

[As originally published online at former Science and Justice website <http://www.forensic-science-society.org.uk/pdf/correspondence2.pdf> , and referenced in Science and Justice 46(3):199 (2006).]

**Acoustic synchronization: Rebuttal of Thomas' reply to Linsker et al.**

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In his reply, Thomas asserts [1] that Linsker et al. [2] “relies more on assumptions than on data,” in coming to our conclusion that he erred in his paper [3]. In that paper he concluded that the alleged gunshot from the Grassy Knoll was contemporaneous with the assassination of President Kennedy. However, it is Thomas' argument that relies more on assumptions than on data.

The principal issues raised by Thomas' reply [1] concern the use of the dispatcher's time annotations, and the question of whether the utterance “I'll check it” (denoted CHECK) is a valid crosstalk. Regarding the first of these issues, Thomas continues to draw conclusions based on the dispatcher's annotations. These are too unreliable to support a meaningful inference. In fact we used them merely to show that our preferred time line was consistent with them. At no time did we base any conclusions on them. Regarding CHECK, Thomas has misunderstood or misrepresented our analysis, and wrongly claims that the results of our pattern cross-correlation (PCC) tests support his conclusion that CHECK is a crosstalk. In this rebuttal we (a) address both of these issues, (b) show, by straightforward spectrographic measurements that can be performed by any reader, that CHECK is not a crosstalk, and (c) address other issues raised by [1].

**Dispatcher time annotations**

Thomas asserted in [3, p.29] that the dispatcher annotation times prove that “there can be no significant amount of lost time on channel 2 after 12:30.” In [1], he now states that “when the time line is corrected ... based on Linsker et al.'s assumption about recorder

stoppage on Ch-2 the result is a comparatively poor fit to the radio dispatcher's time notations." Both statements are wrong.

The dispatcher timings cannot support a meaningful inference regarding the presence or absence of a significant amount of dead time on Channel 2. Having derived our time line without reference to the dispatcher timings, we used those timings solely to show that the presence of such dead time is consistent with them. The estimated slopes of the least squares fit (LSF) are subject to a standard error of 0.05, which means that the distinction between any LSF slope in the range of 0.9 and 1.1, and a LSF slope of 1.00, is not statistically significant. During the approximately six minutes of annotated time these data are consistent with the possibility of a large amount of dead time.

Figure 1 illustrates this fact. The left panel shows an example timeline that includes 20s of dead time between "12:31" and "12:32," 10s between "12:32" and "12:34," and 22s between "12:34" and the first "12:35" annotation. This timeline differs from the example timeline used in our paper [2] by including the third (22s) dead time interval and the "12:31" annotation. The 22s arises from the difference between the speed-corrected intervals from YOU to ATTENTION on the two channels, using our Tracks 6B and 7 [2]; Thomas notes a similar value of 24s for this difference. Also, we hear "12:31" at a speed-corrected time of 96s after "12:30" (agreeing with O'Dell [4] but slightly differing from Thomas' 94s). The data points plotted are thus: Dispatcher annotations  $x = 0, 60, 120, 240, 300, 300, 360, 360$ ; corresponding timeline values  $y = 0, 96, 141, 242, 321, 353, 382, 414$ ; all in seconds. The LSF (solid line) has slope 1.07. For comparison, the dashed line has a slope of 1.00. The standard deviation of the residual (SDR) refers to the typical, or root mean square, deviation in  $y$  value between the data points and a straight-line fit. Using the solid line the SDR is 17.0s; using the line having slope 1.00 the SDR is 19.1s, about the same. This, as well as visual observation of the plots, shows that both straight-line fits to this data are essentially equally good.

The right panel of Fig. 1 shows Thomas' [1, Table 2] preferred (so-called "corrected") timeline, with its LSF (solid line) having slope 0.99. For comparison, we show the (dashed) line having slope 0.93 that most closely fits his data (given that slope). (We choose 0.93 to show the small effect of changing the slope from 1.00 by the same amount in both panels.) The SDR of Thomas' data using the solid line is 19.2s, while

that using the dashed line is 20.6s, again about the same. In fact, the SDR of Thomas' data using his LSF of slope 0.99 is essentially the same as the SDR of our example data using a straight-line fit having slope 1.00.

