid the visual simulation. They were instructed to raise their hand and turn around when they thought time was up, and the time was recorded. Their impressions were then received. The familiarization process corresponds with those used by DeLong & by Edney to increase reliability of the test interval. In addition, the practice interval relates to those used by Pardes. In this case, accuracy was not confirmed to the subject since the purpose was to encourage scale time and not ordinary clock time. The subjects were asked if their corrected vision was normal or worse. The subjects who viewed the complex and very complex models were asked to describe the rear wall in order to provide another check on their eyesight and on the effect of the fuzzy glass. The instructions were given for the 20 minute test interval. Again they were told to imagine themselves in the scale of the model. The background situation for their imagining was read: no plans for the day, had only briefly seen a few friends earlier and probably would not see them again until later (to discourage imagined conversations), being a little tired (but not at all sleepy) leads to sitting, no one else in room, TV and radio are broken, reading material had just been cleared out, no worries or plans to make, decide to sit for 20 minutes and let the eyes wander around the room. The subjects were asked to stop when they felt (not thought) 20 minutes is up. This used the Production method of estimation just as DeLong, Feifel, and LeBlanc had in their experiments. The length is a little shorter than that used by DeLong but noticeably longer than the intervals used by Feifel and LeBlanc. Observations of the behavior of the subjects were recorded by the experimenter. The experimenter was positioned behind and to the side of the subject, avoiding any possible reflection in the normal glass. No boredom surveys were used since those which have been developed have not held up well under scrutiny, and those which did, such as the Boredom Survey (Leckart & Weinberger, 1980, pp. 54-58) deal with chronic and not situational boredom (Turner, 1983, pp. 34-36). See Appendix A for Data Sheet.

<u>Pretests</u>

Two college subjects were pretested with the very complex model, one viewing through the normal glass and the other through the fuzzy glass. The pretests allowed a check on the clarity of the instructions and on the effectiveness of the equipment. Few problems were encountered in the pretests. The use of cotton balls in the ear to reduce sound was changed to the use of fingers since cotton balls were found to be ineffective. In addition, the request for the subject's assessment of their eyesight was changed to "normal - not normal" since some of the foreign participants were not familiar with the term "20-20".

CHAPTER V

RESULTS AND DISCUSSION

RESULTS

The statistical analysis of the primary and the secondary hypothesis failed to confirm either hypothesis and the range of duration estimate values ranged considerably, even within subgroups. Some of the behaviors and impressions of the subjects seemed to recur and begin to fall into patterns. See Appendix A for the Data Sheet.

Primary Hypothesis

The primary hypothesis was that increases in spatial complexity result in shorter judgments of subjective time. Statistical analysis of the hypothesis involved the use of a multivariate analysis of variance (manova) procedure to test the overall effect of the complexity of the room. The analysis was multivariate since both the 5 minute and 20 minute estimates were incorporated into the analysis. Statistical support would require that the analysis of the data indicate a rejection of the possibility that varying the complexity of the room has no effect on the estimates of duration at a significance level of .05. In other words, the analysis must reject the possibility that all estimates could be equal regardless of the complexity of the room. However, the results of the analysis failed to reject the possibility that there may be no significant effect from the complexity of the room. See Appendix B for the statistical analysis. The 5 minute estimates ranged from 0:53 to 5:57, and the 20 minute estimates ranged from 1:09 to 23:21. Estimates for one subgroup (complex model with normal glass) in one duration length (20 minutes) ranged from 2:05 to 23:21. Mean estimates for each subgroup are listed in Table 5.

Secondary Hypothesis

The secondary hypothesis was that boredom among the elderly is increased by decreased perceived spatial complexity due to the deterioration of their senses. Since the experiment was only at an exploratory level it was only used to determine whether a finer level of increased spatial complexity would fail to result in shorter judgments of subjective time among those with decreased acuity. The links of boredom with duration estimation and of decreased perceived spatial complexity with deterioration of senses due to age are considered in the literature review of the secondary hypothesis. In the experiment the decreased perception of the elderly was simulated through the use of a fuzzy glass in front of the models.

