

Recommendations for the Creation of a Voice Acoustics Laboratory

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This memo was written as a guide describing recommendations of a basic voice acoustics laboratory setup. The guide lists general equipment, recommended examples and current prices. While such a guide could be inexhaustible, the goal was to provide the basics so that the reader could purchase equipment and thus have the necessary tools to do generic voice research recording.

This memo is available online at the website www.ncvs.org/ncvs/library/tech.

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Introduction

This memo was written as a guide for building a basic recording laboratory. In constructing one's own laboratory, two questions often asked are: *What equipment is needed?* and *How much would one spend to purchase the basic necessary equipment?* This guide offers a general equipment list, as well as recommended examples and current prices. While such a guide could be inexhaustible, the goal was to provide a rudimentary guideline that the reader could use to purchase equipment needed to do generic voice research recording. No attempt has been made to describe basic voice recording techniques or pitfalls in recording or analysis. It should be stated that the tools are only the foundation to allow a researcher to begin and, thus, cannot compensate for poor protocol. If the reader would like to know more, the NCVS Summer Vocology Institute has a Voice Instrumentations course where students get hands on experience with the equipment discussed in this technical note. The text used for the course is also very complete.

Course Website: <http://www.ncvs.org/ncvs/svi/index.html>

Course Text: Baken R.J. and R. F. Orlikoff. Clinical Measurement of Speech and Voice, San Diego: Singular Publishing Group, 2000.

This guide does not endorse specific products, manufacturers, or distributors. Many of the products listed here can be found in numerous locations, including online retailers. Please note that the authors do not have experience with all of the recommended equipment. Also note that there is no guarantee associated with this guide. However, the authors and other members of the NCVS team can consult on lab setup and equipment use. Contact Suzanne Collins (scollins@dcpa.org) for more info on costs.

Spielman, Starr, and Hunter: Recommendations for the Creation of Recording Laboratory

Equipment List and Supplies

Below is a general list of equipment needed to set up a basic recording laboratory. After each item, two estimated prices are given, the ideal version followed by a more economical version, if available (prices are as of March 2005).

NECESSARY EQUIPMENT

ITEM	PRICE	ECONOMICAL VERSION
Sound isolation (basic)	\$4,500	N/A
Microphone	\$600	\$150 (inexpensive, separate mount)
Sound level meter	\$4,500	\$1,700
Microphone power/amp/converter	\$550	\$235
Computer	\$1,000	\$500
Recording software	\$300	\$0-\$50
Backup hard disk recorder	\$799	\$439
Cables	\$300	N/A
Surge protectors	\$60	\$60
Speakers for playback	\$150	\$0 (use ones that come with computer)
Camcorder (mini DV)	\$1,000	\$450-\$800
Video monitor	\$180 (LCD)	\$100 (new CRT) or \$0 (old CRT from Surplus)
Microphone for video camera	\$25	\$25
Tripod for video camera	\$35	\$35
Stand light	\$35	\$35
Chair for subject	\$150	\$0 (use office chair with no wheels)
Music stand to display stimuli	\$60	\$25
Equipment Rack	\$1200	\$0 (use an old desk)
Storage rack and/or binders	\$150	\$0 (boxes on shelves)
Water pitcher and glasses	\$50	\$50
Tape measure (ruler)		
Totals	\$15,624	~\$3,704-4,204

REPLENISHABLE SUPPLIES

Item	Cost
Mini DV tapes	~\$2.50/tape
DAT tapes, if necessary	~\$4.50/tape
CD-Rs and jewel cases	~\$0.67-0.99/ea
Batteries	~\$0.41-1.13/ea (AA)

Special Help for an Economical Recording Lab

As described above, it is perfectly feasible to use a cheaper version of some tools in a recording lab. With a limited budget, however, it is crucial to maintain the following minimum specifications for certain equipment:

1. **SOUND ISOLATION** – If sound isolation is to be incorporated into a sound recording lab, it is essential that a good system is purchased. Look for heavy construction, double walls, floating floor assembly, patch bays, quiet lighting, and cable ducting. If an assembled booth isn't available, a small room can be used with the addition of some acoustic treatment in the form of broadband absorption. Recycled cotton insulation (www.BondedLogic.com – UltraTouch R13) can be used for this purpose. If possible, make sure the booth is not directly attached to the building's structure and the booth "floats" or has some kind of isolation from the floor (for example rubber pads). This is important for eliminating low frequency "rumble" due to building vibration or heating, ventilation and air conditioning (HVAC) related noises.
2. **MICROPHONE** – Look for a good head-mounted microphone with clear specifications of frequency sensitivity, directivity, proximity effects, and a secure mount. The most important feature should be a wide and flat frequency response. An important caution with the use of directional microphones is proximity effect, or the boosting of low-end frequencies. This effect can give misleading results in a frequency or spectrographic analysis. At close distance in a quiet room, omni-directional microphones are recommended for their flatter frequency response and lack of proximity effect. If a directional microphone is chosen, it is important to always make sure that it is placed at exactly the same distance for each speaker because the frequency response will likely change with distance.
3. **SOUND LEVEL METER** – Look for a Class I SLM that has a calibrator. The SLM should have the ability to choose different weighting filters, with a C or Linear weighting being the most desirable for voice recordings. A type II may be adequate depending on your situation.
4. **MICROPHONE POWER/AMPLIFIER/CONVERTER** – Choose a high quality microphone pre-amplifier that offers Phantom Power (if needed by the microphone). In addition, an Analog-to-Digital converter and computer interface are needed. The interface should be compatible with the chosen audio software. A product that incorporates all three devices can offer compactness and great savings. **BACKUP HARD DISK RECORDER** – Look for decent recording redundancy and backup (professional DAT or hard disk). If funds allow, it is best to back up data so that the computer is not the only device available. It is better to use a hard disk recorder for redundancy and backup unless there are old 2-channel DAT tapes that need to be played as DAT tapes will only degrade over time; thus, these will have to be copied to a computer or dubbed (DAT-to-DAT) to share information with other labs.
5. **CABLES** – This is another area where an economical version may be quite problematic; it is essential to have good cables. Look for shielded/balanced microphone cabling.

