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Authors
Bosselmann, Peter
Craik, Kenneth H.

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Peter Bosselmann and Kenneth H. Craik

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PERCEPTUAL SIMULATIONS OF ENVIRONMENTS

Peter Bosselmann and Kenneth H. Craik

The immediate on-site impressions of the environment that we experience in our everyday rounds constitute an important facet of our daily lives. But they are not the only environmental impressions we form. We also encounter environments through newspaper photos, Hollywood movies, television shows, and perusal of our own tourist snapshots. Within the fields of environmental planning, design, management and conservation, a substantial amount of professional communication about environments and their generation takes place necessarily through indirect presentations of sketches, floor plans and maps, and scale models (Appleyard, 1977). And research on environmental perception and assessment, as well as other topics in environmental psychology, often uses indirect presentations of environments that are convenient and manipulatable (Craik, 1971; Holahan, 1982).

This chapter will describe the varieties of environmental simulation; attempt to unpack some of the meanings in the question: "What is a good simulation?"; examine research issues in efforts to address some forms of that question; and describe research, design and planning applications of a dynamic environmental simulation laboratory.

VARIETIES OF ENVIRONMENTAL SIMULATION

The notion of environmental simulation can be construed quite broadly to encompass a variety of simulation techniques. McKechnie (1977) has offered a useful typology based upon the dimensions of conceptual-perceptual and static-dynamic. *Conceptual simulation* seeks to convey abstract forms of environmental information. Static conceptual simulation includes maps and floor plans; dynamic conceptual simulation includes computer modeling of ecological processes (such as the Club of Rome's limits to growth simulations). *Perceptual simulation* aims at conveying specific physical environments or places. Static perceptual simulation includes photographs and sketches; dynamic perceptual simulation includes filmed modelscope tours of scale models of places.

Nested within McKechnie's typology, a further differentiation among dynamic perceptual simulations can be illustrated by three contexts of application: simulation in environmental planning and design; simulation in auto driving, flight and navigational training, and simulation in entertainment feature films and television.

In environmental planning and design, visual simulation (e.g., film) is combined with contrivable environments (e.g., scale models, sketches). The goal is to convey accurate impressions of a place, that is, what is seen to be present in it, what descriptions it evokes, and what evaluations it elicits. The purpose is to provide previews of proposed environments that do not yet exist so that response to them can be considered during the decision-making process (e.g., in planning and design development; in public hearings) and prior to implementation and construction.

In auto driving, flight, and navigational training, visual simulation is combined with performance monitoring. Auto driver simulators, for example, typically consist of a cab in which the driver sits, a motion picture screen and projector, and scoring consoles. The cab approximates a mock-up of an actual vehicle, with steering wheel, brake, signal lights, etc. During a simulated tour, the driver steers, brakes and signals in reaction to various situations presented in the film, and this behavior is recorded and scored for appropriateness. By this kind of device, operators are trained and tested for real-world performance in automobiles, airplanes, space capsules and ships. These applications entail the assumption that simulator performance predicts subsequent real-world performance. Unlike the context of environmental planning and design, contrivable environments (e.g. scale models) are useful in presenting systematically varied situations for operator reaction.

Entertainment films and television are usually visual simulations of real-world settings, if not real-world events, although mock-ups in the form of stage settings are widely used. However, contrived environments achieved by cinematographic special effects and miniaturization have had an increasingly strong role in entertainment. As the recent accomplishments of space adventure films such as "Star Wars" and the genre of disaster films demonstrate, vivid and exciting experiences of imaginary worlds and extraordinary events can be evoked by outstanding expertise and elaborate technical facilities (Dykstra, 1977; Kenworthy, 1973). Unlike the context of environmental planning and design, visual simulation in entertainment is typically interwoven with action, plot, characters and theme.

When employed in environmental planning and design, the use of simulation has similar general aims as in operator training, namely, to predict responses in the real-world setting from responses in the simulated setting. However, the appropriate response domains differ. Rather than *impressions of places*, auto driving, flight, and navigational simulations seek to predict real-world performances. In this sense, the criteria for appraising simulation effectiveness is more clear-cut in operator training simulation. In one empirical study, for example, two research staff independently rated fourteen aspects of the real-world road performance of 304 taxi drivers, including 1) turning without a signal, 2) following too closely, and 3) failure to stay in one lane (Edwards, Hahn, and Fleishman, 1977). At this time, the drivers were not aware that they were being monitored in this way. Officially recorded accidents and violations over a five-year period were also obtained for all drivers. Then their performance was tested on two standard auto driver simulators. The key question is whether on-the-road performance can be predicted from simulator performance. This study failed to demonstrate the psychological effectiveness of the auto simulators; none of the simulator scores showed a significant relation to any of the on-the-road performance indices.

This study does underscore the goal of comparability between real-world and simulation response that is shared by applications of simulation in operator training and in environmental planning and design, and illustrates the difference in appropriate response domains. In the former, the behavioral criterion has to do with skilled performance in operating a vehicle; in the latter, it bears upon more or less direct cognitive and evaluative responses to specific physical settings.

Simulation in entertainment films and video programs are also geared to cognitive and emotional responses, but comparability to real-world response is not an issue. Instead, the aim is a successful level of engagement, thrill, curiosity, excitement, and wonder on the part of the audience in the special social context of theatre. Unlike entertainment simulation, presentations of simulated physical settings in environmental planning and design are typically devoid of plot, characters, action and theme. In this respect, these contexts (e.g. environmental public hearings) also constitute special kinds of social situations. By calling for responses that are more or less directly and exclusively focused upon the physical environment, they differ from most, but not all, everyday life experiences.

