SENSE PERCEPTION AND DEPRIVATION

Sensory deprivation studies have had a major impact on our understanding of the effects of taking away stimuli which one normally experiences on a day to day basis. Most sensory deprivation studies entailed a near total elimination of all stimuli that a person might experience. These particular studies have been short term deprivation studies due to the inability of the subjects to withstand deprivation of severe nature for extended periods of time. Other studies have been done using minimal levels of deprivation and constant monotonous levels of stimulation such as "whitenoise". Such studies give an indication of the expected reactions to deprivation. However, these studies can only be considered as generalizations since they deal with studies of only a few hours to several days, and in underground design, people are subjected to low level deprivation for much longer periods. Although many sensory deprivation studies were done twenty to thirty years ago, it can be assumed that the human physiology has held at a constant over this period and what was true then is predictably true today.

Deprivation of perception and sensory stimuli, for example, is an obvious problem in underground habitation. In related sensory deprivation studies, "hallucinations were reported by the perceptually isolated subjects" (Zubek, 1969, pg. 85). An equally if not more significant finding in sensory deprivation studies is the effect of
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deprivation on intellectual performance of the subjects.

In several studies conducted, the people whose senses were being deprived of normal levels of stimulation for several days "reported that they were unable to concentrate, could not think clearly, and had difficulty in organizing their thoughts" (Zubek, 1969, pg. 127). The indication of aversive effects has reoccurred through numerous other studies. Subjects continually showed an inability to perform at a previous level in some intellectual activities like problem solving.

Still more important is the indication that prolonged periods of perceptual deprivation have brought about a depressed ability to perform intellectually and cognitively which may persist for several days after the deprivation period ends. This finding is extremely important concerning all facets of underground design. No office manager will want to have his employees working in an underground structure that causes sensory and perceptual deprivation to the point that their cognitive processes will be impaired. A prospective client will be unwilling to have an underground house if living in it will have a detrimental effect on his long term job performance abilities.

Therefore, it is imperative to insure an adequate level of sensory stimulation to maintain productive work.

Important not only to people with children who are considering an underground home, but also to futurist designers who want to place whole cities underground, are
the implications that sensory deprivation may retard development in young children. Depending on one’s stand on psychology, from the behaviorists who emphasize stimulation from the environment as being the prime element in development to those who believe most learning tendencies and abilities are inborn, the degree to which sensory deprivation is assumed to affect children will certainly vary. However, there is little disagreement with the statement that children are at their most active learning and discovery level from birth to five or six years of age. Developing children need a good source of environmental stimulation and the underground designer must consider this. It is important to note that “putting time in with the child is not enough. It is the quality of the input that is important” (Provenz, Madow, Snow, 1970, pg. 65). A parallel can be drawn here that the amount of environmental stimulation is not as important as the overall quality of environmental stimulation. A designer must keep this in mind when developing a design solution for underground structures that is expected to provide an adequate level of stimulation for all of the occupants.

When providing an adequate level of stimulation, it must also be taken into account that over stimulation may result in loss of abilities as well. Stimulus and response action often follows a curve similar to the one in the right hand margin. The graph shows that as stimulation continually increases the response level begins to increase, reaches a high

"Infants require feedback or stimulation from their own motor activities for perceptual learning. Normal behavior is delayed or distorted with sensory or motor deprivation. Sulu tribes in Africa who live in round houses cannot perceive straight lines like white people in our Western culture who live in square houses" (Beatty, 1969).
level, and then begins to drop. As stimulation reaches a high level, sensory overload occurs and the stimuli interfere with one another causing response levels to drop.

Hence, the optimum performance will be at a moderate level of arousal. As would be shown by sensory deprivation studies, a very low level of stimulation or a very high level of stimulation would result in lowered abilities to perform (Zubek, 1969, pg. 121). This particular condition can be correlated to the aforementioned optimum of quality of input over quantity.

As stated earlier, the sensory deprivation studies are not fully applicable in reference to underground design partly because of the difference in time elements involved. Also, problems result from the inherent differences in all humans and their different needs and outlooks on underground design. The particular areas of sensory deprivation concerning vision, noise, and temperature levels alone with perception of odors will be discussed in the following sections.

Visual sensory deprivation is a key factor to be dealt with in designing for underground structures. The point made earlier concerning development of children is of foremost concern in visual deprivation. Children learn a great deal by viewing their outside environment. A designer must carefully consider the visual needs of occupants in a structure. In making a case for providing visual stimulus, the effects on blind children's ability to learn and the observed behavior of patients during eye patching after eye
surgery should be illustrated. It has been noted that blind children have a great difficulty in learning their position in the environment around them. When those individuals who cared for blind babies left the babies alone and walked just a few feet away, the babies became disoriented. The babies obviously relied on touch and sound to sense their relationship to the world around them. Even though the parents or providers were just a few feet away, these children obviously felt alone and detached from their world. It took much longer for those babies to discover that their parents would return even though the babies could not see them. This would contrast a normal child's ability to make visual contact with his parents and hence, not fear being just a few feet away from them (Provenza, 1980, pg. 57). This particular case in point illustrates how important visual access is in order for a child to perceive his relationship to the environment in which he exists.