Statistical analysis of the hypothesis involved the use of a Hotelling's T^2 Test. Support would require that the analysis of data indicate a rejection of the possibility that varying the room model from complex to very complex when viewing through the normal glass would have no effect on the estimates of duration at a

Table 5

Mean of Estimates by Subgroup

Room/Glass	5 Min.	20 Min.
Standard/Normal	2:31	5:31
Complex/Normal	2:32	8:46
Very Complex/Normal	2:02	3:30
Standard/Fuzzy	2:19	3:59
Complex/Fuzzy	1:32	7:37
Very Complex/Fuzzy	3:56	6:58

* Excludes subjects who were observed to be excessively sleepy.

level of .05. In addition, the analysis must accept the possibility that varying the room model from complex to very complex would have no effect when viewed through the fuzzy glass. In other words, only if the increase in spatial complexity can be perceived should there be a change in the estimates. However the result of the analysis failed to reject the possibility that there may be no significant effect from increasing the complexity in both cases, not just the second. See Appendix C for the statistical analysis.

Behavior of Subjects

Notations on the behavior of the subjects were gathered through the observation of the experimenter and the verbal responses of the subjects while giving their impressions of the rooms. Two types of behavior appeared among a number of subjects: sleepiness and restlessness.

Sleepiness. Sleepiness was recorded among 8 subjects. Two were so sleepy that their estimates were possibly significantly affected and therefore replacement subjects were found for the 2 in order to prevent their data from distorting the analysis. Their estimates were the second and third longest among all the subjects. Under observation these 2 were obviously straining just to keep their eyes open, and one actually closed his eyes for about half a minute. The other 6 were not as obviously sleepy, and verbal responses were required to gain that information. Incidence of sleepiness occurred mainly with subjects viewing the standard model or viewing the more complex models through fuzzy glass. A record of this behavior is listed in Table 6.

Restlessness. Restlessness was recorded among 9 subjects. The main observational clue was the shifting of the body, including pulling back from the glass. In addition, three subjects indicated that they wanted to stop the 20 minute tests early and had to be encouraged to continue. In 2 cases verbal responses of restlessness were given even though the subject did not display any obvious manifestation of the behavior. One interesting aspect of the behavior was that it was not recorded for any of the standard models. In addition, the incidents were about evenly split between the subjects viewing through the normal glass and those viewing through the fuzzy glass. A record of the behavior is listed in Table 7.

Subjects' Impressions of Room

Impressions of the room were the given reason for the experiment. A first impression was recorded after the 5 minute estimate and a second impression after the 20 minute interval. The impressions were open ended. Three categories of impressions were repeated frequently and offered insight into the experiment: boredom, description of room as empty/simple/etc., and desire to explore the room.

Table 6

Behavior - Incidence of Sleepiness

Room/Glass	No.	Observation	Verbal Response
Standard/Normal	2	-	Tired, wanted to sleep
		*Dozed at times	-
Complex/Normal	1	* Fought staying awake	-
Very Complex/Normal	-	-	-
Standard/Fuzzy	2	-	Would have gone to sleep because he could not see
		-	Could have gone to sleep
Complex/Fuzzy	1	-	Felt sleepy
Very Complex/Fuzzy	2	-	Almost fell asleep
		-	Sleepy at end

* Includes subjects who were observed to be excessively sleepy.

Table 7

Behavior - Incidence of Restlessness

Room/Glass	No.	Observation	Verbal Response
Standard/Normal	-	-	-
Complex/Normal	2	Shifted body	Restless
		Sat back	-
Very Complex/Normal	3	Stopped, restarted	-
		Shifted body	-
		-	Restless
Standard/Fuzzy	-	-	-
Complex/Fuzzy	3	Sat further away, wanted to stop sooner	-
		Wanted to stop early	-
		-	Do not have long attention span
Very Complex/Fuzzy	1	Moved body	-

<u>Boredom</u>. The usage of various forms of "boredom" by 6 subjects is especially intriguing since the responses were unprompted. The concept is a key part of the secondary hypothesis. Testing of the level of boredom was initially desired during the process of designing the experiment but was dropped because no adequate survey was found. One interesting aspect of the distribution of the responses of boredom is that they were made by subjects viewing the standard model or viewing the more complex models with the fuzzy glass. The distribution was very similar to the distribution of the subjects indicating sleepiness. A record of the impressions of boredom is listed in Table 8.