Three side points: First, Thomas refers [1] to "the Linsker et al. timeline based on the assumption of recorder stoppage on Ch-2." Some readers may be misled by this label, since the so-called "Linsker et al. timeline" [1, Table 2] is actually not any timeline of ours, but an example scenario generated by Thomas. He has chosen to insert 31s of Channel 2 dead time between "12:31" and "12:32," and 24s between "12:34" and "12:35a." Second, all the regressions (Thomas' and ours) are of an example timeline (y axis) against the dispatcher annotations (x axis), not the other way around as Thomas states [1]. Third, Thomas correctly notes a correlation coefficient (CC) of 0.99 for each of the regressions [1, Table 2]. Such a value seems quite impressive, because it is not customary to get such high correlations in typical applications comparing a pair of related random variables *where the existence of a relationship is questionable*. However, in this case there is a very strong relationship between both variables and time, and this large a coefficient is to be expected. To see this, note that the SDR is about 19s (shown above), and the standard deviation of y itself, SDY, is 140s (for our example above) or 130s (for Thomas' preferred timeline). It can be shown that  $(1-CC^2)$  equals  $(SDR/SDY)^2$ ; this yields  $CC=0.99$ . The high CC value does *not* imply that the LSF slope is a precise indicator of the true slope. The scatter of the data points (Fig. 1) is too large to determine a precise value of the slope, as we have shown above.

Thomas wrongly asserts [1] that the "burden of proof" is on us "to show that [our] timeline is superior to the alternatives" *on the basis of the annotation data*. In fact: (a) our timeline is based on the other evidence we have provided [2]; (b) we have explicitly shown that the annotation data is *only* useable as a consistency check; and (c) our results satisfy that consistency check. It is Thomas who incorrectly argues that the annotation data provide evidence for or against a particular timeline: "because the regression analysis shows that *no time is missing* from the relevant section of the Channel 2 tape, then the fragment from Sheriff Decker's broadcast is only explained by the overdub hypothesis." [3, p.30, emphasis added.] Thus Thomas has the "burden of proof" to show that the dispatcher's time annotations can be used to make a reliable inference that there

is no dead time, since he relies on those annotations to claim that the “overdub” hypothesis is correct. And in fact the regression analysis shows nothing of the sort.

The question is what can be inferred at all from the dispatcher annotation data. We have proved that, because the timing of the annotations is so imprecise, the annotations cannot be used to prove either the presence or the absence of significant Channel 2 dead time, nor to prove that time offsets are present on both channels (Thomas’ “corrected timeline” assumption [1]). We have further proved that significant Channel 2 dead time (without Channel 1 time offsets) is entirely consistent with the annotations.

### **Is “I’ll check it” a crosstalk?**

The significance of the CHECK utterances on the two channels is that, if CHECK is a valid crosstalk, it puts in doubt any conclusions drawn from the timings on the recordings. This is the case because HOLD is a valid crosstalk, and the acoustic images of HOLD and CHECK (if CHECK were also a crosstalk) could not both be in their proper positions on the recordings of the two channels. Here we prove that the CHECK utterance on Channel 1 (denoted CHECK1 in [2]) is not a crosstalk from the CHECK utterance on Channel 2. [Note: Although Bowles [5] identified the Channel 1 utterance as “I’ll check it,” and Thomas uses this identification, the latter part of the claimed utterance (“check it”) is quite unclear on Channel 1. We refer to that Channel 1 utterance as CHECK (or CHECK1 in [2]) only as a label; it does not indicate our concurrence that “check it” are the actual words that follow “I’ll” on Channel 1.]

The PCC method used in [2] is a powerful mathematical tool for comparing spectrograms. It compares spectrographic features across time and frequency automatically, and can provide evidence of matches or non-matches with high precision. However, in order to resolve readers’ doubts about whether CHECK is a crosstalk, we examine the evidence here by directly measuring the locations (on the spectrograms) of features that should correspond to each other on each of two channels if an utterance is indeed a true crosstalk. Our method (below) applies even in the presence of noise, and

even when the frequency responses of the two channels differ. We present the analysis in a way that the reader can verify and experiment with for him/herself.

First, a crucial fact: If a spectrogram  $S1$  is made of a portion of acoustic material played at one speed, and another spectrogram  $S2$  is made by playing the same material twice as fast, then the frequency  $f$  of every feature point (an identified point of the spectrographic pattern) in  $S2$  will be twice as great as that of the same feature point in  $S1$ , and the time interval  $T$  between every pair of feature points in  $S2$  will be half as long as that between the same pair of feature points in  $S1$ . In effect, changing the speed simply stretches the spectrogram along one axis and shrinks it along the other, by the same factor. More generally, for any choice of uniform playback speed the product  $fT$  will be unchanged. (To understand why this is true, imagine that a steady tone at frequency  $f_1$  is started at the beginning of time interval  $T_1$  for copy 1, and that a tone at frequency  $f_2$  is started at the beginning of time interval  $T_2$  for copy 2. Then the number of cycles of the tone, which is just the product  $fT$ , must be identical on copy 1 and copy 2, if they are true copies of one another. It does not matter whether or not there is any steady tone anywhere in the spectrogram; the stretching and shrinking of the spectrogram along the two axes by the same factor must occur nonetheless.)