Consider also the eye surgery patients who exhibited disturbed and disoriented behavior during their recovery period (Zubek, 1969, pg. 371). Not only patients of eye surgery, but any ill person in general can be shown to benefit from visual stimulation. While confined to a bed, whether in a hospital or in an underground home, a sick individual may become extensively deprived of stimulation. Even a limited view would be better than none at all for those people who cannot get out of bed to
seek an adequate variety of stimulation. The contribution
to psychological well being and quickened recovery given by
windows for patient view has been documented and it is com-
mon design practice to supply sufficient window space in any
room where patients will spend most of their time recovering.

In small underground structures, such as a home, visual
stimulation can be provided by inserting windows with select-
ed views that provide a variety of stimulation. The amount
of window area provided may be tied to the amount of time
spent in a particular space. This subject will be discussed
later in a section on zoning in underground design. A pos-
sible consideration for windows would be their actual height
placement in a room. Windows in children's rooms might bet-
ter be placed at a lower height to facilitate easy viewing
for children. Central locations for views work well to pro-
vide necessary visual stimulus not only in small underground
structures, but also in large buildings.

Large central spaces with a view to the exterior pro-
vide that needed contact with the above ground world and
associated feeling of relationship with it. An example of
effective use of space and visual connection to the exterior
in a large scale underground structure can be seen in the
underground library at the University of Michigan.
Views from offices to central spaces that have an exterior
view may provide needed visual connections for office per-
sonnel. Though some people prefer solitude and do not want
to be distracted by exterior views in the office setting,
a majority of people prefer at least a minimum of having visual connection with the outside world via a central rest break area with windows. As documentation to this, a personal interview of first year architecture students in the fall of 1982 revealed that most students took frequent breaks from their studio space in order to move to an area with some view of the exterior. Several students indicated that having a space with windows "broke the monotony and assisted their creative thoughts in developing designs." The bottom line points to a significant importance of visual stimulation from the outside world in all designs which certainly becomes more acute in the confines of an underground structure.

Noise perception can be affected by sensory deprivation as well. Actually, deprivation may increase sensitivity at some levels. It has also been shown that reduced noise levels may slow down hearing loss (Zubek, 1969, pg. 243). In the case of noise, a designer can readily use underground conditions to create a more inviting space. Obvious noise problems from heavy city and air traffic can be minimized by building underground. It is important to consider as well, the sounds which may normally be pleasing to people, such as sounds often occurring naturally from the animals and insects in the environment. These sounds can have a positive effect on people psychologically and whenever possible the designer should try to provide for ways to allow these sounds to find their way into an underground structure, especially
in the case of an underground home.

Perhaps one of the most important senses in our perception of the overall environment is that of smell. Odors, both good and bad, tell us a great deal about our environment. Odors instill a very strong feeling in one's mind about the surrounding area. They also have a strong influence on the degree to which a space or environment is liked. Strong psychological reactions can be seen to the pleasant odors associated with a wooded area in spring or a fragrant array of flowers. Odors may also be perceived in a negative way. Implications of bad odors are quite significant in underground design. A strong psychological aversion for underground spaces may be instilled if the space smells like a cave. Damp, musty odors caused by excessive humidity will certainly bring a strong cave association to mind no matter how excellent the rest of the design may be. A designer is well advised to consider odor control and perception in his design; for, if a space smells like a cave it will be perceived as a cave.

Odors can be controlled by good insulation, vapor barriers, and an efficient H.V.A.C. system. The importance of these systems both in initial design and in continued maintenance is obviously broadened by the need to effectively control musty odors for psychological reasons. However, it may not be advisable to completely close an underground structure from the outside world of natural smells. If a wooded area or large garden area is nearby, the accompanying pleasant
odors may enhance the perceived attractiveness of a space. Exterior ventilation should be considered as a possible way to bring in these pleasant odors. The perception on the interior of known scents which normally occur outside in open spaces may help the transition from exterior to interior and make a space more inviting.

Surrounding temperature is another variable that can affect our perception. Though actually treating temperature deals more with the physiological considerations of design, the results of poor control over temperature can result in severe psychological reactions. In earth covered structures, a cold interior atmosphere may be perceived as tending toward the cave atmosphere and may also increase the chances of moisture collecting and causing odors. It is important to keep the space warm. The layer of earth above a space can be advantageous because of its insulation qualities. As with odor perception, the control becomes important due to the psychological strain and reactions occurring when control is inadequate. As a designer of underground buildings, one should try to maximize the comfortable atmosphere because people in a cold space become progressively more uncomfortable as they continue to stay in that cold environment. Personal preferences of the client weigh heavily here and must be considered in the design of an adequate control system. A consideration of breaking the house into heating zones or providing several points of control for the system will allow an occupant to
adjust temperature to his own specifications and provide his with an element of control over the environment. Often one perceives a space as more comfortable and acceptable if he can more easily control the interior conditions.

COLOR PSYCHOLOGY

An important but sometimes poorly considered element of design is color. Perception of color can have a wide variety of psychological effects. Different people are attracted to different colors. Several psychological studies have been done in an attempt to correlate desired colors with personality traits. People who are considered well adjusted to the world and extroverted like all colors and especially warm ones. Those individuals who are not well adjusted or are introverted tend to favor cool colors and may not prefer any color at all. "Those with an intimate relationship to the perceptual world are warm color dominant. A cold color dominant person has a split off attitude to the world (Birren, 1965, pg. 138). Research has also shown that "prolonged sensory deprivation can produce an impairment of color perception" (Zubek, 1969, pg. 214).

