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Production of Intoxication States by Actors—Acoustic and Temporal Characteristics*

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ABSTRACT: This paper is the second of a series; the first has been published (J Forensic Sci, 1998;43:1153–62). The goal in the initial pair of experiments was to determine if speakers (actors) could effectively mimic the speech of intoxicated individuals and also volitionally reduce the degradation to their speech that resulted from severe inebriation. To this end, two highly controlled experiments involving 12 actor-speakers were carried out. It was found that, even when sober, nearly all of them were judged drunker (when pretending) than when they actually were severely intoxicated. In the second experiment, they tried to sound sober when highly intoxicated; here most were judged less inebriated than they were. The goal of this second paper is to identify some of the speech characteristics that allowed the subjects to achieve the cited illusions. The focus here is on four paralinguistic factors: fundamental frequency (F0), speaking rate, vocal intensity, and nonfluency level. For the simulation of intoxication study, it was found that F0 was raised along with increased intoxication but raised even more when this state was feigned. A slowing of speaking rate was associated with increasing intoxication, but this shift also was greater when the speaker simulated intoxication. The most striking contrast was found for the nonfluencies; they were doubled for actual intoxication, but quadrupled when intoxication was simulated. On the other hand, the shifts exhibited by the subjects when they attempted to sound sober were not as clear cut. Indeed, no systematic relationships were found here for either F0 or vocal intensity. Both speaking rate and the number of nonfluencies shifted appropriately, but these changes were not statistically significant. In sum, discernable suprasegmental relationships occurred for both studies (but especially the first); further, it is predicted that useful cues also will be found embedded in the segmentals (the sounds of speech).

KEYWORDS: forensic science, intoxication, simulation, speech, actors, substance abuse, alcohol, driving under the influence

This paper is the second in a series of investigations designed to determine if it is possible for individuals to sound intoxicated when they are not and, conversely, to sound sober when severely intoxicated. Their success in either case would increase the difficulty of correctly assessing the presence and level of inebriation—at least by means of speech evaluation. If the results of the first study (1) had led to the realization that even trained actors could not achieve these goals, then continued research in the area would have been dropped as counterproductive. However, it was found that listeners could be misled by the actors as to the presence and level of inebriation; the effect being greater for simulated intoxication than for simulated sobriety. The question now arises: What changes in their speech characteristics did the subjects employ to mislead the auditors? Specifically, what measurable elements within their speech created the observed illusions and did these alterations occur in a consistent manner?

The focus of the present report is on paralanguage. Specifically, it is to quantify the extent to which the shifts in the actor/subjects' suprasegmental patterns correlate with the cited relationships. The variables quantified for this purpose were speaking fundamental frequency, speech rate (sample duration), vocal intensity and speaker nonfluencies.

Background

The significance of this research program was reviewed in the first paper (1); hence, only a brief critique will be provided here. First, however, it must be stressed again that assessment of a person's behavioral states can be very important to many groups of people. Sometimes the assessment of intoxication—and especially intoxication level—must be made very quickly. In other instances, law enforcement personnel must interview witnesses such as bartenders, supervisors, family members, friends and onlookers about this behavior, and their responses may be based on little but their observations of the target person's speech. Additionally, it can be either forensically or socially important for the aforementioned personnel to be able to directly identify a suspect as being seriously inebriated when he or she is attempting to act (and sound) sober. Perhaps even more critical for law enforcement personnel is to be able to detect when a suspect or perpetrator is feigning drunkenness. To be misled in either instance (but especially the second) could be potentially dangerous. In any event, if determinations of the cited type are to be made, functional information about speech-intoxication relationships is necessary. Indeed, an efficient checklist of the speech-language changes that can result from intoxication would be desirable.

