Soloist evaluations of six Old Italian and six new violins

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Many researchers have sought explanations for the purported tonal superiority of Old Italian violins by investigating varnish and wood properties, plate tuning systems, and the spectral balance of the radiated sound. Nevertheless, the fundamental premise of tonal superiority has been investigated scientifically only once very recently, and results showed a general preference for new violins and that players were unable to reliably distinguish new violins from old. The study was, however, relatively small in terms of the number of violins tested (six), the time allotted to each player (an hour), and the size of the test space (a hotel room). In this study, 10 renowned soloists each blind-tested six Old Italian violins (including five by Stradivari) and six new during two 75-min sessions—the first in a rehearsal room, the second in a 300-seat concert hall. When asked to choose a violin to replace their own for a hypothetical concert tour, 6 of the 10 soloists chose a new instrument. A single new violin was easily the most-preferred of the 12. On average, soloists rated their favorite new violins more highly than their favorite old for playability, articulation, and projection, and at least equal to old in terms of timbre. Soloists failed to distinguish new from old at better than chance levels. These results confirm and extend those of the earlier study and present a striking challenge to near-canonical beliefs about Old Italian violins.

subjective evaluation | music | perception

The violins of Stradivari, Guarneri "del Gesu," and other Italian makers of the 17th and 18th centuries are widely believed to possess playing qualities that are both immediately discernable to experienced players and not found in new instruments. Over the past two centuries, numerous playing and listening tests have challenged this belief by pitting new violins against old (1–3). Although results often favored new instruments, the tests typically lacked sufficient rigor for the results to stand as scientific evidence.

It is only recently that well-controlled studies of player preference have appeared in the literature (4–6). In a 2010 double-blind test held in a hotel room at the International Violin Competition of Indianapolis (4), 21 experienced violinists compared three new violins with two by Stradivari and one by Guarneri del Gesu. Results showed that the most-preferred violin was new, the least-preferred was by Stradivari, and players seemed unable to tell whether their most-preferred instrument was new or old. However, the small number of violins and brief evaluation periods (less than an hour for each player) left many questions unanswered, the most obvious being whether results would hold with a larger set of test violins, a different group of players, longer evaluation periods, and more true-to-life test conditions.

Although the Indianapolis study focused on player preferences, violin quality can be judged from several other relevant points of view—including those of listeners, colleagues in an ensemble, recording engineers, and orchestral conductors. There is no a priori reason to assume that all should agree or that one party's preference is more "correct" than the other. For example, a violinist might prefer an instrument that is the easiest or most inspiring to play whereas listeners choose another because it carries better in a hall.

That said, violinists have at least two advantages over their audiences when evaluating instruments. They are inside a feedback loop and so base their judgments upon interaction rather than passive listening. They are also very close to the instrument, where its sound is most intense and least colored by room modes. And, in the end, it is violinists who choose their instruments and whose judgments are therefore most consequential.

The current study was designed to retest the Indianapolis findings with a larger number of violins and then explore how well judgments carry from a small venue to a larger one. Whereas the Indianapolis study relied on 21 players of various levels, this study concentrated on the judgments of 10 renowned soloists. Blind tests were conducted in both a small rehearsal room and a concert hall, with the option of piano accompaniment and listener feedback in the latter.

Materials and Methods

The Team. Although it is unusual to describe the team, given the nature of this experiment, we believe it important to provide some details. Designing an ecologically valid experiment that answers questions relevant to the violin world requires a variety of experts with differing interests. The team thus included several scientists, a violin maker and researcher who builds and sells new violins, a violin soloist who owns and plays an Old Italian violin, a professional violist and instrument dealer who owns several Old Italian instruments, and a string engineer and amateur violinist who owns and plays an Old Italian violin.

General Design. The experiment was designed around the hypothetical premise that each soloist was looking for a violin to replace his or her own instrument for an upcoming solo tour. Tests were structured to emulate as far as possible the way a player might do this search in real life. Typically, a number of instruments are informally tested at a violin shop; then one

Significance

Some studies open new fields for investigation; this study attempts to close a perennially fruitless one—the search for the "secrets of Stradivari." Great efforts have been made to explain why instruments by Stradivari and other Old Italian makers sound better than high-quality new violins, but without providing scientific evidence that this is in fact the case. Doing so requires that experienced violinists demonstrate (under double-blind conditions) both a general preference for Old Italian violins and the ability to reliably distinguish them from new ones. The current study, the second of its kind, again shows that first-rate soloists tend to prefer new instruments and are unable to distinguish old from new at better than chance levels.

