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Original Paper

Multi-Dimensional Joint Judgment in Online Violin Instruction: Integrating Technical Criteria, Audiovisual Processing, and Video-Based Diagnosis

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Abstract

The main difference between online and face-to-face instrumental teaching is not whether teacher and student are in the same room. It is that the teacher's channel of perception has changed. The sound that arrives through conferencing software is no longer the raw acoustic signal; it is a representation that has been processed and filtered by algorithms. A teacher who keeps the listening habits of the face-to-face lesson will therefore make systematic errors of diagnosis. This paper proposes a conceptual framework for online violin pedagogy, the multi-dimensional joint judgment method. The argument is that reliable technical diagnosis requires four sources of information to be integrated at the same time: (i) technical criteria grounded in the physics of sound production, (ii) the visual evidence of bowing movement, (iii) the transmitted audio signal, and (iv) an understanding of how the conferencing software processes that signal. The paper describes how noise-suppression algorithms can classify a good violin tone as noise, and proposes a four-quadrant scheme that turns this side effect into a diagnostic aid. It further argues that the claim "tone production cannot be taught online" is overstated, once the technical criteria are specified at the level of visible movement: bowing rather than bow-changing, and the unity of the bowing plane. Finally it proposes a reproducible diagnostic sequence for video, with the hand first, then the shoulder and upper arm, then the elbow and forearm, together with a routine of self-monitoring that compensates for the loss of mutual observation online. The framework comes from the author's teaching practice. It is offered as a practitioner's method, not as a validated empirical result.

Keywords

online music education, violin pedagogy, noise suppression, motion feedback, motor learning, networked music performance

1. Introduction

The decisive difference between online and offline instrumental teaching is not that teacher and student are in different rooms. It is that the information available to the teacher changes fundamentally. In a face-to-face lesson the teacher hears the violin as a raw acoustic event, and observes the student's movement from a viewpoint that moves and can be chosen freely. In an online lesson the sound is no longer the raw sound. Before it reaches the teacher's ear it has passed through a microphone, an analog-to-digital conversion stage, and a software pipeline that was designed mainly for speech. The image likewise arrives as a fixed projection bounded by the camera frame, and not as a live three-dimensional scene. If the teacher keeps applying the auditory habits of offline teaching, and treats the transmitted sound as a reliable record of the student's technique, the result is a systematic bias. Problems may be identified where none exist, and real problems may be hidden by the very systems that are meant to make communication clearer [8, 11].

The pedagogical consequence is that accurate online diagnosis cannot rest on a single channel. It must be a *joint* judgment, one that combines technical standards, video evidence, audio evidence, and knowledge of how the software and hardware transform the signal. When these dimensions are integrated, the teacher can locate the source of the fault in each bow stroke quickly and accurately. When they are not integrated, the teacher is easily misled by what appears on the surface, and most often by an over-reliance on audio. This over-reliance is exactly what supports the widespread belief that online education has severe limitations in the teaching of instrumental technique. The present paper develops the argument in four stages: the noise-suppression mechanism as a hidden confounding variable; the specification of precise and visualizable technical criteria; the arc-line problem of bowing and its compensation; and a concrete procedure of video diagnosis.

The problems discussed here are not hypothetical. Instrumental instruction migrated rapidly to videoconferencing platforms, a process accelerated by the COVID-19 pandemic, and this has produced a substantial literature on both the feasibility and the specific difficulties of remote music teaching [8, 11]. Research on networked music performance established long ago that latency, audio quality, and the loss of visual information are not incidental inconveniences. They are structural constraints, and they alter the very information on which musical interaction depends [4]. The contribution of the present paper is to show how these constraints interact with the specific demands of violin technique, and to derive from that analysis a method that can be used in practice.

A note on the status of this paper is necessary here. This is a conceptual and practice-based contribution. The framework proposed below was developed from the author's own online teaching over several years, and from the established literature on acoustics and pedagogy. It has not been tested in a controlled trial, and no quantitative data are reported. Claims that are identified below as resting on teaching experience should be read as hypotheses that the framework makes testable, and not as validated findings. Section 6 states the resulting limitations.

