I

GENESIS *of* THE RESEARCH

1.1 Introduction

75% of each working day is spent in some form of communication (Hanks et al, 1977). Thus, communication, whether it is verbal or visual, is a core professional activity.

Architecture is not different to other disciplines in using the tool of communication, but in an architectural context, what is particularly important is graphic communication; the transmission of information and intention through visual representation of the real world.

In the early days of Computer Aided Architectural Design, the attention of software writers was particularly focused on applications which could produce outputs that were aimed at communicating information to site: in other words using the computer as an electronic drawing board to produce traditional drawings. But the last decade has seen major developments in image processing software, and other parallel changes in both hardware and software.

However, in order to use the new computer-based media efficiently we need to understand how the human agent (designer, client, occupant or other party) reacts to and interprets the images produced. We need to understand how to convey design intentions using various representation techniques and media and how people interpret the information they receive.

Porter (1997) in "The Architect's Eye" highlighted the fact that since the Renaissance, architects have been increasingly investing in graphic interpretations of ideas. This places a tremendous responsibility on the designer to understand the implications, both of the limitations and creative potential that drawing, and of its representation can have on spatial thinking and on communicating architectural ideas. It is easy to agree that the keystone in communicating design intentions is to convey much information about what it feels to experience the real building; good buildings exceed our expectations while poor ones look even worse in real life (Richens, 1994).

Evans (1995) confirms Porter's point of view that Renaissance architects were concerned advance the methods that were used to represent their designs. Using the three types of drawings in concert; plans, external elevations and internal elevations (sections) was the revolutionary step made at that time. These drawings were presented in a way such that corresponding parts were joined together by parallel lines, from plan to elevation and from one elevation to another, to emphasise the viewer's distance from the building.

In this chapter, I will present the review the problem of communication between the architect and the client in a contemporary setting. How do we represent architecture and how do we communicate it both traditionally and digitally. I will discuss the kind of problems the architect is facing in conveying design intentions to the client, and others in the design team in a computer mediated environment (Coyne, 1997).

Moreover, this chapter presents an overview of the scope of this thesis, in which I explain the nature of the research, the research objectives and the methodology used to design it.

1.2 The Starting Point

An early study was conducted by Hershberger (1969) to find out whether there are differences in the way architects, architectural students and lay people perceive architectural images. The images used in Hershberger's study represented buildings that were known by most of the respondents and were projected from 35mm coloured slide and were of buildings known by some or many of the participants[1].

[1] See section 4.6 for details of the study.

Hershberger found, from his investigations, significant differences between architects and non-architects in the interpretation of the same image. One group of the respondents would judge a building to be "good, beautiful, unique and stimulating", another would judge it to be "bad, boring, common and calming". The most significant differences were related to differences in the *affective* (novelty-excitement) and the *evaluative* (pleasantness) characteristics of the buildings.

The evident differences in perceiving architectural images between architects and non-architects groups raises two problems; the first is that people differ in perceiving architecture depends whether they do or do not have architectural background, and following from this the second problem of how architectural designs should be most appropriately communicated for a particular purpose. It is important that the architect understands that the message, which is intended to be given by images of buildings, might be very different to the message which the viewer receives.

As a response to his own work, Hershberger recommended that if architects want to utilise their media to communicate design intentions to their clients, they must either re-orient architectural education such that the architect is taught how forms and spaces are interpreted by lay people as well as by architects or make greater effort to educate lay people to see and appreciate architecture the same way as architects. We believe that these conclusions need reinvestigating (Brown et al, 1996), but what is significant here is whether differences appear in the perception of architectural images by viewers from different backgrounds.

In his study, Hershberger used only one technique to represent architectural images; photographic representations of real architecture. What might the result be in the case of using different techniques and media to present architecture? For example, if an image is presented in a range of ways (such as mechanical drawing, or a photorealistic rendered image or as an animation), will this affect the way we interpret it or not? (Brown et al, 1996). In other words, What is the appropriate way to present architecture in order to achieve a better understood communication between the architect and the other participants in realising a design?. Leslie (1992) has looked at this very question and referred to the prospect of communication design ideas that our aim is, being able to convey design ideas fully without fear of misunderstanding.