Author contributions: C.F., J.C., J.P., and H.B. designed research; C.F., J.C., H.B., I.W., F.-C.T., and T.G. performed research; C.F., J.C., and J.P. analyzed data; and C.F., J.C., and J.P. wrote the paper.

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or more are taken away for testing in other contexts—almost certainly including a concert hall, with one or more colleagues present to give feedback. We decided to allow the soloists the greatest possible freedom to test instruments as each saw fit, believing this freedom would give the most meaningful results—as opposed to standardizing interactions between players and test instruments (e.g., by requiring players to spend the same amount of time with each instrument, or to play the same musical excerpts on each), which would however have the advantage of eliminating some variables.

We believed that 12 violins (6 old, 6 new) would allow a nice variety of instruments, yet still be manageable for the players. In a real-life situation, players would rarely be presented with so many instruments at once, but in the authors' experience, players tend to quickly eliminate instruments they find unsuitable, then spend more time on those that seem a better fit. We polled nine soloists (by means of a questionnaire sent before the experiment) about the time needed to comfortably evaluate instruments within the context of the experiment (i.e., choosing from among 12 violins a replacement for their own for an upcoming tour). Their average estimate was 50 min, with a SD of 30 min.

In light of this average estimate, each soloist was scheduled for a pair of 75-min sessions, each held on a different day in a different venue (see *Venues*). Before each session, soloists were given written instructions (*SI Text*). After their first session, they were interviewed; after the second, they answered a brief questionnaire.

When testing violins in real life, players typically use their own bows, which through constant use have become, in effect, extensions of their right arms (5). We therefore asked the soloists to use the bow they normally played and to use that same bow throughout the study. We are aware that the choice of bow may affect the perceived quality of a violin and so introduce an unconstrained variable—but so too would asking all players to use a single, unfamiliar bow. To facilitate testing, we provided players who used shoulder rests with additional ones of the same model.

During both sessions, soloists wore modified welders' goggles, which together with much-reduced ambient lighting made it impossible to identify instruments by eye. The fact that the new violins had been antiqued helped eliminate any tactile clues to age, such as unworn corners and edges. It was proposed that a dab of scent be placed under the chinrest of each violin to mask any distinctive smells. This idea was, however, deemed unacceptable by those responsible for the condition of the old violins, who felt the essential oil might possibly infiltrate the varnish. However, no distinctive smells were detected by the authors, nor were any reported by participants.

Two of the authors (C.F. and I.W.) were present during the sessions; they made notes of the subjects' comments but responded only to confirm what had been said and to move players from one task to the next. The researchers were seated behind the players and, in any case, were scarcely visible to subjects, given the dim light and goggles.

A large, back-lit timer helped participants keep track of the time.

Test Instruments. A pool of 15 new and 9 Old Italian violins was assembled by the authors. The new violins (none of which were used in the Indianapolis experiment) were built by professional makers in Europe and North America and were between several days and two decades old. Makers were invited to submit only instruments that were "antiqued" (i.e., made to resemble old instruments). The makers agreed not to publicize their involvement in the experiment and were aware they would never know whether their instrument had been included in the set of 12 test violins. Old violins in the pool included 2 by Guarneri del Gesu (both made after 1740), 6 by Stradivari, and 1 by another well-known 18th century Italian master. None of these violins belonged to or were played by the invited soloists. All were loaned on condition that their identity remain confidential (thus, the very general descriptions used throughout this paper).

It was assumed that the parties who loaned instruments had an interest in them sounding their best and so had them set up and adjusted accordingly. All violins were therefore kept in the exact condition in which they were received. This condition was monitored throughout the study by separate "guardians"—J.C. for new violins and T.G. for old. Other than a slight buzz that developed with one of the new instruments and the replacement of a reportedly uncomfortable chinrest on one old violin, none of the instruments presented problems, nor did any soloists report difficulties with setup or adjustment.

Six old and 6 new violins were selected from the pool by means of informal blind tests designed to eliminate instruments with the least impressive playing qualities (*SI Text*). Just which instruments were included in the final 12 was not revealed to the makers, dealers, collectors, and players who submitted them. None of the test instruments were unusual in terms of size, proportions, or setup. Although not all had the same strings, all had very typical combinations of a steel E-string and metal-wound synthetic-core lower strings.

