Blind Listening Evaluation of Classical Guitar Soundports

by R.M. Mottola

AMERICAN LUTHERIE #91 featured a survey article by Cyndy Burton on the use of soundports in guitars and other instruments. These ports are small holes in the ribs, intended to direct more of the sound of the instrument towards the player and thus serve as monitors. Research performed by Alan Carruth and published in *AL#94* showed that sound does indeed emanate from an open port. During the first half of 2008 I conducted research to determine if players could actually hear a difference in a guitar equipped with ports which could be opened or closed.

Research is both expensive and time consuming. I was very fortunate in this effort to be aided by a number of generous individuals and organizations. The guitar used in this experiment was provided by Alan Carruth. The New England Luthiers group (http://newenglandluthiers.org) provided a population of assessors (players) at one of their regularly scheduled monthly meetings. Jim and John Mouradian and Dennis Keller at Cambridge Music in Cambridge, Massachussetts (www.cambridgemusic.com) provided space to perform some of the evaluations, and a steady stream of assessors as well. Robert Sullivan, Eliot Fisk, and Steven Lin of the New England Conservatory (www.newenglandconservatory.edu) also provided space and access to assessors at Boston GuitarFest 2008, an annual classical guitar workshop and competition. This article is substantially better than its initial draft due to careful review and commentary by Mark French and David Cohen. Content of the commentary section of this article is due largely to discussions with Cyndy Burton and Jeffrey Elliott. The assessors were kind enough to take time to participate in this study.

The question this research intended to address was whether players could hear the difference between an instrument with an open port and the same instrument with a closed port, all in a context that is representative of a player's instrument selection decision. Although at first blush it may seem overkill, a controlled, blind, multiperson study is necessary to address this question. Human sensory evaluation is quite a mature area of study, and years of research have demonstrated a number of things that tend to confound less formal attempts at evaluation. Humans vary greatly in sensory sensitivity, and even the sensitivity of an individual can vary greatly as a result of exposure, training, and bias. The latter is a major issue for research, as substantial bias can result from the context in which a sensory assessment is made, and can also result from simultaneous input from another sense. We understand some of this intuitively — it is difficult to differentiate small volume changes in a quiet musical passage immediately after hearing loud volume material for a few minutes. In the realm of taste (which is not unrelated — general principles of human response to sensory input pretty much apply to all senses), chefs know that food is perceived to taste better if it is also visually appealing. And sensory assessment is highly subject to expectations, something which must be controlled for in any experiment intending to produce meaningful results. I am just touching on some of the issues here. Anyone interested in a more complete background in sensory evaluation may want to take a look at a textbook on the subject. The introductory chapters of the book *Sensory Evaluation Techniques* by Meilgaard et al. provide a good succinct overview.

The work by Alan Carruth mentioned has shown that sound emanates from the soundport(s) of a guitar so equipped. And a simple test can be performed which indicates that an open soundport has an audible effect on the sound of an instrument, although in a context which is not particularly representative of actual instrument selection or performance. If an open string is struck and let ring, and then a hand is used to alternately cover and uncover the soundport at a rate of about 1Hz, pretty much everyone can hear the resulting wah-wah-style pitch filtering. But human perception of sonic difference is highly influenced by both the way in which sound samples are presented and by the amount of time separating them. This informal test is optimized for detection of difference, but as mentioned, is not representative of the kind of comparison that an individual interested in comparing two different instruments would perform.

Another shortcoming of the informal test described above is that it is not blind, a shortcoming shared by most informal evaluations. An interesting nonlutherie experiment was performed recently by Antonio Rangel and others on the perceived taste of wine, and published in *Proceedings of the National Academy of Sciences* ("Marketing Actions Can Modulate Neural Representations of Experienced Pleasantness," 1/22/08). In this study, subjects were asked to sample wines and then to report on how good they were. They were told nothing about the wine other than its cost, and the cost ranged from cheap to very expensive. The general trend of the results showed that the subjects found that the more expensive the wine, the better it tasted. But the experimenters used exactly the same wine for all trials and the cost figures they gave were all made up. These results (and the results contained in a recent book on the same subject, *The Wine Trials* by Robin Goldstein) are consistent with many previous experiments in the area of human sensory perception — people's perception of sensory input is highly influenced by expectations as well as by ancillary sensory input.

Experiment Design. The soundport listening evaluation was designed to eliminate expectations and ancillary sensory input as influential factors in the experiment and to emulate the type of comparison a