1.2.1 Computer Based Studies

1.2.1.1 Static Images

The first computer based study that I consider involves a technique developed initially by Van Bakergem and Obata (1991) at Washington University. The technique involves producing a computer generated image which had the appearance of a free hand drawing.

Results from an experiment[2] by Van Bakergem and Obata to explore architects' reactions to these images, indicated that architectural respondents (when they were presented with two sets of images; a conventional plotted laser one and a simulated hand drawn), revealed that there was a remarkable difference in the way the two sets were rated. Broadly speaking respondents found the first set (clearly computer generated) unstimulating while the second set (apparently hand drawn) was found to be inspiring

[2] See section 4.9 for details of the study.

and fascinating. Both sets had been produced by a computer, from computer data by a device driven by a computer.

Time has passed. Now, we have become familiar with the computer generated image as a fact of everyday life. So, if we repeat the test done by Van Bakergem and Obata, in a contemporary setting with the computer deliberately generating the simulated hand drawn effect, would there be a change in the perception of these two types of images?

To investigate this question, the test was repeated as part of the CAAD workshop programme run by me at Sheffield Architecture Winterschool'98. A group of eight architectural students were presented with five architectural schemes in two sets of images; the first set was represented as *mechanical* drawings (figure 1.1), and the second set as *simulated hand drawn* images (figure 1.2).

In this test, architectural students were split into two groups, the first group was given a set of drawings for several architectural schemes produced as *mechanical* drawings, while the second group was given the same images but they were produced as *simulated hand drawn* images. Each group of students had a set of 16 images of various drawing types; plans, site plans, sections, elevations, and perspectives. Students were asked to work as a group to rate these images and to write their comments. This exercise was followed by a discussion with each group.

The students had several tasks to perform in the CAAD workshop. Besides the above-mentioned test, students had other exercises to accomplish such as investigating the implications of some rendering techniques, for example the *Post Processed* one by using Photoshop software.

Figure 1.1

Examples of the first set of images; produced as mechanical drawings

Figure 1.2

Examples of the second set of images; produced as simulated hand drawn images

The list revealed that the most common descriptions by architectural students to rate the *mechanical* set were:

Simple drawings, expressive, contrast, dramatic location, abstract drawing, bold, confusing, design doesn't look balanced, formality disrupted, confusing, high tech, formal, diversity, discordant, confident, expressive.

Whereas the descriptions by the group of architectural students for the *simulated hand drawn* images set were:

Clear detail, good design, good function, clean, very suited, very friendly, looks like a design concept, suitable, small scale and a small building, dynamic, modern, nice, aggressive, impressionist sketch, good , nice balance, very dramatic, very strong, unclear.

The Sheffield students group's reaction was similar to those findings of Van Bakergem and Obata (1991), when architectural staff found *the simulated hand drawn* images were more stimulating and appropriate than the mechanical drawings. However, it is worth mentioning that in some cases when the architectural student described some of the *Simulated hand drawn* images they sometimes used words like "aggressive" or "unclear".

It is also worth mentioning that from discussions with architects in some practices that on some occasions and after producing the drawings as a conventional *mechanical* image from a laser pen plotter, architects add hand drawn effects to the drawing to be used for communicating design ideas with the clients (see figures 1.3 and 1.4 for some examples). In other cases, architects generally think that producing Photorealistic rendering is the most appropriate solution to communicate design with the clients.

More recently than the software developed by Van Bakergem and Obata, was a technique created by Schofield (1994) who wrote software to turn the physical effects of

a wobbly pen into a computer generated effect. This *Post Process* technique which basically introduces a new form of rendering as an alternative to *Photorealistic* rendering (Schofield, 1994; Zhao, 1994; Richens, 1997 and Woolley, 1997). It arises out of both the work of Van Bakergem and Obata (1991), and that of Mark (1992) who described the virtues, through examples, of non photorealistic animation[3].

Another technique which is similar to Schofield's technique was developed by Paul Haeberli (1990). It produces different versions of the same rendered image, by reprocessing the rendered image with a range of different sorts of marks. This mark could be a broken line, a brush stroke with variability in its width, length, colour, transparency and so on. The use of each one of these marks results in a rendered image with a particular quality.

The above mentioned studies (Haeberli, 1990, Van Bakergem and Obata, 1991, Schofield, 1994 and Nahab (1998) are the most relevant ones among others that were taken into consideration in this the research study.