Venues. The experiment took place at two locations, both on the outskirts of Paris, France. The first was the home of a family of professional string players. The room used was one favored for rehearsals and individual practice. The second was a 300-seat concert hall, well-regarded for its acoustics (*SI Text*). An acoustically transparent screen was installed between the stage and the seats, where a small, varying audience included at times soloists not currently involved in a test, authors other than C.F. and I.W., and a few interested outsiders.

Violinists. Whereas the Indianapolis study involved players of varying levels, including soloists, orchestral players, and amateurs, this study involved only soloists. Although the preferences of players at all levels is potentially interesting, the preferences of soloists were felt to be most important for our purposes due to their high playing standards under widely varying conditions and their (typically) broad experience playing top-quality violins. We also considered the common belief that it takes a top player to "get the most" out of an instrument, especially in terms of projection. And there is the fact that the real-life choices of soloists have been very important in forming the reputations of individual violin makers, past and present. To give the experiment maximum credibility, we tried to choose internationally known soloists and/or those who had won major international competitions.

Time constraints limited the number of players we could work with. The old instruments were available for just a few days, and the auditorium for a day and a half. Considering the estimated time (50 min on average; see *General Design*) required by soloists to choose a single favorite violin from a set of twelve, we judged that giving more time to fewer players would lead to more reliable judgments than would the converse.

In the end, 10 soloists (*SI Text*) were invited, along with an eleventh who participated in the final session only. Ranging in age from 20 to 62, their combined awards included Avery Fisher career grants (2) and first prizes in the Tchaikovsky (2), Sibelius (1), Paganini (1), and Long-Thibaud (3) competitions, along with many other lesser awards, including a silver medal at the Queen Elizabeth Competition.

Although 10 soloists may seem a relatively small number, it should be remembered that the world population of players at this level is not large—indeed, the combined number of first prizes awarded in the above competitions in the past 50 y is about 90. Given our selection process, however, the 10 soloists can hardly be regarded as a random sampling of this population, and we have no information on how and to what extent they might differ from it. Consequently, in this paper, we consider those 10 individuals as our population of interest and limit ourselves to descriptive statistics (i.e., avoiding confidence intervals and significance tests).

Two of the soloists regularly play new instruments but have in the past played extensively on violins by Stradivari and/or Guarneri del Gesu. A third soloist, who owns and performs on both a Guarneri del Gesu and new violins, came to the experiment with a new instrument. The other seven soloists play old violins—including instruments by Carlo Bergonzi, Gagliano, Gobetti, Guarneri del Gesu, Storioni, and Vuillaume.

Soloists were given no information about the test instruments although the publicity generated by an earlier study (1) may well have led them to expect a comparison between new and old.

Detailed Procedure. In session 1, all 12 instruments were laid out in random order on a table. In the authors' experience, when players test violins, they tend to quickly eliminate those they find unsuitable and then spend more time with those that seem a better fit. Soloists were therefore given 50 min to test the instruments as they wished, with the goal of (*i*) removing any violins that seemed unsuitable and (*ii*) choosing the four they liked most, and then arranging these in order of preference. As a reference, and to get a sense of the space, they were instructed to play their own violins first, and then anytime it seemed useful thereafter.

For the last 12 min of the session, they were presented with three violins. One was their own. One was their chosen favorite. The other was (unbeknownst to them) their most-favored of the opposite new/old category to their favorite. As one player's top-four were all from the same category, he was given his two most-favored violins. The soloists were then given 30 s to rate each instrument (beginning with their own) on a (continuous) scale from 0 to10 for (*i*) loudness under the ear, (*ii*) estimated projection, (*iii*) playability, (*iv*) tone quality, (*v*) articulation/clarity, and (*vi*) overall preference/quality.

These terms, all commonly used by players when evaluating instruments, were left undefined. Note that, unlike the other criteria, loudness under the

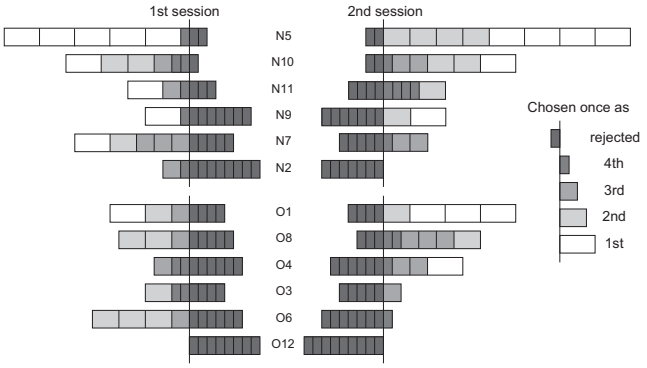

Fig. 1. For each session, the number of times each violin was chosen as first, second, third, and fourth on a soloist's top-four list and the number of times it was rejected. The horizontal width of each box is proportional to the points scale defined in the description of Table 1.