<u>Empty, Simple, etc.</u> The usage of these types of terms by 19 subjects was by far the most frequent behavior or impression recorded. 10 different phrases that seemed to reflect a somewhat similar impression are included in this grouping. At least two subjects offered impressions of this type in each subgroup. However, it is interesting that every subject viewing the standard or complex model with normal glass offered this impression, while two the the subjects viewing the very complex model through normal glass did not use terms that clearly fit in the category. A record of the impressions using terms such as "empty", "simple" is listed in Table 9.

<u>Desire to Explore</u>. Five subjects indicated a desire to explore more than the scale of the model would permit. One desire was to be able to look out of the window and the other was to explore the

Table 8

Impressions - Report of Boredom

Room/Glass	No.	1st Impression	2nd Impression
Standard/Normal	3	Boring	-
		-	Could get bored quickly
		-	More boring
Complex/Normal	-	-	-
Very Complex/Normal	-	-	-
Standard/Fuzzy	1	-	Bored
Complex/Fuzzy	1	-	Boring
Very Complex/Fuzzy	1	-	Dull

* Include subjects who were observed to be excessively sleepy.

Table 9

Impressions - Description of room as empty, simple (or similar)

Room/Glass	No.	1st Impression	2nd Impression
Standard/Normal	5	Empty	Too empty
		Empty	-
		-	Sparse
		Little visual stimulation	Shadow only stimulation
		*Not much to it	-
Complex/Normal	5	Barren	-
		Empty	-
		-	Plain
		Simple	Simple
		-	*Bare
Very Complex/Normal	2	Simple	-
		Needs more decor	-
Standard/Fuzzy	2	Empty	-
		Empty	-
Complex/Fuzzy	2	Simple	-
		Bare	-
Very Complex/Fuzzy	3	Bare, simple	-
		-	Desolate
		Incomplete, empty	-

* Includes subjects who were observed to be excessively sleepy.

room. The latter desire was indicated by 2 subjects viewing the very complex model through the normal glass and by one subject viewing the model through the fuzzy glass. The responses seemed to roughly parallel in distribution those for impressions of the room using terms such as "empty". A record of the desire to explore is listed in Table 10.

DISCUSSION

The failure of the experimental data to confirm either hypothesis may simply be a result of the relatively small sample in the exploratory experiment. The observed behavior of the subjects as well as their impressions of the room, however, seem to indicate some support for the hypotheses as well suggesting possible directions for future research.

Primary Hypothesis

The statistical analysis of the data failed to support the primary hypthesis that increases in spatial complexity result in shorter judgments of time. However, the large range of the duration estimate values point to the clear possibility that the failure may have stemmed from the need for a much larger sample to even out the effects of range of values. The range of values may partly reflect the use of active and possibly impatient college-aged students instead of elderly subjects. The ranges of estimates within each subgroup are listed in Table 11.

Table 10

Impressions - Desire to explore

Room/Glass	No.	1st Impression	2nd Impression
Standard/Normal	-	-	-
Complex/Normal	2	-	Wanted to look out
		-	*Wanted to look out
Very Complex/Normal	2	Wanted to look out wanted to explore	-
		-	Wanted to explore
Standard/Fuzzy	1	Wanted to explore	Wanted to explore
Complex/Fuzzy	-	-	-
Very Complex/Fuzzy	-	-	-

* Includes subjects who were observed to be excessively sleepy.

Table 11

Spread of Estimates by Subgroup for 20 Minute Estimates

Room/Glass	Min.	Max.
Standard/Normal	3:39	7:38
Complex/Normal	2:05	23:21
Very Complex/Normal	2:15	4:54
Standard/Fuzzy	1:09	6:25
Complex/Fuzzy	1:54	12:19
Very Complex/Fuzzy	6:04	8:04

*Excludes subjects who were observed to be excessively sleepy.

Secondary Hypothesis

The standard analysis of the data failed to support the secondary hypothesis in that it failed to determine whether a finer level of increased spatial complexity would result in shorter judgments of subjective time among those with decreased acuity. However, the effect of the smaller numbers would be even greater for the secondary hypothesis since only one subgroup was being compared with another in each step of the analysis.

