SIZE AND STRUCTURE OF FREELY FORMING CONVERSATIONAL GROUPS

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Data from various settings suggest that there is an upper limit of about four on the number of individuals who can interact in spontaneous conversation. This limit appears to be a consequence of the mechanisms of speech production and detection. There appear to be no differences between men and women in this respect, other than those introduced by women's lighter voices.

KEY WORDS: **Conversation; Group size; Speech detection; Spacing.**

Language provides the primary means of exchanging social and other kinds of information in pre-literate human societies, though its function in facilitating the effective management of social relationships is fundamental in all human societies. Such exchanges conventionally take place in small interacting groups (conversational groups) whose members engage in a carefully ordered sequence of exchanges that follow well-established rules (Argyle et al. 1968; Kendon 1967). Conversational groups, however, are never unlimited in size, and there is some psychoacoustical evidence to suggest that there may be an upper limit to the number of individuals who can take part.

The accuracy of speech detection is known to decline as ambient noise

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(Webster 1965) and distance between speaker and hearer (Beranek 1954) increase. Sommer (1961) concluded that the maximum nose-to-nose distance for comfortable conversation is 1.7 m. If individuals stood on the circumference of a circle, this would impose a limit of five on the number of individuals who could take part in a conversation, assuming a shoulder-to-shoulder distance of 0.5 m. Sommer, however, made no reference to ambient noise levels. Cohen (1971) later reanalysed the data relating speech detectability to ambient noise level and the distance between speaker and listener. Extrapolating from these equations, he concluded that the number of individual that could take part in a conversation would be limited to a maximum of seven under conditions of minimal ambient noise and would decline exponentially as noise levels increase. Extrapolation from his graphs suggests a limiting group size of four or five in the kind of environment typical of most everyday situations in which conversations take place (e.g., restaurants, busy offices, and city streets, where speech interference levels typically average 45–55 dB).

In an attempt to test Cohen's hypothesis that there is an upper limit to conversation group sizes, we sampled conservations in a number of contexts. We then use these data to examine certain other structural aspects of human conversational groups.

METHOD

We censused groups of people in several public settings, distinguishing *group size* (the total number of individuals present in an interacting group) and *clique size* (the number of individuals taking part in a particular conversation, as evidenced by speaking or obviously attending to the speaker).

Two sets of data (samples ND and RD) were obtained in a college refectory during the lunchtime period. Individuals who came into the refectory together and occupied one of the long (up to 30-seat) tables (or were later joined by other individuals with greetings or other visual acknowledgment) were defined as constituting a (social) group. These groups were censused at 15-minute intervals so long as any individuals remained. A 15-minute interval was considered sufficient for the statistical independence of each sample because of the high turnover of both whole groups and cliques (conversational subgroups) within groups. A total of 388 cliques were censused by RD over a 12-month period in 1991, with a further 414 cliques censused by ND over a 3-month period in 1992. For each sample, the group's division into cliques (interacting subsets) was determined on an instantaneous scan, noting the sex of each clique member as well as the sex of the speaker. An individual was scored as being a member of a given clique if s/he was speaking or paying close attention to the speaker (as indicated by direction of eye gaze and his/her general focus of attention). Individuals who were present but were obviously not involved in one of the conversations in the group were scored as being in a clique of size 1.

Because the arrangement of the tables in the refectory might have limited the number of individuals who could easily take part in a conversation, an additional sample (sample DN) was obtained in less structurally constrained settings during 1993. Five groups of people waiting outside university buildings during fire drills were censused, and four additional censuses were taken at 30-minute intervals at a large evening reception (ca. 200 people) held in a national museum. In the samples from fire drills, only a single sample was taken on each occasion; the sample was taken only once the crowd had settled from its initial alert state and conversations had begun to form spontaneously (usually within a few minutes once it became clear that the event was one of the regular fire practices rather than the real thing). Owing to the nature of these occasions, it was not possible to collect data with as much detail in this sample. Information on the sex of speakers and listeners, for example, was not recorded.

RESULTS

Table 1 gives the distribution of clique sizes for each sample. As Cohen (1971) predicted, conversational cliques larger than five are rare: only 0.5% of all groups in the two refectory samples and 2.4% of the groups in the unconstrained samples contained more than five members. Overall, approximately 95% of all cliques contained four or fewer individu-

Table 1. Distribution of Conversational Clique Sizes for the Three Samples.

			Sample DN		
Clique Size	*Sample ND*	*Sample RD*	*Fire Drill*	*Reception*	*Overall %*
2	237	231	25	77	53.9
3	98	93	27	66	26.9
4	57	44	20	22	13.5
5	22	16	7	5	4.7
6	0	3	2	2	0.7
7	0	1	2	0	0.3
Total groups	414	388	83	172	1057

als, and in all four samples a clique size of four marks the last significant increment in the cumulative distribution of clique sizes.

Figure 1 plots mean clique size against group size for samples ND and RD. Clique size seems to reach an asymptotic value of 3.0–3.5 at a group size of four individuals. The asymptotic clique size (estimated as the mean of the means of clique size for group sizes of greater than four) is 3.09 for sample ND and 3.26 for sample RD. The mean clique sizes for sample DN are 3.26 for the fire drills and 2.77 for the evening reception, very close to the asymptotic clique sizes for the refectory samples. In sample DN, clique size is significantly smaller in the larger gathering (the reception: $\chi^2 = 15.422$, df = 3, $P = 0.015$), as would be predicted from the higher ambient noise levels that a larger group would generate (Legget and Northwood 1960).

