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A mobile research laboratory

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A .75-ton van was modified to make a mobile research laboratory suitable for visual psychophysical testing under well controlled conditions. The laboratory can be adapted easily to other types of psychological research in which environmental control and/or special-purpose equipment is required.

Psychological research is often limited by restricted access to subjects outside the university. This is especially problematic for research, such as in developmental or clinical areas, which requires special-purpose equipment or a well controlled environment, as well as an unbiased sample from which generalizations to a larger population can be made. A carefully designed mobile research laboratory can significantly improve access to relevant subject groups. If these include preschool children, the mobile laboratory can be driven to homes or day-care centers. When testing older children, the laboratory can be used at schools without placing demands for space on often crowded facilities. Older populations can be contacted through retirement homes or community centers and tested with a minimum of inconvenience to the subjects. Finally, populations located at some distance from a university can also be tested under controlled, replicable conditions.

This is a description of a recently designed and constructed mobile laboratory for visual psychophysics (see Figure 1). It is a converted van that can be powered from any 110-V electrical source, including its own generator. The stringent design requirements for visual psychophysical research do not necessarily apply to other types of psychological testing; therefore, the laboratory's design can be appropriately simplified for other uses. However, because it is difficult to control exterior sounds, the mobile laboratory is not suitable for most auditory psychophysics.

MANEUVERABILITY AND FLEXIBILITY

The first design consideration, for driving ease and adequate but flexible interior space, led to the selection of a .75-ton, 125-in. (3.175-m) wheel-base van (Chevrolet). It is maneuverable, relatively fuel efficient, and easier than larger vehicles to garage during extreme weather conditions. A sliding side door allows easy access to the interior without requiring more space next to the van. Visibility while driving and parking is increased by windows in the rear and side doors and by large rearview mirrors on both sides (the right one with a "fish-eye" mirror).

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SUBJECT COMFORT

Both space and temperature variables affect subject comfort. A standard recreational vehicle (RV) fiberglass roof modification increases the height of the testing space to the rear of the driver-passenger area from 1.37 to 1.83 m so that adults can stand. A hinged door allows access to the space between the metal and fiberglass roofs above the driver-passenger area, making a convenient storage space.

Floor space is arranged so that subjects have minimum interaction with testing equipment (see Figure 2). Subjects enter the testing area by the side or passenger's door on the right side of the van and are seated in a comfortable chair located toward the front of the area. (For visual psychophysical testing, subjects face the rear of the van to view stimuli.) All testing and control equipment is on the left side or to the rear of the van.

Temperature is regulated both actively and passively. All walls and doors are filled with fiberglass insulation, which is then covered with a finished surface. The fiberglass roof and thick foam padding and carpeting on the floor, tacked to a .5-in. (1.27-cm) plywood subfloor, also provide insulation. The exterior of the van is a very light color, to minimize absorption of solar heat. All windows are tinted, and those in the testing area have an additional heat-/light-reflective coating.

Active cooling is provided by a small (4,000-BTU/h) energy-efficient air conditioner (Sears, "Kool'n'Lite") designed for installation in a casement window. Instead, a wooden frame with a 16.5-cm sill is "fiberglassed" into a hole cut in the nearly vertical section of the fiberglass roof at the back of the van (see Figure 1). The air conditioner is also fitted with a plywood frame,