Thus, if there is a true crosstalk, measurements made on corresponding pairs of feature points on the two channels must yield the same value of  $fT$  within measurement error, independent of any assumptions about the speed correction factor used. Furthermore, the feature point used for measuring  $f$  may be the same as, or different from, either of the two feature points used to measure the interval  $T$  (since the entire spectrogram is stretched and shrunk uniformly).

We now measure feature points that correspond to portions of the “I’ll check it” utterance on each channel, and compare their values of  $fT$ . If the reader believes that CHECK may be a valid crosstalk, s/he is invited to find feature points that correspond on the two channels, and to perform the  $f$  and  $T$  measurements.

Figure 2 is a spectrogram of Track 7 (“FBI Channel 2” recording [2]) from 12m38.804s to 12m39.938s. (The original waveform was downsampled and filtered, and the spectrogram was computed and plotted, as described in [2, p.211, last full paragraph].) The utterance “I’ll” occurs between approximately time bins  $x=55$  and 90

(as confirmed by listening to the track during the corresponding time interval). Its chief spectrographic feature is a set of concave-downward arcs, corresponding to harmonics of the fundamental pitch of the speaker. The peak of the dominant (darkest) arc is at  $(x,y) = (74.25, 41.4)$ , marked by a square and a vertical line. This arc is the  $n^{\text{th}}$  harmonic of the fundamental pitch, and the peaks of the other visible arcs must be located at multiples of  $y/n$ . Using this fact we find that  $n=5$ . The squares on the vertical line are placed at  $1/5, 2/5, \dots, 8/5$  times the measured frequency of the peak of the dominant arc ( $y=41.4$ ), and match the peaks of the clearly visible  $2^{\text{nd}}$  through  $6^{\text{th}}$  harmonics. The  $6^{\text{th}}$  harmonic (used below) has its peak at  $(74.25, 49.68)$ . The position of each harmonic depends on the resonances of the vocal tract at that moment, and the underlying pitch frequency of the speaker. The darkness of the arc for each harmonic (which increases with the spectrographic feature power in that harmonic) depends on the vocal resonances, pitch, and also on the frequency response function of the channel transmission and recording processes.

The visible right endpoint of the dominant ( $5^{\text{th}}$  harmonic) arc of “I’ll” is at  $(88.51, 33.22)$ . The frequency of the  $6^{\text{th}}$  harmonic at that time is  $6/5$  times  $33.22$  or  $39.86$ . Both points are marked by squares. Finally, the visible onset of the utterance “check it” in the  $6^{\text{th}}$  harmonic (this harmonic index is determined in the same manner as above) is at  $(110.28, 29.90)$  (marked by a square); the positions of the  $5^{\text{th}}$  and  $7^{\text{th}}$  harmonics at the same time are marked by circles.

Figure 3 is a spectrogram of Track 1 (“Bowles Channel 1” recording [2]) from  $3m46.399s$  to  $3m47.352s$ . The utterance “I’ll” occurs between approximately  $x=15$  and  $50$ . It contains a clearly visible concave-downward arc (starting just to the left of its peak), a set of concave-upward arcs at higher frequencies, and an approximately horizontal feature at frequency  $f_{\text{het}}$  (bin  $\sim 150$ ) that corresponds to a prominent heterodyne signal. There are corresponding features at many pairs of points  $(f,t)$  and  $(f_{\text{het}}-f, t)$ , where the latter feature is a “reflection” of the former that is generated by nonlinear interaction between the source feature and the heterodyne. The peak of the dominant downward arc at  $(21.11, 52.45)$ , and the heterodyne at  $(21.11, 150.11)$ , are marked by squares and a vertical line. While the harmonics lying below the downward arc are not clearly visible, the reflections of three harmonics (marked by circles lying between frequency bins  $90$

and 120) are. Measuring the frequencies of the troughs of several such reflected arcs, and that of the peak of the dominant (downward) arc, shows that the dominant arc is the sixth harmonic of the fundamental pitch. The right endpoint of that arc (square mark) is at (46.10, 41.76). Finally, the visible onset of the utterance that is transcribed as “check it” in the 6<sup>th</sup> harmonic (this harmonic index is determined in the same manner as above) is at (75.15, 41.76) (marked by a square); the positions of the 4<sup>th</sup> and 5<sup>th</sup> harmonics at the same time are marked by circles.

We now compare the product  $fT$  for Tracks 1 and 7, using for  $f$  the frequency bin of the peak of the concave-downward arc that corresponds to the sixth harmonic of “I’ll,” and for  $T$  the time interval (measured in time bins) from that peak to the visible endpoint of that arc. (If the utterance is a true crosstalk, we must compare the same harmonic of the same utterance on each channel, even if the dominant harmonic – that containing the most power – is different on each channel, perhaps because the channels have different frequency response.) For Track 7,  $f = 49.68$  and  $T = 88.51 - 74.25 = 14.26$ , so  $fT = 708.4$ . For Track 1,  $f = 52.45$  and  $T = 46.10 - 21.11 = 24.99$ , so  $fT = 1311$ . Rather than being equal (up to measurement error), as they should be if CHECK is a valid crosstalk, the Track 7  $fT$  value is 54% of that for Track 1.