At environmental public hearings, attention is directed to the proposed physical setting and structures. The project might be the rennovation of an interior, the addition of an office building to the urban skyline, a planned residential community, or surface mining within an undeveloped valley. Responses to the simulated environment typically focus upon what is being proposed, how best to characterize it, and how to evaluate it. Another feature of this particular kind of presentation is that responses are usually first impressions. That is, the observers often are viewing the proposed project for the first time and only rarely are they afforded opportunities to examine it repeatedly and over a period of time.

EVALUATING THE PSYCHOLOGICAL EFFECTIVENESS OF PERCEPTUAL SIMULATIONS

During the past two decades, efforts have been made to appraise the psychological effectiveness of static and dynamic forms of perceptual simulation. The impetus for this research comes from two sources. First, within the process of planning and design, static and dynamic forms of perceptual simulation are ubiquitously employed. Photographs of the site are used within agencies and firms as surrogates for repeated stie visits; sketches, renderings, plans, and scale models are an integral part of the process of formulating and communicating planning and design concepts and possibilities to colleagues, clients and the public (Appleyard, 1977; Cuff and Hooper, 1979). Second, research on topics in environmental perception, cognition and evaluation often uses photographic simulations of environmental settings. For example, Groat (1982) has studied the meaning of post-modern architecture among laypersons and experts. Prototypic examples of buildings for the design categories she examined are located in Chicago, Marsailles, Tokyo, Boston, Brasilia, Philadelphia, Newcastle-upon-Tyne, and elsewhere around the world. Rather than take research participants on a global tour, photographic presentations of the buildings were employed. Thus, appraisal of the psychological effectiveness of perceptual simulations has practical and scientific importance.

To convey the nature of this enterprise in environmental psychological research, three issues must be discussed. First, the question: "How good is a simulation?" must be unpacked of its various meanings. Second, the complexity of the research generated by the question must be appreciated and its several facets described. And third, the alternative ways of analyzing findings and converting them into evidence relevant to the question must be reviewed and illustrated.

UNPACKING THE QUESTION; "HOW GOOD IS THE SIMULATION?"

By limiting ourselves to the use of static and dynamic perceptual simulations in 1) environmental planning and design and 2) environmental psychological research, the question: "How good is the simulation?" can be reformulated as: "How well do responses to the simulation predict first impression of them? Actually, our knowledge of how people comprehend and evaluate everyday physical settings is not well developed. The topic of environmental perception has only recently received concerted scientific attention, as part of the agenda for the field of environmental psychology (Craik, 1970, 1973, 1977; Stokols, 1978; Russell and Ward, 1983; Holahan, 1982; Daniel and Vining, 1983; Saarinen and Sell, 1981).

The study of environmental perception seeks to understand the impressions we form of settings and places, which constitute an aspect of everyday experience, and focuses upon the processes and factors influencing the varied impressions that observers form of environments. In this context, the term "perception" has been used broadly, to encompass not only immediate visual and auditory perception but other forms on environmental awareness and pertains to both descriptive and evaluative responses. The topic of environmental perception has generated one of the most active lines of research in environmental psychology and has engaged the efforts of geographers, architects, and planners as well as psychologists (Craik, 1973; Holahan, 1982; Ittelson, 1978; Porteous, 1977; Rapoport, 1977; Saarinen and Sell, 1981; Daniel and Vining, 1983; Zube, Sell and Taylor, 1983; Feimer, 1983).

The research to date on environmental perception reveals that the levels of responding to places are multi-faceted, subtle and complex. Of course, an individual's experience of a place is not directly accessible to others, but must be expressed and communicated if it is to be studied. One of the major tasks facing environmental psychology is the development of standard devices for assisting the individual in recording descriptions, inferences, knowledge, evaluations, and other reactions to places and judgments of them. Thus, in order to compare the degree of match or equivalence between impressions of a place formed on the basis of direct site visit versus simulated presentation, adequate means of recording this domain of responses must be at hand.

In light of our purposes, another complicating recognition has emerged from research on environmental perception. That is, many factors other than medium of presentation of a place influence the impression individuals form of it. Four sets of variables have been identified as integral to investigations of environmental perception: 1) characteristics of the observers (e.g., environmental attitudes and dispositions; professional training); 2) medium selected for presenting the settings (i.e. how the place is encountered, e.g., via direct site visit, photoslides, scale models, sketches); 3) the response formats used and the range of reactions they encompass, and 4) the environmental attributes of the settings (Craik, 1968, 1971, 1981; Goodey, 1971; Pervin, 1978; Saarinen, 1969; Zube, 1974). A fifth set of variables has also received attention, dealing with the nature of the transaction with the specific setting, such as cognitive and instructional sets and prior familiarity (Craik, 1983a; Leff, Gordon and Ferguson, 1974).

Our general question: "How good is the simulation?" perhaps inevitably requires a narrower specification before it can be properly addressed. How good is what kind of simulation, for what kind of environment, with regard to whose impression of the place, formed under what conditions of encounter with it and as recorded on which response formats? As we shall see, decision must be made about each facet of this specification statement in any psychological appraisal of environmental simulation. Before discussing these matters in more detail, however, a preliminary strategic option must be dealt with.

We have established the need to compare impressions of a place based upon a simulated presentation with those based upon a direct site visit. One option is to select an existing place, develop a simulation of it, and compare impressions formed in direct and simulated presentations of it. An alternative that appears to fit more closely with the application of simulation in environmental planning and design is to select a proposed project, develop a simulation of it, obtain impressions based upon the simulated presentation and then, at a later time when the project has been implemented, obtain impressions of the actual place.

Despite its appeal on many counts, the second option introduces a formidable array of confounding factors into an effort to appraise the psychological effectiveness of the simulation itself. Planning and design development are incremental processes that occur in an on-going social context. Because they are incremental, the level of detailing of the plan or design varies from point to point in the process and probably is never as comprehensive, thorough, explicit and inclusive as the details of an existing place. This observation implies, of course, that any implemented plan or design inevitably yields a host of unanticipated outcomes that have not been clearly conceived or considered in advance of implementation or construction. Because the process occurs in an evolving or at least ever-changing social context, detailing becomes more precise but also increasingly subject to modification as financial and institutional commitment to implementation of the project advances (Sheppard, 1982a, 1982b).