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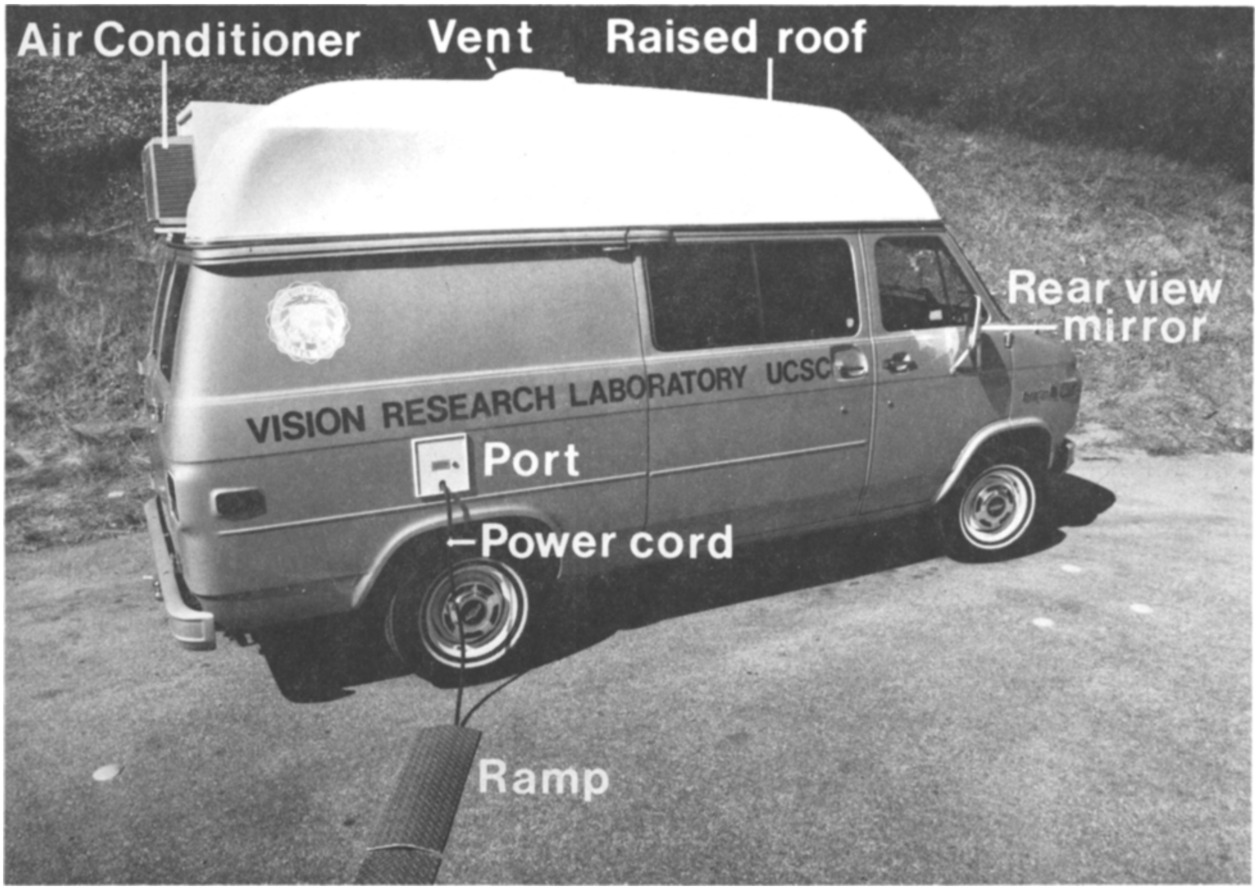

Figure 1. View of right side of mobile laboratory.

