The accuracy of a voice vote

Ingo R. Titze^{a)} and Anil Palaparthi^{b)}

Department of Communication Sciences and Disorders, The University of Iowa, Iowa City, Iowa 52242

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The accuracy of a voice vote was addressed by systematically varying group size, individual voter loudness, and words that are typically used to express agreement or disagreement. Five judges rated the loudness of two competing groups in A-B comparison tasks. Acoustic analysis was performed to determine the sound energy level of each word uttered by each group. Results showed that individual voter differences in energy level can grossly alter group loudness and bias the vote. Unless some control is imposed on the sound level of individual voters, it is difficult to establish even a two-thirds majority, much less a simple majority. There is no symmetry in the bias created by unequal sound production of individuals. Soft voices do not bias the group loudness much, but loud voices do. The phonetic balance of the two words chosen (e.g., “yea” and “nay” as opposed to “aye” and “no”) seems to be less of an issue. © 2014 Acoustical Society of America.

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I. INTRODUCTION

A voice vote (*viva voce*) is one of several legitimate ways of determining a majority opinion according to Robert’s Rules of Order (Robert, 1915, 2000). It is efficient because it does not rely on counting raised hands, standing individuals, or written ballots. Its accuracy has always been somewhat suspect, however, for determining a simple majority. As a dramatic example, the voice vote was put to a test on September 5 in the 2012 Democratic National Convention in Charlotte, NC. The convention was held in the 20000 seat Time–Warner Cable Arena. The issue at hand was a change in the party’s platform on whether a reference to “God-given talents” and “Jerusalem is and will remain the capitol of the State of Israel” should be re-inserted into the platform document after having been removed in an earlier version. The chairman of the convention, Los Angeles Mayor Antonio Villaraigosa, brought the issue to a voice vote in the large convention hall with several thousand delegates and media personnel in attendance. The vote, in the form of an “aye” or “no,” was judged inconclusive twice but passed in the affirmative the third time. A two-thirds majority was expected and announced as the final outcome, but many in the audience (and those listening over broadcast media) had to stretch their perceptive imagination to confirm any kind of majority. As it turned out, the outcome was a *fait accompli* because the result was already posted on the chairman’s prompter prior to the last vote. Apparently, the voice vote defaulted to a ratification rather than a binding vote.

The anecdote stimulated the lead author of this paper to raise some questions about the accuracy of a voice vote and

how it can be shored up. The following questions were formulated:

- (1) What is the smallest group majority that can be judged accurately?
- (2) Does the individual loudness of voters affect the outcome?
- (3) Should the two words expressing agreement or disagreement have the same vowels or diphthongs (for example, “yea – nay” instead of “aye – no” or “yes – no”)?

Additional questions can be raised about the size of the voting audience, the physical seating and spacing of the yeasayers, the nay-sayers, and the judge, as well as the influence of amplification and electronic play-back in large halls. These are highly variable, however, and therefore are not part of this investigation.

II. BACKGROUND

Some perceptual studies are available for loudness discrimination between pairs of sounds. For intensities more than 30 dB above the threshold of hearing for noise and sinusoids, the just noticeable difference (JND) is on the order of 0.5–1.0 dB (Miller, 1947; Jestaed *et al.*, 1977) for ideal conditions of listening over headphones. For free-field conditions and room noise, the JND is on the order of 1–2 dB, based on studies with rodents and cats (Saunders *et al.*, 1987; Saunders, 1969) and estimates using Weber’s law (Plack, 2005).

If all voices in a group are equal in sound power and the phases of their acoustic pressures are random (a virtual guarantee), a two-thirds majority voice vote would yield a 2:1 difference (3 dB) between groups. This is likely to be above the JND and should therefore be a clear vote. For a simple majority, however, the most ideal JND of 0.5 dB would allow a judge to discriminate a ratio of no smaller than 1.2:1, which would translate to a 55:45% majority vote. These rough predictions will be validated and refined in this study.