The practical consequence for appraisal of environmental simulation is that if this strategy is adopted, any failure to achieve comparability between impressions formed on the basis of pre-construction places may due either to incompleteness or errors in the detail project information used in the simulation or to inherent limitations of the simulation medium. In contrast, the first option, i.e., taking an existing place, simulating it, and comparing impressions based upon each, offers a more straightforward and interpretable appraisal of the capabilities of the simulation medium.

By adopting this option, however, one cannot thereby escape the problems that the second option carries for the application of simulation in environmental planning and design. That is, incompleteness and error in the information available about the proposed place, upon which simulations must be formed, may significantly reduce the accuracy of predictions of post-construction response to the places. This issue warrants empirical study in its own right. But it can be put aside here, for it does not bear directly upon the psychological appraisal of simulation effectiveness.

FACETS OF THE RESEARCH DESIGN

Any appraisal of the psychological effectiveness of perceptual simulations inescapably entails decisions regarding 1) which modes of presentation of the environment to compare, 2) what domains of response will be compared, and 3) who will serve as participants in the research. Drawing upon simulation appraisal studies that have been reported, each of these facets of the research design can be reviewed and illustrated.

1. Modes of presentation

The modes of presenting research environments to observers fall into three major categories: 1) *direct presentations*, including auto tours, walking tours, use of the facilities, and viewing from specified vantage points; 2) *post-construction simulations*, including film, photography, and television for indirect presentations of already existing environments, and 3) *pre-construction simulations*, usually combining the techniques of model-making or sketching with film, photography or television for presentations of proposed or experimental environments prior to their construction or development. Some modes of simulation, such as computer graphics, have been notably neglected by empirical appraisals, while holography has been the focus of only one study. With the exception of film and video presentations (Acking and Kuller, 1973; Appleyard and Craik, 1974, 1978), the visual simulations are static rather than dynamic in character, although the use of photoslide sequences may achieve a dynamic quality.

Most empirical appraisals include at least one direct presentation which serves as a criterion standard for appraising visual simulations (e.g., Appleyard and Craik, 1978; Craik, 1983b), but some simply compare pre-construction with post-construction simulations (e.g., Cunningham, Carter, Reese, and Webb, 1973), or even two pre-construction simulations (e.g., Carter, Benyon and West, 1973). Color photoslides used singly or in sequences for post-construction simulations appear to be the most frequently studied mode of presentation (e.g., Daniel and Boster, 1976).

The selection of modes of presentation in these studies appraising simulation may not adequately represent the frequency with which various forms of perceptual simulation are employed in practice and research. Little is known in particular about the base-rate of usage for forms of perceptual simulation in everyday planning and design contexts. Sheppard (1982a, 1982b) conducted a survey of working simulations for projects involving large-scale landscape impacts. Out of a sample of 130 project presentations using a form of perceptual simulation, tonal and line drawings accounted for 39 percent of all portrayals, followed by: black-and-white photomontage (18 percent), full-color renderings (14 percent), scale-models (9 percent), computer-graphics (9 percent), color-photomontage (8 percent), and others (3 percent). Thus, this set of findings raises the possibility that film and photographic simulations are over-represented and sketches are under-represented in appraisal studies, perhaps reflecting researchers' concern with the scientific rather than practical applications of perceptual simulation.

2. Response formats

Research appraising perceptual simulations requires the specification of appropriate criterion measures. Progress in environmental psychology has not yielded a comprehensive array of standard response measures. Furthermore, different applications of perceptual simulation may entail varying forms of appraisal. While an adequate delineation of criterion measures remains a complex and open-ended matter, empirical appraisals of perceptual simulation have commonly opted for a small number of descriptive and evaluative dimensions for recording responses to actual and simulated environments.

The use of bi-polar descriptive-evaluative dimensions, often presented as a version of sematic differential ratings, has predominated. Indeed, this technique has served as the sole response format in many investigations despite its limitations (Ward and Russell, 1981; Craik, 1981).

Although research in environmental perception and assessment has sought to identify a basic set of descriptive and evaluative measures (Craik, 1971; Craik and Feimer, in press; Feimer, 1984); Craik, 1971; Daniel and Vining, 1983), it has not yet produced a standard set of response formats commonly accepted in evaluation research in visual simulation. Consequently, empirical appraisals of perceptual simulation tend to employ lists of descriptive-evaluative adjectives that vary in content and length.

Supplements to descriptive-evaluative dimensions have been employed from time to time, and are noteworthy. Closely related are free descriptions and descriptive checklists, on the one hand, and more explicit forms of evaluative judgments, on the other. Judgments of objective properties include estimates of size, distance, and height. A toggle switch apparatus has been employed to register interest patterns during dynamic presentations (Cunningham, Carter, Reese, and Webb, 1973). Behavioral intentions and self-predictions include judgments of how much one would enjoy residing in a setting (Rabinowitz and Coughlin, 1971) and how far one would be willing to walk to use a facility (Wood, 1971). The most overt behavioral criterion remains the monitoring of routes through a museum, in the research of Bonsteel, Sasanoff, and Winkel (Bonsteel and Sananoff, 1967; Winkel and Sasanoff, 1976). Cognitive indices have been relatively neglected, but can be illustrated by the use of map-sketches, and inferences regarding the function of buildings (Wood, 1972; Appleyard and Craik, 1978; Craik, 1978b; Bryant, 1984). Surprisingly, in this research tradition, direct judgments of the subjective adequacy of simulation media (in contrast to responses to the environments simulated) have rarely been reported (Anderson, 1970; Wood, 1972).