ear is not necessarily a positive attribute for all players. Note too that, whereas projection can by definition be judged only by a distant listener, players routinely estimate projection when testing a violin—and typically acknowledge (as did many of our subjects) the provisional nature of such estimates and the need to retest in a large hall with trusted listeners. However, this portion of the study was designed to test the subjective preferences of the subjects under a specific set of conditions, rather than objective qualities of the instruments themselves. Due to space constraints, the table on which the instruments were laid was on the small side; to reduce any risk of damage, the instruments were passed from table to soloist by T.G., who wore goggles.

We were interested in how choices made in the rehearsal room carried through into the concert hall, and so all violins (including those rejected in session 1) were presented again in session 2, although now divided into three groups: the four favorites (in random order); those rejected during session 1; and any remaining instruments. It was hoped this procedure would best enable soloists to build upon earlier impressions as they would in real-life tests.

Although their first task was identical to that in the previous session, they had 45 min this time, and the option to (*i*) ask for feedback from a designated listener chosen before the session—for example, from a friend or colleague, H.B., another soloist who had already taken the test, or somebody else from the audience; (*ii*) ask H.B. (who wore goggles) to play a violin for them while they listened from anywhere in the hall; or (*iii*) ask the professional pianist (available at all times) to accompany them or H.B. for any of the violin/piano excerpts in the portfolio (Franck Sonata, second movement; Beethoven Kreutzer Sonata, third movement; and Brahms Sonata no. 1, first movement).

In the questionnaire sent to the soloists before the experiment, we asked the following: "*If you had a dozen instruments to test in an auditorium in order to choose one to replace your own for an upcoming tour, would you need any help? If yes, which one(s) among the three [above] options?*" Of the nine players who replied, option 1 was chosen four times, option 2 seven times, and option 3 three times. We therefore allowed all three options. During the course of the experiment, nine participants used the piano accompaniment, five asked for listener feedback, and three asked H.B. to play for them.

As in the previous session, soloists were then given 12 min to evaluate their favorite violin, their most-favored of the opposite new/old category, and their own instrument, using the same six criteria.

Next they were presented with a series of violins (one at a time, in random order) and given 30 s to play each one before guessing what kind of instrument it was. If a soloist was unclear about the meaning of the question, he/she was prompted to guess whether the violin was new or old. The series consisted of (*i*) that player's favorite old violin; (*ii*) the player's favorite new violin; (*iii*) an old and a new violin the player found unsuitable; (*iv*) the old violin and the new violin that, in session 1, were most often included in top-four lists and that were on average most highly ranked within those lists; and (*v*) the old and the new violin that were most often rejected as unsuitable in session 1.

If it happened that two of the above criteria described the same instrument, the player was simply given one fewer instrument to judge. During these sessions, the table size allowed ample space for each violin, and so soloists were allowed to handle the instruments themselves.

Table 1. Number of points attributed to each violin in each session

Violin	Session 1	Session 2
N5	**19**	**26**
N10	**13**	**13**
O1	**5**	**11**
O8	**3**	**8**
N11	4	3
O4	**-2**	**3**
N7	8	0
N9	**-2**	**0**
O3	1	−3
O6	5	−6
N2	−5	−7
O12	−8	−9

Instruments with session 2 scores equal to or higher than session 1 scores are printed in bold. Instruments are listed in order of descending scores in session 2.

Results and Discussion

Favorite and Rejected Violins. Soloists are (almost by definition) individualists so it is hardly surprising that they do not all have the same taste in violins. In this study, a large interindividual variability in preferences (*SI Text*) was indeed observed, and this is consistent with the results of previous studies (1, 5, 6).

Fig. 1 shows how often each violin appeared on a soloist's top-four list, where on that list it appeared, and how often it was rejected as unsuitable. Five of the 12 test instruments were the top-choice for at least one player; 10 were included in at least one top-four list; and all 12 violins were rejected by at least two players. It should be borne in mind that soloists spent very little time with rejected instruments, instead focusing on their favorites. About all that can be said of the least-preferred instruments is that they made a poor first impression on the majority of players.