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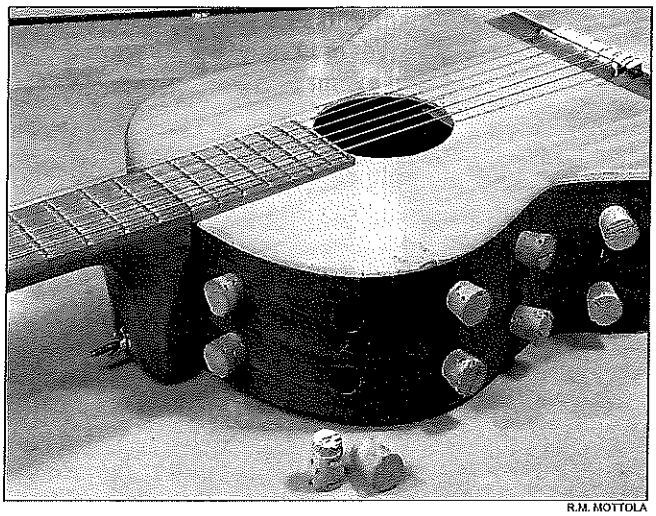
player would perform in selecting an instrument. A single test instrument (Alan Carruth's "corker" classical guitar, shown in the photo) with ports that could be opened or closed, was used. A single port pair located approximately 4″ from the neck heel on the side of the instrument was opened or closed for this experiment. This port pair was used because it showed substantial volume in Carruth's experiment and also "points at" and is located close to the player's face when the guitar is held in typical playing position. Port placement and area are probably critical factors in this and similar investigations, as frequency spectrum, volume, and proximity to the player's ears will all vary with position and/or size. Assessors were evaluated one at a time in a quiet room following an explanation of the experiment and instructions. Assessors performed their evaluation blindfolded so they could not see which port configuration was in use.

As mentioned, human sensory evaluation is a mature area of study, and as such the experimental methodology for this study did not have to be designed completely from scratch. The study was conducted to comply with the specifications detailed in standard ASTM E 2139-05, Standard Test Method for Same-Different Test from ASTM International (formerly called the American Society for Testing and Materials). The standard includes specifications for the design and implementation of the experiment as well as the methods used to analyze the results.

Each assessor played the instrument twice, the first time with one port configuration (the port pair opened or closed) and the second time with another port configuration (the port pair opened or closed). All port permutations (open/open; closed/open; open/closed; closed/closed) were used in the experiment in equal number but each assessor evaluated just one permutation. During instruction the assessors were made aware that there was a 50% chance that the port configuration of the instrument would be identical both times they played it. The assessor played the instrument for thirty seconds in the first port configuration, then the instrument was taken from the assessor and configured for the second port configuration and then returned to the assessor ten seconds later. The assessor then played the instrument again and was asked to state whether the instrument sounded the same or different between the two trials. Since removing or replacing the corks in the ports makes some squeaking noise, the corks were made to squeak even in those cases where there was no change in port configuration between trials. To minimize sensory fatigue and for statistical accuracy, each assessor participated in only one two-trial session. A preliminary experiment indicated that potential assessors could not determine port configuration by detecting weight differences of the instrument with the corks in or out. Assessors were free to choose the material played in the evaluation. Although the choice of material could affect one's ability to differentiate between an open and a closed port, preparatory investigation indicated that as a practical matter assessors could not be expected to both play a recently learned piece and pay careful attention to listening to the instrument at the same time. Some of the assessors were luthiers, and as an anecdotal observation, the luthiers tended to play in a more probing fashion, working at the extremes of volume, pitch, and timbre.

One critical area not specified in the ASTM test standard was the manner in which the samples are presented to the assessor. Simultaneous presentation is preferred, but that is not possible for a player playing an instrument. Sequential presentation does present some potential problems in an evaluation of this type. There are certainly well established presentation methods which provide for better detection of sonic differences, such as the ABX method (described succinctly and accessibly at www.hydrogenaudio.org/forums/index.php?showtopic=16295), but none of these were deemed practical for evaluation of an instrument by a player. The method chosen also emulates well a typical real-world evaluation of two instruments by a player, and the corresponding level of sensitivity was considered to be appropriate for this type of evaluation.


R.M. MOTTOLA

Data Collection. The test was run on twenty-four assessors at four sites. The number of assessors was determined by practical considerations, primarily the limited resources available to conduct this experiment. This number was suboptimal in terms of the sensitivity of the test, as will be described in detail in a later section. Assessors were all competent professional musicians or conservatory students and/or luthiers. Some assessors were known to be primarily classical guitar players as described below. Six assessors were recruited from among professional players picking up repair instruments at the repair shop of a busy music store (CM). The test was conducted at this site in a small, quiet lesson room. Eleven assessors were recruited from among player/luthiers at a monthly meeting of a regional luthiers group (NEL). The test was conducted at this site in a quiet, moderately sized wood shop. Four assessors were recruited from among professional classical guitar players and/or conservatory students attending a classical guitar master class

workshop (NEC). The test was conducted at this site in a quiet, small recital hall. Three assessors were recruited among professional classical guitar players and/or conservatory students (LR). The test was run at this site in a quiet suburban living room. Assessor responses were recorded by the author in all cases, and are listed in **Table 1.**

Analysis and Interpretation of Results. The data from the test are summarized in **Table 2.** Following instructions for analysis specified in the ASTM test standard, the initial analysis is to determine whether the number of different responses from those assessors receiving different port configurations is less than or equal to the number of different responses from those that received the same port configuration in both trials. In this case the hypothesis of no assessed difference can not be rejected, which is to say that, given the limitations of the experiment, assessors could not tell the difference between open and closed ports. Although close, the results of this test do not meet these criteria, as the number of different responses from those assessors receiving different port configurations (ten) is greater than the number of different responses from those that received the same port configuration in both trials (nine). In this case, the test standard specifies that statistical analysis of the data is required to determine whether the samples are perceptibly different or not. The analysis specified is called Fisher's Exact Test, a statistical test of the equality of two independent binomial proportions. This test is described in detail in the textbook *Principals and Procedures of Statistics* by R.G.D. Steel and J.H. Torre and also in other statistics texts. Simply put, the goal of the statistical analysis for this experiment is to determine the likelihood that the test results indicate the ability of assessors to detect the difference between an open and a closed port. Just