3. Research participants

The external validity, or potential generalizability, possessed by empirical appraisals of perceptual simulation is partially determined by the representativeness of research participants. As Table 3 shows, most investigations have studied university students. However, about half of these studies have employed architecture and design students, representing a pertinent domain of simulation users. Studies enlisting the participation of practising envrionmental professionals also focus upon important population of simulation users. Some investigators have sought out members of the general public, typically having recourse to ready-at-hand groups (e.g., office workers), while systematic sampling from specified populations is rare.

The museum visitors in Seattle (Bonsteel and Sasanoff, 1967; Winkel and Sasanoff, 1976), the campus visitors at the University of British Columbia (Seaton and Collins, 1972) and the residents of a county in California (Appleyard and Craik, 1978; Craik, 1983b) constitute the most broadly representative samples thus far recruited to appraise perceptual simulation.

ANALYZING THE FINDINGS OF PERCEPTUAL SIMULATION APPRAISALS

The question "How good is the simulation?" takes on further and more specific meanings when an appraisal study has been conducted and the findings are available for analysis. The form of the analysis inevitably generates a more detailed specification of our question.

In order to illustrate these analytic options, a simulation appraisal project will be described, and then the analytic alternatives and their implications can be discussed.

The simulation appraisal project was linked to an effort to create an innovative laboratory at the University of California at Berkeley whose goals were to develop new techniques in dynamic environmental simulation, to appraise the psychological effectiveness of the techniques, and to explore the range of new applications of dynamic perceptual simulations in environmental decision-making, public communication, and psychological research. The laboratory was initiated by the late Donald Appleyard (Anthony, 1983; Craik, 1982; Cuff, 1984). The present facility was constructed in 1971 through a National Science Foundation grant to Appleyard and Craik (1974, 1978).

THE BERKELEY ENVIRONMENTAL SIMULATION LABORATORY

The primary component of the laboratory is a dynamic environmental simulator which enables one to "walk" or "drive" through small three-dimensional scale models of urban, suburban and natural environments. A remotely guided television camera equipped with tiny viewing attachments moves through scale models of the environment and projects continuous eye-level views on closed circuit television screens. Trips through miniature environments can be displayed "live" to large television audiences. Color film and videotapes can also be made, by using either manual or computer-controlled guidance system, for comparative feedback, permanent records, and later presentation. The laboratory had model-making and film-making facilities.

The uses of the laboratory in facilitating decision-making, citizen participation, and psychological research is a topic to which we will return. Now let us examine the issues presented by attempting to gauge the psychological effectiveness of this form of dynamic perceptual simulation of environments.

1. Research choices

The first decision was to select an existing place, develop simulations of it, and compare descriptive and evaluative impressions formed in direct and simulated presentations of it. The second decision was to recruit samples of the general public and of environmental professionals to participate in the appraisal project. Their experience of the study depended upon further decisions regarding the setting, the media of presentation, and the response formats.

2. The setting and the scale model

After considering several possibilities, a research site was selected in Marin County, which is located north of San Francisco, California, just across the Golden Gate Bridge. While Marin County is internationally known for the extraordinary scenic beauty of its coastal zone, including Pt. Reyes National Seashore, the research site lies within the inland, eastern, more developed Route 101 corridor and is a better representative of the more ordinary low rolling hills and valleys of northern California. The setting for our study, approximately two by four miles in extent, embodies a broad array of land uses, including several types of residential areas, a regional shopping center, an older commercial highway strip, a light industrial park, an office complex and some grazing land. The topography features hillsides with extensive grasses and occasional oak and bay trees. The small hills throughout the site create a system of differentiated places. The residential areas, mostly along the valley floors, are cultivated with vegetation that is not native to the area, including Eucalyptus trees, liquidambars, and oleander.

Settings vary in the adequacy of the challenge they offer to the effectiveness of environmental simulation. Little is learned about the capability of a simulation technique if the difficulty level of the research site is not set sufficiently high. Initially, we had considered Nicasio Valley, which runs east-west across the northern part of the county, as a research site. Extensive ecological information had been gathered on it by colleagues in the College of Environmental Design, which would have been available in constructing a scale model of it. However, an auto tour of the valley offers a predominantly linear route moving through dairy farms and open hillsides. Thus, even a quite primitive simulation might succeed in conveying the uncomplicated and redundant character of this setting. In contrast, the research site we eventually selected consists of a number of distinct places characterized by varied land uses and a more complex system of roadways, including a major highway, a parkway, connector roads, residential roads and even a stretch of unpaved road. In addition, because of the small hills throughout the central portion of the site, observers never see the setting in a single glance but must instead organize its spatial layout cognitively.

A scale model of the research site, at one inch to 30 feet, was then constructed. This scale appeared to be compatible with the current state of the art of model building while permitting the construction of models within our laboratory to depict regions several square miles in area and thus large enough for the study of new communities, transit system projects, high-rise buildings, and the like. Aerial photographs of the site provided contour information for cutting and shaping the basic polyurethane terrain model. The detailed "dressing" of the model with roadbeds, vegetation, signs, equipment, vehicles, and structures was guided by photographic field studies of the setting and a color film of the auto tour through it. Photo-reduction techniques were used for some signs and building facades; other features and the cycloramic background were handpainted.

3. The media of presentation, standard tour route and general instructions

In everyday life, we encounter places in varied ways: we stride, stroll, jog, rollerskate, bicycle, skateboard, and drive through places and some of us fly, glide and parachute over them. The closest analog to our dynamic environmental simulator, with its moving point of vision and variable acceleration and viewing direction, seems to be the auto tour. Because it is also a ubiquitous way of becoming acquainted with a place for the first time, the direct auto tour (AT) of the research site was selected as the basis for comparing and appraising three forms of simulated tours of the setting: a color film of the scale model tour (MF), a color film of the auto tour (AF), and a videotape of the scale model tour (MV). The primary focus of appraisal was upon the principal product of the dynamic simulator: a 16mm eye-level color film of the scale model tour. A 16mm color film of the real-world auto tour, made with a camera mounted in the front passenger side of an auto after its windshield had been removed, afforded an opportunity to differentiate between possible effects due to use of color film, with its fixed orientation and restricted angle of view, and effects due to the use of a scale model, with its inevitable detail distortions of the real-world setting. Finally, a black-white videotape of the scale model tour was included in the study to appraise the form of simulation being employed in the laboratory for live, direct feedback uses. We now use color video.