But, what is currently known about these relationships? Some attempts have been made by the present authors to systematically structure an approach to the problem (1–4). While these attempts are as yet a little tentative, at least limited information about the relevant relationships already is available. But first, a short general review. It has been demonstrated by others that, since the consumption of even moderate amounts of alcohol can result in impaired cognitive function (5–9) and degraded sensory-motor performance

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(7,10–12), it would be legitimate to suggest that disruptions of, or impairment to, the flow of the speech/language process also would be possible (13). Moreover, since the speech signal has been found to contain features which can be utilized to provide information about such complex behaviors as a speaker's identity (14–17), we predict that intoxication too can be reflected in the voice and speech of the talker.

Yet, it is without question that any type of research on the effects of intoxication on human behavior (of any type) is difficult to conduct and it now seems apparent that the study of alcohol-speech relationships can be numbered among the more severe of these challenges. Indeed, the relatively few investigators who have studied correlations between motor speech and alcohol consumption have experienced substantial problems in designing and conducting studies with acceptable precision. However, some work has been carried out and, as stated, it was reviewed in the first of this series (1). Additionally, Chin and Pisoni (18) provide an excellent overview of the area. Nevertheless, a very brief listing of a few of the possible relationships is considered useful.

Some investigators have focused on the quality of the speech of inebriated speakers using an "intoxicated-sober" continuum. For example, when certain of them (19,20) had their subjects speak under both conditions, they found that intoxication often resulted in degraded articulation, slower speech rate, and the perception of raised intoxicated states. In addition, the Pisoni/Martin listeners (21) were correct 62 to 74% of the time when asked to perceptually judge if a talker was drunk or sober. Degradations in morphology, and/or syntax, also have been found (22,23), as have nonfluencies involving phoneme substitutions, omissions, distortions, and devoicing (19,24,25). However, the preeminent focus here (see the above cited references plus 3,4,26) appears to have been on paralinguistic relationships. The authors cited above have reported that: (*a*) speaking fundamental frequency level (SFF), although variable, often is lowered and variability of SFF usage can be increased, (*b*) speaking rate is often slowed, (*c*) the number and length of pauses is very often increased, and (*d*) amplitude or intensity levels are (sometimes) reduced.

Unfortunately, there is a lack of uniformity among these opinions and the data which support them. For example, most of the research suggests that F0 is lowered as a function of increase in intoxication whereas Hollien et al. (4) found that it is raised. Even though these latter data are extensive, Cooney et al. (27) recently reported that they found no significant SFF shift at all. It is hoped that the present project will aid in the clarification of these controversies—plus stabilize some of the relationships.

Results from the Prior Study

As stated, the first study (1) was designed to determine if listeners could be misled by actors regarding the actual level of intoxication being experienced. Actors were chosen as speakers as it was hypothesized that, due to their experience in manipulating speech plus the training they had received in simulating inebriation, their capabilities would be more robust than those of untrained individuals. Moreover, it has been suggested that actors may have assisted in the establishment of many of the commonly held stereotypes about speech-intoxication relationships and that they did so when, for dramatic purposes, they exaggerated its effects on motor speech. In any event, subjects were asked (1) to "sound" severely intoxicated when sober, and (2) to "sound" sober when severely intoxicated. The results demonstrated that they could succeed at both tasks. That is, the listeners rated them as being more inebriated than when they actually were and did so 88% of the time. Likewise, when subjects attempted to sound sober (while actually intoxicated), the listeners judged them as being less so over 61% of the time. These data suggest that it often is possible for speakers to successfully simulate intoxication as well as the reverse. As these behaviors could (and do) create problems for law enforcement personnel, it would appear useful to determine exactly what the speakers did to create these illusions.

Method

The methods used to generate the data in the first report (1) have been described in some detail. As was stated there, each procedural step was carefully structured and controlled. Hence, that account will not be repeated here. Suffice it to say that the 12 actor-subjects were carefully selected; that they produced controlled speech (1) when sober (baseline), (2) at three levels of simulated intoxication, (3) at three levels of actual intoxication, and (4) when severely intoxicated but attempting to sound sober. Listeners were asked to judge intoxication severity.