Subject number	Trial 1 port configuration	Trial 2 port configuration	Subject's Response	Location	Classical player
1	open	open	different	CM	?
2	closed	open	same	CM	?
3	open	closed	different	CM	?
4	closed	closed	different	CM	?
5	open	open	different	CM	?
6	closed	open	different	CM	?
7	open	closed	different	NEL	?
8	closed	closed	same	NEL	?
9	open	open	different	NEL	?
10	closed	open	different	NEL	?
11	open	closed	different	NEL	?
12	closed	closed	different	NEL	?
13	open	open	different	NEL	?
14	closed	open	different	NEL	?
15	open	closed	different	NEL	?
16	closed	closed	different	NEL	?
17	open	open	different	NEL	?
18	closed	open	different	NEC	yes
19	open	closed	different	NEC	yes
20	closed	closed	same	NEC	yes
21	open	open	same	NEC	yes
22	closed	open	same	LR	yes
23	open	closed	different	LR	yes
24	closed	closed	different	LR	yes

Table 1. Port configurations and assessor responses for all twenty-four assessors.

looking at the summary data in **Table 2** indicates that this is not likely, and in fact the analysis yielded a resulting p-value of 0.5, which indicates that the port open and port closed states are not perceivably different.

Discussion. The results indicate that the population of assessors could not perceive a difference whether or not a port was open in this experiment. In any experiment there are always factors which would limit the extent to which it is appropriate to extrapolate from the results to real world application. Two I would like to discuss here are the composition of the assessor population and the sensitivity of the test as a consequence of the limited number of assessors.

That the assessor population is not homogeneous by a number of criteria is a given. One criterion that could affect the applicability of these results is the type of instrument usually played by each assessor. I did not track this reliably during data collection, but it is reasonable to assume that those assessors whose primary instrument is not classical guitar typically play steel string acoustic guitar or electric guitar. It is possible that close familiarity with the type of instrument used in this experiment (classical guitar) could influence sensitivity to subtle differences in tone or volume from that type of instrument. It is anecdotally interesting to note (but not statistically significant) that the known classical guitar players used as assessors later in the experiment scored better at determining a port difference than did the rest of the assessors. Again, the numbers are too small to consider in the context of this study, but this is something that subsequent similar studies may want to consider.

As mentioned earlier, the number of assessors used in this study was suboptimal. The ASTM test standard provides data in tabular form to help determine the number of assessors needed for desired test sensitivity, given some information about the likely profile of the data. With no previous assessment studies of this type, I had no data profile information available. Using the default values for that and for the parameters specifying the desired test sensitivity, a minimum of eighty-four assessors would have been required to obtain results with reasonable confidence in their accuracy. As studies of this type are often limited by practical considerations in the number of assessors (as this study certainly was), the tables in the ASTM test standard can be read to indicate test sensitivity as a function of the number of actual assessors, in this case twenty-four. **Table 3** shows both the nominal test sensitivity values and associated number of assessors required (eighty-four), and the test sensitivity values I selected based on the number of assessors used in this experiment. The sensitivity parameters include:

α (alpha) risk — The probability of concluding that a perceptible difference exists when in reality one does not. This is also known as Type I error or significance level;

β (beta) risk — The probability of concluding that no perceptible difference exists when in reality one does. This is also known as Type II error;

Δ (delta) — The minimum difference in proportions that the test should detect;

p1 — The proportion of assessors in the population that would respond different to the matched (i.e., not different) sample pair.

For the case of the sensitivity parameter values resulting from the use of twenty-four assessors in this experiment, the following can be stated about the sensitivity of this test:

There is a 30% probability that the test will indicate perceivable differences where there are none ($\alpha = 0.3$); The test provides an 80% certainty ($\beta = 0.2$) of detecting a 40% difference ($\Delta = 0.4$) between the proportion of assessors who would correctly identify the unmatched port configuration and the proportion who would say the matched port configuration was different in the population. The logic may be a bit hard to follow, but what this means in simple terms is that the probability of the test being acceptably accurate with this number of assessors is good but not great.

Of possible interest to future research in this area is the proportion of different to same responses, which is heavily biased toward different. Various acoustic, psychoacoustic, and psychosocial possibilities could explain this bias, and this could itself be an interesting area of research.

Conclusions. The results of this experiment indicate that the port-open and port-closed states are not perceivably different. These results may be of practical value for those considering adding soundports to guitars. Future efforts may also want to attempt to identify narrower populations that may be more able to detect the presence of a soundport. If this can be done, such ports may prove advantageous to that population. Additional research using larger assessor populations and a more consistent test environment may also provide better confidence in study results.