In seeking to appraise the effectiveness of environmental simulation in conveying impressions of a place, we must operate at the boundaries of our knowledge of environmental perception and cognition. Thus, we are unable to appeal to prior scientific findings to judge the consequences of our focus upon the auto tour, in contrast to the stroll or helicopter flight. That these differing ways of encountering a place affect the impressions visitors form of it is a reasonable hypothesis but one not yet examined by environmental psychologists. All we can assert at this time is that by having to choose one of them, we have added another specification to our inquiry: "How good is the simulation?"

Nevertheless, the auto tour is an attractive options because in our society it represents an important form of everyday environmental experience. After much exploration along the roadways of the research site, we devised a standard tour of about 25 minutes and nine miles through it. We had considered the alternative of developing much briefer and shorter tours through more restrictive models of several research sites. However, these presentations would not be typical of an auto drive and the scale models would not be useful for other research applications. The present standard tour is more representative of the social context of "going for a drive" and also affords a sufficiently challenging level of complexity for appraising the simulations. The findings from this study can also provide baseline findings for subsequent research examining the effects of briefer tours and tours combining several travel modes (e.g., ground level auto tours plus helicopter overflights).

As a full-fledged social event, an auto tour requires a purpose. Of course, our research volunteers would already be endowed with purpose: to enact the role of research participant ably and to advance the overall goals of our project through their cooperation. We considered the possibility of adding a hypothetical social purpose to the research design, for example, by instructing our participants to assume that during the tour, they were 1) searching for a particular restaurant where they were to meet a friend for dinner, or 2) as newcomers to the region, they were evaluating this areas as a possible place of residence. However, the hypothetical nature of these purposes and their openness to individual variation in interpretation lent an unwanted complexity to the research design. Yet some orientation to the participants would be expected. We finally settled upon pre-tour instructions that combine the context of the scenic tour of "Sunday drive" with the context of an environmental public hearing where a new proposed project is being previewed.

Thus, prior to their tour, participants were informed that they would be touring an area of Marin County and that they were to take a good look at it, to note what impressions it made upon them, what caught their attention, what they liked and disliked about it, and in general, to size up the place. They were informed that following the tour, they would complete procedures that would assist them in recording their impressions of the tour area. They were requested not to smoke during the tour and not to take notes. Individuals in the auto tour condition were asked to aim for a minimal yet comfortable level of social conversation, rather than complete, awkward silence, but not to talk about the area being toured. Individuals in the other conditions were told they would be viewing a film of the tour, film of the scale model tour, or video tape of the scale model tour, as appropriate.

4. Response formats

The appraisal project required a full day commitment. In the morning session, participants were presented with the tour either directly or via simulation and then completed an extensive battery of procedures. In this systematic debriefing of their descriptions, cognitions and evaluations of the research site, participants completed mood-checklists, map sketches, environmental adjective checklists, regional Q-sorts, inference, information and recognition tests, and environmental evaluation forms (Appleyard and Craik, 1978; Craik, 1983b; Bryant, 1984; Feimer, 1984). Following lunch, they completed additional procedures dealing with personal background, environmental attitudes and dispositions, leisure activity styles and related observer characteristics.

5. Analytic strategies

The question "How good is the simulation?" is constrained at yet another level by the options selected in analyzing the findings of a simulation appraisal. Three examples can be illustrated from results of the simulation of the Marin research site.

First, the overall *congruence* in the descriptive impressions and evaluations of a place yielded by direct and simulated encounters with it can be gauged. For example, all participants rated how satisfactory they found the research site on 28 dimensions of residential quality. For each sample, these 28 dimensions can be ordered, according to mean ratings, from the attributes found to be most satisfactory to those found to be least satisfactory. In summary, the auto tour sample rated these features as most satisfactory about the research site:

nearness to professional offices (doctor, dentist, etc.)
nearness to shopping
good climate
nearness to freeway
maintenance of public areas (streets, sidewalks, etc.)
resale value of homes
nearness to schools

and found these features the least satisfactory:

amount of community spirit
good places for children's play
amount of visiting among neighbors
availability of public transportation within region
diversity of residents' age
diversity of social status and life styles
adequacy of separation from neighbors' houses (to ensure privacy)

The similarity with which two samples, say the auto tour (AT) and the model film (MF), evaluate a place can be estimated by the correlation between their mean ratings, across the 28 attributes. For the Marin research site, that correlation was above +.90, indicating substantial congruence in the overall evaluation of features of the site, regardless of the mode in which it was presented. Indeed, strong congruence in both descriptive impressions (as recorded on environmental adjective checklists and Q-sort decks) and evaluations prevailed in the findings from this study (Craik, 1983b).

Second, the question of whether the mode of presentation has any significant impact upon the main levels of the many dependent descriptive, cognitive and evaluative variables can also be addressed. This form of the basic question: "How good is the simulation?" quickly moves us into the realm of advanced multivariate statistical analysis. Several issues, however, can be noted briefly.

6. Factor analysis

Factor analysis can be employed to simplify the analytic and interpretive task by providing a smaller set of orthogonal summary variables. Thus, the 300 items of the environmental adjective checklist yield five factor scales (satisfying-delightful; monotonous-ordinary; neat-maintained; active-busy). Similarly, the 67 items of the regional Q-sort deck provides five factor scores and the 28 items of the environmental evaluation form generates five factor scores (Craik, Appleyard and McKechnie, 1978). These new factor scores still represent descriptive, cognitive or evaluative variables whose influence by the mode of presentation must still be examined. A similarity in factor structure across media conditions itself grants no assurance that specific research sites will be described or evaluated comparably (Craik and Feimer, in press; Wiggins, 1973).