[3] See section 1.2.1.2.

Figure 1.3

Example for producing the drawing as mechanical[4]

[4] Drawing is reprinted by permission from John McCall Architects, Liverpool and Riverside Housing

Figure 1.4[5]

Example of adding the hand drawn effect to a mechanical drawing

1.2.1.2 Animated Images

As described in the beginning of this chapter, from the very early civilisations, designers have used various forms to represent architecture aiming to convey the appropriate message to the client. One of the techniques used was the mock-up model which was used in different terms and stages of the design with different scales even up to 1:1 to enable both the architect as well as the client to visualise the building and its visual affect before construction (Porter, 1997).

The idea of the mock-up model resulted in creating a more sophisticated environment from the associating the mock-ups with the computer. This idea which was introduced initially as Sutherland's prototype (the connected helmet to the computer) in 1970 could place the observer in a dynamic computer generated graphic space and allow him to move around. This new device opened the gate to a new animated technology which is the second type of computer based studies I wish to consider here.

Association, Liverpool.

[5] Drawing is reprinted by permission from John McCall Architects, Liverpool and Riverside Housing Association, Liverpool.

This technology which deals with animation, movie making techniques, VR[6] and cyberspace[7], has potentially shifted the architect from a static design stance to one that is cinematic by experiencing the virtual space so we can enter and move around this virtual space either on foot as a walkthrough or in flight as a flythrough (Porter, 1997). Accordingly, this resulted in various evaluations of VR by researchers as a technology under rapid development. They consider both its potentials and the possibility of combing this technology with others. Bollinger (referred to in Novitski, 1994) indicated that VR might be the solution to solve our communication problem with clients. Moreover, VR as technology can be used as a design tool. A good early example which can be referred to here, is the study by Mark (1992) who showed the possibilities presented by viewing the building in real time and recording changes such as the appearance of architecture and light changing over time, moving through sequence of spaces, and the appearance of people and objects while moving through architectural space. All these changes can be used to study the building and its appearance through the real time transformation of architectural forms and revealing the aesthetic and spirit of the design.

VR as a computer technology that simulates the experience of moving through and interacting with a 3D environment was investigated by Rees (reported by Richens, 1994). While examining the potential use of VR in architecture, Rees found that walking through virtual spaces is not sufficient to give a sense of scale for the space and the proportion of the objects in the space. The VR environment did not convey three-dimensional information to the brain in the way that the real world conveyed it.

[6] Virtual Reality

[7] Cyberspace describes the virtual environment where data is composed and transposed from one digital medium to another.

In the beginning of this chapter, I mentioned our urgent need to understand how the human agent interprets computer generated architectural images in order to use them properly in conveying and representing architectural design ideas. There is a need to examine the psychological effects of representational methods, as they will not only influence the formation of ideas but the appearance of architecture (Porter, 1997). Next, I will discuss the nature of architecture as a kind of art and consequently its perception following this I consider the different ways of communicating architectural images both conventionally and digitally.

However, it is worth mentioning here that my research is concerned with testing only the static type of computer generated image, and investigate the differences in perception of static architectural images displayed by various groups of people (architects and non architects). The second type of image, the animation, has been left for future investigations.

1.3 Architecture: How do we Perceive it?

For centuries, architecture, painting and sculpture have been called the Fine Arts (Rasmussen, 1959), that is, the arts concerned with "the beautiful" and the appeal to the eye. Broadly speaking, people judge architecture principally by its external appearance.

Here I should note that in psychological studies of perception, architecture has not been examined extensively. In most literature on perception, researchers and writers deal with either paintings or geometric patterns, only few investigated the perception of

architecture[8] (Smith, 1987 and Porter, 1997). The reason behind this could possibly be due to the nature of architecture, which is different from other types of visual arts in important ways.

Paintings for example have been analysed by psychologists through defining the surface characteristics of art that make up the physical art objects; lines, colours, shapes and other features (Solso, 1994). Architecture is concerned with the physical relation of space like other disciplines such as painting and sculpture but in different ways and this is what distinguishes architecture from the rest of fine arts. It is always involved with the depiction of a habitable space (Porter, 1997).