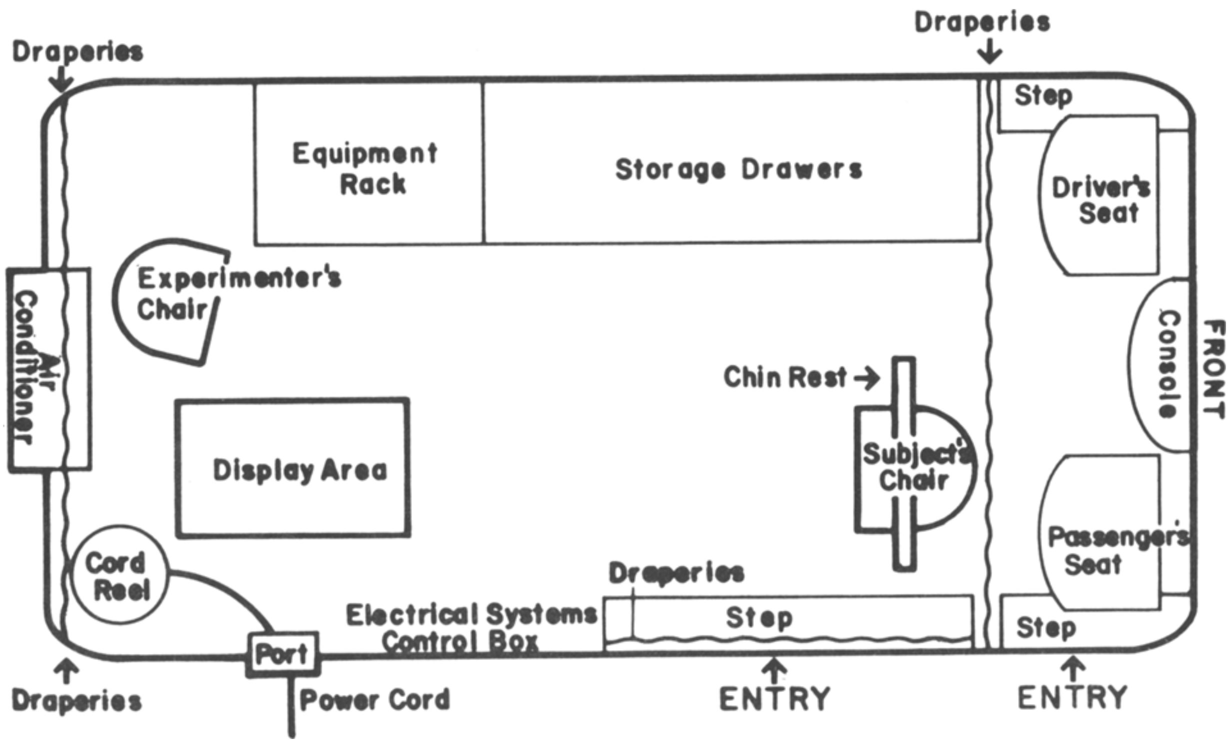

Figure 2. Sketch of floor plan of mobile laboratory.

which is then bolted into the opening in the roof. The base of the air conditioner rests on the sill, which is bolted to the frame of the van where the original metal roof was once attached. This elevated position (approximately 1.32 m from the floor) provides for efficient withdrawal of heated air and good circulation of cooled air. The fan of the air conditioner can be used for general ventilation when testing, and a small vent at the center of the fiberglass roof can also be opened. (A standard RV cooler is not used because they usually run on 12 V rather than 110 V. "Swamp coolers," which cool by evaporation, are inappropriate for humid environments.)

In cool weather, the air conditioner is replaced by an insulated board, bolted to the "window" frame in the roof. Active heating comes from a small, efficient, commercially available electric space heater, which sits in any convenient spot on the floor of the testing area.

LIGHT CONTROL

Exterior light is eliminated from the testing area by heavy black velvet drapes. These are hung from slide tracks (available at RV supply stores) attached to the van frame above the windows and between the testing area and driver-passenger area. The drapes hang to the floor, and their backs, which face the testing area, are lined with white material. Although windows in the testing area were included to increase visibility while driving, experience has shown that these can probably be omitted, thus making elimination of exterior light easier. To further cut out sunlight, we mounted additional black material over each window with Velcro tabs.

Controlled interior light comes from three adjustable (Lutron Nova fluorescent solid state dimmer) fluorescent lighting fixtures (each with two 30-W lamps), attached to the roof of the van, and from small portable fluorescent lights (inexpensive, about 1 ft long, sold for supplementary home lighting in most hardware stores). Neutral, light-colored carpeting and white canvas on the walls help diffuse the light. The canvas, a fire-retardant variety used for awnings, is stretched over the fiberglass insulation and stapled to wooden strips screwed to all frame members of the van. Half-round wooden molding finishes the seams. (This method was chosen rather than covering with commercially available RV paneling because the fire-retardant material was considered an advantage, because white was not a standard paneling color, and because the canvas provides more flexible access to electrical wiring carried in the wall space.) Finally, all furnishings (tables, chairs, storage cabinets) are light and neutrally colored.