2. The Mechanism of the Noise-Suppression System: An Easily Overlooked Confounding Variable

Most conferencing platforms, such as Zoom and Tencent Meeting (released internationally as VooV Meeting), contain a noise-suppression system. Its working logic is to identify the parts of the incoming audio that are noise-like and attenuate them, while keeping the parts that are speech-like. This design comes directly from the speech-enhancement literature. Classical spectral subtraction removes stationary noise by estimating its spectrum and subtracting it [1]. Modern real-time systems such as RNNoise, which is based on a recurrent neural network, are trained on corpora of speech and noise so that they can decide whether a given energy is voice or noise [2]. The WebRTC audio-processing module, on which many conferencing applications are built, states this speech-oriented goal explicitly in its documentation of noise suppression and gain control [3].

When such a pipeline is applied to a musical instrument instead of a voice, it produces misclassifications, and these matter greatly for teaching. The important point is that the misclassification is not decided by loudness or amplitude alone. It follows from two particular classes of signal feature.

Transient suppression. A strongly bowed note, or the instant of a bow change, has a rapid rise in amplitude and a complex spectral structure that does not match a standard model of the human voice. Such a signal is easily classified as transient noise, in the same category as a keystroke or a slamming door, and it is suppressed. But these are exactly the moments when the string is most fully excited and the overtone spectrum is richest. The better the tone, the more complex the spectrum, and the more likely the system is to trigger suppression.

Steady-state suppression. Open strings and scale practice produce a sound that is sustained and spectrally stable, without the fluctuations of amplitude and timbre that characterize speech. Its energy distribution is continuous and stationary, which places it close to the system's model of steady background noise such as an air conditioner or a fan. This is why the open-string and scale work of a student is so often attenuated. The problem is not the quality of the sound. It is that the signal morphology of such a sound is itself close to what the system defines as noise.

The major platforms do provide a music mode that is intended to bypass this processing. Zoom's "Original sound for musicians", with its high-fidelity music mode, is documented as disabling noise suppression and echo cancellation for that participant [12]. In teaching practice, however, open strings and scales are still attenuated even when the student has enabled that mode. Two factors seem to contribute. The first is procedural. The option is off by default; it must be enabled in the settings and then activated separately in the meeting window; it is restricted on mobile devices; and it has to be set on the *student's* side, which is the side least likely to be configured correctly. The second is that disabling the noise-suppression stage does not remove every stage of a pipeline optimized for speech. A sustained tone of nearly constant frequency and amplitude is still, in signal terms, an unusual input for such a system, and the attenuation observed in practice suggests that it may still be treated somewhere

in the chain as content that carries no information. The documentation does not predict this behavior, and the account given here is an inference from classroom observation that would need acoustic measurement to confirm. For the teacher the practical consequence is the same either way. The teacher cannot assume that the audio arriving from a student is an unprocessed record of what the student played, even when the student reports that music mode is on.

Two further points follow. First, different implementations use different sensitivities and thresholds of detection. In the author's teaching experience, the rate at which Zoom falsely suppresses a good violin tone is clearly lower than that of Tencent Meeting. This comparison rests on classroom observation rather than measurement, and suppression behavior changes with the software version. Noise suppression is therefore not a uniform standard. Before deciding whether a sound is distorted, suppressed, or genuinely deficient, a teacher must know which platform is in use and roughly how its suppression logic behaves. Second, once the behavior of the suppression system is understood, it can be inverted and used as an auxiliary diagnostic instrument. The condition is that one gives up any simple linear mapping such as "standard action = suppressed, non-standard action = not suppressed." The correct reading is a judgment in four quadrants, given in Table 1.

Table 1. Four-quadrant Reading of Movement against Audio Suppression

Movement	Audio	Reading
Standard	Suppressed	A well-excited, spectrally rich tone has been misclassified. The technique is correct, and the movement pattern should be fixed in place.
Non-standard	Not suppressed (loud)	The bowing technique is genuinely faulty. It must be corrected by reference to the video evidence.
Non-standard	Suppressed	Still a technical fault. The teacher must not be reassured by a sound that seems normal, and must not overlook the defects that are visible in the movement.
Standard	Not suppressed (poor tone)	The problem most probably lies in the mechanism of force application. See the discussion below.

The fourth quadrant requires further explanation. Excessive downward force on the string drives the bow toward Schelleng's upper force limit, or beyond it. At that point the Helmholtz motion of the string breaks down and the tone becomes constricted [5]. Why such a sound is nevertheless *not* suppressed is, in the interpretation proposed here, again a question of signal morphology. An over-pressed tone is subjectively poor, but it is sustained, its amplitude envelope is relatively stable, its transients are weak, and its energy in the high partials is reduced. It therefore sits closer to the speech-like category of the

system than a freely resonating tone does. This is an inference from observed behavior, not a measured result, and it is the point in the present framework that most needs empirical testing.