Behavior of Subjects

Sleepiness. The fact that sleepiness was not recorded among the subjects viewing the complex model through normal glass may indicate that perceivable complexity may reduce the tendency for sleepiness. In fact, one subject who viewed the model through the fuzzy glass raised an interesting point. His uncorrected vision lacks depth perception, and he noted that if he were in a situation with little to do but look at the surroundings he would fall asleep rather than strain his vision. Even though his vision was corrected through glasses in the experiment, the fuzzy glass brought him back to the effects of his uncorrected vision. In the case of the 2 subjects who nearly feel asleep, their 20 minute estimates were not longer judgments of subjective time (i.e. estimate shorter intervals in the Production method) as the secondary hypothesis would predict. Instead, their Production method estimates were unusually long.

Their consciousness seemed to come and go during the observation of the subject by the experimenter. It may be possible that reduced acuity as well as boredom may stimulate sleepiness in some cases, and in those cases the effect of reduced perceived complexity seems to be opposite of the effect predicted in the secondary hypothesis.

Restlessness. The distribution of the incidence of restlessness is interesting when compared with the distribution for sleepiness. Restlessness seemed more characteristic of the subjects viewing the more complex while sleepiness occurred more among those viewing models with less perceived complexity. It may be possible that the two types of behavior may be two different levels of behavioral response related to the spatio-environmental realm.

Subjects' Impressions of Rooms

Boredom. The distribution of the responses of boredom was weighted toward those viewing models of less perceived complexity. This result matches the secondary hypothesis. Though the sample is too small to claim definitive support, the distribution does offer encouragement for further research.

Empty, Simple, etc. That so many subjects among all the subgroups used terms in this category indicates that the level and range of complexity in the models probably was too low. However, at least some range seemed to be evident since among those viewing through the normal glass only the very complex model was not labeled in this category by all the subjects in the subgroup. In addition, one subject viewing through normal glass described the very complex model as "normal". Still, that seems far short of being complex. The description of the room as being "empty" or "simple" seems to reflect the lack of furnishing and household items in the model which were severely limited to help reduce the variables.

Desire to Explore. Though fewer subjects included impressions of this type, the fact that these impressions were weighted toward the more complex models is supportive of the secondary hypothesis. The distribution indicates support for the role of increased spatial complexity in reducing boredom. In addition, since the distribution among the subgroups is similar to that for restlessness, it may be possible that part of the restlessness might be out of a desire to explore rather than out of boredom.

Additional Comments by Subjects

Several comments by subjects, besides those in the categories already mentioned, offer additional insight into the experiment. Two subjects who viewed the complex models through the fuzzy glass normally had poor uncorrected distance vision. Though their eyes were corrected by wearing glasses during the experiment, they both commented that the fuzzy glass produced a very good simulation of their uncorrected distance vision. However, 2 other subjects expressed that they were bothered by the difficulty in seeing through the fuzzy glass. They both had corrected vision also. The attempt to simulate decreased perception, no matter how successful, may fail at some point or produce subtle side effects.

Another interesting response was the unprompted use of the phrase "little visual stimulation" used by one subject to describe the standard model viewed through normal glass. The terminology and the application to a simple model was similar to the usage in the thesis.

CHAPTER VI

CONCLUSIONS

CONCLUSIONS - PRIMARY HYPOTHESIS

Possible building design implications are offered for the primary bypothesis that increases in spatial complexity result in shorter judgments of time. Restraints on the application of the implications are also considered. Directions for future research of the primary hypothesis are suggested based on the exploratory experiment and the literature review.

Possible Design Implications

Some possible building design implications of the parimary hypothesis have previously been suggested by researchers. Rapoport and Kantor suggest that designers should allow more opportunity for reconfiguration of the built environment. They also suggest the need for more unspecialized settings. Both of these offer temporal complexity (Rapoport and Kantor, 1967). From a designer's standpoint, Venturi argues that complexity and ambiguity provide richer experiences, and are recognized in other fields such as science and literature (Venturi, 1977). One seemingly natural way to ensure a degree of complexity would be to reverse the trend toward increasing isolation from ever-changing natural environment. This applies not only to the visual senses but also within ranges to the other senses. The implications of the heavy reliance on the visual senses are not clear. Would that support the heavy focus on visual concerns of designers or would it point toward a need to vary the type of sensory stimulus? The value of movement, change of speed and change of point of view may be heightened by their ability to increase complexity.