Architecture is not simply produced by two dimensional drawings of plans, sections and elevations as well as three dimensional perspectives. It is something else and something more than merely a drawing; it is through these drawings relies the architect's responsibility to communicate architecture with the client. Rasmussen (1959) in his book "Experiencing Architecture" indicates the nature of architecture and the role of the architect:

> *The architect works with form and mass just as the sculptor does, and like the painter he works with colour. But alone of the three, his is a functional art. It solves practical problems. It creates tools or implements for human beings and utility plays a decisive role in judging it.*

[8] See chapter IV for examples of these studies, Hershberger, 1969; Lowe, 1969 and Van Bakergem and Obata, 1991.

Architecture is a medium of expression which, like a language, is founded upon a code or certain rules even though the drama is sometimes enhanced by challenging the rules. In his book Architecture and The Principle of Harmony (1987), Peter Smith describes these rules. Likewise Ching (1979) illustrates, literally, through various examples, the properties and visual aspects of each one of the architectural elements and the relationship to one another and the nature of their organisation. Consequently, architecture involves shaping the environment around humans to be lived in, and is not only to be seen from outside. This is the significant difference between architecture and other forms of visual arts.

1.4 Architecture: How do we Communicate it?

Communication during the design process has a substantial role because it exchanges messages and conveys ideas to people with different skills and interests (Barritt, 1982; Klercker, 1996). In order to draw a comprehensive picture, we need to discuss communication of architectural designs by referring to the three main issues that influence it:

- The parties involved in the design process
- Type and nature of the communication
- Stages of the design process

Although the complicated process of design involves a lot of parties, we can still identify two main parties; the multi disciplinary Building Design Team and the client. The multi disciplinary building design team consists of architect/s, engineers (structural, electrical and mechanical), project managers and surveyors. Sometimes, the architect acts as a

leader and manager for the whole team. The client (who falls into the second party of participants) differs here according to both the nature and size of the project. The client could be one person or a group or groups of people.

Communicating architecture, which occurs in all stages of the design process, will be explained in detail in the next section. It takes place between the various parties and within members of the same party. One of the main interests of this research is to explore whether there are differences in perceiving architecture between architects and non- architects (lay people) and between groups of architects and other agents such as the building industry professional.

Going back to the three main issues in communication of design process; the types of communication could be divided into: verbal, written and graphical. Choosing the appropriate communication type depends on the stage of the design process and the parties involved. More than one type is likely to be used by the same party during a particular stage.

Communication by the first two methods could be through a telephone conversation, a schedule, minutes, a memo, a fax or a personal visit, all of which are used to give specific instructions in a particular situation. On the other hand, the graphical method which is the core of this study has been the obvious way to discuss design ideas through the different stages of the architectural design process. As Edward Robbins (1994) stated:

> *Drawing of images has been part of human culture production for a very long time. If evidence from hunting gathering societies is any guide, people drew before*

> *they built. As ritual image, as sympathetic magic, and as story telling, drawing has served as a totem, a palladium, a mnemonic and as an important instrument of human creative practice.*

Contemporary drawing techniques provide a multiplicity of two and three dimensional techniques for representing a design (Robbins, 1994). However, the nature of the drawing used by the architects changes significantly through the different stages of the design process. In their attempt to analyse Le Corbusier's design of TheCchapel at Ronchamp, Brown et al (1992), observed that the design work proceeded through three stages; the sketch, the detail drawing and the working drawing. In each one of these stages, drawings were produced using different media when design was communicated with different party. At aech sat

The third issue in communicating architecture, concerns the design process. There are various maps of the design process produced by design methodologists and the resulting organisational structures seem to be derived more by thinking about design than by observing it (Lawson, 1990). The RIBA handbook of architectural practice and management illustrates several maps for the design process[9]. The simplest version describes phases of design process as; Briefing, Sketch plans, Working drawings and Site operations. The design process is not necessarily sequential, it can go forward and backward at any stage.

The sketch plan phase involves stages 2-5 of the RIBA "Plan of Work"; feasibility, outline proposals, scheme design and detail design (Maver, 1970). Communicating design

[9] The four phases of design; Assimilation, general study, Development and Communication; The 12 stages of Plan of Work and the Usual terminology.

between the architect and the client mainly occurs during the outline proposal and the scheme design stages via drawings.