As a second comparison, we use for  $f$  the same values as above (i.e., at the peak of the 6<sup>th</sup> harmonic of “I’ll”), and for  $T$  the interval from that peak to the onset of the 6<sup>th</sup> harmonic of “check it” (or whatever the second part of the utterance is on Track 1). For Track 7,  $T = 110.28 - 74.25 = 36.03$ , so  $fT = 1790$ . For Track 1,  $T = 75.15 - 21.11 = 54.04$ , so  $fT = 2834$ . The Track 7 product for this set of feature points is 63% of that for Track 1.

If CHECK were a valid crosstalk, each of the  $fT$  values for Track 1 should equal the corresponding value for Track 7, within measurement error. If it is not a valid crosstalk, there is no reason for the  $fT$  values to be the same for the two tracks, nor for the  $fT$  ratios to be the same for two different sets of feature points.

By way of contrast, applying the same method to Track 1 and Track 7 spectrograms of the YOU crosstalk [2, Fig. 7, except that now no speed correction is applied to Track 1] and similarly for the ATTENTION simulcast, in each case measuring

several sets of corresponding features, yields fT equality to within about 1% for each comparison. (Details, omitted to save space, are available on request.)

### **Timing of the assassination**

It is important to note that our results do not depend strongly on the validity of a particular time line of ours vs. the Thomas time line. Our principal result arises from the overlap in time of the segment containing the acoustic images of the alleged shots, and the words “Hold everything secure” on Channel 1. As Thomas also notes [1]: “On Ch-1, the HOLD utterance is essentially simultaneous with the suspect sound identified as the last in an 8.3 sec sequence of putative gunfire.”

No timeline is necessary, then, if HOLD is a valid crosstalk in its correct position. Still, this position of HOLD must not be inconsistent with time lines that can be derived from rock-solid crosstalks, simulcasts, and even dispatcher's time annotations, imprecise though the latter are.

The overlap of the HOLD crosstalk and the alleged shots on the Channel 1 recording is, by itself, evidence that the alleged shots occurred at least 30s after the assassination [2]. Dismissing that single crucial piece of evidence cannot be done without a valid reason. Thomas [3] dismisses it by arguing that the dispatcher’s time annotations preclude HOLD being in the correct location on the Channel 1 recording. We have disproved this claim, both above and in [2]. We also analyzed in detail [2, p.225] Thomas’ assertion that HOLD is overdubbed on the region of the shots by virtue of a very substantial skipback of the recording stylus on Ch. 1. Taking this assertion seriously, we showed that the supposed skipback must be *at most* 29.8s, and also (if one assumes the validity of the CHECK crosstalk) that the same skipback must be *at least* 86.6s, leading to a contradiction.

Thomas says that we failed to establish the time of the assassination on Channel 2, since we did not make use of the utterance “approaching [or ‘at’] the triple underpass,” which begins at 12m42s on Track 7 (Channel 2), which is 28s (in Track 7 recording time, apart from any possible dead time) prior to “GO to the hospital.” But the assassination obviously occurred prior to GO on Channel 2. Even if it occurred many seconds before



GO, that only increases the time interval from the assassination to the alleged shots. Note also that, if the assassination did occur many seconds before GO, it is striking that the intervening sounds and utterances on Track 7 are of normal tone and character, not suggesting knowledge of an emergency event, until the screeching noises that start at about 13m11, just 2s before the first GO utterance.

### **The pattern cross-correlation (PCC) method**

The PCC signature of a valid match (with overlaid noise and possibly some distortion) typically comprises: (a) a single strong peak relative to background, where the position of the peak gives the time offset between the two sound patterns; (b) such that this peak is greatest when the speeds of the two sound patterns are matched, and the peak decreases when one of the speeds is changed significantly from its matched value; and (c) such that this peak either tends to be strongest when no unphysical “duration-only warp,” or “d-warp,” is applied (i.e., when the “d-warp” factor is unity), or to be relatively insensitive to “d-warp” (as in the case of a sustained tone of near-constant frequency). The crosstalks YOU and HOLD pass the PCC test well; CHECK does not [2, pp.220-22]. Contrary to Thomas’ assertion that we failed to provide relevant information about CHECK (whereas we did for YOU and HOLD), most of [2, p. 222] is devoted to the discussion of CHECK.