As a designer, one should consider both differences in likes for colors and the possible effect on perception of color that a person might experience while under conditions of long term deprivation of some sensory stimuli.

A designer should keep in mind the following concepts concerning color. Warm colors are considered as active,
and cool colors perceived as passive. Objects seem larger and heavier under warm colors. Cool colors make elements seem lighter and smaller. As an application of these concepts to underground design, it might be possible to introduce warm colors on the walls and floor to make the space seem larger and less confining. The warm colors could even imply a more active atmosphere. In conjunction with this the ceiling could be illuminated with a cooler colored light so as to make it appear lighter. Hence one has a space that appears larger due to warm wall colors and yet we also have a ceiling which appears lighter, less menacing, and less confining in the underground environment.

Color can be achieved by different means. It can be done by an applied coating such as paint or material which reflects a specific wavelength of light. Color can also be generated at the light source by using colored lamps. At first glance, this difference does not seem to be significant. However, consider the difference in psychological effects when the color green is used. Green is normally considered a tranquil color when used in carpet or seen in plants, but when a green light shines on human flesh it appears repulsive. This paradigm illustrates the significant importance of considering how color is perceived in relation to a reflective object or a light source. Moods can be affected by colors. Deep orange will have a very exciting influence on behavior. Contrast this to yellow-green and some blues which have a more passive, tranquilizing effect. Violet can have a very
subduing influence on behavior. In some cases, a designer may wish to instill a certain mood in the occupants, and certain colors can assist him.

ZONING IN DESIGN

The control of temperature is one area where zoning can be an extremely useful tool in several areas. Whether used in temperature control, room location and grouping, visual need assessment, view selection, or activity level, zoning can help the designer enhance his underground solution. It is possible to zone areas in relation to specific sensory need and time spent in a specific area. Based on time spent in a specific room, the bedroom becomes one of the most important design areas. In determining the amount and type of visual stimulation needed, such as the amount of window area, the longer period of time an individual spends in a specific room the more window area is needed. However, putting more window space in a bedroom than in a kitchen, where less time is spent, would probably not be the best design solution. Therefore, the consideration of what activity is undertaken in a space becomes just as important in making a correct analysis of window area needed. In a space where a specific activity does not require as much exterior view, time is not as important. Hence, a careful analysis of both time spent in an area and activity are essential.

Perception of zoning by occupants must also be considered and predicted by the designer. Some areas may be
perceived as very active and highly populated such as a
hotel atrium. An area could evoke an atmosphere of quiet
solitude such as a chapel. These two ends of the spectrum
can be used by a designer to suggest a use of a space by
size and by zoning. Large spaces in a central area will
usually suggest a high level of social interaction; whereas,
a series of smaller spaces zoned together would indicate a
more private and intimate potential.

In underground residences, for example, the kitchen,
laundry, garage, and storage areas could be zoned into a
group which requires little or no view. In contrast, a
living space or breakfast area would require an excellent
view. Their groupings and their associated needs might
help an architect make a design decision. The same justi-
fication for zoning can be used in large underground
structures. The concept of placing high activity areas
and low level activity areas together and assessing the
visual needs of each is used here. An example could be
drawn from the zoning of office and central atrium areas.
Obviously, more time is spent in the office zone than the
atrium. Whether or not windows are needed in either space,
and whether the atrium is visually active enough to over-
come the need for an exterior view are questions which the
designer must answer. It should be pointed out though that
people will notice poor zoning. They will also notice when
activities, needs, and design solutions are in conflict and
create a poor psychological feeling.
An integral part of a design is the psychological mood created by natural and artificial lighting. In an underground design, perception of natural light is important to the relationship between the occupant and the world above. It is possible to use artificial light in such a way as to be perceived as natural light. Numerous modern lighting fixtures and equipment have been designed in order to make artificial light appear as natural daylight. Through the use of particular lamps which emit light in the perceived color range comparable to the light of the sun and with the use of computer control of illumination levels, it is possible to accurately mimic changes in light during a day.

Light wells can be effectively used to bring natural light into an underground space. They may be used by lighting specific areas of the space at different times of the day. In some cases, a false light well might be concealed within a ceiling (See diagram at right). Psychological warmth created by the light of the morning and evening sun when correctly used by a designer may enhance the enjoyment of a particular space. In deep underground structures, natural light and exterior views are achieved by the use of mirrors in deep light wells. (Science Digest, Sept. 1983, pg. 29). Natural light or at least the perception of light as being natural by the correct use of artificial lighting is an imperative for the psychological connection of the underground space with the outside environment. An adequate design should always include a well
thought out use of natural and artificial light to enhance the warmth and attractiveness of an underground space. The desired psychological effect might be derived by the use of a central atrium from which natural light would be allowed to filter into adjacent earth-covered spaces, or by the use of artificial point source lighting to create an intimate atmosphere. Finally, light level is related to behavior in a space. Bright light is extremely important in doing muscle-oriented jobs. In contrast, high light levels may inhibit mental and cognitive-oriented tasks.