Materials

The materials selected for analysis were recordings of one of the four types of speech produced, i.e., the 98-word standard oral reading passage. This reading was common to all of the experimental conditions, i.e., when the talkers were: (*a*) sober, (*b*) sober yet simulating severe intoxication, (*c*) at an actual BrAC level of 0.12 to 0.13, and (*d*) at 0.12 BrAC, but when making an effort to sound sober. The first trial (sober), was recorded after the subjects were shown to be sober (BrAC = 0.00) and after they had completed their practice runs. This condition was used to provide a sober-speech baseline with which to compare all other conditions.

Analyses

Analyses of the four cited suprasegmentals were carried out in order to identify some of the techniques employed by the subjects to simulate the desired behavioral states. As stated, they included: speaking fundamental frequency (SFF), vocal intensity, speaking rate as defined as the time in which it took speakers to read the passage, plus identification of several types of nonfluency errors. Of course, this study need not have been confined to these types of analyses, yet they appeared to provide an important first step in understanding the techniques employed in achieving the cited successes.

The procedure for assessing SFF for each of the two studies was to isolate approximately 30 s of the standard reading passage and process that segment by means of FFI-12 (14). The resulting data included mean SFF (in Hz and ST) and the standard deviation (in ST).

The primary prosodic measure (i.e., speech rate) was the period of time subjects took to orally read the passage. To carry out this analysis, the utterances were digitized by a Kay Elemetrics CSL system (Model 4300B) with the first and last inhalation removed by means of its edit- and trim-module. Sample duration was provided by its internal clock. Third, this same system also was used to provide the analysis of vocal intensity. Here the speech sample was digitized, all inhalations and pauses removed, and average sound pressure level (SPL) calculated. Reasonably valid measurements of vocal intensity could be made because, during the experiments, the microphone was placed—and held—in constant relationship to the subjects' lips. Thus, intensity artifacts were kept to a minimum.

Finally, the actors' nonfluencies were systematically measured by a trained phonologist with random checks made by a phonetician (96% agreement). Eight different phonemic and word-choice errors were assessed (substitutions, repetitions, omissions, etc.). Once the evaluation was complete, the errors were classified according to type and separated by sex and level of intoxication. Since no trends were found for the different types of nonfluencies or for gender, the data here were collapsed to a single value for the intoxication conditions. Finally, the analyses of all four sets of data, plus the statistical procedures, were processed on a Dell Pentium computer (Dimension P166v).

Results and Discussion

It will be remembered that subjects in both of the two experiments (i.e., simulation of severe intoxication and simulation of sobriety) were generally successful with these respective tasks, with the success rate in the first experiment being particularly high. Yet, a few of the subjects in each group exhibited difficulty in achieving the respective goals. Accordingly, the results of each of the studies were organized in two ways: first with respect to the overall differences between the experimental conditions, and second as a similar contrast but with the focus on the "highly successful" subjects. However, before proceeding, it would appear desirable to compare the baseline data for this group with those for the 35 subjects (19 males and 16 females) reported in the primary or baseline study (4); these contrasts are presented in Table 1. As will be seen, the male actors exhibited somewhat higher fundamental frequency levels (SFF) than did the lay subjects (the females did not); they also spoke at a somewhat slower and more deliberate rate. However, the data for the actors are consistent with what is known about professional voices (see among others 28–31) and, in any event, their levels clearly fall within the normal range. The major parallel for the two groups is that their shift patterns are very similar when they become intoxicated. Note that all subjects from both studies show (*a*) a rise in SFF with intoxication, (*b*) slowing of speech rate, and (*c*) marked increase in nonfluencies (Fig. 1). Therefore it can be said that, under ordinary conditions, the actors behaved in ways similar to other young, healthy individuals.