### **Other issues**

Thomas says that our “stated reason (p.221) for [concluding that CHECK is not a valid crosstalk] is that ‘if CHECK were a valid crosstalk its timing would be incompatible not only with HOLD, but also with the timing of the well established crosstalk YOU ...’.” No, this was not our stated reason for our conclusion about CHECK. Our statement of the incompatibility is a statement of fact, as is shown arithmetically directly following that quote. Our conclusion that CHECK is not a valid crosstalk stemmed from several lines of convergent evidence, including PCC analysis, direct spectrographic comparisons, and the timing incompatibilities discussed both at p.221 and p.225. As for Thomas’

blanket statement [1] that “because there are offsets between all of the crosstalks, any crosstalk is incompatible with all other crosstalks!” it is a fact that recorder stoppage during transmission silences was a built-in feature of the recording system, so the assumption that such stoppages occurred at such times is not an “unsupported” assumption. The particular times and durations of such stoppages are indeed unknown, and we have not relied on any assumptions about the particular times and durations of any such stoppages.

Thomas [1] asserts that the speed-correction factors we derived in [2] are unreliable, since the “instantaneous speed of the recording mechanism wobbles around the motor speed,” that it is “for this reason that the PCC comparison is performed iteratively at increments of deviation from the expected speed,” and that our reasoning is circular. All of these statements are incorrect. In [2], we determined the playback speed correction factors by using AC hum and pattern cross-correlation (PCC) (pp.210-211 and 213-215). We also showed, using AC hum [2, Fig. 2] that the recording speeds are constant for all tracks other than track 7 (made from the FBI copy of Channel 2), and vary linearly with time for track 7. [The “warble” that we discovered on Track 5 (the FBI copy of Channel 1; see [2, p.219 and Fig. 5]) is a rapid fluctuation of speed by about  $\pm 3\%$  that oscillates about 20 times per second. As we showed, it does not affect the measurement of time intervals that are much greater than one second. In any case, we did not use Track 5 in any of our timing or cross-correlation analyses.] Multiple lines of analysis yielded a fully consistent set of speed correction factors over the entire relevant time interval. If there is doubt about these correction factors, the burden is on the doubter to show why they are incorrect. Furthermore, in our PCC analysis, we studied deviations from the correct speed to assess whether or not the PCC peaks behaved in a way characteristic of a valid crosstalk.

Thomas asserts that we did not “acknowledge” the simulcast ATTENTION or a possible crosstalk ALL. However, in his previous paper and his private communication in which he suggests other crosstalks, he did not introduce or discuss a possible ALL crosstalk. In any case, Thomas’ timing places it so soon (12-15s) after the universally agreed upon crosstalk YOU, which Thomas calls the Bellah-2 crosstalk, that it would not

provide a useful additional time-tie for synchronization. The fact that we did not consider a possible ALL crosstalk is thus not an “error” of omission.

As for ATTENTION, we discussed it in some detail at [2, pp.214-15]. Since it occurs so long after YOU, it does not provide a useful additional time-tie for synchronization of events closer to the time of the assassination. However, it does provide an additional speed comparison between the recordings of the two channels, providing further evidence for the speed constancy of Track 1 (Channel 1) [2, p.215]. We have discussed its compatibility with the dispatcher time annotations above.

Thomas says that “Linsker et al. also failed to provide the reader with the information that the ‘I’ll check it’ broadcast was first recognized as crosstalk by the Dallas Police officers who prepared the official transcripts, preferring to attribute the assertion to me ‘and others,’ and cited by them as an error by me. In point of fact, the officer ..., JC Bowles, not only identified the transmission as crosstalk, but cites it as the exemplar of the crosstalk phenomenon.” In fact, our paper [2, p.225] states: “Thomas (pers. commun., 2002) and others (e.g., Bowles [11]) have claimed that [the CHECK transmissions] constitute a ‘time tie’ [i.e., a valid crosstalk].” It is true that our earlier reference [2, p.220] does say “claimed by Thomas ... and others,” and inadvertently omitted to cite Bowles at this point. The reader may judge whether we “failed to provide ... the information” regarding Bowles’ prior claim, as Thomas asserts.

We take this opportunity to make two corrections: (1) In column F of Table 1 of [2], the entry for CHECK1 should read 3:46.5, not 3:45; similarly in the main text at pp. 220 and 221. This can easily be confirmed by listening to Track 1. The column G entry for CHECK1 should read -10.9. The PCC discussion at pp.221-22 refers to the correct location. (2) At [2, p.211, last para.], “Hamming window” should read “Hanning window.”

## **Conclusions**

We have shown the following:

- 1) Multiple lines of evidence converge to yield a single consistent set of speed factors for several recordings of both Channel 1 and 2. The speed factors for

Tracks 1 (Channel 1) and 2 and 3 (Channel 2) are constant with time, and that for Track 7 (Channel 2) varies linearly with time.