7. Analysis of variance

Even with a reduced set of factor scores and other summary variables, an ambitious appraisal of perceptual simulation still retains a large number of dependent variables, calling for the use of multivariate analysis of variance. This analytic approach allows us to pinpoint any specific dependent variables that show a significant influence due to the mode of simulation employed. For example, the auto film (AF) condition resulted in significantly lower mean scores on the EACL scale: *beautiful-scenic* and on a set of four landscape descriptors (Craik, 1983b). Closer examination of the media suggests that an atmospheric haze and glare were picked up in the auto film presentation that was less noticeable in the direct auto tour setting and absent from the brightly lighted laboratory conditions of the model film (MF) and model video (MV) settings. As a second example of this kind of finding it can be noted that the research site was seen as lower on the EACL scale: *neat-maintained* under the model film (MF) condition. One of the challenges of the model making task was miniaturization of residential lawns and shrubbery. In the model film (MF) presentation, the residential landscaping did appear somewhat overgrown and unkempt, which probably led to this effect of the simulated presentation.

8. Discriminant analysis

The detailed search for specific effects of simulation provides precise feedback and guidance for improvements in simulation techniques and for better understanding of the processes involved. Another form of multivariate statistics, known as discriminant analysis, provides a means for judging how functionally important the detailed media effects may be. Discriminant analysis weighs and combines the entire array of dependent variables linearly to achieve maximum possible separation between media and conditions. It tests the utility of the overall diagnostic value of the full set of descriptive, cognitive, and evaluative variables in predicting which media conditions the participants had been assigned to. That is, if we had available to us only all thirty-four dependent measures and knew nothing else about the individuals, how successfully could we use this information to decide which of the participants had taken the direct auto tour and which had seen, say, the model film simulation?

The diagnostic separation turned out to be the most successful for the auto tour (AT) versus auto film (AF) contrast, followed by the auto tour (AT) versus model video (MV) contrast and then the auto tour (AT) versus model film (MF) contrast. Obviously, the worse the diagnostic ability of the full set of dependent variables, the more psychologically effective the simulation. In fully effective simulation, the responses of observers should offer no basis for estimating which medium of presentation observers used in encountering the setting.

Third, the question "How good is the simulation?" must be placed in a comparative context. The magnitude of the effects of simulation on descriptive, cognitive and evaluative variables is difficult to appraise in an absolute fashion. Craik (1983b) has reported that the proportion of variance accounted for by the media of presentation is modest (less than 10 percent for most dependent variables). As a comparison variable, the amount of prior familiarity with the site accounted consistently for more of the variance. In a somewhat different but complementary analysis of this data, Feimer (1980, 1984) estimates that the media of presentation accounted for about 3 percent of the variance, while a combination of personality and other observer characteristics accounts for five to ten times as much of the variance in the descriptive-evaluative variables. The effects of the media of presentation upon spatial-cognitive variables is somewhat higher (Craik, 1983b) and in a thorough analysis by Bryant (1984) it is estimated to approximate the magnitude of the effects of personality factors.

TRENDS IN RESEARCH FINDINGS ON THE PSYCHOLOGICAL EFFECTIVENESS OF PERCEPTUAL SIMULATION TECHNIQUES

We have identified three ways of reformulating the question "How good is the simulation?" from a statistical viewpoint. Most research findings thus far have focused upon the first formulation: "How good is the overall congruence of descriptive and evaluative impressions between direct and simulation presentations?" Most studies have reported substantial congruence, with correlations in the +.70 to +.95 range (Craik and Feimer, in press).

Simulation appraisal studies have devoted less attention, and less adequate statistical analysis, to the second formulation: "How extensive and of what kind are the detailed differences in descriptive, cognitive and evaluative responses due to the use of various forms of perceptual simulation?" As our unpacking of our basic question of our basic question has suggested, this formulation highlights the potential complexity of our research task. The number of forms of simulation and their combinations with the facets of observer characteristics, transactional contexts, and response formats pose a formidable but worthwhile research program. The studies to date amount to a sampling from this larger range of experimental conditions and do not provide the basis for generalizations. This research can be reviewed (Craik and Feimer, in press) but its primary message at present is that detailed, fine-grain understanding of alternate forms of perceptual simulation techniques and their contexts of application will require an imposing and long-term program of inquiry.

The third formulation of our question: "How consequential is the mode of presentation of places in comparison with other factors influencing impressions of them?" recasts our inquiry in the form of basic research on the understanding of environmental perception. It suggests that appraisal of the psychological effectiveness of perceptual simulation techniques may be best conducted within a larger scientific framework. The few analyses to date that have framed the question in this way derive from our study of the Marin County simulation project. In those findings, the media of presentation studied have consequences that tend to trail in magnitude to those due to prior familiarity with the site, personality characteristics, of the observers, and sociodemographic backgrounds of the observers. However, once again, the detailed implications warrant more attention (Craik, 1983b; Feimer, 1980, 1984; Bryant, 1984) than any generalizations that can be supported by them.

Overall, a review of studies on this topic suggests a falling off in the amount of research directed at the question "How good is the simulation?" (Craik and Feimer, in press). Clearly, this decline makes no sense in light of our very modest and fragmented knowledge and the generally thin amount of empirical evidence that has been gathered to date.