Sound power differences between individuals in a group can be a significant factor in judging group size. Figure 1

^{a)}Author to whom correspondence should be addressed. Also at: the University of Utah, Salt Lake City, Utah 84101. Electronic mail: ingo.titze@ncvs2.org

^{b)}Also at the University of Utah, Salt Lake City, Utah 84101.

FIG. 1. (Color online) Average voice range profile for 10 females (after Gramming, 1988).

shows an average voice range profile obtained from 10 females vocalizing a vowel /a/ (Gramming, 1988). Standardization of voice range profiles is an ongoing process (Pabon *et al.*, 2011). Upper and lower boundaries are for very loud and very soft utterances, respectively. Note that the sound pressure level has a range of more than 20 dB at fundamental frequencies in the 200–400 Hz range, where women would utter single words. Choral singers were found to utilize a mean range of 26 dB across all voice classifications when singing a vowel /a/ at loudness levels ranging from *pianissimo* to *fortissimo* (Coleman, 1994). Thus if a sound pressure level (SPL) of 70 dB @ 0.5 m is assumed as an average speaking level in a voice vote, a range of ± 10 dB is certainly possible for each individual speaker, but a variation of ± 5 dB is more reasonable for speech in a voice vote where “very loud” and “very soft” are unlikely to be used. This variation will become an important variable in our analysis.

A few data sets exist to size up the nature of the word-pair problem. Two half-century old studies addressed the intrinsic loudness of vowels. Lehiste and Peterson (1959) reported VU (volume unit) meter readings of five vowels as follows: 80.1 for /i/, 81.1 for /e/, 85.7 for /a/, 83.5 for /o/, and 80.4 for /u/. Fónagy (1966) reported dB levels relative to /a/: -9.7 for /i/, -3.6 for /e/, -7.2 for /o/, and -12.3 for /u/. It is also known from basic acoustics of sound radiating from the mouth (Flanagan, 1972) that the radiated sound power is proportional to the mouth area. MRI data (Story, 2005) indicate that mouth areas for /æ/ and /a/ are about ten times greater than for /o/ or /i/. From these studies, one would expect a difference of anywhere from 1 to 10 dB between words containing open and closed vowels. Lehiste and Peterson’s difference was 5.2 dB and Fónagy’s was 12 dB, but we do not know the exact mouth shapes or effort levels that were used by the speakers. For words typically used in a voice vote, “yes,” “aye,” or “yea” for the affirmative and “no” or “nay” for the non-affirmative, all but one contain diphthongs ending in /i/ or /u/, which would weaken the word strength relative to the initial vowel. In contrast, “yes” ends in a consonant, shortening the duration of the vowel. A preliminary conclusion would be that “no” is the weakest word because it contains no open vowels. However, when people are speaking loud or shouting the diphthongs /ai/ and /nou/, the differences is likely to be smaller than in

conversational speech because /nou/ tends toward /noʊ/. In any case, for phonetic balance, it would seem logical that voice votes be conducted with two words that have the same vowel or diphthong, either /ai/ and /nai/ or /jei/ and /nei/. The often used /jes/ and /nou/, or /-i/ and /nou/, would appear to be problematic. Evidence provided in this report will show, however, that word-pairing is a minor problem in comparison to differences in individual sound power of speakers.

III. METHODS

A. Speakers

A university acoustics class of 54 women and 5 men participated in an assignment on loudness discrimination. Institutional review board (IRB) approval for publication of this class project was sought and discussed but deemed unnecessary because no individuals were identified and the project was a regular academic exercise. Because of the obvious gender imbalance in the class, only the women were asked to vocalize. They were divided into a control group of 27 (group 1) and an experimental group of 27 (group 2).