- 2) YOU and HOLD are valid crosstalks.
- 3) Contrary to Thomas' claim [3] and his current assertions [1], his dispatcher annotation time argument provides no basis whatever for inferring that HOLD may have been recorded on Channel 1 in an incorrect position (i.e., not in accord with the actual time at which events occurred) as the result of a skipback.
- 4) The known and designed-in feature of recorder stoppage during radio silence can readily account for the observed timings of YOU, HOLD, and ATTENTION, even though the particular times and durations of such stoppages cannot be known.
- 5) Those known crosstalks place the alleged shots between approximately 30 and 60s following the utterance "Go to the hospital." This bracketed time interval result is independent of any specific choice of Track 2 recorder stoppages.
- 6) The utterances CHECK and CHECK1 do not constitute a valid crosstalk, as shown by PCC analysis and now by direct spectrographic observation.

## **Acknowledgements**

We thank Michael O'Dell and Paul Horowitz for useful comments on this MS.

## **References**

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### Figure captions

Fig. 1: Plot of actual time (assuming a given timeline) vs. dispatcher's time annotations, both in seconds. Solid line denotes least squares fit. Dashed line denotes fit using a different slope. Left panel: Our example timeline assuming Channel 2 dead time (see text). Slopes of lines are 1.07 (solid) and 1.00 (dashed). Right panel: Thomas' "corrected" timeline [1]. Slopes of lines are 0.99 (solid) and 0.93 (dashed).

Fig. 2: Spectrogram of a portion of Track 7 (Channel 2) containing "I'll check it." Abscissa represents the time bin (each bin starts 64 samples or 7.256ms after the previous bin); ordinate represents the frequency bin (17.23 Hz/bin). Added markings (white) identify selected feature points. See text for details.

Fig. 3: Same as Fig. 2, but for a portion of Track 1 (Channel 1) containing the utterance that has been transcribed as "I'll check it."

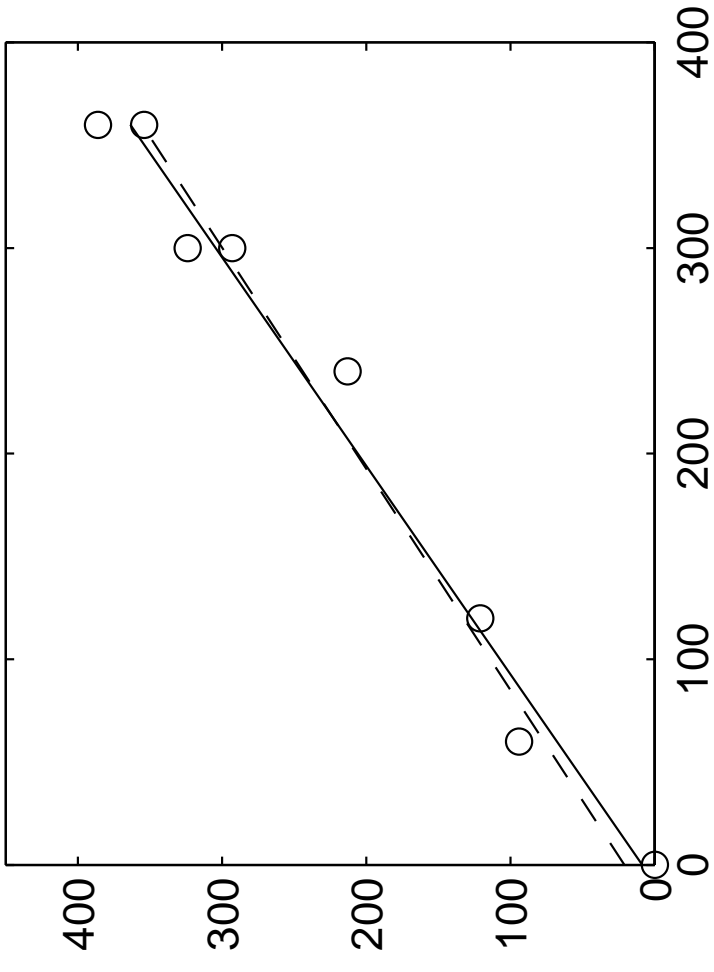
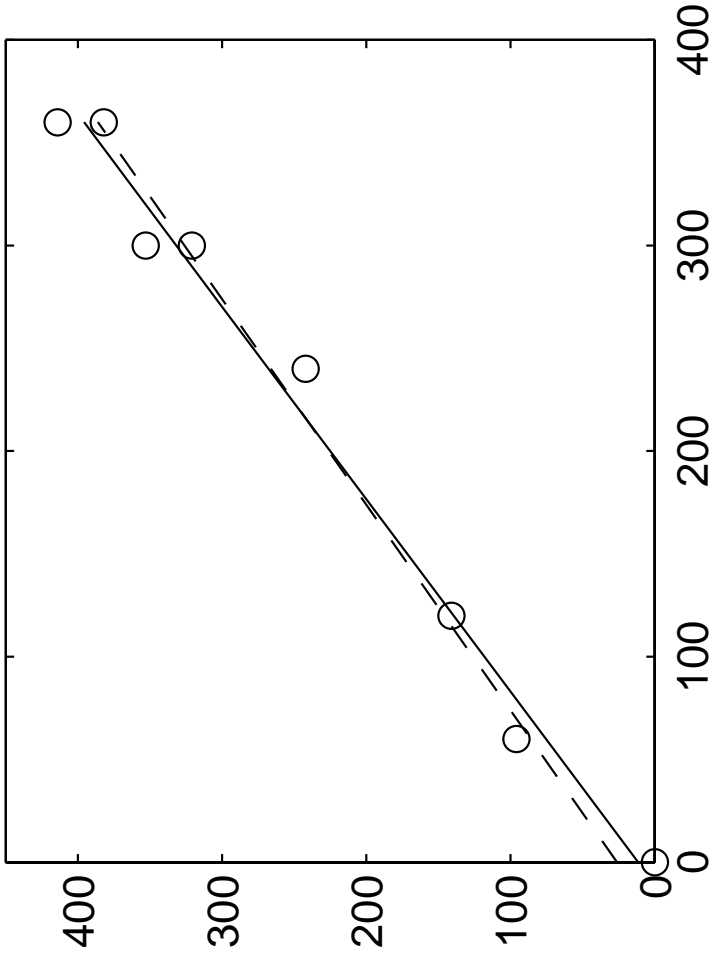