Preference scores were assigned to each instrument as follows: four points each time it was first on a top-four list, three points for second, two points for third, and one for fourth. A point was subtracted each time it was rejected. Table 1 shows the scores for both sessions.

By design, the soloists built on experience gained during session 1 to arrive at their final choices in session 2. Here, a single new instrument, N5, was easily the most-preferred. It was the top-choice for four soloists, second choice for another four, and rejected just twice, garnering a total of 26 points. Next came N10 with 13 points, the top-choice for just one soloist. Third was O1, a Golden Period Stradivari, with 11 points. Although it was the

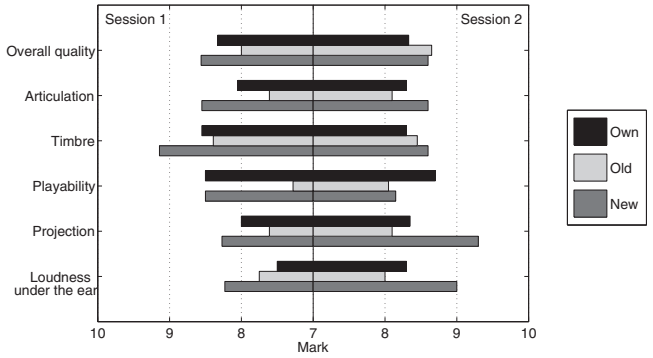

Fig. 2. Averaged ratings for each criterion for each category of violin (new, old, own). Session 1 is left of the centerline, and session 2 is right.

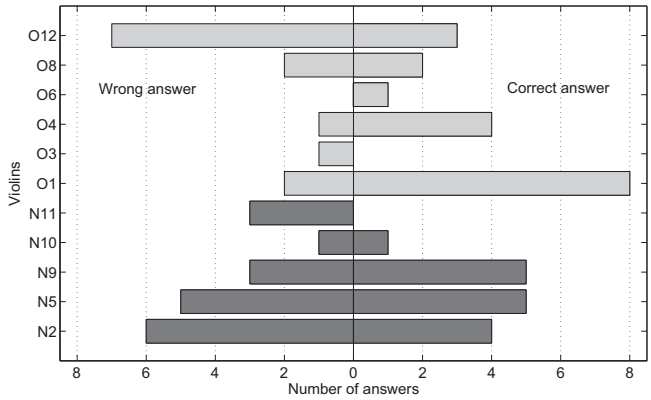

Fig. 3. Soloists' guesses about the age of each test instrument. Five indeterminate guesses about old instruments are not represented here.

top-choice for three soloists and second choice for one, it was also rejected four times. At the other end of the scale, we saw N2 and O12, a new violin and a Stradivari that scored −7 and −9 points, respectively, entirely on the basis of rejections.

Other scoring systems produce slightly different rankings. For example, if rejections are ignored or if top-choice instruments alone are considered, O1 moves up to second place, and N10 (which is on average more popular) moves down to third. O8 seems to appeal to many players, but is never a top-choice. By contrast, O4 and N9 are the top-choice of one soloist each but are also rather frequently rejected. Still, if a "successful" violin is defined as one that a soloist would use on a concert tour, both O4 and N9 are successful instruments. Their appeal, however, seems rather narrower than that of N5 and O1.

Summing the scores for new and old separately, we get 35 and 4 respectively—almost 6:1 in favor of the new. If rejections are ignored, the sum changes to 62 and 38, or about 3:2 in favor of the new. Ignoring all but the five top-choice violins, it is 24 and 16—again 3:2 in favor of the new. We can find no plausible scoring system by which the old fare any better.

Evolution of Preferences from Rehearsal Room to Concert Hall. The Indianapolis experiment was criticized for its use of a relatively small room for testing instruments. As one distinguished violinist remarked, "You don't test a Ferrari in a parking lot." Although this study does indeed take the instruments out of the parking lot, keep in mind that other factors were almost certainly involved in the observed preference shifts, including the following: (*i*) more time spent with the violins; (*ii*) the possibility during session 2 of playing the violins with piano and of receiving listener feedback; (*iii*) intraindividual variability (a player would not necessarily give the same rating if asked to repeat the task under strictly identical circumstances—i.e., if it could have been possible that he/she had forgotten doing it the first time!); and (*iv*) individual violins may or may not have been recognized or remembered across the sessions so the extent to which session 2 ratings are affected by those made in session 1 is not known.