B. Listeners

A panel of five normal adult listeners was asked to make loudness judgments. They were three faculty members, one staff member, and one graduate student at the Wendell Johnson Speech and Hearing Center at the University of Iowa. All judges claimed to have normal hearing for their age. Judge 1 was a 60 yr old male, judge 2 a 50 yr old female, judge 3 a 57 yr old female, judge 4 was a 39 yr old female, and judge 5 a 30 yr old male. We sought no special qualifications for these judges because special sensory and cognitive qualifications are generally not a requirement for chairpersons conducting a voice vote.

C. Recording

A single microphone (Shure 158) was placed centrally between the class and the listeners, who faced the class. The microphone signal was recorded with a Zoom R-16 recorder on an SD card (16 bits, 44.1 kHz) for the entire duration of the experiments.

D. Experiments

Four experiments were conducted. In experiment 1, the group sizes were changed systematically by having 1–10 individuals shift successively from group 2 to group 1. Thus the balance shifted gradually from 27:27 to 37:17, which is slightly greater than a 2/3 majority. For each of the 10 progressive group sizes, each group was instructed to speak the word “yea” at a medium loudness level (L2). Some preliminary training was given in this loudness level. Two additional loudness levels were practiced for later experiments, such that in total the loudness levels were:

- L1: “Speak as if across a table or desk with someone.”
- L2: “Speak as if teaching a class of about 40 students.”
- L3: “Speak as if shouting to someone across a busy street.”

The order of vocalization of group 1 and group 2 was varied randomly so that systematic size changes could not be predicted. The listener judges were unfamiliar with the purpose of the experiment. They were called into the classroom after instructions and practice had taken place for the students. The judges were given a score sheet to mark A (first is louder) or B (second is louder) or “same.” They could not identify individuals belonging to either group because they were asked to close their eyes during the class’ vocalizations so that no visual clues could be obtained. Seating of students in the lecture hall was random, not clustered by groups. Prior to vocalization, the class instructor (first author of this paper) announced each A-B paired stimulus, i.e., “stimulus pair 1,” “stimulus pair 2,”..., for clarity to both students and judges. To coordinate their vocalizations, students were then conducted with hand gestures by the instructor to initiate each word in the two-word stimulus. An up-beat prepared them, and a down-beat elicited the word response. In addition, the instructions to switch voters gradually from group 2 to group 1 were projected on a screen behind the judges, invisible to them. The entire procedure was audio recorded and monitored for compliance by two teaching assistants.

In experiment 2, ten individuals in the experimental group (group 2) successively spoke at a louder level (L3). The number in each group did not change. The judges used the same score sheet as in experiment 1. All else was controlled as in experiment 1.

In experiment 3, the ten individuals successively spoke at the softer level (L1). All else remained as in the preceding text.

In experiment 4, word pairs from *aye*, *yes*, *yea*, *no*, and *nay* were created randomly. Each word occurred four times in an A-B comparison, for a total of ten pairs. One group spoke the first word, the other group spoke the second word, but group order was randomized. As before, the judges were asked whether A was the loudest, B was the loudest, or if they were the same loudness.

IV. RESULTS FROM ACOUSTIC ANALYSIS

The audio recording was trimmed with MATLAB on a computer to eliminate all chatter and silences. A concatenation of isolated group-spoken words remained, nearly equally spaced [Fig. 2(a)]. The sound energy level in each group-spoken word was computed as

$$E = 10 * \log_{10} \left(\frac{1}{N} \sum_{i=1}^N P_i^2 \right) \text{ dB}, \quad (1)$$

where P_i is the recorded pressure (arbitrary units), and $1:N$ is the range of time samples in the analysis window. Two approaches were taken for window size. In the first approach, a running 50 ms window (no overlap and no gaps) was taken over the entire utterance and peaks were detected automatically. In the second approach, the window length was taken as the entire word, marked visually by sharp turns from background noise to signal. Word onset and offset were confirmed auditorially by the analyst. Figure 2(a) shows the raw pressure signal for the 22 word utterances of “yea” when group size was varied in experiment 1. Each word was about 1 s in length. Figure 2(b) shows the short-term (peak) relative energy levels in the successive words as computed from Eq. (1). The horizontal axis is now a word count instead of time. Figure 2(c) is the long-term (word-length) energy for the same data, which seems to be a bit more stable because it takes into consideration the length of the word along with the peak value. The short (50 ms) window was basically only 1/20 of the word length.