Response:	Assessor Received: Matched Pair	Unmatched Pair	TOTAL
Same	3	2	5
Different	9	10	19
TOTAL	12	12	24

Table 2. Summary data for the test is represented in a 2×2 table.

α-risk	β-risk	p1	Δ	Number of assessors
0.05	0.2	0.3	0.3	84
0.3	0.2	0.3	0.4	24

Table 3. The number of assessors is a function of the desired sensitivity of the test. Nominal values for sensitivity parameters shown in the first row indicate a test using eighty-four assessors is required. The test outlined in this article used only twenty-four assessors, resulting in the sensitivity parameter values shown in the second row. Descriptions of these parameters appear in the text.

Dear Tim, Jon, and everyone at the GAL,

In behalf of Don Manuel, we wish to thank you for your support and articles you have published over the years. Dad was very happy to see the most recent article in *AL#96*. We wish to thank you for the wonderful way all you attended to us at the 2006 convention and especially in accommodating Dad's needs. We will cherish the memories forever.

Dad will be celebrating his 92nd birthday on February 22nd. He still comes to work three times a week, and works on his own instruments. His dedication and passion for his work is something that many of us will find inspiring for many years to come.

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Hi Tim,

In a new Super-Target store near my home I noticed a "Two-Tone Round Accent Table" made of natural "Sheesam" wood, a common name for *Dalbergia sissoo,* aka Indian rosewood. On the bottom of the table top it was marked "Made in India." Referring to my article in *AL#95,* I believe I can now confirm that *Dalbergia sissoo* from India is practically identical to the *Dalbergia sissoo* that grows in South Florida.

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Dear Mr. Mottola:

Your article "Blind Listening Evaluation of Classical Guitar Soundports" in *AL#96* presents its data in probably the most scientifically precise way that I have seen in *AL* or any other popular journal. Bravo! Your careful discussion is concise, precise, readable, and informative. I think it would sit nicely in a scientific journal, yet it is also enjoyable to read (not true of most scientific articles!) I especially appreciate that you included the Type I (alpha) and Type 2 (beta) risks and the Fisher p-value. Anyone making real-life decisions based on scientific data can immediately understand the result of the experiment (null hypothesis not rejected: the players were unable to detect a difference) and the power of the experiment (moderate) to reliably find the correct experimental result.

I also appreciate your discussion of bias in listening experiments. Personal bias ruins the value of most such comparisons. Most discussions of sound quality preference and guitar-making adjustments to improve the volume or quality of sound are conducted with fuzzy qualitative words, which allow almost any desired interpretation, much like horoscopes. Your experiment and article are fine efforts to get beyond vague assertions and shine the light of science on this subject.

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Dear Tim and GAL Staff,

I read R.M. Mottola's article with interest as I plan to add ports to one of my guitars. I never thought my mind might make me believe that it actually sounds better. Mottola deserves kudos for the research and use of testing and statistical theory.

Mottola had issues with the data: quantity; locations; backgrounds of participants. Why not perform the experiment at a future GAL Convention? There would be many willing participants, and you could have a blind listener test at the same time as the blind player test.

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Dear GAL Members —

There's really nothing to be objective about when discussing the sound quality of guitars, especially in terms of aging. We have no single source of data to build upon. We cite the soundboard as being the principal component in the production of sound, but no two soundboards are the same. I am tired of us always arguing about sound. In the scientific method you have to have something identical to start your conversation from.

I located a tree which had six usable feet of tone wood that I have converted into 106 tops, all within three to six feet of each other. All the wood is select, super stiff, and perfectly quartered. It is highly figured bear claw with an unusual reddish color. This wood has never been soaked in water. There is a documented chain of evidence to prove it all came from the same log, which was lifted by helicopter from Prince Edward Island. There is brace stock also available from the same tree. Todd Taggart is serving as custodian.

I propose to distribute eighty tops to guitar makers who will agree to craft an instrument that would be brought to the Healdsburg, Montreal, or Newport guitar shows in the next two or three years, where each instrument will be photographed, recorded, and sonically profiled. A tracking chip or identification sticker will then be permanently attached to it. At future festivals, the instruments can again be examined and recorded, and we can start building and enriching the database that we have all wished for. These instruments will be tested and examined by the public, played by other luthiers, and examined by the critical press. We will begin our new conversations with a powerful starting point.

I have consulted suppliers and makers, including some with highly scientific backgrounds. All are enthusiastic about this project and its potential. The project will give us an appreciation of what construction means in terms of sonic performance by giving us a scientifically valid set of data points that shows how instruments change over time in the hands of performers. It's the right idea at the right time.

The golden age of lutherie is dependent upon on the interest of our clients. Many old and new luthiers working together will draw more attention to all of us as individuals and gives us something to inspire each other to take chances. This is not a competition. There are historically significant reasons to undertake this project. This will be the first time someone has undertaken this type of project, but it won't be the last.

These guitars will become instantly collectible because of their association with the project. This will change forever the type of conversations that we will have, and that future generations will have long after the initial project artists are dead. The more quickly it happens the more we have to talk about over the coming years. Share your creativity and talent with posterity. Let us establish our credibility forever.