That said, Table 1 shows that the two top-scoring violins from session 1 do as well or better in session 2: N10 maintains its score whereas N5 gains 7 points. The converse is true for the two lowest-scoring violins, O12 and N2, which lose 1 and 2 points, respectively. For instruments at either end of the preference scale, at least, impressions formed in the rehearsal room seem to be reinforced in the hall. However, for the other instruments—whether old or new—all patterns can be observed. For example, N7 (third highest score in session 1) and O6 (tying with O1 for fourth highest in session 1) lose 8 and 11 points, respectively, whereas O1 gains 6 points in session 2 and moves up from fourth to third. (The above pattern is very similar with other scoring systems, such as an exponential one, where the top-four violins are given 8, 4, 2, and 1 points, respectively, thus weighting in favor of the most-preferred instruments.)

At an individual level (*SI Text*), 4 players chose the same favorite in both sessions. For 2 players, their session 2 favorites had been their second choices in session 1, and for a further 2 players, their third and fourth choices, respectively. So, in total, 8 of 10 players chose their session 2 favorites from their session 1 top-four lists, suggesting that meaningful testing about general preferences is possible outside a concert hall. Indeed, loudspeaker research (7) shows that, within certain limits, listeners are quite capable of subtracting the effects of room acoustics from their judgments of loudspeaker quality. Given a few minutes to adjust, they arrive at the same judgments in a wide range of listening environments. The same may prove true when evaluating violins; more research is needed. In terms of old versus new, some old violins score much higher in the hall, as predicted by critics of the Indianapolis study, but then some do worse—and this pattern is true for old and new alike. There is certainly no evidence here to support the belief that Old Italian violins come into their own in concert halls whereas new ones fall behind.

Evaluation by Specific Criteria. Fig. 2 shows the ratings (on a 0–10 scale, averaged over 10 soloists) for each of six criteria: overall quality, articulation, timbre, playability, projection, and loudness under the ear. Soloists rated their own instrument, their chosen favorite, and their favorite of the opposite new/old category. In session 1, 11 ratings are for new violins and 9 for old because one player's top-four list contained only new violins. In session 2, 10 ratings are for new and 10 for old.

On average, the ratings given to test violins are similar to those given to the soloists' own, suggesting that the two groups are similar in terms of their playing qualities. In both sessions, the soloists rate new violins more highly than their own for all criteria except playability. Although old violins are rated much lower than both new and soloists' own in session 1, they almost catch up to the soloists' own in session 2. Keep in mind, however, that, for these averaged ratings, (*i*) each violin was evaluated by a somewhat different group of soloists in sessions 1 and 2, and (*ii*) intersession differences may also be attributable to one or more of the factors mentioned in the previous section.

That said, the improved ratings, in particular for playability, for old violins in session 2 could be taken as support for a commonly held belief that it takes more time to learn to play an old violin than a new one, or it may be that player judgments are affected by the change from rehearsal room to concert hall—positively for old violins and negatively for new. More evidence would be needed to make a case for either of the above explanations. Easier to understand are the higher playability ratings soloists give their own violins in both sessions: they have played these instruments for years, and the test violins for some fraction of 2 h.

Old Italian violins are commonly believed to project better in a hall than new ones, despite seeming less loud under the ear. Fig. 2 shows that the soloists do indeed rate the old lower than the new for loudness-under-the-ear, but they also rate them

Table 2. Soloists' guesses about the age of old and new test instruments

Violin	Correct	Wrong	Indeterminate
New violins	15	18	—
Old violins	18	13	5

Table 3. Wrong and right guesses about the five violins chosen as the single favorite by at least one soloist

Violin	Wrong guess	Right guess
N5	3	1
N9	1	0
N10	1	0
O1	1	2
O4	1	0
Total	7	3

lower for projection. (This belief of course says nothing about actual projection, as evaluated by listeners.)

It is widely believed that new violins may be louder than old ones, but at the expense of tone quality. Our data show that, whereas the new violins are indeed more highly rated for loudness-under-the-ear and projection, they are also rated equal to or better than the old for timbre. Their perceived advantage in the former two criteria seems to account for the overall preference for new violins, as both categories are rated quite equally on the other criteria.