Simulation of Intoxication

The experiment where the subjects attempted to sound intoxicated will be considered first. Table 2 provides the relevant data here. Note the center column; it provides experimental data on the speech characteristics exhibited when the subjects attempted to "sound drunk" but were completely sober. The left-hand column provides comparative data about their speech behaviors when they actually were severely intoxicated and the right-hand column (in parentheses) provides reference data showing what could be expected if the subjects had not been modifying their utterances for the stated purpose. With only one exception, the SFF, speaking rate and nonfluency shifts (from the 0.00 BrAC level) were equal to or greater for the simulated condition than they were for intoxication.

TABLE 1—*A reference table where the speech characteristics of the 12 actors are contrasted with those for the 35 subjects in the baseline study, both when sober (BrAC 0.00) and when intoxicated (BrAC 0.12).*

	Actors		Main	
Parameter	0.00	0.12	0.00	0.12
FO (SFF) M	121	126	112	119
F	183	192	199	204
Duration, sec	26.5	31.4	25.3	27.1
Intensity, dB	74.0	73.7	64.0	64.5
Nonfluencies	2.6	5.0	3.2	8.6

Values are for all subjects except SFF, which is reported as a function of gender.

TABLE 2—*Summary table of speech characteristics when they are contrasted for actual and simulated intoxication. The reference column is to provide comparison data re: the levels subjects would exhibit if they were not attempting to simulate intoxication.*

Parameter	Intoxication Level (BrAC 0.12)	Simulated Intoxication (at BrAC 0.00)	(Reference) (Performance at BrAC 0.00)
FO (SFF) M	126	127	(121)
F	192	180	(183)
Duration, sec	31.4	38.5	(26.5)
Intensity, dB	73.7	74.4	(74.0)
Nonfluencies	5.0	11.6	(2.6)

Values are for all subjects except SFF, which is reported as a function of gender.

First, note the shifts for speaking rate. These data were significantly different (difference = 4.9; $t = 3.86$, $df = 11$, $t_{05} = 2.20$) when the actual sober (BrAC = 0.00) condition was contrasted to severe intoxication (BrAC = 0.12). An even more striking difference was found for the sober versus feigned intoxication comparisons (difference = 12.0; $t = 4.18$, $df = 11$, $t_{05} = 2.20$). Indeed, the differences between the actual and simulated intoxication shifts just missed significance ($\alpha = 0.07$).

Second, these relationships were even more robust for nonfluencies. Here the sober to intoxicated shift was significant ($t = 3.00$, $df = 11$, $t_{05} = 2.20$) but that for the simulated intoxication (versus sober) was triple the first (difference = 9.0; $t = 4.98$). In this case, the difference between the feigned and actual intoxication was significant ($t = 2.77$, $df = 11$, $t_{05} = 2.20$). Finally, it should be noted that neither vocal intensity nor SFF appeared to be robust predictors as there were no systematic changes at all for intensity, and, while the increases in men's SFF were essentially parallel for both conditions, the women actually showed a reversal for the pretended intoxication. In short, it appears that speaking rate and the presence of high nonfluency levels correlate both with actual and simulated intoxication.

Data contrasting the most successful and least successful groups of actors simulating intoxication are not presented as only minor differences were found. The analyses showed mixed relationships for SFF and a virtual lack of any trend at all for vocal intensity; hence, very little useful clarification was provided by these two factors. On the other hand, the data on speaking rate and nonfluency states provided at least a little insight. While not statistically significant, a slightly greater increase in nonfluencies was noted for the successful subjects. The duration measurements also exhibited a trend with the less successful subjects speeding up their speech and the more successful ones slowing it. In short, these data also support the position that shifts in duration and nonfluencies constitute those speaking characteristics most closely associated with the perception of intoxication.

