Facial perception studies using the Macintosh

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Research on how people perceive human faces has benefited from recent advances in micro-computer technology. The present paper describes techniques that can be used to prepare and present facial stimuli on a Macintosh computer and the advantages of using a computer for preparing and presenting such stimuli.

Using a microcomputer to present complex visual stimuli in perception research has become increasingly practical for several reasons: the quality of displays has improved, it is easier to render images into versions that can be manipulated and stored on diskettes, and the stimuli can be presented and cleared quickly. There are two additional advantages. First, computerized versions can be modified to achieve effects not available from the original material, and second, the presentation rate makes it possible to collect more data per session. This paper describes the steps I used to implement a series of facial perception studies on the Macintosh microcomputer.

DIGITIZING

The first step was to digitize the stimuli. Digitizing is a process that converts a stimulus to one that can be presented and manipulated by a computer. There are many digitizers on the market, and they vary in cost and in quality of reproductions. Two relatively inexpensive products are New Image Technology's Magic (Suite 104, 10300 Greenbelt Road, Seabrook, MD 20706) and Thunderware's ThunderScan (21 Orinda Way, Orinda, CA 94563). Magic costs about \$400 and includes a digitizer that is used with a video camera. Most video cameras work with it. Magic has the advantage of being able to digitize three-dimensional objects. ThunderScan, a product that digitizes two-dimensional objects or pictures, sells for about \$230 and includes a scanner that replaces the ribbon of the Imagewriter (a printer for the Macintosh). ThunderScan digitizes pictures rolled into the carriage of the printer. Both of these products can produce images in MacPaint (a graphics editor for the Macintosh) format. Certain kinds of editing can be done during the digitization process; for example, with ThunderScan, one can select either halftone or high-contrast digitizing in order to preserve shading differences or to produce black-and-white images without halftones.

The images I used were likenesses derived from the 1960 edition of the Identi-Kit facial reproduction system (2100 Roosevelt Avenue, Springfield, MA 01101) used

by law enforcement agencies. The Identi-Kit consists of clear plastic foils that have a facial feature (i.e., hair, eyebrows, eyes, nose, lips, or chin) on each foil. Composite faces are made by laying the foils on top of one another. Figure 1 was made by forming a composite from the foils, photocopying it, and then digitizing it.

Pages from the Identi-Kit catalogue containing facial features were also digitized with ThunderScan. This was originally done as a test of the equipment, since the features in the catalogue are considerably smaller than the features on the foils or transparencies of the Identi-Kit. Much like other copying processes, the larger the originals, the better the reproductions are likely to be. However, the likenesses that resulted from digitizing the features in the catalogue were of reasonable quality and were used as stimuli.

Figure 1. A face made by digitizing an Identi-Kit composite.

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EDITING

Once the facial features were digitized and on disk, they could be manipulated in a variety of ways to achieve likenesses not available in the original Identi-Kit versions. The Macintosh has the advantage of allowing several different applications to access the digitized image to edit it. The MacPaint file created by the digitizing application can be manipulated with graphics editors, such as MacPaint, MacDraw, FullPaint, Paint Cutter, Graphics Works, and SuperPaint. Each of these graphics editors has its own capabilities for manipulating the appearance of the digitized image.

The most direct manipulation is to change the status of the pixels (the $\frac{1}{4}$ -in. units of the display), and several of these editors are able to effect changes in individual pixels for detailed editing. This is useful for fine tuning the appearance of the digitized image.

There are other techniques for manipulating graphics in a more systematic manner. The two chins shown in Figure 2 were derived from a single representation digitized from the Identi-Kit catalogue. The Identi-Kit "chins" include the ears and the complete outline of the jaw. The width of the bottom of the chin was manipulated by an auxiliary application, called ClickArt Effects, from T/Maker Graphics (2115 Landings Drive, Mountain View, CA 94043). ClickArt Effects costs about \$50 and adds distortion, perspective, slanting, and rotating editing functions to MacPaint. The perspective editing function allows the bottom of a rectangle containing a figure to be lengthened or shortened without affecting the top of the rectangle. Since the figure (the chin) is modified to conform to the shape of the rectangle that contains it, the width of the bottom of the chin can be changed without changing the width of the top of the chin (or the distance between the ears). The two different versions of the hair shown in Figure 2 were made by digitizing two different versions of the hair in the Identi-Kit catalogue. The same is true of the two different versions of the eyebrows. The two different versions of the hair, the chin, and the eyebrows were put into a disk file along with one version of the eyes, the nose, and the lips. This was done by putting the features in the "Scrapbook" and then renaming it "Facial Features."

An additional advantage to using the Macintosh for producing and editing graphics is that the edited graphics can be displayed from programming languages such as C, Pascal, and BASIC. The appearance of the stimuli can also be manipulated in the way the figure is displayed on the screen from the programming application. For example, the different figures in the file "Facial Features" were displayed from BASIC. The different versions of the eyes, noses, and lips in Figure 2 were achieved by manipulating the size of the rectangles in which the features were presented. The presentation rectangles are outlined in the face in Figure 2 that has the larger features. The size of the rectangles were specified with Microsoft BASIC. One

Figure 2. Small and large versions of facial features digitized from the Identi-Kit catalogue; the rectangles in which the features were presented are shown on the face with the larger features.

of the Macintosh ROM routines scales the figures to conform to the rectangles. The different versions of the eyes were achieved by changing the height of the rectangles in which the eyes were presented. The width of the nose and the thickness of the lips were likewise manipulated by changing the width and height of the rectangles for the nose and lips, respectively. Other techniques that alter the appearance during presentation can be achieved through systematically degrading or revealing a stimulus in stages (see Brooks, 1987; Snodgrass, Smith, Feenan, & Corwin, 1987).