Group size began with an equal ratio of 27/27 (pair of dark gray bars) and ended with a ratio of 37/17, slightly greater than 2:1. If all voices had been of equal energy as per instruction, the final energy difference should have been $10 \log_{10} (37/17)$ or 3.4 dB. The data show this final difference, dark bars being group 1 and light bars group 2.

FIG. 2. (Color online) Successive “yea” utterances with changing group size, (a) raw microphone signal, (b) calculated energy levels in dB with short (50 ms) window, (c) calculated energy level in dB with long (word length) window.

FIG. 3. (Color online) Successive “yea” utterances with individuals in group 2 (light bars) changing loudness one-by-one, (a) getting louder, (b) getting softer.

The same analysis was performed for experiments 2 and 3, but only the word-length energy level calculation will be shown. Figure 3(a) shows the energy levels when group 2 became gradually louder by successive individuals speaking at level L3 instead of level L2 (light bars). The final difference (10 of 27 voters speaking at L3) is on the order of 4 dB. Even two to three people speaking at level L3 (comparing bar 5 with bar 6 and bar 7 with bar 8) produced a group difference of 1–2 dB in this 27:27 group comparison.

The situation is quite different when several individuals speak softly, at level L1. Figure 3(b) shows group energy levels when group 2 becomes gradually softer by successive individuals speaking at level L1 instead of level L2. The final difference (10 of 27 people speaking softly at level L1) is only on the order of 1 dB. If the ten people were not to speak at all, there would be a group difference of 27:17 or 2 dB. This mere 1 dB difference between soft speech and silence for about one-third of the voters suggests that people speaking softly in a voice vote do not count much. Those with normal or loud voices carry the vote.

The last acoustic analysis was performed on the random pairwise combinations of the words *aye*, *yea*, *yes*, *nay*, *no*. Each word was uttered four times in combination with each of the four other words. Figure 4 shows the results, clustered

by the four repetitions of the same word rather than by the original word pair order. For this small sample average, *aye* had the highest sound energy (6.7 dB on average), followed by *yea* (6.2 dB), then *no* (5.9 dB), then *nay* (5.6 dB), and last by *yes* (5.5 dB). The result does not suggest a great preference for word pairing. The *aye*–*no* pairing differs by 0.8 dB in favor of *aye*. The *yea*–*nay* pairing differs by 0.6 dB in favor of *yea*, and the *yes*–*no* pairing differs by 0.4 dB in favor of *no*. Given that these differences are all in the 0.5–1.0 dB JND range under best hearing conditions, it appears that the energy differences between words should not be detectable with much reliability. The perceptual experiments will bear this out.

V. RESULTS FROM PERCEPTUAL EXPERIMENTS

A baseline test was first conducted to determine whether the judges would favor the first or second stimulus in a word-pair comparison. The stimuli were the controls in each experiment, i.e., the initial pairs for which no difference should have been detected. Table I shows the results.

The five judges (collectively) agreed on A-B neutrality in experiment 1, but for experiments 2 and 3 they tended to be biased toward B. In a progression from experiments 1 to 3, there was a marginally significant linear trend to find B

FIG. 4. (Color online) Relative sound energy level for four repetitions of five words, *aye*, *nay*, *no*, *yea*, and *yes*.

TABLE I. Number of judgments from five judges for control stimuli.