ARCHITECTURAL DETAIL PSYCHOLOGY AND PERCEPTION "TRICKS"

When designing an underground structure, the architect should be aware of some particular architectural details and perception tricks that deserve consideration. It might be possible to slant a ceiling line or some other obvious structural line such that it appears to be converging at some point like lines in a perspective drawing. This would make a space appear longer when viewed from a specific point. Another way to enhance perceived size of a room is to use mirrors. Mirrors at strategic locations would cause rooms to appear almost twice as large or hallways twice as long at first glance. The application of "tricks" in perception could be quite useful in underground design to help break away from the closed-in and confined stigma associated with some designs. Lines of structural members could also be manipulated such that they carry the occupant's eye to a certain point
or possibly set up a rhythm which may be perceived as continuing farther than it actually does. The use of fish tanks in underground design is an interesting method for providing a source of visual stimulation. When a fish tank is placed in a wall or at the end of a hall or entry, the water will produce a visual perception distortion such that the tank appears much larger than it really is, especially if a mirrored surface is placed behind the tank.

An important element of design involves predicting how an occupant will perceive the particular space. In order to be receptive to the space and be willing to interact with other people in the space, a person must "feel" comfortable in it. This becomes important especially in invoking a feeling of well being in underground structures. Ceiling height is one area that is often not considered in design. One study has shown that a curve of the desired ceiling heights peaks with the ceiling at about ten feet. This is contrary to the more traditional design guideline in most residential construction. Also a study of ceiling slope showed peak preferences at 0° (horizontal), and at 4/12 (Baird, Cassidy, Kurr, 1978, pp. 719–727). In designing an underground home it would be worthwhile to consider the preference for ceiling height and slope of a particular client in order to have one more psychological edge on designing a usable, livable, and inviting space. Ceiling height preferences were also studied with a variable of room function. The diagram at the right shows preferred
ceiling heights for various room functions such as reading, dancing, and dining.

TRADITIONAL VS. NON-TRADITIONAL MATERIALS

When designing for underground structures, the architect must consider the use of non-traditional materials for a building or at least the use of common materials in somewhat non-traditional ways. The use of concrete for walls and ceilings in an underground house is certainly not traditional construction for a residence. It is possible though to use this necessary structural element to one's advantage for an exciting design. Concrete, being a plastic material, is capable of being "molded" to fit almost any design idea. It could be used to respond to different spatial orders, a concept discussed in the next paragraph, and form concepts in new and stimulating ways. It is also easier to adapt to new ceiling heights, as noted previously, since construction is not limited to a specific predetermined material size such as the common 2x4 stud. Concrete could also be used to develop forms such as curves, arches, or domes that might respond to perceived spatial organizers. Though concrete seems to be very adaptable, it is up to the architect to discover new ways of using concrete and other materials to interpret spatial concepts and respond to psychological considerations.

SPATIAL ORDER PERCEPTION

In designing for underground structures, it becomes imperative
to consider spatial order perception by occupants. Spatial orders are those which are perceived as controlling and organizing the elements in a design. In one's own perception of a home there are internal and external orders. "The internal order takes the collection of activities, objects, and places that comprise who we are." The external order involves our terms of public, landscape, and "defines us by locating our home with respect to important categories of people and places" (Lym, 1980, pg. 32). Spatial orders are extremely important to analyze since "experience of space becomes an experience of issues in one life" (Lym, 1980, pg. 9).

A designer must delve into the inner feelings, life issues and rituals that comprise the individual personality. To neglect these underlying orders could easily set up a contradicting set of stimuli and bring about an inhospitable feeling toward that building.

Exterior orders involve our perception of orders in nature and public interaction. Too often we neglect the exterior orders or put a barrier between internal and external orders. A Japanese tea house is an excellent example of a building that respects the exterior orders. By allowing a wide range of sense experiences with the environment, it begins to integrate these two orders. By allowing orders that occur in nature to permeate a building and vice versa, we can begin to meld these orders into perceivable harmony. Ordering scales of elements and ordering principles of activities that occur on the exterior may be applied on the interior to

"From our experience of space, we formulate spatial standards by which to shape and select environments for ourselves. These standards are our spatial orders" (Lym 1980, Pg. 17).

"Kahn intended for Exeter Library to be in chronic space for the inspiration of the individual with a book. Instead Exeter was in chronic space for the individuals through seating. In Kahn's spatial order, the central void proclaimed an invitation to a ritual with books..... For the student users, the central void proclaimed the meeting of friends" (Lym 1980, Pg. 92).
create a psychological harmony in a design. To allow natural land forms to begin to shape a design, such as Frank Lloyd Wright's "Falling Water" house, is to allow the natural orders to associate more with internal, personal orders and bring about this harmony in design.

Internal orders are those associated with personal desires and activities. They are concerned with the way we perceive and act in our immediate personal space. For example, one person's internal order may dictate a direct open connection between a den and the more public area of the house such as the living area. Contrary to this another individual may be directed by internal orders such that he feels a den should be totally separated from the rest of the home environment. The den represents an element detached from the main stream of life. Another polarity would be a person who is very extroverted and spatial orders dictate a preference for an open plan house with few interior partitions. In contrast to this, an introverted person may want a house zoned into dramatically different public and private areas. Spatial orders provide a design criteria which when applied can significantly increase the success of a design. However, when they are ignored a design could suffer total failure. As a conscientious architect, one must be aware of other individual's spatial orders. A designer must be extremely careful not to put his own spatial orders in place of his client's, but rather try to help the client better understand his own orders and include them in the final design solution.