Some notes of restraint seem advisable while advocating increased complexity. As previously observed, individuals adapt to non-intense stimulation so that they hardly become aware of it (Lawton, 1980). This may imply that a bombardment of certain changes may minimize their effect. More serious concerns may also arise. Other forms of complexity may be already present besides those under control of the building designer (e.g. tasks or relationships). In addition, various situations (e.g. sleeping) may call for different degrees of complexity. Studer affirms the need to determine the appropriate level of stimulation (Studer, 1970). Above all, Rapoport and Kantor imply that designers must recognize the need to balance complexity with familiarity. (Rapoport and Kantor, 1967).

Future Research

An additional battery of tests are required to gain reasonably confident results and help control the effect of the great range in estimate values. The exploratory experiment offers some guidance for future research. The tendency for some subjects to become sleepy indicates that multiple or lengthy tests by one subject at a given time may yield distorted results. Providing the subjects with an acitivity that would increase alertness may provide one solution, but it also increases the number of variables. Restlessness does not seem to be as much of a problem when it occurs. However, it would still seem helpful to identify the occurrence, characteristics and occasions of restlessness more carefully. One significant change in design that the exploratory experiment seems to point to is the need to increase the level and complexity of the rooms. The controlled use of more furnishing and household items may help. Different methods for controlling sound should be tested including industrial ear plugs.

Considering the review of literature, further guidance for the future can be found. Some tests should be administered in a series of full-scale mock-ups of rooms. A variety of duration lengths might be tested (e.g., 10 minutes to 24 hours). In addition, subjects could be tested for the effects of familiarity by bringing them in a number of times over a period of weeks or months. Familiarity related to the novelty or ease of recognition of a spatio-environmental setting should also be considered. The ambiguity of the room could be manipulated separately from complexity as well as in concert, and the results compared. Since the experience of complexity might also be influenced by the nature of the subjects' tasks or by the presence of others, these should be considered. The desirability of spatio-environmental complexity should be measured, though developing a reliable and valid survey or other instrument may be no simple task. Other spatio-environmental factors in the experience of time (e.g. size and proportion) could also be tested. On a larger level, defining of duration estimation techniques still requires a lot of work as well as better coordination among researchers.

CONCLUSIONS - SECONDARY HYPOTHESIS

Possible building design implications are offered for the secondary hypothesis that boredom among the elderly is increased by decreased spatial complexity due to the deterioration of the senses. Restraints to the application and directions for future research are considered in a similar manner as to the primary hypothesis.

Possible Building Design Implications

Since the elderly undergo deterioration of their senses, the effects of different losses should be considered. Several changes in the visual sensory system occur. The ability to discriminate colors decreases which may imply that complexity should focus more on differences in tones. Since acuity decreases, perceiving complexity may require increasing the scale of the objects or bringing them closer to the viewer. Reduced accommodation ability may point to clustering some of the spatio-environmental complexity. The requirement for increased illumination and the difficulty in dark adaptation, along with problems such as glare and fluorescent flicker reduce the designer's freedom in using such lighting to increase complexity. Auditory losses in acuity and speech discrimination would limit appropriate complexity through that sensory system because of its potential to interfere with the task of listening. Perhaps certain controlled periods of time could be set aside for such things as concerts. Tactile sense reduction may point to an increase in the scale of tactile properties and in the use of the more perceptible range. However, they must not increase risk of injury. Such a balance seems difficult and certainly would reduce possible design solutions. The effects of decreased natural ability for movement could be reduced by increasing their ability to be ambulatory and by designing facilities to support such movement. It is possible that even beds could be used as more mobile devices in some cases if handled in an appropriate way.

Viewing the senses as a whole, the fact that different systems (e.g. visual) deteriorate at different rates for different individuals may signify that designed complexity should therefore be geared toward a combination of systems. Burnside recognizes the value of such compensatory stimuli (Burnside, 1976, pp. 383-384). The elderly also tend to lock themselves into expected perceptions. This may be an attempt to retain a sense of reality based on schema previously developed (Breines, 1981, p. 136). This would seem to imply that changes should occur at a more gradual rate to allow adaptation. Burnside mentions the value of increasing sensory stimulation as an environmental prosthetics for the elderly, as well as its value among the elderly with brain damage.