ELECTRONIC EQUIPMENT

Electronic equipment used in the laboratory imposed five major design considerations. (Typical equipment has included a display monitor, waveform generators, microcomputer and printer, evoked potential waveform averager, FM instrumentation recorder, X-Y plotter, and miscellaneous interfacing devices.)

First, while the van is in motion, the equipment must be securely fastened and yet be as free from vibration as possible. This is accomplished in several ways. Less vibration-sensitive instruments are bolted into a small equipment rack constructed from 1.5 x 1.5 in. (3.8 x 3.8 cm) slotted-angle steel. Predrilled holes in the angle steel make assembling the rack and mounting equipment on it quite easy. The back of the rack is welded onto the vertical framework of the van. The front lower section is bolted through the floor (see Figures 2 and 3). Other equipment is carried in or on top of two lateral file cabinets. The cabinets are bolted to the floor and left side of the van, with foam padding at all contact points. Work space is provided by a plywood counter, which is bolted across the top of the cabinets and the top of the adjoining equipment rack. Larger pieces of equipment bolt to the counter top and rest on thick foam padding. Portable equipment is placed in a secure spot on the floor or in a cabinet drawer while the van is moving.

The drawers of the file cabinets are heavily padded with foam to further insulate the equipment carried in them from vibration. Although drawers of commercially made lateral file cabinets lock, an additional restraining rod prevents their opening while the van is in motion. A metal bracket with a hole is mounted on top of each cabinet so that the hole projects just in front of the drawers. Through this, a .3125-in. (.79-cm) diameter aluminum rod is inserted that spans the height of the cabinet and seats securely into a hole drilled in the wooden subfloor (see Figure 3).

The second consideration is that the interior environment be suitable for equipment even when the laboratory is not in use. Under extremes of heat or cold, the van can be garaged. However, moisture proved to be more of a problem than was originally anticipated. During a cool, wet winter spent in the Pacific northwest, moisture condensed on metal parts. This was controlled partly by covering smaller pieces of equipment with airtight plastic as soon as they cooled after each use. A small resistive heater was also installed in one larger piece of equipment (the waveform averager) to prevent condensation. The resistor is attached to a section of the internal aluminum frame of the instrument and is powered by the 12-V van battery. The most delicate equipment (such as computer disks and magnetic tapes) are simply removed from the laboratory.

Third, equipment has to be out of contact with the small children who typically are tested in the mobile laboratory. This is accomplished partly by the floor layout, as shown in Figure 2, and partly by placing small instruments that do not generate heat or are used for only short periods of time into drawers. Their wires are attached either temporarily by pulling them through