I am giving the tops away to support this database. You, the individual luthier or guitar maker, will pay shipping and handling. In return, you will agree to bring the instrument to any of the major guitar shows or conventions to be measured and evaluated. Build anything you want — the wood is available in extra widths. Five guitars have already been commissioned.

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Hi Tim,

What do you do when a "scientific" study directly contradicts your own experience? Which are you more inclined to believe, a statistical body of "evidence," or your own ears?

This is my dilemma now, having read R.M. Mottola's paper on his statistical listening test with soundports (*AL#97*). This experiment seems at first glance to be thorough and well designed. In his conclusion he states that there is no perceivable difference between port open and port closed. This is followed by the comment that this may be "of practical value to those considering adding soundports."

His conclusion is that there is no difference, and that definitely contradicts my experience. At this point, in spite of this "evidence," I'm going with my ears. Since Robert Ruck introduced me to the idea of sound ports in 1998, I've made hundreds of guitars with ports. I don't do it for no reason; I do it because it works. It makes the guitar sound better. Scores of times I've made guitars without ports, and drilled them after, and the difference is clear. Many times I've drilled ports with an audience, and it has always, always improved both the sound for the player, and the sound perceived by the listener. Although I have usually done this sideshow in my own show room, I've also done it on stage in concert halls, and I have seen the reaction on the faces of the listeners even before hearing their comments.

Not all ports are created equal. I think Al Caruth's Corker guitar is very cool, a fine way to mix and match, to get a sense of the effect of a variety of possible locations. But frankly, those two small ports used in the experiment don't reflect any luthiers' porting solution that I know of. My own are bigger, and on both sides of the neck. I think most successful ports are bigger.

Not all guitars are created equal. As with any other detail of guitar music production, the overall sensitivity

of the instrument will correlate directly to any element — the player's touch, strings, finish, or ports. In my experience, effective porting will give more of whatever is already there. I've ported cheap plywood guitars, and got small results. I am guessing that Al's cool Corker was not really constructed as a concert instrument, that it does a good job at its original intended purpose, but was not built to prove or disprove the validity of soundports as a useful guitar design element.

I've done blindfold tests on two occasions, and I don't think I will do it again. It's too unnerving. My own blindfolded listenings have been among very sophisticated players, dealers, and myself with my own guitars included among other guitars of high quality and low. Blindfolded, all of us were completely lost. We couldn't tell ports or not, spruce or cedar, our own guitars, even cheap or expensive. That is demoralizing. I never want to do that again. The only thing I did come away with is that the guitar is much more than the sum of its parts, and our relationships with the guitar are very complicated indeed.

Frankly, I don't really care if people build guitars with ports or not. I get good results, and that's what I have to worry about. Many other builders are finding good use for them too. I don't do it on all guitars, and I never do it to other builder's instruments. But I do wonder about attempts, however well meaning, to create data-based criteria for goodness, through statistics, meters, oscilloscopes, CAT scans, and such. I have had physicists tell me that ports don't work, can't possibly work, and yet I have seen them work over and over.

In the introduction to his study, Mottola states that "Human sensory evaluation is quite a mature area of study." Really? This seems like arguing that space exploration is advanced area of study. Yes, there's been a lot of study, but how much do we really know?

The difficulty I have with statistical "science" is that it is delivered with such an implied irrefutability, that data don't lie, and in this case perceptions be damned. If the results of a study are to discourage experimentation or tamp down enthusiasm, then let the buyer beware! I don't want this kind of research to stop, but I hope for it to add to the body of knowledge and insight, not to become a new fundamentalism that reduces possibilities rather than expands them.

Mottola's study made a very sincere effort to include broad factors and create neutrality, to reduce subjectivity. Yet I came away from it scratching my head, wondering if this is all true, why do soundports work so well for me, and for so many of my colleagues? 'Splain that to me, wouldja?

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Dear Tim, Deb, and Crew:

I continue to be astonished by your magazine, even though I have long known that it is great.

I have a couple succinct messages for your readers.

▸ Don't be intimidated by the level of excellence, skill, and erudition that may characterize some of the feature articles. What is really important is for you to do *something,* especially when you are young and interested. Whatever you build will be good and will move you onward. You'll like it and you'll get better at it.

▸ Be conscious of potential hazards to health and safety and do something about them before they sneak up on you. Fumes, sawdust, cluttered spaces, badly maintained machinery; these can be your worst obstacles if you are not alert to them.

Best wishes from a mediocre but happy craftsman,
Frederick C. Lyman, Jr.
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Hi Tim,

You may get feedback about *GAL Plan #60* saying that one instrument is Tuvan and the other, the Morin khuur, is Mongolian. I conform to this view. However, if one were really pedantic, an argument could be made that the distinction may be a more recent one. Prior to 1926, both Tuva and Mongolia were the same country. Tuva was originally the Mongolian administrative region of Urianhai and was encouraged to break away by the Bolsheviks, renaming it Tannu Tuva.