"To design Unity Temple, Wright explored in detail the formal devices implied by the spatial order of the church as a meeting room. A meeting room should be quiet. So he placed its entrance away from the noisy intersection outside... It was a space focused on the pulpit, yet open and responsive to the calls from the seated congregation. People entered from passages where below the roof so that they would not disturb the dignity and quiet... Like Le Corbusier, Wright's formal design devices.... were at the service of the spatial order of Unity Temple as a meeting room" (Lys 1986, pp. 72).
Finally, a point which deserves considerable attention by the architect as well as a great deal of creativity is that of interior to exterior transition which should not be confused with internal and external spatial orders. Here, the element is the actual physical transition between the above ground environment and the underground space. A good transition is important to the positive psychological perception of the underground space. The transition may be such that an entry way becomes somewhat confined and then explodes into a large interior space which "feels" quite open. It is important not to restrict the entry too much or people will not even want to venture through the transition point. The transition may take place abruptly, as a single entry point, or possibly be a slow transition which gradually moves one from the above ground environment to a subgrade courtyard and finally into the actual underground structure. A smooth transition might be derived by minimizing the significance of the access point and maximizing a visual connection and visual flow of elements from the exterior to the interior, such as, a garden area where the plantings seem to continue right on into the structure. Another transition might play upon a vertical airlock where one moves down into a lower courtyard and then back up through an entry point. Here the airlock qualities are maximized since the warm air will not fall and cool air will not rise. Also, the apparent ascension through the
entry may lessen the feeling of being deep underground as
the building is entered. Clearly the transition from ex-
terior to interior is very important to the overall success
of the design.
CONCLUSION

In summary, numerous elements contribute to the success of an underground design. An architect must first realize the importance of psychology itself in making a design solution work. Psychological considerations in design are imperative if that design is to be readily accepted and free of details which make people leary of using the space. In underground design these psychological principles tend to be of even greater significance. A designer must be aware of all of the sensory stimuli which contribute to the overall perception of a building and the associated problems with depriving the mind and body of the normal levels of stimuli. The psychological principles used in manipulating color, lighting, and architectural details can easily contribute to a beautiful design solution. The designer has an ever increasing resource of new materials and must be creative in his use of existing materials in non-traditional ways. The transition from interior to exterior is very important to a first impression of the structure. Finally, zoning can be readily adapted to the application of existing spatial orders. Spatial orders are some of the most important subliminal design elements to be considered and yet probably are the least often considered because they lie in the subconscious and are not recognized by most people.

In the future underground structures will begin to be more in demand because of the obvious energy savings and the unobtrusive impact on surface features (Science Digest,
Sept. 1983, pg. 29). David Benett, a Minneapolis architect, says that due to energy savings "future cities will probably be more subterranean than they are today" (Science Digest, Sept. 1983, pg. 29). Hence, designers must learn to deal with the problems of underground design and psychology will certainly play an important role in understanding and predicting the needs of underground inhabitants. In order to present underground buildings as habitable spaces, the present "cave" stigma must be eliminated. A recent building at the University of Minnesota plunges more than 110 feet beneath the surface. It is so new that an assessment has not been made by occupants yet, but "people who have spent time in similar, though admittedly shallower, buildings have been amazed at how light and airy they can be" (Science Digest, Sept. 1983, pg. 29). The stigma can be broken. More research in the area dealing with analysis of successes and failures presently existing in underground design is needed. With extensive research and the proper training of architects in this field, the psychological needs of underground inhabitants can and will be met in the future.
APPENDIX-B
MODEL STUDY
The model study was conducted to further explore those concepts identified as important psychological aspects of underground design. The study by use of models expands the perception of a space. Many times preliminary concepts are developed from two dimensional plans and sections. These drawings are sufficient to begin theory development. However, the inclusion of models brings in the third dimension of view which is extremely important to adequately understand a concept. By viewing a concept portrayed through a model and a camera, the concept can be more realistically viewed and can be supported or revised as necessary. More importantly, by viewing in a three dimensional format, new concepts may be discovered which were not seen or predicted from the simple plan and section drawings.
The model study was conducted using a model video camera and video tape apparatus. The model was constructed in a form that would allow easy manipulation of walls, ceilings and elements to facilitate the study of a wide variation in spatial perception. In studying the perception of the atrium and the association of view content with the form of the aperture, both centralized and side locations for movement were chosen. The camera was located at a central station point then moved toward the window aperture, followed by a backwards movement to the rear of the space. This camera movement was conducted for a series of atrium size changes. The camera was then centrally placed. The window aperture was manipulated both in form, location and proportion to study the effect on perception. The study was intended to see how the change in view and aperture size will affect level of confinement that is perceived by the occupants. The aperture form and location was manipulated to discover which view elements and view angles are the most significant to providing an adequate level of visual stimulation.
Next the atrium form was studied. The forms chosen for the atrium wall were vertical, sloped, and stepped. First the vertical wall was inserted and the camera moved. It should be noted here that the camera was always moved around when a stationary form was inserted or changed to study the three dimensional aspects. Then the sloped wall and finally the stepped wall were inserted. Not only was the form manipulated but the size of the atrium as well. The content of view and the relative distances were also manipulated by use of different elements inserted in the atrium and a picture of a distant view placed on the wall. All of these variations were studied one at a time and video taped for later review. The following pages will show a series of photographs representing a movement through one space context studied. Also photos of some varied window apertures will be shown.
VIEW IMPACT AND WINDOW SIZE PLACEMENT

View from variable points in room.