Another way of describing the design process, is to break it into three distinct stages (Leslie, 1992); conceptual design, design presentation and construction information. These stages are associated with particular phases in which specific tasks are tackled. These phases are; the preparation phase, the main creative phase and the production phase (Schenk, 1997). That is, having an idea, selling an idea and implementing it. Despite the stage of the design process, drawing historically has been used by architects in many different ways. It has been used as a record and analysis device as well as a communication and a design tool (Edwards, 1994).

Results of the survey conducted by Schenk (1997) to investigate the role of drawing in the three phases of the design process (a preparation phase, a main creative phase and a creative phase as they were defined by Schenk), indicated that the greatest use of drawing was made during the main creative phase, as part of the process of synthesising and presenting potential design solutions. This conclusion was reinforced by the designers who had been interviewed, who strongly agreed that the use of drawing is a vital mean of exploring design ideas.

1.4.1 Communicating Architecture in a Conventional Way

Traditional methods of representing and communicating ideas by producing both two and three dimensional drawings constructed on a conventional drawing board or by using a physical model, has been the accepted way for a very long time. For many years,

drawings have been a valuable tool to design and communicate architecture (Eastman, 1975, Johnson et al, 1993 and Porter, 1997) and the act of drawing was considered as the means by which architects manifest their contribution to a design (Bijl, 1989). Architects produce drawings to convey information about designs to themselves and to other people. Drawings may be impressionistic to show what a building look like and to visualise the design. Drawings may be diagrammatic to show the organisation of spaces, or instructive to tell other people how to execute and build the design.

Physical models on the other hand were the practical alternative to drawings that can represent directly a composition in three dimensions. Wooden scale models were used by architects in the middle ages and served to communicate architects intentions to the client and also to the estimate of cost (Porter, 1997). Drawings serve as both the subject of communication and the object of our endeavours (Robbins, 1994). Drawings also, to a great extent, serve and structure the value of the social interaction between the architect and the various parties involved in design mediation.

Several studies have looked at the role of drawing in design cognition and on the process and media of drawing and its role in design, focusing on engineering design, architectural study drawing, categories of drawings and their uses and the sociology of design drawing (Robbins, 1994). From interviewing architects in various practices, Robbins summarised that some architects use various forms of individual drawing approaches when they sketch out their ideas for themselves and for others along with the commonly shared drawing types (site plan, plan, elevation, section, Axonometric and perspective). Architects invent their own type of doodling such as the Cocktail Napkin Project[10]

[10] This prototype-diagramming environment is pen-based interface to give the designer freedom to work with computers in the early design stage and to move gradually from early to more advanced stages in the design process.

which enables the designer work with drawings that can be ambiguous (Gross, 1996), or sometimes architects use colour codes to represent various architectural issues.

From the most personal to the most conventional, architectural drawing provides a number of vantage points from which to conceptualise, develop, present, and realised architectural ideas. These drawings are variously accessible to other architects and lay persons. Each drawing type represents a different and often very personal ways of dealing with a wide array to tools with which to approach design.

Paper has been the traditional medium used to communicate architecture for a very long time. Paper as a medium has inherited physical properties such as the affordability, accessibility, ease of use, transport and store. On the other side of the scale, we can see that paper has its own disadvantages as well; it can not manipulate or process the information as the desktop computer software (Tweed, 1997).

1.4.2 Communicating Architecture in a Digital Format

The use of CAD in architecture had a rapid development from a drafting tool to a design tool and then for presentation and communication uses which is the main interest of this research to investigate the role of CAD as a communication tool.

By examining the techniques by which architecture could be communicated digitally in a variety of formats such as still or animated images, VR, multimedia, CAVE[11] and others,

[11] Computer Aided Virtual Environment.

it is noticeable that these new trends involve more than a sense in the communicating process which distinguishes it from the conventional way that was dominant by paper as a medium. The digital technology can imply the effect of sound, images, words, drawings, gestures and even expressions whereas paper exchanges messages via a single sense which is seeing. In addition to the implication of time as a fourth dimension which is unachievable while using traditional techniques.

From literature on the use of CAD as a communication tool in the architectural design process (Sasada,1995; Klercker, 1996 and Ferrar, 1996), it was found that CAD can create the potential for a new way of conveying design ideas which could result in more successful co-operative work, and in a better shared understanding of design intentions.