As with the primary hypothesis, restraint of complexity seems necessary, perhaps even more so for the elderly. Since their competency level is reduced, as Lawton noted (Lawton, 1980), the need for familiarity would seem to be greater. Several facts further support that supposition. First, the elderly experience a degree of memory loss, severely in some cases (Breines, 1981, p. 135; O'Neil and Calhoun, 1975). In addition, the tendency to lock themselves into expected perceptions means that cues important for safety should not be altered for the sake of complexity. The elderly also sometimes misperceive the environment (e.g. seeing a red neon light as fire) (Burnside, 1976, p. 388). Perhaps restraint in complexity might be best served by allowing the users to adapt it to their competency level.

Future Research

Beyond the areas of future research proposed for the primary hypothesis, additional tests would be required to validate and understand the secondary hypothesis. Future tests should attempt to use elderly subjects rather than simulations as much as possible. One set of tests would involve comparing the effects of spatio-environmental complexity on isolated senses. Another aspect to consider is the effect of drugs. The elderly use disproportionately more drugs than other age groups (Burnside, 1976, pp. 436-437), and some researchers have found that drugs alter the experience of time (refer to page 16). At a more basic level, there is a need to more fully understand boredom. This would include the ability to identify it and to distinguish situational boredom from chronic boredom, as well as to understand their interaction. In addition, it would involve developing tools such as surveys or observational techniques. Included in the tools might be a way to test the desire to explore the spatio-environmental realm, and the relationship of that desire with boredom. Furthermore, the relationship between boredom and sleepiness indicated in the exploratory experiment should be studied more fully.

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APPENDIX A
DATA SHEET

No.	Model/ Glass	Age	Sex	Eye-Sight	5 Min. Est.	20 Min. Est.	5 Min. Impressions of Room	Description of Wall	Investigator's Observations	20 Min. Impressions of Room
1	C/N	24	M	Corrected less but close	5:16	2:05	Barren Geometric Big echo "What can you do?"	Molding	Restless Moved body	Restless Not relaxing Thought time test
2	S/N	25	M	Normal	2:06	3:39	Spacious Empty Boring	-	Attentive	Relaxing Too empty
3	VC/N	28	M	Normal w/glasses	1:42	4:45	Normal Simple	Cross	Stopped - restarted Sat back	Big
4	VC/F	31	M	Normal w/glasses	2:58	8:04	Dizzy Bare Simple	Chair Cubby hole Molding Wall change	Attentive	Still dizzy Focused on spot "Almost fell asleep"
5	S/F	22	M	Corrected less but close	1:10	1:09	Warm Empty	-	Stopped - would have gone sleep in reality	Quiet Bored
6	S/F	27	M	Not normal w/glasses No depth perception	4:41	5:01	Empty Functional Primitive Cold Spacious	-	Attentive	Same but quiet

No.	Model/ Glass	Age	Sex	Eye- Sight	5 Min. Est.	20 Min. Est.	5 Min. Impressions of Room	Description of Wall	Investigator's Observations	20 Min. Impressions of Room
7	S/N	24	M	20-40 No glasses	4:05	5:00	First-empty Uncomfortable Next-warm	-	Attentive	Harsh w/o Lonely Depressing Uncomfortable Warmth left
8	C/N	25	F	Normal w/glasses	1:56	23:21	Empty Clean Peaceful	Molding	Moved body Sat back	Quiet Open
9	C/N	28	M	Normal w/glasses	1:33	5:07	Big Peaceful	Molding	Wanted to give impression before time was up	Plain Calm Reaceful Not bored or excited
10	VC/F	19	F	Normal	5:57	6:04	Quiet Depressing Top	Shelf Door Molding	Attentive	Desolate Not pleasant
11	S/F	21	M	Almost normal	2:12	3:22	Quiet Old Lonely	-	Attentive	Confining Tiring Could have gone to sleep Quiet
12	S/F	26	F	Problems w/far objects	1:44	6:25	Calm Want to explore		Attentive	Want to explore Calm Light