Critics of the Indianapolis experiment voiced the importance of testing violins in a large space, where the (supposedly) superior projection of Old Italian violins would become evident. Although these old and new violins (all of which are favorites) were generally rated more highly for individual criteria during session 2, the effect was slightly greater for the old violins, but the difference was too small to make a convincing case that Old Italians have any special advantage in the hall, especially since their averaged ratings were lower than new violins (see *Favorite and Rejected Violins*). Remember, too, that differences could be related to the other factors listed in *Evolution of Preferences from Rehearsal Room to Concert Hall*.

A surprising result is that, whereas old and new violins have similar ratings for overall quality, the old are on average lower for the other five criteria. Looking at individual results, this result can be explained by a single outlier: One soloist gave very high scores to his second-favorite violin (new) for all criteria except overall quality, which received a surprisingly low rating. We have no way of knowing why because a player's estimate of overall quality is not necessarily the simple average of our five criteria. For example, timbre may be especially important, or loudness under the ear may be a negative criteria. There are also numerous factors outside our criteria that may affect a sense of overall quality, such as neck thickness, bridge curvature, string heights, type of strings, or wolf notes. Still, if we ignore this player's data, the overall quality becomes higher for new violins (8.9) than for old (8.5), in total agreement with the averaged marks over the four positive criteria projection, playability, timbre, and articulation (loudness-under-the-ear being potentially negative for some players)—8.7 and 8.1 for new and old, respectively.

It is interesting to put these results into perspective with responses to the question asked at the end of session 1: "*In your experience, are there general differences in playing qualities between new and old violins?*" Seven soloists responded that there are general differences; six of them believe that (in summary) (*i*) new violins are easier to play, speak more easily or more immediately, and are more powerful and "direct" than old ones; (*ii*) old violins may not be powerful enough to play with a modern orchestra; and (*iii*) old violins have more colors, personality, character, and refinement, and are sweeter and mellower than new ones.

The soloists' responses are in agreement with the averaged ratings for beliefs *i* and *ii*, but not for belief *iii*, at least not if the characteristics listed in belief *iii* can be considered aspects of timbre.

Old or New? Each soloist was presented with a series of violins and, after playing each of them for 30 s, was asked to guess what kind of instrument it was. If the instrument was new, a correct guess was "modern," "new," or some similarly unambivalent attribution. If old, a correct answer was any that suggested the instrument was an Old Italian, regardless of whether it was attributed to the right maker (thus "Guarneri del Gesu" was considered correct for a Stradivari). Five answers (e.g., "19th century French") were considered indeterminate.

The soloists played between six and eight violins each and made a total of 69 guesses—33 of them about new violins and 36 about old. Note that these guesses were made at the very end of session 2, by which time the soloists had typically spent a good deal of time with their more-preferred violins, and very little with rejected ones.

Soloists' guesses are compiled in Fig. 3 and summarized by category of instrument in Table 2. Considering all guesses about all instruments, 33 were wrong, 31 right, and 5 indeterminate. These guesses were rather evenly divided between old and new violins (36 and 33 respectively) (Table 2) so the data rather clearly demonstrate the inability of the players to reliably guess an instrument's age, whether the instrument was in fact new or old.

Table 3 shows the distribution of right and wrong guesses about the top-choice instruments (i.e., the instrument chosen at the end of session 2 to replace a soloist's own). The preponderance of wrong guesses can be attributed to chance, or there may be an easily understandable tendency to believe one's favorite violin is old. Indeed, out of the seven wrong guesses about top-choice violins, five were due to guessing that three new violins (N5, N9, and N10) were old.

Table 4 shows how the guesses were distributed among (*i*) rejected, (*ii*) intermediate (i.e., neither rejected by a player nor on his/her top-four list), and (*iii*) top-four instruments. Data for individual soloists are provided in *SI Text*.

Considering now the top-four instruments, 12 guesses were made about new instruments and 9 about old, yet the instruments were guessed old 14 times and guessed new just 7—suggesting again a tendency to believe a favorite instrument is old (*SI Text*). Given the small size of this study, however, further research is needed to establish whether or not this effect is real.

While one might expect a converse tendency to believe that rejected instruments are new, the evidence for such tendency is

Table 4. Number of guesses (new, old and indeterminate) about rejected, intermediate, and top-four instruments

	Rejected			Intermediate (neither favorite nor rejected)		Top-four			
Violin	Guessed new	Guessed old	?	Guessed new	Guessed old	Guessed new	Guessed old	?	Total
New violins	11	**7**	—	0	**3**	4	**8**	—	33
Old violins	**9**	10	4	**1**	2	**3**	6	1	36
Total	20	17	4	1	5	7	14	1	69

Bold type indicates wrong guesses.