Spielman, Starr, and Hunter: Recommendations for the Creation of Recording Laboratory

With the above key points in mind, below is information about equipment where corners can be cut (our own choices on the specific of some of these are below):

1. **COMPUTER** – These are getting cheaper and cheaper, and the new low-end computer is very capable of doing audio tasks. It is important to have a CD burner (so data can be burned directly to CD- remember to choose the software option to do a data verification when the burn is done) and a large enough hard drive to archive data and to run the recording equipment. Any laptop or desktop computer purchased new should have a hard drive of at least 80-100 GB. It won't be long before terabyte drives are available! A USB 2.0 interface for a/d hardware connection is also important. Some external hard drives/audio devices also have Firewire/IEEE 1394 interfaces, but this generally is not necessary as long as USB 2.0 is available. In fact, USB 2.0, at a data transfer rate of 48 Mbps is faster than Firewire 400 (MBps); only Firewire 800 is faster. If recording directly to computer and then burning CDs, make sure to record to a second hard drive other than the one running your programs; this can be done even if the PC only has one drive by partitioning the hard drive so that programs run on one part (usually C) and data is recorded to and stored on another drive. Another option is to buy an external hard drive and use it for recordings, which would allow for the data to be plugged into different computers without (or in addition to) burning on CDs. Also, we do not recommend recording data using the computer's sound card.
2. **RECORDING SOFTWARE** – There is no need for an expensive package because most of the package features are for editing rather than recording. It is more important to find something that is easy to use. It should record a minimum of two channels.
3. **CAMCORDER** – Depending on what your needs are, it is useful to video record some sessions. Unless fancy things will be done with the recordings (analysis or just video record), it is not important to have an expensive recorder. Look for a mini DV camera with a back or side (not bottom) loading tape compartment so it doesn't have to be removed from the tripod every time tapes are changed. Also look for a camera with an external microphone attachment for better sound.
4. **VIDEO MONITOR** – This is only necessary if it is otherwise difficult to see and hear what is going on within a sound-treated booth. LCD monitors take up less room when lab space is at a premium, but CRT monitors are perfectly good if size/space is not an issue.
5. **CHAIR** – Any reasonably comfortable chair will do if the subject will only be sitting for a short period of time. Although it is not necessary to have a chair with arms, it is essential to have one *without* wheels. An adjustable chair is helpful but will cost significantly more money; if needed, consider a used dental or ENT chair. Chairs should encourage good posture/breath support, therefore easy chairs should be avoided.

With these budget modifications, it would be possible to create a recording laboratory capable of collecting high-quality data for about \$5,000.

A Note About Recording Hardware and Software:

When shopping for such things as microphones, mic preamps, hard disk recorders, camcorders, or recording software, it may be tempting to buy something that is classified as “Hi-Fi” or “Pro Audio” or similar. If so, be aware that some features commonly used for recording or broadcasting in high quality are actually undesirable for scientific voice recording. These include any non-linear distortions such as noise canceling, Automatic Gain Control (AGC), noise reduction (Dolby, THX), or a Boost feature for recording low-level signals. All of these introduce unwanted frequency components (or delete important frequency components) in the spectrum of the recorded signal which can lead to erroneous analysis results. And of course, any kind of Equalization or filtering feature is undesirable. Remember that vocal accuracy, quality and cost are not synonymous.

Appendix

Note that the following is not an exhaustive list; some items were chosen out of experience in our own laboratories, while others were chosen based on recent research. There are many other models and manufactures of these but beware of the specifications of new equipment: years of research could be tainted.

Sound Level Meter: Class I or Class II (e.g., a Radio Shack SLM is class II). (NOTE: Radio Shack Model 33-2055 Owner’s Manual says “This meter does not meet the requirements set forth by ANSI Standard S1.4.” SO presumably it is not even a Type 2 meter?) Class I is far superior but more expensive. The cheapest Class I SLM we have seen is the Quest Model 1100. With calibrator, it is priced at \$1,680. A good Class I SLM is the B&K 2238, which costs about \$4,500 plus calibrator (another \$650). B&K also has a new, cheaper Class I SLM, the 2240. However, it may not be possible to program it for the exact measurement you want. :

http://www.quest-technologies.com/Sound/11_2100.htm

Head-mounted microphone.

