Q: Imperfect camber (Geo Kloppel)

Greetings Knut, There's a widespread (though not universal) belief among musicians and bow technicians that a "flat spot" or similarly localized irregularity in the camber of a bow can produce a localized performance defect ("weakness" is a common descriptor) at the corresponding location along the hair. I'm not having much success in trying to imagine a physical mechanism (if any) that could account for the referral of this putative effect to the location directly under the irregularity. Any insight? Geo Kloppel

A: (Knut Guettler)

I am familiar with the phenomenon, because I have experienced very similar effects on certain bows. However in my experience the difficulty in controlling the bow always happens about 10 to 20 centimeters from the tip, which is a troublesome area anyhow, for a number of reasons. First you have a nonlinear coupling between "hair modes" and "stick modes" (acousticians dislike using such terms, but that is actually the best way to describe it). See the figure below:

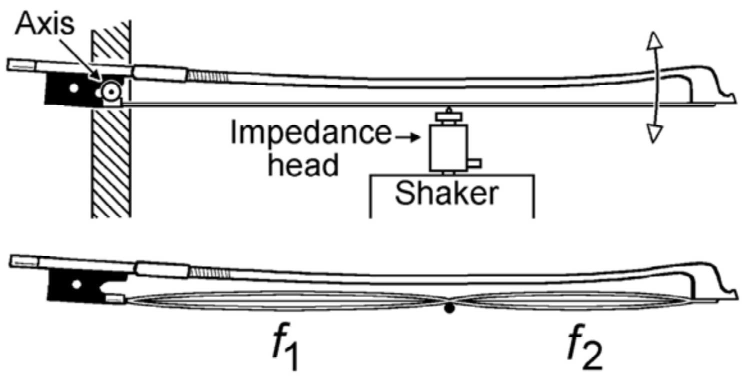

Figure 1: Dependent on the position of the contact point (string-hair), the hair will resonate with two frequencies (f_1 and f_2). At certain contact positions, one of the hair modes will couple strongly to one or two of the stick modes, causing the bow to tremble. (Illustration from ref. 1)

Without sufficient damping, trembling of the stick may result in loss of bow-hair grip on the string. Around that area you also have the "point of percussion" (PoP), at which spot the bow-hold damping of the bow stick changes phase: to dampen a ricochet stroke ending at the tip-side of PoP, you have to press the frog *down*, inside (the frog side of) PoP you have to flex the fingers *up* in order to catch the vibrations. At PoP itself there is not much you can do, the energy stays in the stick.

That being said, I am trying to get my regular acoustical companion Anders Askenfelt to abuse one of the cheap violin bows we often torment: give it a pronounced kink or angle to see if we get a wave reflection at that point, which again might couple to the hair modes mentioned above. I shall certainly return to this question. Thank you!

Knut

Ref. 1: 1997: "Bow Notes", K. Guettler, (invited paper) keynote presentation, Proc. International Symposium on Musical Acoustics, Edinburgh, Scotland.

Ref. 2: 1998: "The bouncing bow: an experimental study". A. Askenfelt/K. Guettler JCAS Nov., Vol. 3, 6 (II) pp 3-8.

C: Imperfect camber (Colin Gough)

Dear Knut,
Thanks for including me in the invitation to become involved in the question and answer session on your new web site.

The question you pose from Geo Kloppel is an interesting one and I am sure your response is the correct one. It seems to me that the centre of percussion of a bow is always likely to be a weak point on the bow since when holding the bow in the normal way there is no reaction at the holding point when the bow strikes the string—exactly the same situation as hitting a ball at the "sweet point" on a bat. This means that the player has virtually no control on what happens to the force between the string and horse hair during the important period of initial impact when the adjustment of downward pressure on the string is an important parameter for successful initiation of Helmholtz motion. As you have shown, all such factors will affect the bouncing rate off the string and the control of transients at the start of any bowed note.

As is well known, the centre of percussion of a bow is determined by the position of the centre of mass and moment of inertia about the holding position. Such parameters are determined by appropriately averaged values of the mass along the whole length of the bow stick. The centre of percussion and resulting "flat spot" on the bow, where there is a transition from an upward to a downward reaction to the holding fingers and thumb as the bow strikes the string resulting in a loss in ability to control the downward pressure, is a function of mass and taper along the whole length and is not specific to any local physical properties of the bow at that point along the stick.

Using the standard method for measuring the centre of percussion (the equivalent simple pendulum length that matches the period of the bow acting as a pendulum about the inner holding position on the frog) I have measured the centre of percussion for several bows of varying quality. The resulting lengths vary very little (only a cm or so) from bow to bow—so, assuming the flat spot is identified with the centre of percussion—it is not surprising that it varies very little from one bow to the next. It also follows that any flat-spot cannot be identified with a weakness in properties at that particular point along the bow stick, but is a result of global averages of mass distribution along the complete length.