Simulation of Sobriety

The second experiment was conducted in order to determine if it were possible for severely intoxicated speakers to sound sober. As

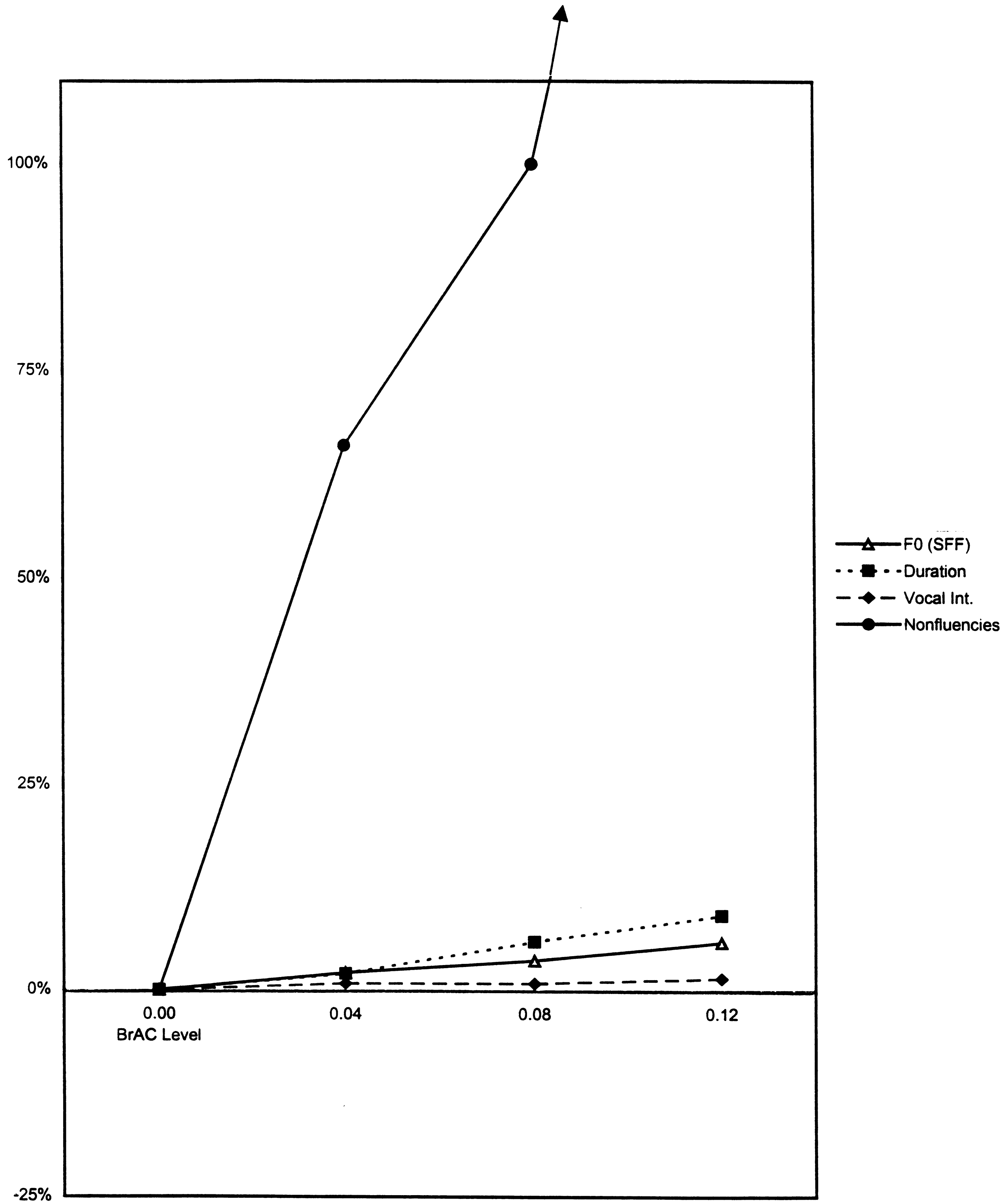

FIG. 1—*Data from several studies contrasting the shifts in four types of suprasegmental speech features as a function of increasing intoxication. Included are speaking fundamental frequency, vocal intensity, speaking rate (i.e., sample duration), and nonfluency level. The relationship for rate and nonfluency always has been statistically significant; that for F0 usually is also.*