No.	Model/ Glass	Age	Sex	Eye-Sight	5 Min. Est.	20 Min. Est.	5 Min. Impressions of Room	Description of Wall	Investigator's Observations	20 Min. Impressions of Room
13	C/F	25	M	Normal	1:32	11:52	Big Simple Comfortable	Wall changes	Sat Back Wanted to stop sooner	Boring Relaxing
14	S/N	33	M	Normal w/glasses	1:56	5:45	Quiet Private Light Warm	-	Attentive	Could get bored quickly Closed in Sparse Somewhat comfortable
15	C/F	26	F	Normal	0:58	4:25	Bare Light Pleasant	Shadow Beam Column Molding	Wanted to stop early	Darker
16	C/N	22	M	Normal w/glasses	1:22	4:30	Comfortable Simple Warm Lived in	Molding	Attentive	Wanted to sit on window ledge and look out Simple Relaxed
17	VC/N	25	F	Normal	2:49	2:15	Want to explore Want to look out	Cross	Impatient moving	Stare at wall More focus on room Mesmerized by patterns
18	VC/F	24	F	Normal	3:33	7:05	Large Incomplete Empty	Painting Not much else	Moved body	Sleepy towards end Got used to it

No.	Model/ Glass	Age	Sex	Eye-Sight	5 Min. Est.	20 Min. Est.	5 Min. Impressions of Room	Description of Wall	Investigator's Observations	20 Min. Impressions of Room
19	C/F	26	M	Normal w/contacts	2:46	12:19	Bothers - can't see Spacious	Shadow Column Beam Shelf	Moved body	Warm Peaceful Felt sleep Good simulation of poor eyes
20	VC/F	21	F	Normal w/contacts	3:15	6:37	Peaceful Frustrating Dark spot distracting	Shelf Molding Column	Attentive moved arms	Waited change Looked at spot Dull Peaceful Good simulation of poor eyes
21	VC/N	27	F	Normal	1:04	2:04	Roomy Needs more decor Trapped Peaceful light	Molding Cross	Attentive Said restless	Secluded
22	VC/N	27	M	Normal w/glasses	2:34	4:54	Not relaxed pattern	Cross	Attentive	Understood in a few minutes Wanted to explore Notice details in time
23	C/F	24	M	Normal	0:53	1:54	Open Light	Dark spot Shadow	Not long "attention span"	Tried to find detail Peaceful
24	S/N	41	F	Normal	1:58	7:38	Serene Lonely 'Little visual stimulation'	-	Attentive	Shadow only stimulation Tired - wanted to sleep
*	S/N	24	M	Normal w/contacts	4:10	16:42	Big Not much to it	-	Sleepy Closed eyes 1/2 min.	More boring
*	C/N	51	M	Normal	6:16	21:19	Distracting	Molding	Sleepy, heavy not shut	Wanted to look out Too constraining Bare

*Subjects who were observed to be excessively sleepy.

APPENDIX B

Manova Analysis of Primary Hypothesis

Statistical Assumptions

Hypothesis: Mean values of duration estimates for each type of room are equal.

Rejection: If $F < 0.05$

Statistical Results

Hotelling-Lawley Trace	$F = 0.4352 > 0.05$
Pillai's Trace	$F = 0.4002 > 0.05$
Wilks' Criterion	$F = 0.4167 > 0.05$

Therefore: Statistical assumptions cannot be rejected. Support for the Primary Hypothesis requires statistical rejection of the statistical assumption hypothesis above.

APPENDIX C

Hotelling's T^2 Test Analysis of Secondary Hypothesis

Statistical Assumptions:

Hypothesis 1: Mean values of duration estimates for complex room and very complex room are are equal with normal glass.

Hypothesis 2: Mean values of duration estimates for complex room and very complex room are equal with fuzzy glass.

Rejection: If observed Hotelling's T^2 Statistic > 13.887

Statistical Results:

Hypothesis 1: Observed Hotelling's T^2 Statistic $= 1.834 < 13.887$

Hypothesis 2: Observed Hotelling's T^2 Statistic $= 10.435 < 13.887$

Therefore: Statistical assumptions cannot be rejected. Support for the Secondary Hypothesis requires statistical rejection of Hypothesis 1 above but not of Hypothesis 2.

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