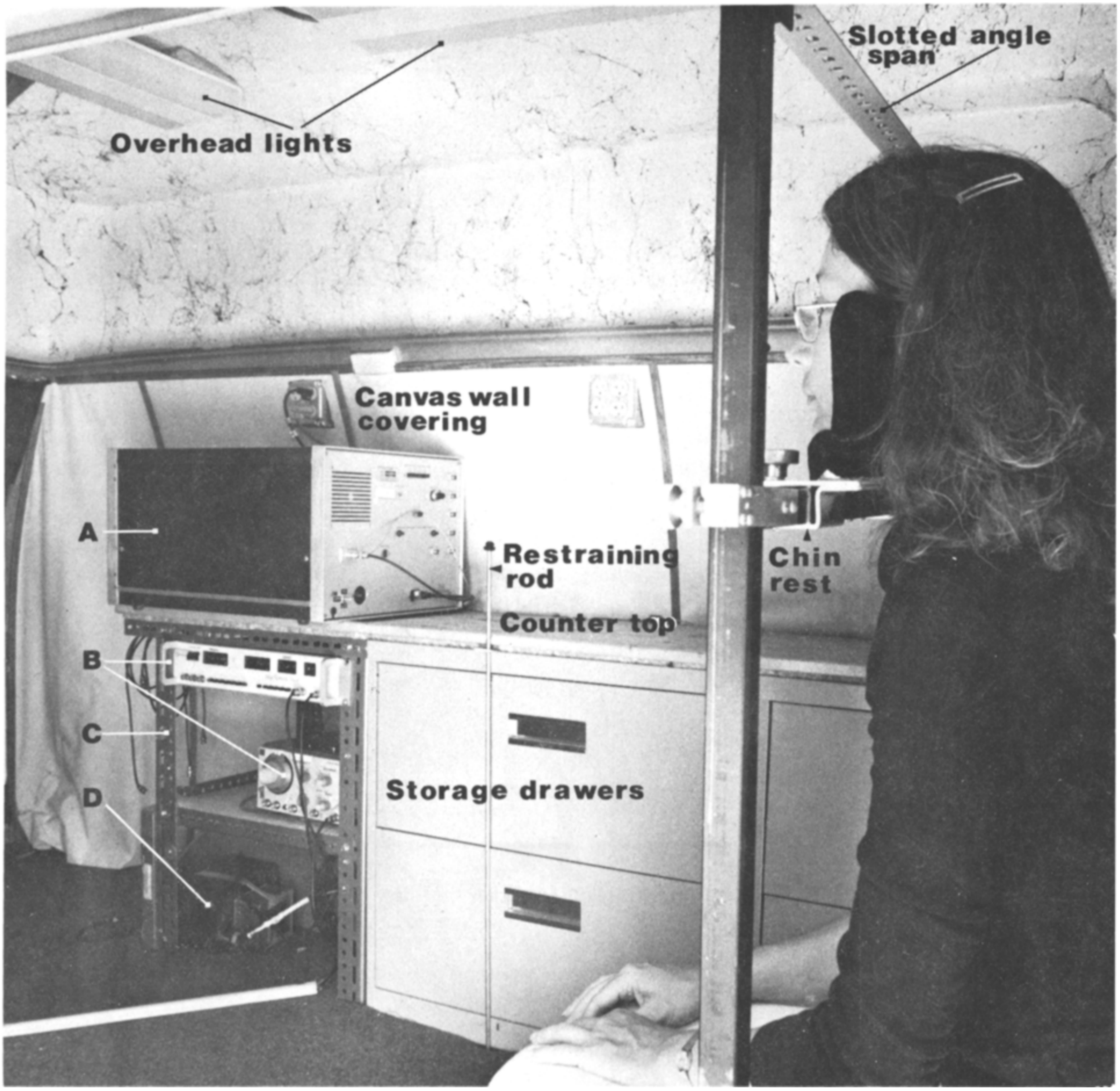

Figure 3. Interior of mobile laboratory showing equipment placement and subject in position. (A) Waveform averager. (B) Waveform generators. (C) Equipment rack. (D) Line voltage regulator.

slightly ajar drawers or more permanently by threading them through the back of the file cabinets.

The fourth consideration is that the equipment be secure from burglary while the van is not in use. The smaller pieces of equipment are kept in locked cabinet drawers. Those instruments bolted to the counter top can be released only by opening a cabinet drawer or by disassembling them. An alarm system (available from auto accessory stores), turned on and off via a hard-to-pick lock, sounds if any door is opened or if the van is moved. Also, the laboratory is usually parked in a fenced and patrolled university lot.

Fifth, a steady and adequate power supply is accomplished by using a large diameter (10-gauge) cord to carry electricity to the van, and by putting all power to the equipment through a line-voltage regulator.

CONSTRUCTION ECONOMY

In order to minimize costs, standard furnishings and RV accessories were used whenever possible instead of custom construction. The 28 x 30 x 18 in. (71 x 76 x 46 cm) lateral file cabinets (Hon) are standard office size and were easily adapted to this setting. Tables and chairs are small and of unfinished wood, with widespread legs for stability. (Nothing rests on these while the van is in motion, but they do sit unattached on the van floor.) The air conditioner and the heater, as described above, are also standard home models, easily adapted for this application.