Find how perception of aperture size and placement varies and what relationships provide a seemingly adequate and not too restricted a view.
LAYERING OF VIEW (2)

To study the relationship between distance of significant view element from station point and the aperture size which provides an adequate view.

ATRIUM FORM AND SIZE

To study the effect on perception of atrium size and the relationship to interior spaces that varying the form and size of an atrium has.
The model study revealed that the farther back one is in the space the more likely that high contrast between the exterior and the interior will cause a person to want to move toward the window.

Through the model it was discovered that a major determinant for a satisfactory view of the atrium was the ability to see a corner of the atrium. When a corner could not be seen there was a stronger desire to move toward the window until this edge was seen and hence the actual atrium size was perceived.
The model study of atrium form revealed an interesting concept. The vertical wall left a feeling of a more enclosed confined space. The sloped wall provides a more open feeling but still strictly defines the boundary of the atrium. The interesting development came with the perception of the stepped atrium form. Even when the height of the steps was well above the level of being used for actual movement, the stepped form itself tended to draw the eye into that space and cause one to want to move from the interior zone to the less confined exterior zone. This feeling of being drawn into the atrium was much stronger for the stepped form than the vertical or sloped forms.
The purpose of this part of my thesis is to propose some principles that need to be studied further. As architects we need to better coordinate studies with social and behavioral scientists. The following is a proposal for a research methodology. A wide, but certainly not all inclusive, list of architectural variations will be given. These variations in architectural elements and perceptual features can serve as a guide to the more detailed research done by social and behavioral scientists. The research methodology will include a sample procedure, hypothesis, expected results and possible data analysis approach. A matrix of perceptual principles and associated changes in architectural elements will be presented as a basis for further research. It is intended that this section will serve as a link between architects and social/behavioral scientists by providing a source of research variables from an architectural standpoint. Once these ideas are integrated with the detailed, analytical research methods of social/behavioral scientists, significant statistical data should be available and may be used in understanding perceptions in the underground environment.
The zone of most activity in a space will occur where occupants can view the defining edges of the atrium.

The ability to see the defining edges of an atrium will have a direct effect on the level of confinement perceived by occupants.

As the camera moves back along dotted line from point B to point A the place where level of confinement will significantly increase will be at approximately point C. This is the point where the vertical corners which define the atrium are no longer visible.

The absence of corners in drawing 2 may cause the occupant to feel a high level of confinement at a point closer to the window.
1. Give name (Don Arnold)
   5th year thesis student

2. Project description (Given to respondent.)

   "This project is a research portion of my architectural thesis studying the psychological principles involved in underground design. It is an attempt to test a research process used to gain more statistical data on the perception of certain architectural features in underground design. The particular section you will be assisting with is the study of relationships between an exterior atrium and an interior space. As the test is administered you will be asked to respond to some specific questions and a few general questions will be asked at the completion of the test. You will be viewing a model through a video camera. The TV screen will be the major communication tool used. After the test is over, feel free to ask questions about the test and procedures involved."
The test begins with respondent seated in front of TV screen and a table in front of him.

Window at position #1 - camera at position C - move to window edge then move camera toward position F - ask respondent to say "stop" when level of confinement is too high to move any farther back. Position of camera is marked.

Window at position #2 - camera at position C - move to edge of window then move camera toward position F - ask respondent to say "stop" ................

Window at position #3 - camera at position C - move to edge of window then move camera toward position F - ask respondent to say "stop" ................

Show pre-recorded picture from points A - F with windows at position 1.

Repeat at points A - F with windows at position 2 and then position 3. Each position is to be rated by the respondent according to the level of confinement. (Circle choice of rating.)

Not Confining 0 1 2 3 4 5 6 7 8 9 Totally Confining

* In order to reduce inaccurate results, the first three tests will be alternated.
The rating points (A - F) will also be alternated in order given.

<table>
<thead>
<tr>
<th>Window Position Alternate</th>
<th>Point of Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 2 - 3</td>
<td>A-B-C-D-E-F</td>
</tr>
<tr>
<td>3 - 2 - 1</td>
<td>A-C-E-D-B-F</td>
</tr>
<tr>
<td>1 - 3 - 2</td>
<td>C-D-B-E-F-A</td>
</tr>
<tr>
<td>2 - 3 - 1</td>
<td>F-B-A-C-E-D</td>
</tr>
<tr>
<td>3 - 1 - 2</td>
<td>B-F-D-A-C-E</td>
</tr>
</tbody>
</table>

The testing should be done twice:

Once with the straight atrium walls.

Once with curved atrium wall.