Voter group sizes ($N = 27, N = 27$)	Second stimulus softer	No difference	Second stimulus louder
Experiment			
1	1	3	1
2	0	3	3
3	0	1	4
Statistical comparisons ^a			
(a) linear trend test (second stimulus judged louder with each successive experiment): $p = 0.079$			

^aMixed effects logistic regression, with judges as random effect, after combining “second stimulus softer” with “no difference” to achieve a binary outcome variable (columns 2 and 3 versus column 4).

louder (linear trend, $p = 0.079$). Acoustic analysis showed that this bias was psychophysical, not physical [recall the first pair of gray bars in Figs. 2(b) and 2(c) and in Figs. 3(a) and 3(b)]. Generally, stimulus B had lower energy than stimulus A. In Fig. 3(a), A and B were nearly equal. The perceptual bias toward B was avoided in all experiments by randomization of stimuli.

In experiment 1, the group sizes were changed systematically by having one to ten individuals shift successively from group 2 to group 1. Thus the balance shifted gradually from 27:27 to 37:17, which is slightly greater than a 2/3 majority. For each of the 10 progressive group sizes, each group was instructed to speak the word “yea” at a medium loudness level (“speak as if teaching a class of about 40 students”).

Results are shown in Table II. The judges noticed an increase in voting loudness in the voter group that was increasing in size from the initial balanced groups sizes (linear trend, $p = 0.015$). This difference in voting loudness was apparent to the judges beginning with 54% to 46% group sizes. A 59% to 41% group majority or greater had two uncertain votes and a 63% to 37% majority or greater had no uncertain votes.

TABLE II. Number of judgments from five judges in experiment 1.

Voter group sizes N:N (%:%)	Larger group softer	Both groups same	Larger group louder
27:27 (50:50)	0	5	0
28:26 (52:48)	1	4	0
29:25 (54:46)	0	0	5
30:24 (56:44)	0	0	5
31:23 (57:43)	0	1	4
32:22 (59:41)	0	0	5
33:21 (61:39)	0	2	3
34:20 (63:37)	0	0	5
35:19 (65:35)	0	0	5
36:18 (67:33)	0	0	5
37:17 (69:31)	0	0	5

Statistical comparisons^a

(a) linear trend test (gets louder as group size increases): $p = 0.015$

(b) rows 3–11 versus rows 1–2, which is 54% or more in larger group versus more balanced groups (visually observed shift in judge responses): $p = 0.007$

^aMixed effects logistic regression, with judges as random effect, after combining “larger group softer” with “both groups same” to achieve a binary outcome variable (columns 2 and 3 versus column 4).

In experiment 2, ten individuals in the experimental group (group 2) successively spoke at a louder level (“Speak as if shouting to someone across a busy street”). The number of voters in each group did not change.

Table III shows the results. The judges noticed an increase in voting loudness in the voter group that was increasing in the number of voters speaking louder (linear trend, $p = 0.008$). This difference in voting loudness was noticeable to the judges beginning with one voter speaking louder than the rest (1/27, or 4% of voters in that group) and was clearly obvious to all judges after three voters spoke louder (3/27, or 11% of voters in that group).

In experiment 3, ten individuals in the experimental group (group 2) successively spoke at a softer level (“speak as if across a table or desk with someone”). The number of voters in each group did not change.

Table IV shows the results. This pattern was more difficult for the judges. They noticed a marginally significant decrease in voting loudness in the voter group that was increasing in the number of voters speaking softer (linear trend, $p = 0.065$), as predicted by the acoustic analysis that showed only a 2 dB maximum difference in SPL.

The combined results of experiments 2 and 3 leave little doubt that loud speaking voters in a group dominate the vote, while soft speaking voters contribute little to the outcome.

In experiment 4, word pairs from *aye*, *yes*, *yea*, *no*, and *nay* were created randomly. Each word occurred four times in an A-B comparison, for a total of ten pairs. One group spoke the first word, the other group spoke the second word, but group order was randomized. As before, the judges were asked whether A was the loudest, B was the loudest, or if they were the same loudness.