Thanks,
Tom Johnson
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Hi Tim, and Guildsters everywhere —

As John Calkin says in "Dulcimer 101," (*AL#98*) the Appalachian dulcimer don't get no respect, and that's a pity. My lutherie career started when I found plans for a dulcimer in (of all places!) a Time-Life craft encyclopedia, and put one together just for fun. One of my guitar students saw it and said, "I must have that!" and it just snowballed from there. I built dulcimers for two years, then quit my day job and went to San Diego to spend a couple of months with Božo Podunavac, learning how to make guitars. That was back in 1980, but dulcimers have been very good to me ever since.

I'd like to share a few thoughts about this much-maligned little instrument. I've heard people say, "But you can only play in one key!" Exactly; it's a simple instrument, designed for simple music. Because it's diatonic, you can never hit a sour note. You may not hit the note you want, but at least it'll be in the right key. I've sold many dulcimers to people who have never played a musical instrument in their lives, and after a very brief demonstration, they're picking out tunes on their own. Bless that built-in success factor, the diatonic fretboard. Also, with only one melody string, it's linear — a lot easier for beginners to understand than, say, a guitar. Just slide and strum.

I've also had customers tell me it's a very meditative experience, just to shift your brain into neutral and noodle at random, finding melodies arising out of your unconscious. (I should be good at that — Kate tells me I spend half my waking hours at one unconscious level or another!)

From a luthier's standpoint, it's got another advantage: it's affordable. While not everybody is able or willing to shell out big bucks for a custom-built guitar, a dulcimer is very attainable financially. Many is the folk festival where a dulcimer sale has made back my booth rental, while prospective customers are trying out the guitars and dreaming of "Someday...."

So thanks, John, for raising the subject. And to my Guild brothers and sisters out there, have a go at this happy little instrument!

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Tim —

I found Kenny Hill's response (in *AL#98*) to R.M. Motolla's study of ports (in *AL#96*) interesting. I'm not going to answer every point he made; some are more properly addressed by R.M. himself. However, there are a couple of things I would like to comment on.

Kenny wrote: "I'm guessing that Al's cool Corker was not really constructed as a concert instrument, that it does a good job at its original intended purpose but was not built to prove or disprove the validity of soundports as a useful design element."

I think the concept of what is or is not a "concert instrument" is slippery enough that we won't settle it here. Nobody is likely to appear on the stage with something as rough as the "corker" so that in itself excludes it from that class. I will note, though, that several people, including one very fine maker, have remarked that it is at least "not bad", and R.M. told me that most of the players had a much higher opinion of it when they were blindfolded.

I built the guitar originally because a customer was interested in having a port, and I wanted to get some idea of the best size and location for one. While I was at it, it seemed a good idea to do a more general assessment of a number of port locations, to see if any

general principles would emerge. Playing and listening tests were always part of the intent.

Kenny is certainly correct in saying that you don't learn much from modifying a poor guitar. That's why I went to the time, trouble, and expense of making one from scratch when I could have gotten a plywood box from the local Junque Shoppe. The material is good, and I did what I could to get a decent sound from it under the circumstances. As always, there are constraints that limit how good it could be, and I'm certainly not putting it forward as one of the all-time best.

Although I don't have R.M.'s expertise in that line, I do know that it's important in pschycoacoustic experiments to limit the time that elapses, and the noise generated, when making changes. Construction time and complexity suggested that corks would be the best closure for the ports, and their size was dictated by the largest corks I could easily get locally. Larger corks would have been welcome, but I'll note that one can pull four or more corks to get the effect of a larger hole, and I've done that in other experiments. In my opinion, this has been quite a successful instrument, and not least because it's not a bad little guitar.

"The difficulty I have with statistical 'science' is that it is delivered with such implied irrefutability, that data don't lie, and in this case perceptions be damned."

Most scientists would, I think, find the phrase "irrefutable science" to be an oxymoron at best. The whole point of science is that it can be refuted. Anything that can't be is religion.

There is no such thing as a perfect experiment. Every scientist does their best, of course, to make things as air tight as possible; science is hard work, and there's no sense in wasting the effort on a bad experiment. But there are limitations to even the best experimental design, and a careful reading of R.M.'s article will suggest some improvements. If you disagree with his findings, then the proper course of action is to run a better experiment that corrects his mistakes.

I'll mention two things in that regard. One is what I call "Feynman's Dictum" from his graduation address entitled "Cargo Cult Science": "The first principle [of being a good scientist] is that you must not fool yourself, and you are the easiest person to fool." If you think something happens a certain way, you have to do the experiment that will prove you wrong. You can always prove yourself right, but if you can't prove yourself wrong, then there's a pretty good chance you're not. And if you don't do that experiment, somebody else will.

The other is that, if you really want to do that experiment, you should talk to R.M. Gabriel Weinrich pointed out that the problem with science is that you're always doing something you're not good at. You come up with an experiment that nobody has done before, and by the time you can make it work pretty well, you've got all the data, and it's time to move on to something else you don't know how to do. R.M. can tell you about some problems that you can avoid, and, of course, you don't have to take his advice if you don't want to.