APPLYING ENVIRONMENTAL SIMULATION IN PLANNING AND PUBLIC COMMUNICATIONS

Capturing the vision of the city in communicable form began with the work of Kevin Lynch (1960). To convey the motion, light, wind, color, and tempo of the city as perceived by all of us became a special kind of design problem (Appleyard, Lynch and Myer, 1964). Although many planning professionals consider the visual aspects of the environment to be trivial in comparison with economic, fiscal and social issues, the fact however is that the public is extremely sensitive to the visual environment, for its symbolic quality and the immediate experiences it affords. Matters of scale, color, shape, street character and view affect a population's image of its city and of itself. The visual qualities convey powerful emotive messages which imply who runs the city, who dominates its environments, and the character of those in power (Appleyard, 1984).

Much needs to be improved in the way that planners and design professionals communicate projects and future plans. If the aim is to let the public become more involved in the planning process, better methods of communications have to be developed. This advance would be to the benefit of all parties involved. Planners and designers are bound to learn as much about their own plans as the public. The ability to describe in experiential terms effects of designs and plans is a rarely found skill among professionals. The terms professionals use to describe such qualities as "urbanity" are vague and they fall short of the qualities ordinary citizens directly experience in existing places. A lack of professional knowledge currently exists in this regard. Professionals have taken more and more to conceptual methods of explaining their ideas. This step has appeared to be a safer route, in that it leaves many visual impacts unrevealed and unexamined.

Even if planners wanted to explain the experience of a new development or plan more effectively, few techniques are available to serve these purposes. The experiential media of 20th century film and video are currently granted little importance in the planning and design professions. The development of the Berkeley Environmental Simulation Laboratory and the challenges of each new project undertaken by it have focused our thinking on all aspects of simulation and have prompted continuous appraisal of the validity of its products and their relation to practice within planning and design. Staff at the laboratory have become more and more aware of the politics of simulation, the relative utility of different media, and the hidden power that media have over our designs, decisions and environment. If done well, simulation can be a tool for realizing a more democratic urban form. It can reach out and involve larger segments of the public whose opinions have traditionally not been sought or heard.

At the Berkeley Environmental Simulation Laboratory, progress has been made with five major applications of perceptual simulation.

1. Illustrating basic planning issues

First, simulation has been used to illustrate basic planning issues. A scale model of San Francisco housed in the laboratory has been used to examine proposed changes in the downtown zoning ordinance (Bosselmann and Gerdes, 1980; Bosselmann, 1983b). Simulations were made to illustrate 1) the effects of transfer development rights, 2) the consequences of new building bulk and height regulations, and 3) the impact of new highrise development on the skyline and neighborhoods of the city. Film simulations illustrated the consequences of alternative planning controls on streetscale, mix of uses, and openness of the street to sunlight and air (Bosselmann, 1983a). The film clips produced at the laboratory were shown to planners and planning commission members. The public saw the film with the alternatives as part of a community affairs program on television. The process educated policymakers and the public about the choices implied in alternative zoning controls. These analyses have led to pioneering development guidelines based on sun-access criteria (Bosselmann, Flores and O'Hare, 1983; Bosselmann, Flores, Priestley, and

Gerdes, 1984).

2. Using visual previews to develop and review proposed projects

A second level of application uses perceptual simulation to offer previews of specific major new projects to the public. Simulation is also used as a testing tool in the planning and development process. In an analysis of the visual impact of alternative highway route alignments across a recreational lake, the modelscope technique provided film presentations of the before and after views generated by each alternative. Residents of the region were systematically sampled and invited to special viewing sessions where they recorded their judgments of visual impacts (Atkins and Blair, 1983). Other projects have dealt with the visual impacts of a redesign of the Great Highway along the ocean coast of San Francisco, a marina development in Richmond, California on San Francisco Bay, and development alternatives for the Berkeley bay waterfront area (Appleyard, Bosselmann, Klock, and Schmidt, 1979).

3. Increasing public participation

A third mode of application has explored ways of increasing public participation in the planning and design process. The systematic sampling of participants who viewed alternative highway alignments in a visual impact assessment procedure has already been noted above. In another project, the design of a mini-park involved neighbors through the use of a model-kit to shape initial ideas, followed by eye-level model tours at the environmental simulation laboratory, which led to additional modifications of the project by the neighborhood participants (Appleyard, et al., 1979).

For another application, a citizens advisory committee charged with assigning preservation priorities in a county open-space program were presented with an array of prototypical development possibilities for the areas under consideration. The various possibilities were simulated for each type of land parcel. Through the use of an electronic switchboard system, their immediately recorded preference votes were tallied and fed back to them for further discussion and consideration.

4. Advancing environmental education

A fourth form of application of perceptual simulation of environments furthers educational aims. Using our San Francisco scale model, a film was developed showing the changes in that city's skyline between the 1930s and 1970s. An early film from the laboratory showed the uses of a proposed automated guideway system for highways. Finally, a recent simulation film conveys the findings and planning implications from Appleyard's (1981) examination of the use of diverters and controllers in managing traffic in residential neighborhoods (Appleyard and Bosselmann, 1982; Bosselmann and O'Hare, 1983).

5. Facilitating research in environmental psychology

A final level of application can be found in the use of perceptual simulation in basic research on land-use compatibility. The degree of fittingness of new uses to present contexts is a pervasive issue in urban design and landscape management (Groat, 1983; Wohlwill, 1977). With the modelscope technique, land-use can be systematically introduced in combination with various current uses and topographic settings. Judgment techniques can be employed to analyze the compatibility of the land-use combinations and to provide guidelines for predicting the impact of specific kinds of projects upon perceived environmental quality. For example, Wohlwill (1977) used the facilities of the Berkeley Environmental Simulation Laboratory to investigate the effects upon observer response of different levels of incongruity in three kinds of structures, each of which was systematically varied in color, texture and size, as located in two different coastal settings. This application of the modelscope technique makes full use of its capability of affording systematic manipulations of the environment for scientific and planning purposes. A more recent research project using perceptual simulations generated by our modelscope technique has investigated the effects of pathway configurations and presence of landmarks upon environmental cognition (Evans, et al., 1984).