Table V shows the results. The judges choice of the louder vote was not affected by the word used by the voters ($p = 0.71$).

TABLE III. Number of judgments from five judges in experiment 2.

Voter group sizes ($N = 27, N = 27$)	Group 2 softer	Both groups same	Group 2 louder
Number of voters speaking louder in group 2			
0	0	5	0
1	0	1	4
2	0	2	3
3	0	0	5
4	0	0	5
5	0	0	5
6	0	0	5
7	0	0	5
8	0	1	4
9	0	0	5
10	0	1	4

Statistical comparisons^a

(a) linear trend test (gets louder as another voter speaks louder): $p = 0.008$

(b) rows 4–11 versus rows 1–3, which is 3 or more voters speaking louder (visually observed distinct shift in judge responses): $p = 0.001$

^aMixed effects logistic regression, with judges as random effect, after combining “group 2 softer” with “both groups same” to achieve a binary outcome variable (columns 2 and 3 versus column 4).

TABLE IV. Number of judgments from five judges in experiment 3.

Voter group sizes ($N = 27$, $N = 27$)	Group 2 softer	Both groups same	Group 2 louder
Number of voters speaking softer in group 2			
0	0	5	0
1	2	3	0
2	1	4	0
3	1	4	0
4	0	2	3
5	3	2	0
6	0	5	0
7	2	2	1
8	0	4	0
9	4	1	0
10	2	3	0
Statistical comparisons ^a			
(a) linear trend test (gets softer as another voter speaks softer): $p = 0.065$			

^aMixed effects logistic regression, with judges as random effect, after combining “group 2 softer” with “both groups same” with “group 2 louder”) to achieve a binary outcome variable (columns 3 and 4 versus column 2).

VI. COMPUTER MODELING OF GROUP SIZE AND INDIVIDUAL'S SOUND LEVELS

Given that the most important vote bias resulted from a few individuals speaking loudly, a simulation was done to verify this result. A 70 dB nominal sound level (at 0.5 m) was chosen for each speaker. Group size was varied from 1 to 100. Sound level for each speaker was converted to sound power at the mouth and added to the sound power from the other speakers. The increase in sound level of the group is shown by the dashed curve in Fig. 5(a). Group size increases the sound level at a rate of 3 dB per doubling of individuals. The sound level of the speakers was then randomly varied with a standard deviation of ± 5 dB (recall the *range* of SPL was ± 10 dB in Fig. 1). The jagged curve in Fig. 5(a) confirms that the loud voices bias the group loudness. Randomly loud individuals can raise the group SPL by 3–5 dB, which can appear as if the group size has doubled from, say,

TABLE V. Number of judges ($N = 5$) $\times$ 10 pairs ($N = 50$ word pairs).

Voter group sizes ($N = 27$, $N = 27$)	Group softer (scored as 0)	Groups same (scored as 0.5)	Group louder (scored as 1)	Mean score
Words				
Aye	31	15	4	0.23
Yes	32	13	5	0.23
Yea	37	11	2	0.15
Nay	33	11	6	0.23
No	35	14	1	0.16
Statistical comparisons ^a				
(a) comparison of words—comparison of percent of times the word was scored softer, $p = 0.71$				

^aMixed effects logistic regression, with judges as random effect, after combining “groups same” with “group louder” to achieve a binary outcome variable (columns 3 and 4 versus column 2). The word was the predictor, modeling using 4 indicator (dummy) variables in an analysis of variance (ANOVA) fashion.

20 to 40. In Fig. 5(b), we show that one speaker being very loud (+10 dB above the others) affects the group sound level by more than 2 dB up to a group size of 20. Even in a group size of 40, one speaker can raise the group sound level by 1 dB, near the just noticeable difference (JND).