stated, most of the subjects could do so, at least to some extent, and very often were able to sound substantially less intoxicated than they actually were. Again attempts were made to discover those behaviors the subjects changed in order to affect this illusion. The results for the four suprasegmental factors may be found in Table 3. The primary data are in the center column, to the left are those for subjects' actual level of intoxication, and to the right these same attributes when they were, in fact, sober.

First, note that on average, subjects shifted their SFF downward when pretending sobriety and did so to an extent where their mean level was actually lower than when they were sober. Since SFF rises as a function of increased intoxication, it would be expected that this characteristic would be lowered as sobriety was achieved. Such was the case here. It also was expected that vocal intensity would not change, and it did not. Yet (as predicted) speaking rate did increase (i.e., the duration was lowered) and the number of nonfluencies shifted toward a lower level. As will be seen from consideration of rows 2 and 4 of Table 3, however, the shifts were minor, did not approach the level of actual sobriety and were not, of course, statistically significant.

TABLE 3—*Results table for subjects when they attempted to sound sober while severely intoxicated. This table is structured differently than Table 2. Their performance for simulated sobriety (middle column) is compared with their speech when the first reading was at BrAC 0.12 (left column) and then when they actually were sober (right column).*

Parameter	Intoxication Level (BrAC 0.12)	Simulated Sobriety (at BrAC 0.12)	Actual Sobriety (at 0.00)
FO (SFF) M	126	119	(121)
F	192	179	(183)
Duration, sec	31.4	30.3	(26.5)
Intensity, dB	73.7	73.4	(74.0)
Nonfluencies	5.0	4.7	(2.6)

Values are for all subjects except SFF, which is reported as a function of gender.

From consideration of Table 3 alone, it would appear that to sound sober, a person who is intoxicated should attempt to lower his or her speaking pitch and speak more rapidly with fewer errors. However, since the extent of these shifts was somewhat limited, the data were again reorganized to compare the six subjects most successful at "sounding" sober with the three who were not able to perform the task very well. It was found that the reasonably successful subjects showed greater shifts in SFF, speaking rate, and nonfluencies (than did the less successful). While they did not achieve the actual levels found for sobriety, their shifts from high levels of intoxication were consistent (if not significant). As a matter of fact, the group that did not do well at simulating sobriety did not exhibit systematic shifts at all and it appears that their unorganized efforts served to prevent them from providing the illusion that they were less intoxicated or sober.

Conclusions

This research provides, at least, some data about the strategies a person can use to sound intoxicated and, to a lesser degree, on those he or she can employ to sound less intoxicated than they are. It should be reiterated, however, that subjects were more successful in the former than in the latter. Simple logic can serve to explain this difference—at least to some degree—and some independent evidence is available to justify this postulation. As has been pointed out (1,32), there is a tendency for speakers to sound more intoxicated than they are when only mildly intoxicated (see Fig. 2) and less so when they are severely intoxicated. While it is not clear as to whether these relationships are due to the speaker's efforts, the precepts or expectations of the auditors, or a combination of these factors, the fact remains that low levels of intoxication are easily perceived and overestimated but high levels are resistive to correct