The core of this logic is that suppression, or its absence, is only an auxiliary signal. It is never a basis of judgment by itself. The real judgment must always return to the cross-validation of three things: the movement in the video, the sound as produced, and the logic of force application.

3. Refuting the Claim That Tone Production Cannot Be Taught Online: Making the Technical Criteria Precise

Many people hold that whether a tone is good is a question of subjective aesthetics, that different schools and different teachers judge by different criteria, and that the criteria therefore cannot be unified. Observation of actual teaching gives the opposite answer. Whatever the school or the tradition, teachers give the judgment "good tone" to a sound that is penetrating and strongly resonant. This is an observation about pedagogical usage rather than a surveyed finding, and it is offered as such. One concept has to be clarified here, because it is easily confused. Penetration and resonance are not loudness. Loudness can be obtained cheaply, by increasing pressure or by moving the bow faster. A sound with full resonance is the result of the vibration of the instrument itself being excited to its maximum. It is an efficiency, and not a loudness piled up by brute force.

From this a criterion can be derived that is unified across schools: a good tone is one with strong resonance, one that draws on the maximum of the instrument's own sound energy. The criterion does not depend on the aesthetic preference of any school. It rests on the physical laws of vibration in a string instrument, and this is the root reason why it can be judged precisely, and why it can be *seen* rather than merely *heard*.

The physical basis can be stated more exactly. The sound of a bowed string is governed by a small number of measurable bowing parameters: bow velocity, bow force, and bow-bridge distance. Schelleng showed that for any given bow-bridge distance there is a bounded region of bow force within which Helmholtz motion can be sustained. Above the upper limit the sound is surface noise; below the lower limit it is thin and whistling [5]. Askenfelt later measured these parameters under normal playing conditions and mapped the dynamic range that they allow [6, 7]. "Good tone", in the sense used here, is the condition in which these parameters are kept inside the region that sustains stable Helmholtz motion. The parameters that govern that condition are produced by arm and hand movement, and such movement is visible.

Different traditions may take different teaching paths toward this fully resonant sound, and may describe it in different language. But once they are broken down to the underlying logic of movement, almost none of them can avoid the following two technical essentials, and both are standard in the violin-pedagogy literature [13, 14].

1. **Bowing, not bow-changing.** Most teaching systems discuss the bowing movement itself in detail, but one point deserves special emphasis. What all schools describe is the essentials of the *bowing*

movement, not the movement of the *bow-change*. The instant of the change itself should have no significant hand movement, and the fingers in particular should stay comparatively still through the change. If the fingers or the wrist make an obvious extra movement at the bow change, it usually means that the continuity of angular compensation during the stroke has been broken. This is one of the most common roots of a falling resonant efficiency.

2. **The concept of the "plane".** The forearm is one side, the bow is one side, the upper arm is one side, and the instrument together with the body is the last side. Whether these four stay coplanar through the whole stroke, without offset or torsion, is the core technical concept that string pedagogy calls the "plane" [13]. Once the plane deviates during the stroke, the contact angle of the bow on the string and the distribution of pressure change together, and the resonant efficiency of the sound is discounted accordingly. In the terms used above, the bow-bridge distance and the bow force change together, and by the Schelleng relations the stroke may be driven outside the region in which stable Helmholtz motion is sustained [5, 7].

When a teacher holds these two points precisely and uses them as criteria, the teacher can judge whether a student's bowing technique is correct almost entirely from the video image, with very little reliance on the audio. Both points are in essence logics of movement that can be *seen*. Whether the hand makes a redundant movement at the change, and whether the plane stays stable and unified through the stroke, are visual features that can be clearly distinguished on screen, and they in turn directly determine the resonant efficiency of the sound. This is the fundamental reason why the claim that tone cannot be taught online does not hold. Audio is not unimportant. But once the technical criteria are made precise down to the level of action, the quality of the sound can already be anticipated from a judgment of the movement, and the distortion or suppression of the audio is no longer information that the teacher must depend on. As argued in Section 2, the audio still remains one of the three terms to be cross-validated, and it is not discarded.

This account agrees with a growing body of empirical work. Bowing technique can be instrumented and corrected through feedback on motion and sound [9]. Bowing parameters such as bow velocity, bow-bridge distance, and force can be extracted reliably from motion capture and sensor data, and they are the physical quantities that govern the produced tone [6, 7, 15]. These parameters also vary systematically with the type and the frequency of the bow stroke [10].