Modifications can be made to the stimuli anywhere in the production process. Certain kinds of editing can be made during the digitization process, the digitized images can be manipulated with a variety of graphics editors, and the appearance of the stimuli can be changed when they are displayed. However, the greatest variety of graphics manipulations can be done with graphics editors after the stimuli have been digitized and before they are presented. Only a few of the many possible manipulations are discussed here. The image in Figure 3 is a ClickArt Effects distortion modification of the face in Figure 1. A rectangle containing the face was changed to an uneven tetragon, unevenly stretching the face. The face can also be made to conform to a trapezoid for a perspective view, a parallelogram for a slanted view, or a rotated rectangle for a rotated view.

Just as real faces are not perfectly symmetrical, edited faces may not be either. Both of the faces in Figure 4 were made by taking either the right or the left half of the face containing the smaller features in Figure 2, "flipping it horizontally," and combining it with its original likeness. The small differences in symmetry of the original face resulted in two faces that look quite different from each other and also look different from the original.

Figure 3. The face in Figure 1 altered by ClickArt Effects.

Figure 4. Faces made from the left and right halves of a face in Figure 2.

There are many other manipulations that are possible using graphics editors. The size of the original can be manipulated and figures can be overlaid so that the figure underneath either is covered by or shows through the figure laid on top of it. Pixels can be systematically changed in patterns to add textures or delete areas. Figures, or parts of figures, can be mirrored or rotated vertically or horizontally. Smaller images that are combined to form a larger image in MacDraw retain their autonomy and can be removed, changed, brought in front of, or moved to the back of overlapping images. If a face wearing glasses were made by combining features in Mac-

Draw, then the eyes could later be changed without having to redo the glasses.

It thus becomes evident that once images are digitized, it is possible to exercise great control over the stimuli. They can be modified to increase the number of versions or to control precisely the degree to which two versions differ. Once the desired changes have been made in a particular editor, the file can be closed and reopened with another editor so that the editing capabilities of many of the editors can be used on the same figure.

In some circumstances, such as creating facial likenesses from witness descriptions in law enforcement, it is important to create likenesses quickly and to be able to select from a large assortment of facial features. Mac-a-Mug Pro, a product available for \$495 from Shaherazam (P.O. Box 26731, Milwaukee, WI 53226), contains a vast selection of digitized features that can be selected, arranged, and combined quickly. As can be seen in Figure 5, the likenesses are realistic. Like graphics produced by other graphics applications, the images produced by Mac-a-Mug Pro can be further edited by Mac-a-Mug Pro or by other graphics editors.

PRESENTATION

It is possible to present stimuli in a variety of ways. If speed is not important, graphics can be "redrawn" to the Macintosh screen by ROM routines; this can take a second or so for large images to be presented. The studies for which these stimuli were developed were concerned with whether or not features, or groups of features, are perceived independently. It was therefore important that

Figure 5. A face produced by Shaherazam's Mac-a-Mug Pro facial reproduction system.

the features be seen all at once so that they are not perceived sequentially or in isolation from one another.

This was done by converting the faces to bit images and presenting them quickly. The bit image is simply an array in which each number is a record of the status (white or black) of each pixel of a stimulus. Graphics converted to bit images can be preloaded into RAM and presented in 16–32 msec, depending on how much of the screen is covered by the image. Converting stimuli to bit images and presenting them quickly requires special machine language routines.

Once a stimulus is on the screen, the BASIC "Get" statement can be used to get the array, and the OpenResFile, SaveArray, and CloseResFile routines are used to create a resource file, save or put the array in it, and then close the file. This bit image or array can be presented by using the OpenResFile, LoadArray, and CloseResFile routines followed by the "Put" statement or, for even faster presentation, the SPART (Stimulus Presentation and Reaction Time) routine (see Lane & Ashby 1987), which will present the stimuli in one or two sweeps of the screen (16–32 msec), depending on the size.

One advantage of using computer presentation of stimuli is the number of presentations that can be made in a single experimental session. Experiments done using these techniques have resulted in more than 1,700 choice-reaction-time responses from each subject in a 1-h session (Jensen, 1986). Each session included time for the instructions, questions, unrecorded practice trials, 1,728 recorded responses, and 17 self-paced breaks. Each of the presentations was separated by a .5-sec delay so that the presentations would not come one immediately after the other. In these experiments, subjects were presented a face and were asked to determine whether a specified group of features were the larger or smaller version of the features shown in Figure 2 (the rectangles were not outlined). Since the differences between the different versions of the features were designed to be easily discernible, the average error rate across subjects never exceeded 8% for each experiment and was usually much lower.

All the digitizing, graphics manipulations, and data collection for the studies mentioned above were done on 512K RAM Macintoshes with single-sided-disk drives. They also work on the newer machines that have double-sided drives and more memory.

The techniques used in these facial perception studies are also useful for other kinds of perception studies. The digitizing, editing, and presentation techniques have been used for other kinds of visual research, such as attention and display organization. The digitizers and editors used for the visual materials also have their counterparts for auditory materials (see Gibson, 1987), and some of these techniques may also be useful for auditory presentations. For example, the SPART routine that is in the PsychLib library will also present auditory stimuli (see Lane & Ashby, 1987).

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