Cheaper microphone: We can not determine the difference between a \$50 and a \$250 microphone. It is possible to get a cheap omnidirectional lapel microphone for less than \$50 and create a mounting device (which is not particularly easy). Mounts are also available on line.

More expensive microphone: Sennheiser HS2. Head-mounted omnidirectional mic, claims flat frequency response at close miking. Price \$499. Looks good but we have no experience with it.

<http://www.sennheiserusa.com/newsite/productdetail.asp?transid=005336>

Also check out the DPA 4066 mini omni, with adjustable head mount. It does have a 3 dB boost from 8-20 kHz but it appears otherwise completely flat. Again, we have no actual experience with this. <http://www.dpamicrophones.com/> Price between \$550-\$600

Our favorite microphone (the one we use the most) is the Countryman Isomax B3. It is a miniature omni-directional capsule that can be easily mounted to a custom head-mount. Low-cost glassless eyeglass frames can be used effectively to procure a stable mounting with repeatable mouth position. The microphone has a flat frequency response and is capable of handling high SPL. http://www.countryman.com/html_data_sheets/b3data.html Price about \$200

Spielman, Starr, and Hunter: Recommendations for the Creation of Recording Laboratory

Sound Isolation: WhisperRoom sound isolation: 6 x 6 room with Door window, lights(1), cable passages(4), foam sheets(7), ventilation units(2). Price \$4,500. Link: <http://www.whisperroom.com/priSTDB.html> There are several different vendors out there, we don't know anything about this particular room but they seem to be cheap and flexible. A 6 x 6 room should be plenty big for a short recording.

Microphone power, preamp, and a/d conversion: Some options:

Sound Devices USBpre. Available for \$550 .

<http://www.sounddevices.com/products/usbpremaster.htm>

Edirol UA25. \$235

<http://www.edirol.com/products/info/ua25.html>

Tascam US122. \$169

<http://www.tascam.com/Products/US-122.html>

Whichever device is chosen, it is important to test its specifications when installed correctly. When dealing with a product in this low price range, we don't have full confidence that it will arrive and meet published specs. If the capability is available, test noise floor, crosstalk, and distortion. If exact measurements cannot be made, careful listening tests can still spot a bad box before data collection begins.

Computer software for recording and audio storage: *Audacity* is a free, open source software for recording and editing sound. *Goldwave* (our favorite cheap one) is easy to use and can record 2 channels for \$45 license. *Praat* is downloadable for free and records 2 channels but may not be as easy to visualize (very powerful analysis tool but steep learning curve). *Adobe Audition* (formerly Cool Edit) license costs about \$300. Tascam US122 comes free with perfectly good recording software. Our favorite audio compression software is *FLAC* (Free Lossless Audio Codec; which also allows for checking archives for validity), with *7-zip* (free) our favorite general file compression software; neither of these have loss built into them which mp3 and similar compression algorithms do have. *WaveSurfer* is an Open Source tool for sound visualization and manipulation. Steinberg's *Cubase* is our primary recording software. Acronis *Disk Director* is what we use for partitioning hard drives (there are others). We use all of these software tools in our lab.

<http://audacity.sourceforge.net/>

<http://www.goldwave.com/>

<http://www.fon.hum.uva.nl/praat/>

<http://www.adobe.com/products/audition/main.html>

<http://flac.sourceforge.net/>

<http://www.7-zip.org/>

<http://www.speech.kth.se/wavesurfer/>

http://www.steinberg.net/33_1.html

DAT machine or Hard disk recorder for backup. Right now, there are plenty of 2-channel and 24-channel recorders but not a lot in between.

2-track recommendation: Alesis Masterlink. \$799. Includes CD burner. This device can record high-resolution audio.

<http://alesis.com/products/ml9600/about.html>

24-track recommendation: Fostex D-2424LV. \$1299.

<http://www.fostex.com/index.php?file=products/digital/d2424lv>

2-track DAT machine recommendation: SONY PCM-R500 \$1,200

<http://www.sonicsense.com/datpage.htm>

Digital Video camera and tripod. You can get something good for \$750-\$1,000. Add a tripod for \$30, and a good light for another \$30. Canon Optura 30 looks like a good value but I can't tell about the loading thing. To save tape, you can also record to a card and transfer it to your computer later on, depending on how much recording time you require.

Cables for audio and video. While there are many levels of quality in cables, shielded BNC and/or balanced XLR are recommended. Depending on what you need, expect to spend a few hundred dollars. Belden, Canare, and Mogami are all reputable brands which carry a wide-variety of cabling. (Belden 8451, Canare L-2T2S, Mogami 2549) Any audio/video supply shop will carry pre-assembled cabling. (www.sweetwater.com, www.fullcompass.com) Custom lengths are also available (www.Redco.com).

Video monitor. Cheap video display to see and hear what's going on in the booth. (as low as \$100)

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Questions or Comments

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Spielman, Starr, and Hunter: Recommendations for the Creation of Recording Laboratory

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