In the end, scientists can't "prove" anything: they leave that to mathematicians. The best scientists can do is set limits as to how likely something might be. We figure by now that if you drop something, it's likely to move toward the floor, but there's always a chance it might not. R.M.'s experiment showed that, under certain circumstances, a small port is unlikely to be much help to a guitarist. That does not say that under other circumstances a port of a different size or configuration won't work better. We need to do more work to explore the envelope, and, in the mean time, nobody has outlawed ports. If they don't work as well as some of their partisans would like to believe, then they will end up being one of the many fads that has passed through the guitar world over the years. If they do work, then they will become a standard feature, and no amount of nay-saying by scientists will change that.

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Hi Tim,

I received an e-mail from Al Carruth with the sad news that Carleen Hutchins has passed on. It happened that Al was down in my neck of the woods the other day giving us an increasingly rare opportunity to catch up in real time. As it was, we talked a lot about Carleen. I can count on one hand the number of times I spent any appreciable time in her company and all of them were inspiring. As significant as those times were for me, the first time I met Carleen stands out the most in my memory.

In June of 1992 I came along with Al on a road trip to Vermillion, South Dakota, for the GAL Convention. The four days it took us to get out there were an incredible adventure for me. I had just graduated high school (I turned eighteen halfway through the trip) and I was not entirely sure what I was going to do next. By the end of the convention I knew (thanks for that!) and have tried hard since to keep on keeping on.

Our first stop along the way was to visit Carleen in Montclair, New Jersey. Since the Catgut Society was to have a joint meeting with the Guild, we were there to pick up some of the larger instruments from the Octet to deliver for the convention. I had heard quite a lot about Carleen during the course of my studies with Al, and was very curious to meet my teacher's teacher.

Tim,

I was pleased to see R.M. Mottola's article on blind testing of soundports on guitars in *AL#96,* pp. 54–57. It was great to see scientific rigor applied to a question of aesthetic perceptions. Mr. Mottola set out to answer a single question: Can experienced players and builders detect a sound difference between a guitar with and without soundports when they play them blind? The experiment provided hard data that supports the conclusion of rejecting this hypothesis. Mr. Mottola went to great lengths to remove error and bias from his experiment. He explained the experimental method and provided important caveats about the results. He used appropriate statistical analyses in interpreting the results and presented the α and β risk results appropriately. Mr. Mottola acknowledged the limitations of his experiment, especially the limited sample size (probably the only really valid criticism of the experiment) and the selected nature of the subjects. He also clearly indicated areas for future study. This is good science.

What motivates this letter is the following statement from Kenny Hill's letter in *AL#98,* p. 5, replying to the article: "The difficulty I have with statistical 'science' is that it is delivered with such implied irrefutability, that the data don't lie, and in this case, perceptions be damned."

Most basically, science never "proves" anything (as Alan Carruth noted in his response in *AL#100,* p. 4). Science only disproves hypotheses by careful experimentation that is designed to remove error and bias. Science gives us the best explanation, given current data, and is always looking for more data. Science changes its conclusions based on new data, if indicated by the data.

After providing a full page of caveats to and explanation of the results of his blind listening experiment (*AL#94,* p. 56–57), Mr. Mottola's conclusion is:

"The results of this experiment indicate that the port-open and port-closed states are not perceivably different.... Future efforts may also want to attempt to identify narrower populations that may be more able to detect the presence of a soundport. If this can be done, such ports may prove advantageous to that population. Additional research using larger assessor populations and a more consistent test environment may also provide better confidence in study results."

Contrast this with Mr. Hill's statement in *AL#98,* p. 3: "I'm going with my ears. Since Robert Ruck introduced me the idea of soundsports in 1998, I've made hundreds of guitars with ports. I don't do it for no reason; *I do it because it works. It makes the guitar sound better.* Scores of times I've made guitars without ports, and drilled them after, and *the difference is clear.* Many times, I've drilled ports with an audience, and *it has always, always improved the sound for the player, and the sound perceived by the listener."* (My emphasis.) Which statement is presented by its author as more certain, more irrefutable?

Science, properly applied, is designed to remove error and bias, and to self-correct. Science has a long track record of discovering real knowledge about our world. The methods Mr. Mottola applied to this experiment are the same ones that others have applied to medicine, aeronautical engineering, bridge design, electronics, food safety, sanitation, environmental protection, and essentially every vital product or service

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you use every day. Obviously, since science is done by humans, we sometimes fail. But science learns from these mistakes and feeds those data back to improve future knowledge and performance. On the other hand, preconceived notions and anecdote are impervious to new data ("I just know") and therefore are quite incapable of improving our performance.

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To the GAL Staff:

We have built guitars in our school shop here in Waldheim, Saskatchewan, Canada for about ten years now and it has been a great addition to our Industrial Arts program. Aside from teaching high-level woodworking skills, it is a wonderful vehicle for building confidence and self-esteem. The articles published in *AL* have been very helpful.

Tyrell and Joshua made these guitars as their Grade 10 projects. Both are finished with Tru-oil, and they look and play great. The body of Tyrell's 5-string bass is curly maple and the maple neck has a cherry insert. Tyrell was the first student that I've worked with that had selected and purchased his own material in advance. He came to the shop ready to work and did an excellent job. Joshua's 6-string was constructed on a tight budget. He used our basic Strat templates, but incorporated a Tune-o-matic bridge and attached the strings through the body. Joshua had a very precise vision of what the final product would be and persistently worked to that end.