The point was affirmed by Klercker (1996) who, while trying to focus on the role of communication between architectural students and clients by using CAAD, found that the students reactions differed from those of the clients as well as the use of CAAD in their experiment created a better communication between the two participants (architectural students and clients).

As it has be explained before, CAD has its influence in the design practice within some aspects as the drafting and documentation process, modelling, visualisation, CMC[12] on the other hand changed has its own influence on the communication process and through different ways of collaboration (Coyne and Lee, 1997).

1.5 Research Methodology

[12] Computer-Mediated Communication

The research methodology is explained here, through defining the issues for the adopted approach to design the research. The procedure I followed in this research has three main issues; identifying the research strategy (nature of research), followed by selecting the research format which is experimental and finally the choice of collected data technique.

1.5.1 Nature of the Research

The character of the research strategy that I adopted is described as an *explanatory* approach according to classification of strategies proposed by Wright and Fowler (1986). This kind of research aims to explain a psychological phenomenon through data collection and analyses. The psychological phenomenon being studied in this research is the effect of computer generated architectural images on the perception of architecture. I have chosen the experimental investigation, which is designed to test the research phenomenon.

1.5.2 Objectives of the Research

The broad aim of the research is to examine the role of computer generated architectural images on the way different people perceive architecture, and within this I have established a list to define specific points of interest to examine. The following list of the main research objectives served as a guide in designing the experimental test:

- Study the effect of both representation techniques and the used media on perceiving architecture.

- Establish the differences (if there are any) of perception between different groups of people; principally architects and non-architects, but also subsets of each of these two groups.
- To suggest the appropriate technique for presenting architecture for a particular group in a particular stage in the design process.
- To investigate the influence of CAAD in architectural education on the students' perception for architectural images.

1.5.3 The Experimental Study

To meet the above objectives, an experiment was conducted (which inevitably raises a number of contentious issues) in order to achieve set of discussible data. The problem with this kind of subjective experiment is that measuring human perception is difficult. There is no right or wrong but instead, a scale which is very extensive between the two extremes. Here, I will only describe the experiment in outline. Designing the experiment is discussed in full details in chapter five.

The experiment was conducted with two primary groups, the architects group and the non-architects group. Each one of these main groups has sub groups. The respondents of each sub group were asked to rate a set of schemes. The images of each scheme were represented with a particular representation technique by a particular medium. Then, the data collected was analysed for comparison of the various groups ratings of the images.

1.5.4 Data Collection and Analysing Techniques

The questionnaire was the chosen measuring technique used to collect data in this experiment for its appropriateness as a way of collecting response data. *Semantic Differential* (SD) scale was the measuring device adopted within the main part of the questionnaire. The use of *SD* scales was chosen because it is an efficient instrument to measure perception of human behaviour and it is appropriate for this kind of research format. Formulating the questionnaire with its various types of questions is explained fully in Chapter 5.

The collected data was analysed statistically. That data was broadly divided into three regimes; *Semantic Differential* data, Open questions' data and the Demographic data. See chapters six for details of the analyses of each one of these data sets.

1.5.5 The Pilot Study

It has been recommended by most researchers (Oppenheim, 1968; Weisberg et al, 1977 and Fiske, 1982) that the designing of such an experiment should entail, initially, a pilot study to test the experiment.

In this research, the pilot study played a critical role in relation to a number of different aspects. It was used to refine the experiment before the final setting, and to check the suitability of the questionnaire. Furthermore, the pilot study assisted in estimating the required time for the final test.

1.6 Framework of the Research

The following figure summarises the structure of the thesis chapters and their contents.

Computer Generated Architectural Images Evaluation

Titles of chapters	*Overview of chapters*
Chapter 1 **Genesis of the Research**	Overall concept of research , contents and a review of the problem of communication.
Chapter 2 **Interpretation of the Image**	The various types of both the visual and the mental form of the image.
Chapter 3 **Generating the Digital Image**	Techniques for generating the digital image.
Chapter 4 **Studies of Visual Perceptual Testing**	Analysis of studies on visual perception.
Chapter 5 **Setting the Experimental Study**	The procedure used to design the the pilot study and the experiment.
Chapter 6 **Analysing Data and Discussion**	Analysing the experiment's data.
Chapter 7 **The Next Move**	Recommendations for further research and investigation.

Figure 1.5

Framework of the thesis

1.7 References

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