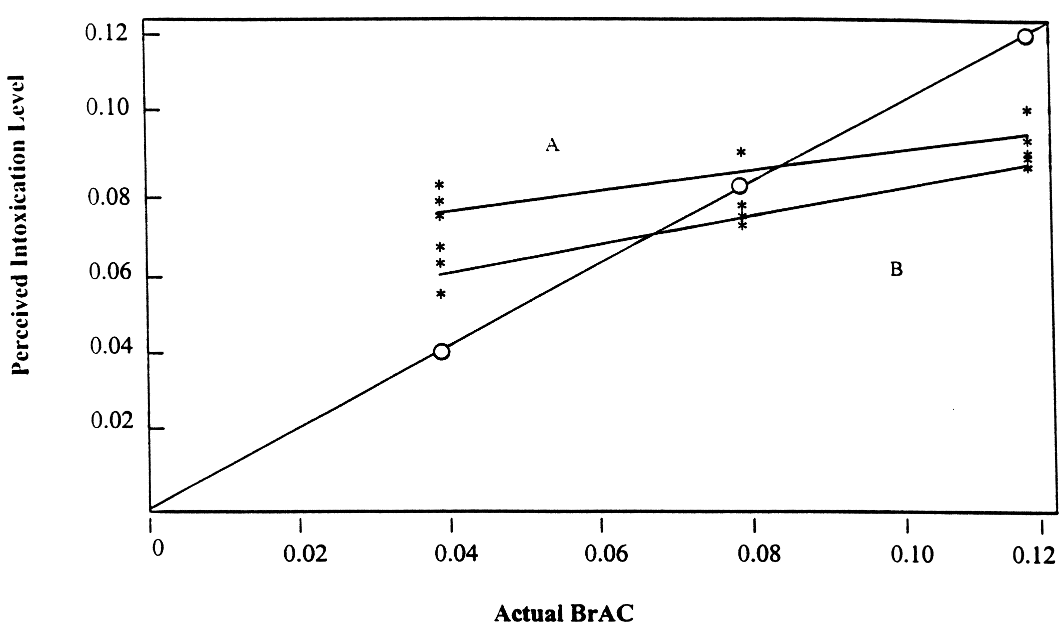

FIG. 2—*Perceived intoxication level contrasted with the physiologically measured levels from sober to severely intoxicated (BrAC 0.12 to 0.13). Six studies are represented: four involve 5-pt scaling of intoxication severity (Curve A) and two employ a direct magnitude scaling approach (Curve B). Data are summed for 35 talkers and 85 listeners in the first case and for 36 talkers and 52 listeners in the second (32).*

classification. On the other hand, it is also possible that even moderate amounts of ethanol sharply degrade motor speech but adaptation mitigates these effects at the higher levels of intoxication. In any event, while it would appear easier to "sound" drunk than to "sound" sober, either condition can create a hazard for law enforcement personnel.

To conclude: the two major cues employed in both types of simulations involved speaking rate and nonfluencies. These shifts led to near universal judgments of intoxication when, indeed, it did not exist. The negative shifts in these two factors also correlated to some extent with the subjects' attempts to sound sober but they (the speakers) were not quite as successful in this instance. These factors, along with expected shifts in certain of the segmentals (speech sounds), should lead to a useful set of predictors.