Our school shop often displays student work in Saskatoon, the closest city to our small town. Guitars are shown along side furniture projects, skate and longboards, and an assortment of projects turned on the lathe. When I approached Tyrell and Joshua about showing their instruments, they both hesitated and then stated, "Well, if you really need them, but we would prefer not to because we play them every day." This was the ultimate compliment of our program and their workmanship.

Thanks for the help,

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GLEN FRIESEN

Although noncommittal about exactly what they intended to pursue with or through these entities, it's obvious they could very easily initiate investigations not only on the vendors but also on individual luthiers as named in customer files or membership lists.

Because this appeared to be a genuine possibility, it was suggested that FWS hold off on any pending enforcement plans aimed at luthiers until after an in-depth article could be published by both GAL and ASIA, which would give industry businesses enough information and time to become "voluntarily compliant" with all the regulations. FWS responded that this would be not only reasonable, but would greatly simplify their enforcement efforts. Thus this article.

The laws are complex and intertwined, and there's just no way to reduce them to a few simple formulas. In fact, for a number of reasons, different officials within the same agency will typically give different or conflicting advice about their own regulations, even though it's legally required that you and I clearly understand them! Since the full-text summary of these laws and procedures is too lengthy to print in a single journal issue, it has been archived and can be accessed on the GAL website (www.luth.org). It reflects the conclusions of many, many hours of research, phone calls, e-mails, and personal discussions, but will without doubt contain a few things (hopefully minor) that need to be corrected or augmented. Consider it a basically trustworthy guide to what you need to do to stay out of trouble; but also a document that can be modified as needed as we all discover new facts that need to be brought to the discussion. So print it out, read it more than once, mark it up, start doing whatever applies to you as soon as possible... and best wishes for many years of bureaucratically unchallenged luthing!

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Tim —

I appreciate R. M. Mottola's in-depth comparison of the hazards of alcohols in *AL#105*. His comments in reference to his and Cyndy Burton's experience of eye irritation after French polishing with denatured alcohol only confirms what I have been told by medical folks. Methanol, the main denaturing ingredient in denatured alcohol, is very readily absorbed through the skin and irritates the optic nerve, causing swelling. Too much exposure can lead to permanent blindness. The PEL limits may seem small when considering dispersion in the atmosphere, but that's not how most absorb it when French polishing, unless they are using cumbersome methanol-proof gloves. His PEL data also confirm something that has been the rule in my shop, which is that we only use three solvents besides water: pure 95% ethanol, acetone, and naphtha. Also, the methanol in denatured alcohol dissolves some of the waxes of some shellacs which ethanol doesn't dissolve, which is probably the reason the old recipes for spirit varnishes usually call for "spirits of wine" (ethanol).

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Hello all,

Folks interested in the science and technology of stringed instruments will be interested in a new research journal on those subjects. *The Savart Journal* is an open-access online journal featuring peer-reviewed research articles on all aspects of the science and technology of stringed musical instruments. Full text of all articles is available for all readers online; no need to register or login to view articles. Articles are published continuously as they are received and reviewed. The journal is named after and inspired by the work of 19th-century French physicist Felix Savart, an early researcher in the acoustics of stringed musical instruments. For more information about the journal please visit the website at http://SavartJournal.org.

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Hello Tim,

I read *AL#105* with great interest as usual. Thanks again for your good work. Robert Simon's letter regarding soundport listening tests caught my eye. I think the discussion in the pages of *AL* around sound differences between instruments is very healthy. Mr. Simon's letter emphasized that most tests or claims for soundports are focused on volume.

The blind listening experiment, reported by R. M. Mottola in *AL#96*, pp. 54–57, tested whether the players themselves could detect any difference between the guitar with and without ports open. The scoring was only "same" versus "different." A double-blind test of listening from close in front of the guitar with and without ports may also be useful. Because we know the power of non-audio information (non-test, generally) to influence our perceptions, the only way to isolate whether there actually is a sound difference is to perform the tests blind. This is a basic principle of all testing for effects. If it is violated, the data are literally worthless: They cannot prove the effect.

I also noticed that the data from Mr. Mottola's experiment show a strong placebo effect. The listeners/subjects showed a powerful bias towards hearing a difference between the trials regardless of the actual trial. The results are: for matched pairs (data = same) three votes for "same" and nine votes for "different"; for unmatched pairs (data = different) two votes for "same" ten votes for "different." I tested the results from Mr. Mottola's test against the expected random result (50/50 different/same) and the actual trials, also 50/50. A 2-Proportion test (Fisher's exact) of the whole set of results yields a p-value of .069 which indicates a placebo bias, but it doesn't quite meet the .05 α requirement (the subjects expected to have a difference in the test and did report one). A Proportion test (Fisher's exact) of the matched pair results yields a p-value of .001, which very strongly shows a placebo effect: No change was present, but the subjects expected a change and reported one. (Stats run on MINITAB 15.)

I can understand the community's ambivalence about blind listening experiments. They are difficult to do properly (good science is hard) and consistently show that people cannot distinguish sound differences for changes like soundports without other cues. This is disappointing for people striving to make their instruments *sound* better.

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