As you may already be aware, I have recently written two theoretical papers on the bow, one on the static properties and the second on the dynamic properties, which may be of interest to you and others with similar interests. The first paper on static properties - the influence of taper and camber - has already been published by JASA (Ref. 3) and the second on the dynamic properties of the stick and interaction with hair modes is to appear in the May issue.

As soon as I get back to a proper computer on my return from Australia in just over a week's time, I will send you details and copies of both papers. I would welcome feedback from all your forum members on the content!

Very best wishes
Colin

Ref. 3: C. Gough “The violin bow: Taper, camber and flexibility” J. Acoust. Soc. Am. 130(6) (2011) p 4105–4116.

C: Imperfect camber (Geo Kloppel)

Hi Knut, I read Colin's comment with interest, and it makes perfect sense to me, provided I interpret the idea of a "flat spot" in the metaphoric sense that he describes. But we have a terminological confusion here; this is not at all what I meant by a "flat spot" in my original question, titled "imperfect camber". I was referring to a literal flat spot, a visible discontinuity in the smooth curvature of the stick. Diagnosing the presence of a flat spot in this sense is just a matter of sighting down the stick, and such visible flat spots or camber imperfections are not restricted to the PoP area, but can be found anywhere in the stick, including right behind the head and even under the frog. So I feel that my question remains unanswered... Best regards, Geo Kloppel

A: (Knut Guettler)

I understood "flat spot" the way you describe it above; a discontinuity that possibly would cause a wave reflection. I think the only way to get wiser here, is to do nasty things with a bow stick, and measure if there are changes of the bow's resonances (with and without hair tension) after bending it. This should preferably be done in both ends of the bow, and not limited to the PoP region. Askenfelt wants to do this experiment, but we can at the earliest expect a result mid May. In the meantime we have to play patient.

Knut

A: (Colin Gough)

Dear All,

Please excuse my delay in responding to Knut's questions and particularly about the influence of the so-called flat spots on a bow.

In my view, there can be very little correlation between the player's apparent sense of a flat spot on the bow stick and the playability of the bow at the same distance along the bow hair. The bow hair can only sense the affect of the the taper, camber and weight distribution via its influence on the bow hair at the tip and frog ends of the stick. Such properties will depend on averages of the variations of all the bow stick properties along the whole length of the bow stick. There is therefore no way that the local position of any weakness (or strength) of a bow stick could be communicated to the player via any aspect of the hair-string interaction at a similar point along the bow hair—contrary to what many players clearly believe. There is no obvious scientific way in which the influence of local variations in stick properties could lead to any correlation with playing weaknesses or strengths at the same position along the bow hair, as this can only be determined by global properties of the stick. This is also clearly true for properties like the mass, centre of mass, centre of percussion and moments of inertia of the bow about the frog, which affect the dynamical properties and playability of the bow both on and off the string.

Furthermore, local variations in camber and taper along the length of the bow stick will be relatively insensitive to variations in local properties unless they occur over an appreciable length of the stick (corresponding to a significant fraction of the wavelength of a particular bending mode of the bow). Moreover, it is far from clear that the transverse vibrations of the bow play a significant role at all to the sound of the bow, apart from their possible influence on the slip-stick mechanism and subsequent shape of Helmholtz kinks circulating around the bowed string. But both measurements and theoretical analysis suggest that any such interaction is likely to be very small.

Direct measurements, show that the the vibrations of the bow produce a negligible amount of sound, so the only significant influence of such vibrations to the sound of a violin could only occur via their coupling to the bow hair, which is very weak due to a large mechanical mismatch at both tip and frog. The major influence of the dynamical properties of the bow stick involves the bouncing modes both on and off the string. As Knut first showed experimentally and theoretically, the frequency of such modes depends largely on the moment of inertia of the bow about the frog, string tension and positional along the string. Only when the bow is bounced close to the tip do the lowest vibrational modes of the bow stick become important (see the second reference below).

I therefore remain highly skeptical about the possibility of correlating any perceived weakness when playing at a position along the bow hair with some kind of weakness at the same distance along the length of the stick, However, as argued previously, playing the bow at a distance corresponding to the centre of percussion of the bow will present particular problems, as at this position there will be very little reaction and a reduction in the helpful feedback via the right hand fingers that helps the player control the bowing forces and pressures on the string at and immediately after the moment of impact or a change in bow direction.

For those of you that may be interested, my two papers on the static and dynamic properties of the bow have now been published as

The violin bow: Taper, camber and flexibility, J.Acoust. Soc. Am. 130(6) December, 4105-4116, 2011.

Violin bow vibrations, J.Acoust. Soc. Am. 132(5) May, 4152-4116, 2012.

Best wishes to you all,

Colin