Figure 1

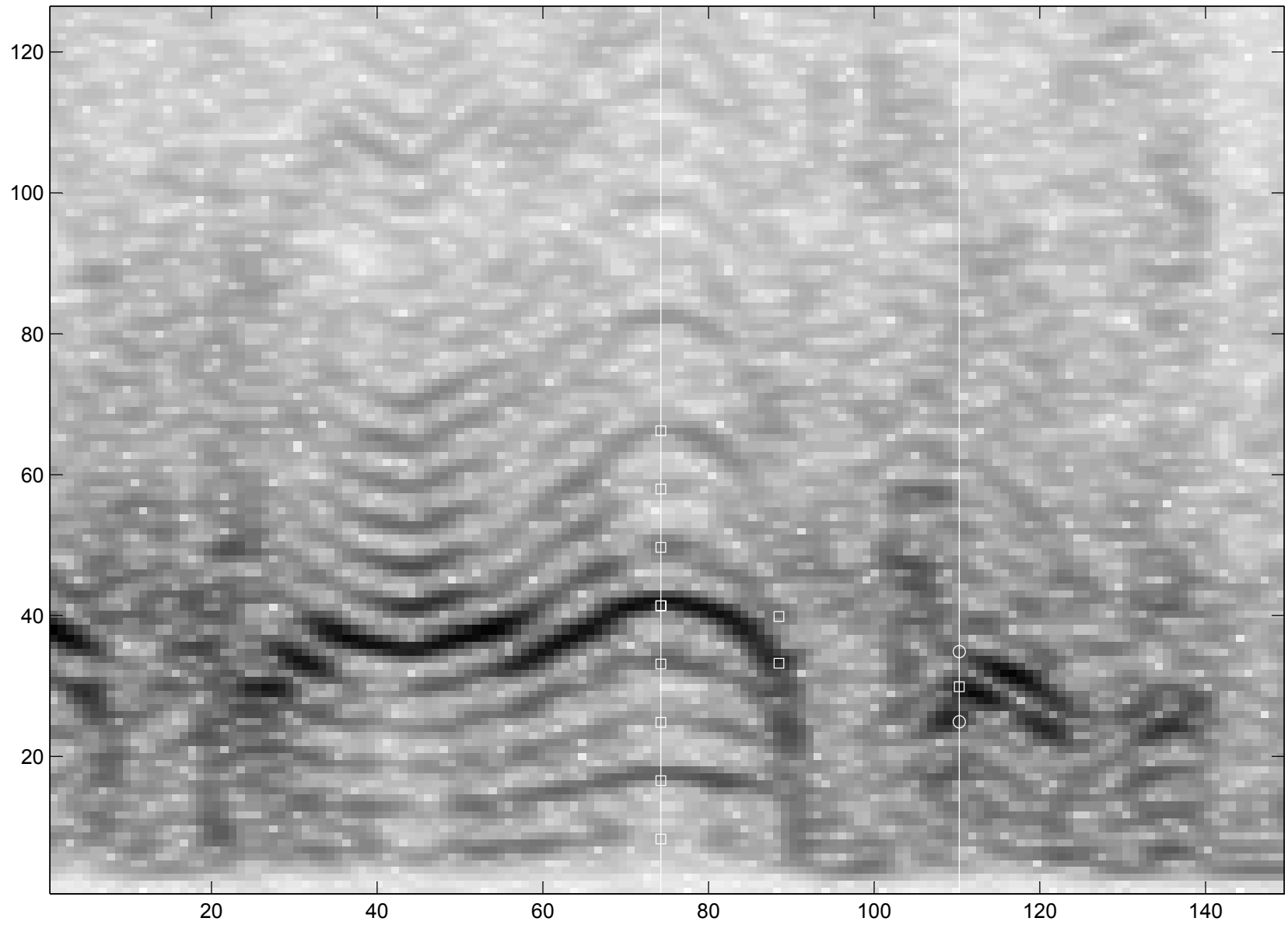