4. The Frog and the Tip: The Most Easily Overlooked Core of Fundamental Technique

At the level of the body, every human movement is an arc at the joint. The wrist, the fingers, and the arm all rotate around their joint axes. But bowing requires the bow hair to trace a *straight* line along the string. This is the fundamental contradiction of bowing technique: joints that naturally describe arcs must execute a path that has to be straight [13].

The contradiction is most visible at the two ends of the bow. Taking the body as the axis, the tip tends to drift toward the left-rear of the body as the bow approaches the frog; at the tip, conversely, the frog

tends to drift toward the right-rear. This natural arc, with the body as center and the arm as radius, would pull the bow path off the line if it were left uncorrected. The consequence is acoustic, and not merely cosmetic. A bow path that deviates changes the bow-bridge distance continuously through the stroke, and the admissible range of bow force becomes narrower as the bow moves toward the bridge [5, 7]. A stroke that drifts therefore tends to leave the stable region at the extremities. This is why the tone so often seems to deteriorate or to become hollow at the two ends. The coordination problem that this poses to the learner is related to what the motor-learning literature describes as the organization of redundant joint degrees of freedom into a controlled trajectory [16].

The only way to resolve the contradiction is through many small movements of angular compensation. They actively cancel the arc and restore a straight bow trajectory at the macroscopic level. This is the essence of *angular compensation*. It is the finest part of bowing technique and the most easily neglected, and for online video teaching it is of particular importance.

Beyond the global angular compensation, the frog and the tip each involve the independent use of one specific finger.

1. **At the frog, the use of the little finger is the key.** The frog is the position where the weight of the bow is greatest and the lever shortest. Here the little finger carries the important task of supporting the weight of the stick and taking part in fine angular adjustment.

2. **At the tip, the use of the index finger is the key.** The tip is the position where the weight of the bow is lightest and the lever longest. Here the index finger has to apply pressure actively and maintain sufficient friction between the bow hair and the string, so that the sound does not become thin and floating at the tip. In the terms of Section 3, this is a matter of keeping the bow force above Schelleng's lower limit [5].

These finger actions are tiny in amplitude, but they directly determine the tone and the stability at the two ends of the bow. They are among the most central details of fundamental training, and also among the details that teacher and student most commonly overlook together [14].

In face-to-face teaching the flow of information goes both ways. While the teacher observes the student's movement, the student observes the teacher's demonstration at close range at the same time, and captures these fine differences through imitation and comparison. The teacher does not need to put everything into words. The structural constraint of online teaching is that this mutual observation is drastically weakened. The camera angle is fixed; the student cannot freely adjust the viewing angle to capture detail; and the student's prior understanding of the movement principles is usually less developed than in a face-to-face context, so the capacity for autonomous observation is correspondingly weaker. The teacher must therefore state actively and explicitly the details that a fixed camera view makes hard for the student to discover alone: in which direction the arc-induced deviation occurs, which joint should perform the angular compensation, and how the little finger at the frog and the index finger at the tip should apply force. These details once depended on mutual observation and on the student's own perception. Only by converting them into the teacher's precise verbal description

and direct video demonstration can the gap of information imposed by online instruction be closed.

5. Practical Video Diagnosis: Order of Examination, Autonomous Training, and Choice of Software

For the principle of angular compensation to be usable in online practice, it must be translated into a diagnostic sequence that is clear and reproducible, and not into a vague instruction to correct whatever looks wrong. On the basis of teaching practice, the sequence should be as follows.

First, the hand. The hand, meaning the wrist and the fingers, has the smallest amplitude of movement and the greatest sensitivity to angular compensation. It is where the technical problems of a student most often appear first. When the bow path deviates in the video, the hand is the first site to examine.

Second, the shoulder and the upper arm. These parts move with a large amplitude and change slowly, and for that very reason they are the easiest to overlook. This happens not only online. Even in a face-to-face lesson the teacher often concentrates on the details of the hand and so neglects the supporting and compensating role that the shoulder and the upper arm play in the whole bowing arc. In many cases a hand-level compensation that cannot keep up has its true source in the failure of the shoulder or the upper arm to provide the correct foundational position.

Third, the elbow and the forearm. The movement of the elbow joint and the forearm lies between the upper arm and the wrist, and it plays a transitional, connecting role. It is normally examined after the first two steps, as the final stage in locating a problem precisely.

This order, from the hand to the shoulder and upper arm and then to the elbow and forearm, is organized by amplitude of movement from small to large, and by the salience of problem exposure from high to low. It makes rapid online diagnosis possible, and it keeps the teacher from focusing prematurely on fine detail and so overlooking a more fundamental source in the larger joints of the body.