The overall cost of the mobile laboratory 1980 was $11,986. Of this, $6,418 was for the van itself; the rest was for modifications and furnishings, excluding the testing equipment.

SAFETY

The 110-V electrical system that runs the laboratory is designed to eliminate all shock hazard. Electricity is usually conveyed to the laboratory by a 37-m three-lead wire (10/3 Type SO). (Alternately, power can be supplied by a 3.5-kV ac generator in locations in which electricity is not otherwise available.) Outlets throughout the laboratory are wired to three ground-fault breaker switches (Gould I-T-E "Instant Shield"). The breaker box also has an amp meter to monitor current demand as various equipment is used. A receptacle circuit tester (Ideal, 61-035) verifies whether there is adquate grounding in the power source. If not, a pointed metal rod with a T-handle at the top is driven into wetted ground alongside the van and a ground wire is firmly clipped to it. When the laboratory's power cord must cross an area where it might be tripped over, it is covered by an aluminum ramp, made from a rectangle of flat aluminum, bent so as to form a channel down the middle through which the cord passes (see Figure 1). To make the steps into the van less slippery, self-adhesive traction strips (sold at hardware stores for house steps) are applied at all entrances.

OTHER FEATURES

A chin rest is supported on a large, U-shape framework of 1 x 1 in. (2.5 x 2.5 cm) square metal tubing (Apton, available at store fixtures supply stores), hung from a strip of slotted-angle steel bolted to the frame and across the width of the van. The bottom of the U-frame almost reaches the floor, where it is secured with a ⎍-shaped metal tongue, bolted on both ends to the subfloor. Between the arms of the U, another piece of metal tubing is clamped to form a span. Tension on the clamps is controlled by large screws, which allow the height of the span to be adjusted to the subject by sliding the span up or down the side bars. A chin rest is permanently screwed to the center of this adjustable span. On either side of the chin rest are head holders,