These five applications of environmental simulation represent a sampling of the broad range of purposes to which environmental simulations can be put. The illustrations are drawn from the work and experience of a single environmental simulation laboratory. The examples are restricted to those generated by the specific technical apparatus of that laboratory. The range of simulation techniques is wider in scope and encompasses considerable diversity, including the recent emphasis upon full-scale mock-up versions of proposed environments in pre-construction evaluation (King, et al., 1982) and in user participation (Lawrence, 1982).

Many researchers and planners have no access to modern simulation facilities. As Sheppard has found, the static sketch and photomontage have predominated in the simulation of projects entailing potential large-scale impacts (Sheppard, 1982, 1982b).

Often design proposals are approved based upon static two-dimensional drawings. The selection of viewpoint, perspective and focus of view is highly controlled by the producer of such simulations and is usually restricted in diversity and coverage. If a colored rendering is produced, the light, shadow, texture, color and usage of environmental features is easy to distort or overemphasize. Sequences of drawings or photomontages, however, can provide understandable visual presentations of motion through space. In a recent study in the Environmental Simulation Laboratory, five important views of an undeveloped waterfront were selected. Through photomontage, alternative development proposals had been generated by community representatives. The simulated views described a continuum of change from low intensity development to high intensity. Upon seeing the images, the community groups engaged in an active discussion about the appropriate level of development. The "trade-offs" were negotiated between the citizen group and the developers in order to move toward a range of suitable development.

The advances in computer technology have been explosive in the last ten years and are likely to continue. Virtually all conventional training simulators for pilots, drivers, and train engineers use electronically generated imagery. The imagery is still very abstract and has a cartoon-like quality. Images for a recently developed driver-simulator for Daimler-Benz are of very high quality: multi-colored and rich in detail. Such effects as shadows moving with the vehicle, fog, and dusk views can be realistically simulated. The driver, however, is taken through a quite abstract landscape with few visual clues or details. Trees and building facades are poor representations of real-world instances. Due to the high cost factor, computer simulations are available only to large firms and research centers. Nevertheless, significant amounts of research and development funds are being devoted to advances in computer graphics and substantial improvements and reduced costs can be anticipated over the next decade. Also, the entertainment industry has developed its own computer generated images. As noted earlier, the aim here is to create illusions and fantasies. The technical capacities for doing so are impressive, as demonstrated by the road scene with a rainbow.

Now, fifteen years after the Berkeley Environmental Simulation Laboratory was established, techniques have been developed for producing model simulation with relative ease and at low cost. Frequently architectural firms bring models to the laboratory for eye-level simulation tours through them. The videotape production of simulations in conjunction with modelscopes has reduced costs, at some sacrifice to dept of field and crispness of image (see for example, Carpman, Grant and Simmons, in press). The turnaround times for film, videotape and photoslide recordings of modelscope views are normally a few hours and work can be done on a day's notice.

Our perceptual simulations are often presented at public hearings. For example, a new ordinance in San Francisco requires all developers of downtown office buildings to construct a scale model of the proposed design. The buildings is placed into the laboratory's scale model of downtown San Francisco and photographed from various angles. Any reasonable number of views can be readily recorded. The simulations are part of the Planning Commission's design review process. In this work the laboratory serves as an extension of the San Francisco Planning Staff.

The simulations have to be accurate and open to accuracy control. In our procedure, developers as well as opponents of the development have access to the model and can take measurements to the dimensions of the proposed and existing development to check for accuracy. The perceptual simulations have to be realistic in color, texture and facade treatments. The simulated sun and shadow patterns have to be consistent and choice of sun angles have to be realistic and representative. The simulations have to be objective. Not only the most attractive or devastating views are taken; instead, views are recorded from an array of representative viewing stations from which the development would be seen. In some instances the corresponding real-world locations are visited and on-site photographs are taken to verify the model simulation (Appleyard, et al., 1979).

San Francisco's new ordinance is useful and innovative. It is the result of a continuous concern by citizens and environmental groups for development compatible with the character of the city. As in other cities, planners often find themselves in an adversary situation. For example, a proposal to expand a hospital has caused neighborhood groups to unite and fight to block the project. The group presented a simulation that strongly exaggerated the negative impacts of the proposal. If the planners responded by showing only diagrams that remain abstract, the public feels misled and has little trust in the professionals. Perceptual simulation should provide a balanced objective viewpoint which allows the identification of conflict areas, and a procedural mechanism for critiques, modifications and the generation of supplemental views. A two-way design process can then be established which allows various compromises to be discussed, simulated and re-examined.

The gradual withdrawal from the use of modern simulations that appears now to be a trend among planning and design professionals would widen the gap between the professionals and the general public. With the loss of credibility in the predictions advanced by planners, the public is demanding, and will continue to demand, complete information and full disclosure regarding the impacts of proposed projects.

CONCLUSION

This chapter has had three main purposes. First, the varieties of environmental simulation have been reviewed and the use of perceptual psychological research has been distinguished from other forms of application. Second, the conceptual and strategic research design issues presented simulations have been delineated. Third, the wide range of useful applications of perceptual simulation in environmental planning and design has been illustrated.

Two major conclusions can be reached regarding psychological appraisals of perceptual environmental simulations. First, these investigations must be placed within the context of basic research on environmental perception and cognition. Second, an extensive agenda of appraisal research remains before us.

Three major conclusions emerge from an examination of specific forms of application of perceptual environmental simulations. First, the diversity of current and possible uses of perceptual simulations calls for more detailed evaluations of their effectiveness within these specific contexts of use. Second, perceptual simulation techniques used in environmental planning and design and in environmental psychological research must keep pace with the rapid technological advances now found within the field of simulation. Third, perceptual environmental simulations are currently under-used in environmental decision-making and their forms of useful applications are limited only by the ingenuity and insightfulness of environmental professionals and researchers.

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