* These should be alternated.
D = Deck
P = Person
PL = Plant

SCALE: 1" = 1'-0"
<table>
<thead>
<tr>
<th></th>
<th>NOT CONFINING</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>TOTALLY CONFINING</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>&quot;</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>&quot;</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>NOT CONFINING</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>TOTALLY CONFINING</td>
</tr>
<tr>
<td>2</td>
<td>&quot;</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>&quot;</td>
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<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Comparison of locations of camera when "stop" command is given to find a general zone or specific point that this command is given for each window position.

Compare this zone or point with point where the atrium wall vertical corners are no longer visible.

Compile rating data for each point under each window position.

Find average rating for each point.

Analyze the average and the individual respondent data for a zone or point where a significant change in the level of confinement occurs.

Compare this zone or point with the location of the point where vertical corners are no longer visible.

For example if at window position 2 point D is the first point viewed where corners are not visible then a greater change in rating number would be expected from point C point D than from either point B point C or from point D point E.

Data from identical window positions and points of view could be compared between the test of atrium wall with corners and the curved atrium wall where no corners will be visible at all.
Data should be compared to see if an even stronger relationship exists between viewing corners and activity zones.
Further tests could be done in groups by use of a computer system which could record, by push button or other apparatus, the response of a large group of respondents. The computer could be set up to record the exact position of the camera as it moves and the point where the respondent presses a button. The computer could also automatically record and analyze the data.

There are numerous variables which could be manipulated in this particular scenario to change the perception of the interior and the atrium.

To assist in the further study of perception of the interior confinement and association with an adjacent exterior atrium, the following matrix of variations is proposed for adaptations in detailed studies.

Several groupings of variables such as atrium form, atrium size, atrium wall height, interior wall corners, window aperture height, aperture height/width ratio, etc. are given. Any particular group could be studied as long as only one variable is changed at a time.

The matrix is not all inclusive of variables but serves as a guide to the most significant variables to be studied.
<table>
<thead>
<tr>
<th>Wall Type</th>
<th>Ceiling Type</th>
<th>Wall Height</th>
<th>Wall Slope</th>
<th>Glass Slope</th>
<th>Wall Finish</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat Wall</td>
<td>Arched Cell</td>
<td>10' Tall</td>
<td>1:1</td>
<td>1:2</td>
<td>Stone</td>
</tr>
<tr>
<td>Flat Wall</td>
<td>Arched Cell</td>
<td>8' Tall</td>
<td>1:2</td>
<td>1:3</td>
<td>Stone</td>
</tr>
<tr>
<td>Flat Wall</td>
<td>Arched Cell</td>
<td>6' Tall</td>
<td>1:3</td>
<td>1:4</td>
<td>Stone</td>
</tr>
<tr>
<td>Flat Wall</td>
<td>Arched Cell</td>
<td>4' Tall</td>
<td>1:4</td>
<td>1:5</td>
<td>Stone</td>
</tr>
<tr>
<td>Flat Wall</td>
<td>Arched Cell</td>
<td>2' Tall</td>
<td>1:5</td>
<td></td>
<td>Stone</td>
</tr>
</tbody>
</table>

**Room Type**
- Residential
- Commercial
- Office
- Industrial
- Retail
- Hospitality

**Sample Matrix of Research Variations**
- Material: Stone, Concrete, Plant Life
- Water
- Atrium Wall
- Central Loc.
- Side Loc.
- Distant Mountain View

**Distance from Wall**
- 10'
- 20'
- 30'
- 40'

**Sample Columns**
- Atrium Depth
- Atrium Wall Form
- Cell Form
- Arched Cell Form
- Flat Wall Form
- Scribed Cell Form
- Plan Wall Form
- Curtain Wall Form
- Core Exit

**Sample Rows**
- 10' Tall
- 8' Tall
- 6' Tall
- 4' Tall
- 2' Tall

**Additional Notes**
- Material Selection
- Atrium Design
- Window Size
- Wall Height
- Glass Slope

**Sample Research Matrix—212**
APPENDIX-D
BIBLIOGRAPHIC BASE
The following bibliographic listing serves as a base list of sources for both the research paper of Appendix C and the initial research for the body of the thesis. The books listed in the first two parts served as major concept generators. The listing is broken down into three parts. The major sources are listed first. They represent the most important sources found concerning the psychology of design and underground construction. The second part lists other significant sources. These books represent a secondary source for psychological concepts. The third section, related sources, represents a base of information concerning all facets of underground design including construction. Depending on the subject and level of interest in psychology and underground design, these sources may or may not apply. Over all, this bibliography is not all inclusive of books in print, but is made up of books most likely found in the Ball State Library. In addition, some sources were obtained through the Inter Library Loan service and may be easily requested through that means.