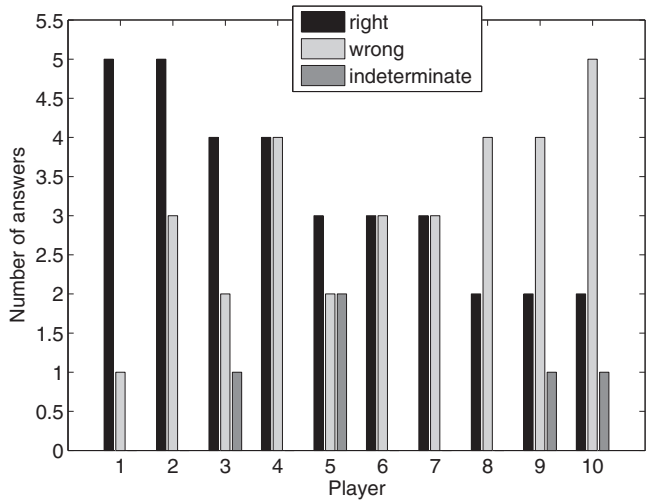

Fig. 4. The number of indeterminate, wrong, and right guesses made by each soloist.

very weak. Although O12 was guessed new seven times and guessed-old just three times, N2 was guessed old five times and guessed new three times. And of the 37 guesses made about rejected violins (18 about new and 19 about old), 20 are guessed new and 17 guessed old.

Fig. 4 compares the number of right and wrong guesses made by each soloist. One soloist had five right and one wrong whereas another had five wrong, two right, and one indeterminate. The other soloists were somewhere in between, including three with an equal number of right and wrong guesses. Without further testing, it is not possible to know the extent to which the results of any given soloist are due to skill or to chance.

Soloist Confidence in the Validity of the Protocol. After each session, the soloists answered a series of questions (*SI Text*) pertaining to their confidence in the choices they made and how these choices might carry over into a real-life situation. Their answers (summarized in *SI Text*) indicate that most of the soloists found the sessions in the rehearsal room and concert hall quite sufficient for choosing an instrument for an upcoming tour—but not for purchasing one. We freely admit that meeting all requirements for a real-life violin search would have been quite impossible within the course of an experiment!

Conclusions

The nominal premise of this study was that soloists choose, from among six new and six Old Italian violins, one that might plausibly replace their own violin for an upcoming tour. After evaluating the instruments first in a rehearsal room and then in a concert hall, six soloists chose new violins and four chose Stradivaris. A single new violin was chosen four times, a single Stradivari three times, and two new violins and a Stradivari once each.

Preference scores were assigned to each instrument based on its placement in top-four lists compiled by each soloist and by how often the instrument was rejected as unsuitable. By this measure, new violins outscored old by almost 6:1. If rejections are ignored, or if only the five violins that were the favorite of at least one soloist are considered, the ratio drops to about 3:2. However, no matter how results are tallied, it is clear that, among these players (seven of whom regularly play Old Italian violins) and these instruments (five of which were made by Stradivari), there is an overall preference for the new.

Ratings for individual quality criteria suggest that this preference is related mainly to better articulation, playability, and estimated projection—but without tradeoffs in timbre. New violins were on average more highly rated for loudness-under-the-ear and, whereas this attribute is not necessarily positive for all players, instruments more highly rated for loudness-under-the-ear were also more highly rated for (estimated) projection—an unquestionably positive criterion for soloists.

By the end of their time in the hall, 8 of 10 players chose an instrument that was one of their top-four in the rehearsal room. Although no one would propose that real-life instrument searches should rely entirely on impressions formed in a small room, these results do suggest that meaningful testing about general preferences can be conducted outside a concert hall. There remains the important question of how well player preferences correlate with those of listeners, particularly with regard to projection in a hall.

Soloists readily distinguished instruments they liked from those they did not but were unable to tell old from new at better than chance levels. This result emphatically confirms the findings of the Indianapolis experiment—and indeed many informal listening tests conducted over the years.

There is no way of knowing the extent to which our test instruments (old or new) are representative of their kind so results cannot be projected to the larger population of fine violins. However, given the stature and experience of our soloists, continuing claims for the existence of playing qualities unique to Old Italian violins are strongly in need of empirical support.

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