Diagnosis and correction are only the first step. What finally determines the effectiveness of online instruction is whether the student can practice correctly after the lesson, without the teacher. For this purpose, once the teacher has identified the problem and the student has completed the correction, the teacher should guide the student in building a method of autonomous observation and self-judgment. The student should repeatedly watch video recordings of their own playing, or practice in front of a mirror, with the specific parts of the body to be observed stated explicitly. The student should judge for themselves whether the action is standard, converting the criteria that have just been demonstrated and explained into concrete reference points for self-observation. And this should be paired with self-observation of the resulting tone, so that the student notices whether the sound changes as the action is adjusted, and links "is the action standard" with "does the tone improve" within their own perception. Watching a recording of one's own performance is an established tool in skill acquisition. The literature on self-modeling indicates that its effect depends on how the material is selected and framed for the learner, and not on mere exposure to the recording [17]. These three steps together create

the clearest possible memory trace. The reason is not that the teacher has imposed a conclusion. It is that the student has actively constructed the understanding through their own observation, judgment, and listening. Only such an actively constructed memory can genuinely support independent and accurate practice after the lesson.

The effectiveness of the whole method described above is also limited, to a large degree, by the transmission characteristics of the software in use. The comparison below reflects the author's long-term experience in teaching, on ordinary consumer broadband connections between 2020 and the present, and should be read as such. Platform behavior depends on the software version, the network conditions, and the hardware, and it will change. Among the three applications most commonly used in teaching, each behaves differently.

1. **Zoom.** Network latency is comparatively higher, but the quality of audio transmission is better. It suits the segments of a lesson that depend more on auditory judgment of detail.

2. **Tencent Meeting.** The network connection is comparatively stable, but the quality of both video and audio transmission is weaker. It suits a poor network environment, where a stable connection is the first consideration.

3. **FaceTime.** Freezing occurs easily, and after a freeze the video image often disappears altogether. Of the three it has been the least stable in the author's experience, and it is not suitable as the primary tool for formal instruction.

The diagnostic method described here takes *judging the movement by watching the video* as its core, and treats audio only as auxiliary verification. In the choice of software, therefore, the stability and clarity of the video image should take priority over audio quality. This is also why the effect of Zoom's network latency on the continuity of video-based judgment must still be weighed in practice, even though its audio performs better [4, 11].

6. Limitations

Several limitations should be stated plainly. First, the framework comes from the author's own teaching practice and has not been evaluated in a controlled study. No quantitative data are presented here. The four-quadrant scheme in particular awaits empirical testing, and especially the account of the fourth quadrant given in Section 2. Second, the observations on platform behavior are specific to particular software versions, network conditions, and devices. Noise-suppression algorithms are updated frequently, and any conclusion about a named platform should be expected to become out of date. Third, the observations come from the author's own students and do not constitute a controlled sample; no claim of representativeness is made here. The method is not understood to be restricted by the age or the stage of the student, however. The need to rebuild the fundamentals of bowing and the essentials of angular compensation arises at every level, including among advanced players and adult learners, and the diagnostic sequence is framed accordingly. What remains untested is the application of the method to settings that differ structurally from one-to-one instruction, such as large-group teaching. Fourth, the

diagnostic sequence has been validated only by its usefulness in practice, and not against an independent criterion. A natural next step would be to test whether teachers who follow the sequence identify faults more accurately than teachers who do not. Another would be an acoustic measurement of suppression behavior across platforms under controlled bowing conditions.

7. Conclusion

If online teaching is to pick out the fault accurately every time, the teacher must first build a comprehensive system of judgment that goes beyond purely auditory experience. It requires a technical foundation: an understanding that resonance, in the sense of a string vibration that is stable and efficiently sustained, is the basis of good tone, and a command of the two technical essentials, *bowing rather than bow-changing* and the *unity of the bowing plane*. It requires an understanding of how the video and audio hardware and software work, and especially of the noise-suppression system, together with the ability to turn the side effects of that system into a diagnostic aid. It requires a clear order of examination that runs from the hand to the shoulder and the arm, and from the large joints to the small ones. And it requires the skillful use of video and mirrors, to help the student complete the change from a passive acceptance of correction to an active self-diagnosis. These elements support one another. Together they constitute the methodological basis on which online violin instruction can be carried out genuinely effectively, and one that stays open to the empirical testing outlined in Section 6.

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