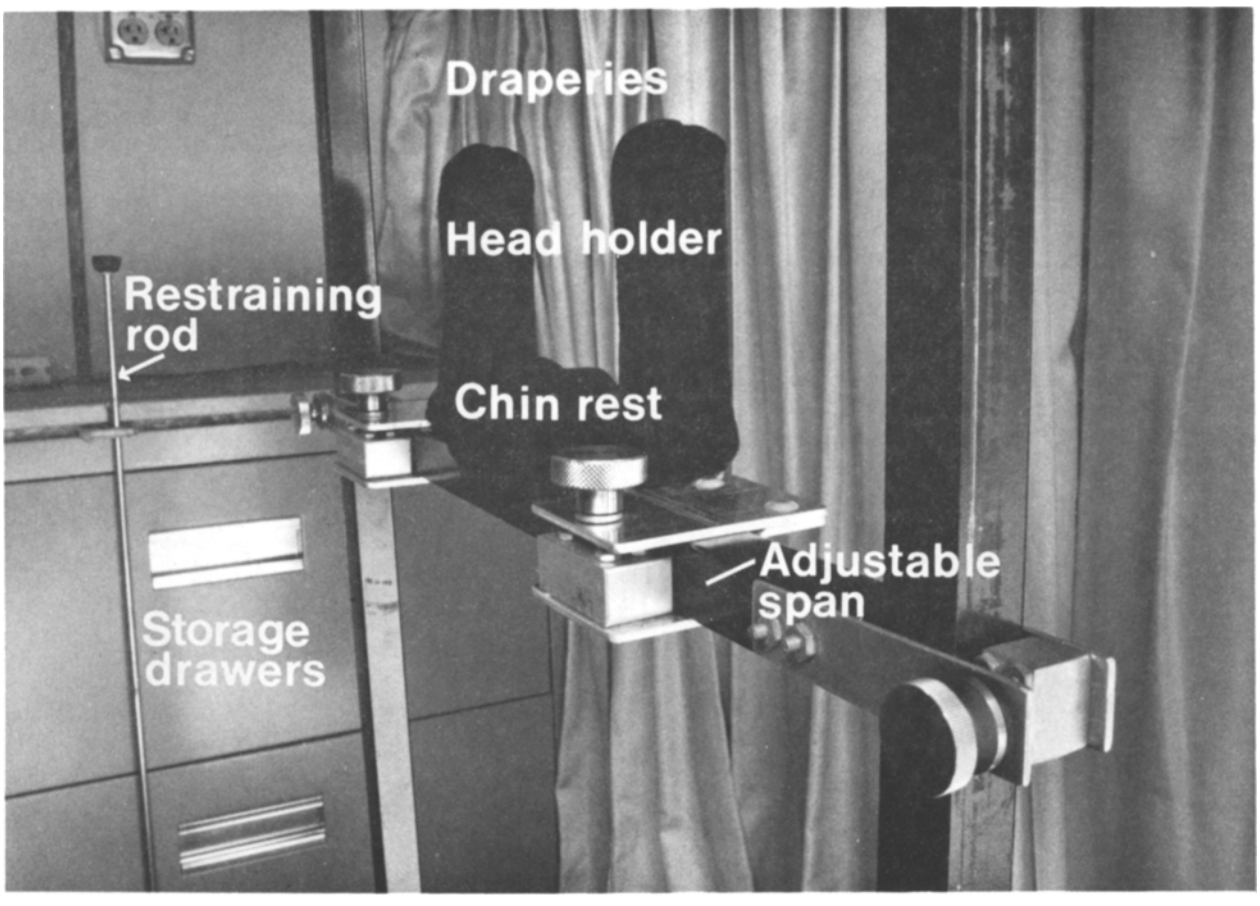

Figure 4. Detail of chin rest.

made of .125-in. (.32-cm) thick bent aluminum, which clamp to the span and can be moved toward or away from the chin rest by loosening the large screw on the clamp. The head holders and chin rest are foam padded and covered with cloth that can be easily removed for cleaning. A detail of the chin rest is shown in Figure 4.

When needed, the laboratory's 3.5-kV ac generator can be carried in the van and moved outside for operation. The generator (Honda ES 3500) rides on large, 10 x 2.75 in. (25.4 x 7 cm) semipneumatic wheels mounted on .3125-in. (1.6-cm) diameter axles welded to the bottom of the generator frame. The generator rolls in and out of the van on a ramp made of two 2.4-m-long 4 x 1.5 in. (10.2 x 3.8 cm) aluminum channels. These are bent at a 15-deg angle, 10.8 cm from one end. A 10-cm-long .5-in. (1.3-cm) diameter rod is welded to the bottom of this bent section to form a pin that drops into a hole drilled in the bed of the van at the right rear door. The holes are spaced so that, when placed in them, the channels are as wide as the span of the wheels on the generator. The heavy generator is pulled up the ramp into the van by a 12-V winch (Sears Superwinch) mounted at the bottom front of the generator cart. The winch cable can be attached to an eye ring welded to the base of the passenger's seat, and power comes from a battery mounted on the generator cart (which also powers the generator's electric starter).

Electrical supply cords enter the van through a small port on the right side (standard RV modification). At the end of testing, the extension cord is loosely coiled by hand in figure eights on the floor to the back of the van so that it is easy to pull out again through the port. Usually, less than the full 37 m of cord is needed, so extra cord is stored on a reel at the back of the laboratory. A separate 4.6-m section joins with twist-lock connectors (G.E., Dyna-Mate, 20A) to the far end of the extension cord, where it plugs into a power source. This smaller section is kept cleaner than the main cord and, so, is better used in a home or building.

SUMMARY

The research laboratory described here has proved very satisfactory for well controlled visual psychophysical testing in a number of locations. It has made testing of nonuniversity populations both feasible and convenient. In some cases, with clinically referred subjects, it has meant the difference between their being willing and their not being willing to participate in a study. With slight modification in furnishings, such a mobile laboratory could be used for other types of psychological research as well.

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