VII. DISCUSSION

We have shown how the sound energy level of a group of speakers varies with the acoustic power of each individual and the number of individuals. In an ideal voting situation, each individual produces the same power with random phase and equal distance from the judge. A two-thirds majority would then produce an SPL difference of 3 dB. A 1 dB difference would be expected from a simple majority of 56:44. The JND of 1.0 dB for loudness discrimination under special conditions (pure tones, middle frequencies, and “regular” background noise; Plack, 2005, Chap. 6) would appear to resolve such a simple majority. Estimates for speech in free field sounds and non-ideal environments are not available, but the current study suggests a JND of about 2 dB. Hence a slightly better than two-thirds majority voice vote can be established accurately, but that assumes the same sound power is uttered by each voter.

In a small group, simple superposition theory predicts that one voter can bias a vote to the degree that even a two-thirds majority perception is challenged. Also, random fluctuations of sound power of a few voters produce a group loudness fluctuation on the order of the JND, suggesting that a voice vote for a simple majority is highly suspect unless individual loudness is controlled. For example, it requires a group of 40 or more voices before a single loud voice bias is overcome to establish a 60:40 majority.

VIII. CONCLUSIONS AND RECOMMENDATIONS

Because a voice vote is used for convenience and speed, it is not feasible to invoke a high level of control. A vote with a hand count or ballot count is the simpler solution, especially if much is at stake for the voters. For a relatively benign vote and a cooperative mindset, however, a few words by the chairman conducting the vote would be helpful:

- (1) Please use a moderate conversational level of loudness in your voice vote.
- (2) Please understand that I cannot judge a simple majority accurately. My judgment is likely to be valid for a 2/3 majority or greater.
- (3) Please use the words “yea” and “nay.” Although it has not been shown that the exact words make much difference, common logic argues in favor of words with phonetic balance.

With this level of control, our results show that a 60:40 majority could be judged with reasonable accuracy. Small groups that conduct many votes (city councils, executive boards, educational departments), may have a chairperson that has gained an internal calibration for intrinsically loud voices in the group, especially if the seating is fairly regular. Barring such a human calibration, a sound level monitor

FIG. 5. (Color online) Increase of sound level with an increasing group size and variation of individual sound power, (a) random Gaussian fluctuation with ± 5 dB standard deviation, (b) a single speaker speaking 10 dB louder.

could be installed on benches or tables where microphones are already present. Green and red lights could signal acceptable and unacceptable sound levels. In very large groups, however (e.g., the convention hall mentioned in Sec. I), a simple majority is unattainable by voice vote unless individuals know how to produce (and agree to produce) a standard sound level, which is unlikely. For general voice vote applications, all voters should realize that a soft vote is basically an “abstaining” vote and that one loud vote is equivalent to several votes with normal loudness. A cultural problem should be mentioned here. In some cultures, loud speech is considered unrefined. Some individuals will never produce it. If they vote often and they wish their vote to count, some training with a sound level meter would be helpful. The same calibration could be useful for chronically loud speakers.

Future investigations should probably include room acoustic effects, especially the configuration of the room or hall (size, reverberation) in relation to the seating arrangement of the voting group and the judge. The simultaneity of the speech (initiation of the words by each voter) could also be an issue. How does the auditory system of the judge integrate advanced and delayed sound bursts into one effective burst? In this study, the timing was relatively well orchestrated with conducting hand movements. A less synchronized combination of sounds may alter the results.

The issue of the two words used to signify agreement or disagreement needs further consideration. The unexpected result that *yea* and *nay* were not superior to other word choices with different vowels and diphthongs deserves a more controlled experiment with more repetitions. Also, mixed gender and age of voters could give slightly different results because the frequency spectra of the words are less matched.

Finally, a word of caution is in order about the overall societal impact of this study. The possibility exists that those who deliberately wish to influence a vote, or discredit it, will realize how easily it can be done and substantiated. It is doubtful, however, that this is not already known and considered by most parliamentarians.

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