DESIGN COMPETITION
The thesis part of the architectural program is to be three quarters long. I chose to do the 1984 Paris Prize competition as part of my thesis experience. The competition program was to design a school of architecture for Columbus, Indiana. Columbus appears to be a center for architecture. There are a wide range of projects in Columbus which modern architects have done. Columbus is almost an architectural museum. Because of this, it is an ideal place for a school of architecture. I chose to emphasize the use of energy as an organizer both for the site and for the buildings. Natural light was an important element used in all of the design. Due to the wide variety of functions in the program there needed to be a flow and unity through the complex. Yet, because of the prime importance of public access to parts of the facility I felt their existed sufficient justification to separate the housing facilities which were more private from the educational facilities which were to be very accessible to the public. There is a definite progression from the public end where the outdoor lecture facility was placed and the private area where the housing is. The park was an important element since it represented the most
likely place where pedestrian traffic to the school would come from. The following two pages show the general statement and the program. I decided to build a model and take pictures of the model for use on the boards. A picture of the model will follow the program statement. Overall the competition was an excellent opportunity to learn to think quickly and generate ideas. It also served as a chance to discover both strengths and weaknesses in design and graphics abilities.
1984 PARIS PRIZE PROGRAM

A SCHOOL OF ARCHITECTURE FOR COLUMBUS, INDIANA

Authors—George Schipporett and Craig Smith

GENERAL STATEMENT

In the years since World War II, Columbus, Indiana has become a living museum of Contemporary American Architecture. More than 40 public and private buildings have been designed by prominent American architects in this midwestern industrial town of less than 30,000 residents. A 1964 article in the Saturday Evening Post first labeled Columbus the "Athens of the Prairies," a slogan that has been adopted and helped to create an unprecedented interest in architecture among its local residents. The design of many of the local schools have been experiments in educational design, including examples by Gunnar Birkerts; Harry Weese; The Architects Collaborative; Edward Larrabee Barnes; John M. Johansen; CRS; Mitchell-Glurgola Associates; Hardy, Holzman, Pfeiffer Associates; among others. The relationship of academic achievement to physical environment is shown in the outstanding reputation of the Columbus and Bartholomew County school system.

Considering this background, it seems natural that individuals have decided to endow a School of Architecture in Columbus. The School would be unique as a residential educational experience, where students live and work with full-time and visiting faculty members.

The Academic Program would consist of a two- to three-year course of study open to those students who have completed required non-professional or pre-architectural coursework. Students with degrees in other areas would also be welcome. Certain facilities and resources will be shared with other nearby institutions such as Indiana University in Bloomington. Students would be trained in a manner that encourages a close association between all of the art forms.

CONCEPT

The School will retain only a small staff of permanent faculty members to administer the program and maintain academic consistency. All other faculty will be resident or visiting professionals or professors on sabbatical leave from other institutions.

Faculty and students will reside in the School in close proximity to the design studios. Each student will have permanent space in the studio to allow the establishment of a more personal learning situation.

As a part of the endowment requirements, the School facility will serve as the archive for all drawings, models, and papers associated with architects whose work appears in Columbus. Architects working in Columbus may reside at the school while visiting their projects.

SITE

The site is adjacent to downtown Columbus, bordered by Mill Race Park on the west, the Flatrock River on the north, and US 3/A and Lindsey Street on the east. It is essentially a flat site, just above the river bottomland. The main shopping street, Washington, is only three blocks east of the School. Railroad tracks run between Lindsey Street and the School site and will remain. There are no sidewalks on the adjacent roadways.
PROGRAM

Number of students to be between 150 and 180.
Permanent design studio space of 50 square feet per student, which may be open-plan or compartmentalized.
Parking spaces associated with housing to be 150; 15 spaces at entry office, and enclosed spaces for faculty members.
Housing is to be provided for 180; configuration to be 90 rooms for two students each, grouping two rooms together with a living room suite for 45 suites. Suites to be grouped into four or five houses directly accessible to design studio space.
Faculty housing for eight families. Faculty Housing should relate to student “houses”.

<table>
<thead>
<tr>
<th>Area</th>
<th>Sq. Ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design studios</td>
<td>9,000</td>
</tr>
<tr>
<td>Four other classrooms of 600 sq. ft. each</td>
<td>2,400</td>
</tr>
<tr>
<td>Auditorium accessible for public use</td>
<td>2,000</td>
</tr>
<tr>
<td>Library</td>
<td>2,500</td>
</tr>
<tr>
<td>Head of school office</td>
<td>150</td>
</tr>
<tr>
<td>Secretaries</td>
<td>150</td>
</tr>
<tr>
<td>Eight staff offices adjoining design studios</td>
<td>800</td>
</tr>
<tr>
<td>School lounge</td>
<td>500</td>
</tr>
<tr>
<td>Dining area—Commons, 12 sq. ft. per person</td>
<td>2,300</td>
</tr>
<tr>
<td>Kitchen/service</td>
<td>600</td>
</tr>
<tr>
<td>Exhibit space to be related to lounge, and available for public viewing</td>
<td>1,000</td>
</tr>
<tr>
<td>Workshop</td>
<td>750</td>
</tr>
<tr>
<td>Reproduction and photo lab</td>
<td>750</td>
</tr>
<tr>
<td>Computer center</td>
<td>500</td>
</tr>
<tr>
<td>Outdoor lecture space—partially covered</td>
<td></td>
</tr>
<tr>
<td>Archives—suppository for Columbus, Indiana</td>
<td>2,500</td>
</tr>
<tr>
<td>Recreation center with exercise rooms, lockers, sauna, whirlpool, and two racquetball courts</td>
<td>2,900</td>
</tr>
</tbody>
</table>

GENERAL REQUIREMENTS

As a demonstration facility the School is expected to be energy efficient. It is planned that the School will be used for special summer “Artist in Residence” programs.