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References

1. Hollien H, DeJong G, Martin CA. Production of intoxication states by actors: Perception by lay listeners. J Forensic Sci 1998;43:1163–72.
2. Hollien H. An oilspill, alcohol and the captain. Forensic Sci Int 1993;60:97–105.
3. Hollien H, Martin CA. Conducting research on the effects of intoxication on speech. Forensic Linguistics 1996;3:107–29.
4. Hollien H, DeJong G, Martin CA. Suprasegmental speech shifts as a function of intoxication level. Presented at the IPS-98, International Phonetics Congress, June 1998, Bellingham, WA.
5. Arbuckle TY, Chaikelson J, Gold DP. Social drinking and cognitive function revisited: The role of intellectual endowment and psychological distress. J Studies Alcohol 1994;55:352–61.
6. Echardt MJ, Rohrbaugh JW, Stapleton J, Davis EZ. Attention-related brain potential and cognition in alcoholism-associated organic brain disorders. Biol Psychiatry 1996;39:143–6.
7. Hindmarch I, Kerr JS, Sherwood N. The effects of alcohol and other drugs on psychomotor performance and cognitive function. Alcohol and Alcoholism 1991;26:71–9.
8. Steingass HP, Saitory G, Canavan GM. Chronic alcoholism and cognitive function. Pers Individ Differ 1994;17:97–109.
9. Wallgren H, Barry H. Actions of Alcohol (vols. 1 and 2) Amsterdam: Elsevier, 1970.
10. Connors GJ, Maisto SA. Effects of alcohol, instructions and consumption rate on motor performance. J Studies Alcohol 1980;41:509–17.
11. Galbraith NG. Alcohol: Its effect on handwriting. J Forensic Sci 1986; 31:580–8.
12. Oei T, Kerschbaumer BA. Peer attitudes, sex, and the effects of alcohol on simulated driving performance. Am J Drug Alcohol Abuse 1990;16: 135–46.
13. Abbs JH, Gracco VL. Control of complex motor gestures: Orofacial muscle responses to load perturbations of the lip during speech. J Neurophysiol 1984;51:705–23.
14. Hollien H. Acoustics of crime. New York: Plenum, 1990.
15. Künzel HJ. Sprechererkennung: Grundzuge Forensischer Sprachverarbeitung, Jeidelber: Kriminalistik-Verlag, Germany 1987.
16. Nolan JF. The phonetic basis of speaker recognition, Cambridge, UK: Cambridge Univ. Press, 1983.
17. Stevens KN. Sources of inter- and intra-speaker variability in the acoustic properties of speech sounds. Proceedings, 7th Inter Cong Phonetic Sci Montreal, 1971;206–32.
18. Chin SB, Pisoni DB. Alcohol and speech. San Diego: Academic Press, 1997.
19. Sobell L, Sobell M. Effects of alcohol on the speech of alcoholics. J Speech Hear Res 1972;15:861–8.
20. Sobell L, Sobell M, Coleman R. Alcohol-induced dysfluency in nonalcoholic. Folia Phoniatrica 1982;34:316–23.
21. Pisoni DB, Martin CS. Effects of alcohol on the acoustic-phonetic properties of speech: perceptual and acoustic analyses. Alcoholism: Clin Exper Res 1989;13:577–87.
22. Künzel H. Influence of alcohol on speech and language. Proceedings of the American Academy of Forensic Sciences, Cincinnati, Ohio, 1990.
23. Natale M, Kanzler M, Jaffe J, Jaffe J. Acute effects of alcohol on defensive and primary-process language. Inter J Addictions 1980;15: 1055–67.
24. Lester L, Skousen, R. The phonology of drunkenness. Papers from the parasession on natural phonology. Linguistic Soc Amer 1974;233–9.
25. Trojan F, Kryspin-Exner K. The decay of articulation under the influence of alcohol and paraldehyde. Folia Phoniatr 1968;20:217–38.
26. Klingholz F, Penning R, Liebhardt E. Recognition of low-level alcohol intoxication from the speech signal. J Acoust Soc Amer 1988;84: 929–35.
27. Cooney OM, McGuigan KG, Murphy PJP, Conroy RM. Acoustic analysis of the effects of alcohol on the human voice. J Acoust Soc Amer 1998;103:2895 (A).
28. Brown WS Jr, Morris R, Hollien H, Howell E. Speaking fundamental frequency characteristics as a function of age and professional singing. J Voice 1991;5:310–5.
29. Cowan M. Pitch and intensity characteristics of stage speech. Arch Speech Suppl 1936;92.
30. Linke E. A study of the pitch characteristics of female voices and their relationship to vocal effectiveness. Folia Phoniatr 1973;25: 173–85.
31. Lynch G. A phonophotographic study of trained and untrained voices reading factual and dramatic material. Arch Speech 1934;1:9–25.
32. Hollien H, Liljegren K, Martin CA, DeJong G. Prediction of intoxication levels by speech analysis, Advances in phonetics. CA Braun, Ed. Stuttgart, Steiner. 1999;106:40–50.

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