Figure 2

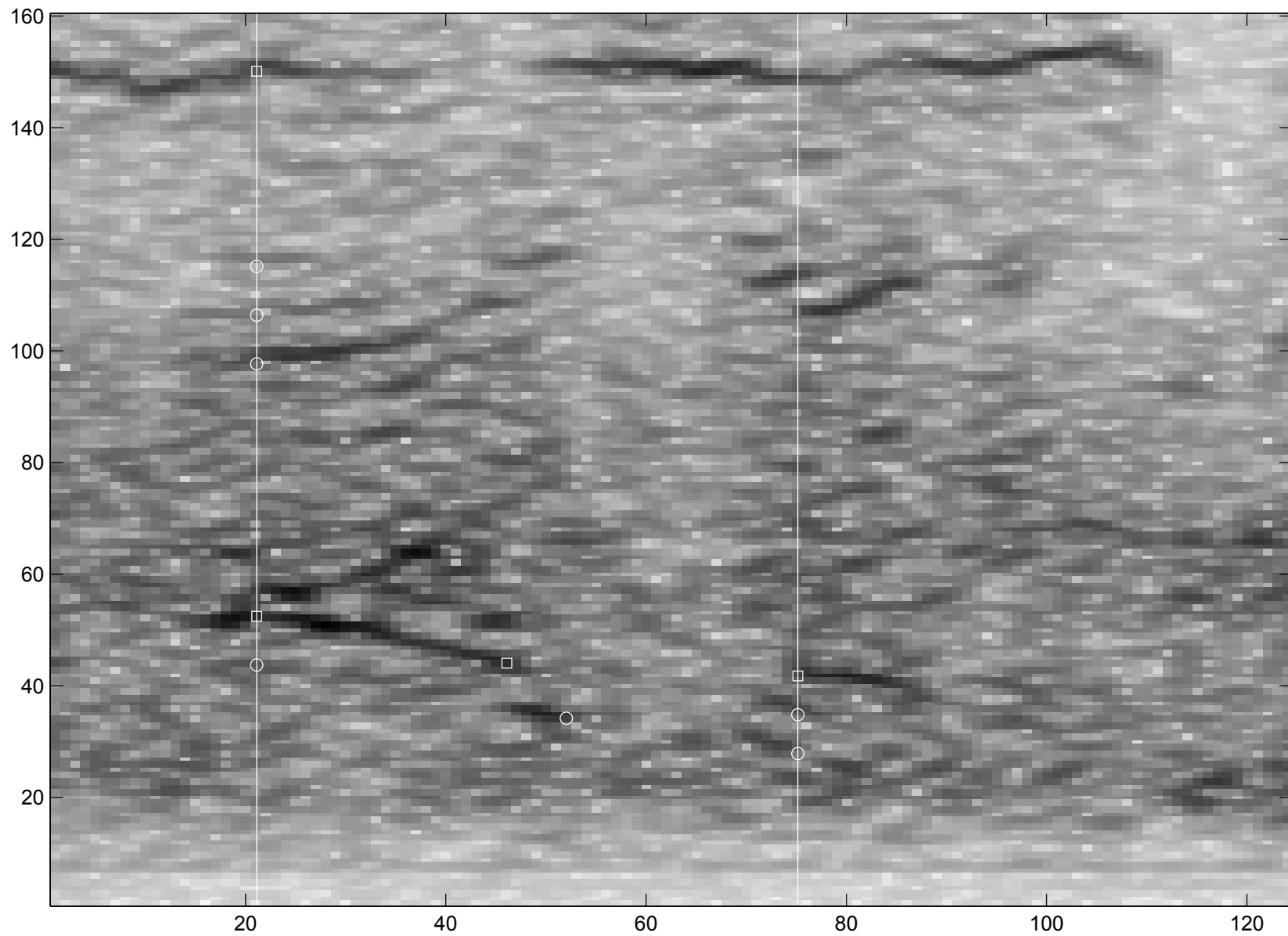


Figure 3