A consequence of roughly constant clique size is that the number of conversations within a group increases with its size (Figure 2; Spearman correlations: $r_s = 0.891$, $P < 0.002$, $r_s = 0.924$, $P < 0.001$ for samples ND and RD, respectively; $N = 10$, two-tailed tests). The maximum clique sizes observed were slightly larger in groups of 6–9 individuals than elsewhere (Figure 3). This suggests an overshoot effect, in which individuals initially try to maintain the group as one clique as its size

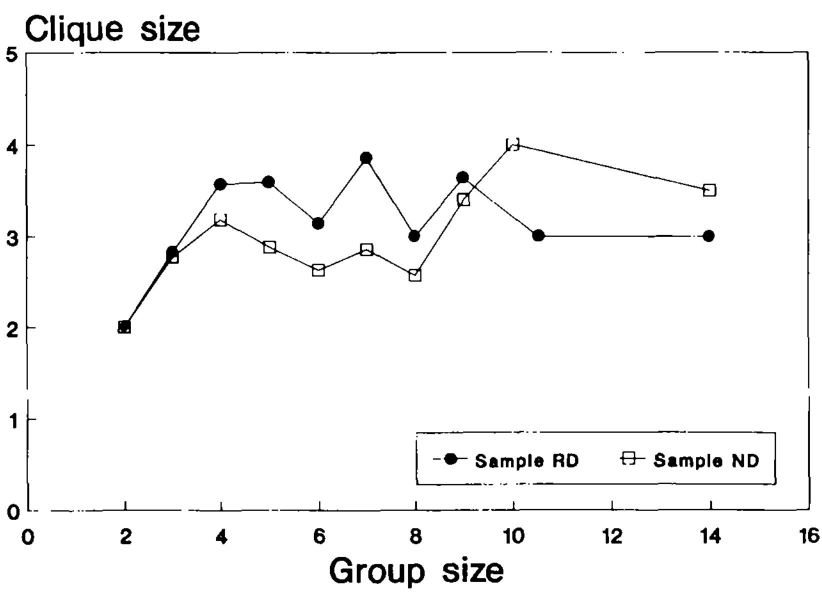

Figure 1. Mean conversation clique size plotted against size of social group for two samples from the college refectory. A clique is defined as the number of individuals actively participating as speaker or listener in a single conversation.

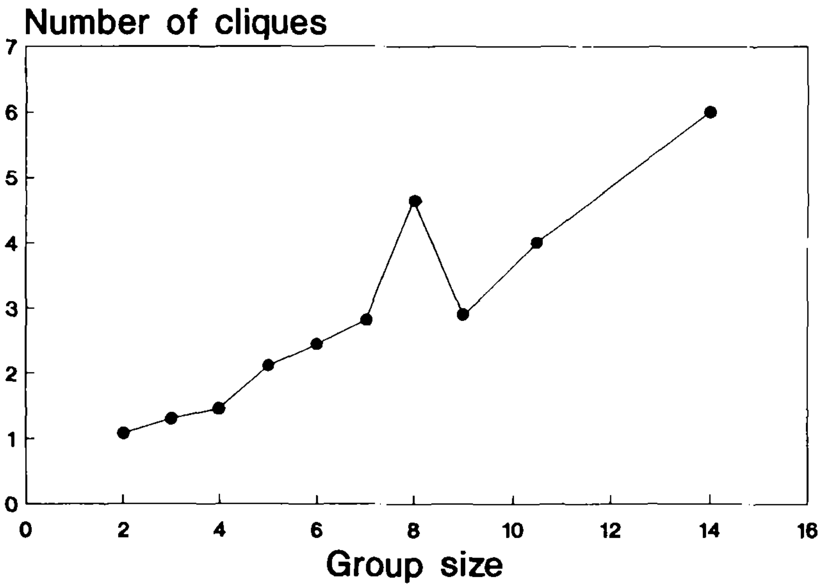

Figure 2. Mean number of cliques per group plotted against the size of the social group for the two refectory samples. For these purposes, individuals not engaged in a conversation were counted as cliques of size 1.

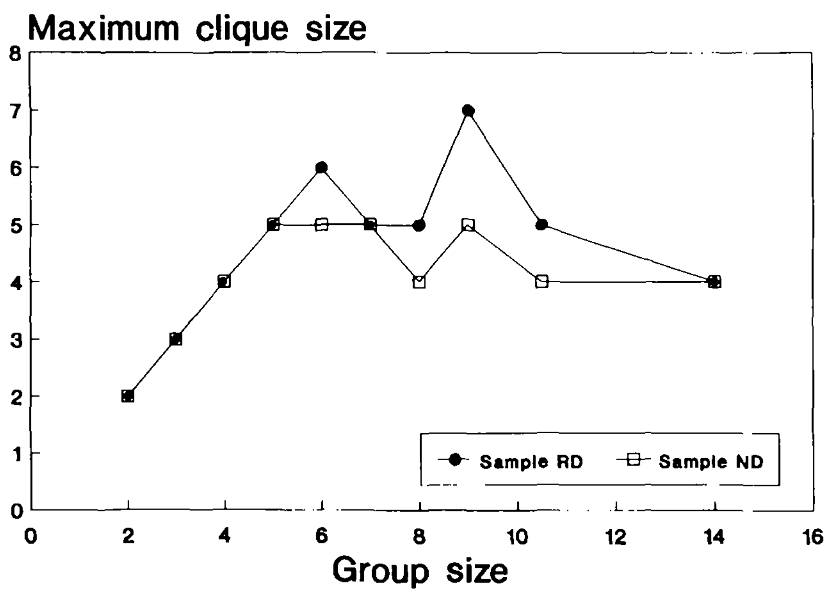

Figure 3. Largest conversation clique size recorded in social groups of different size in each of the two refectory samples.

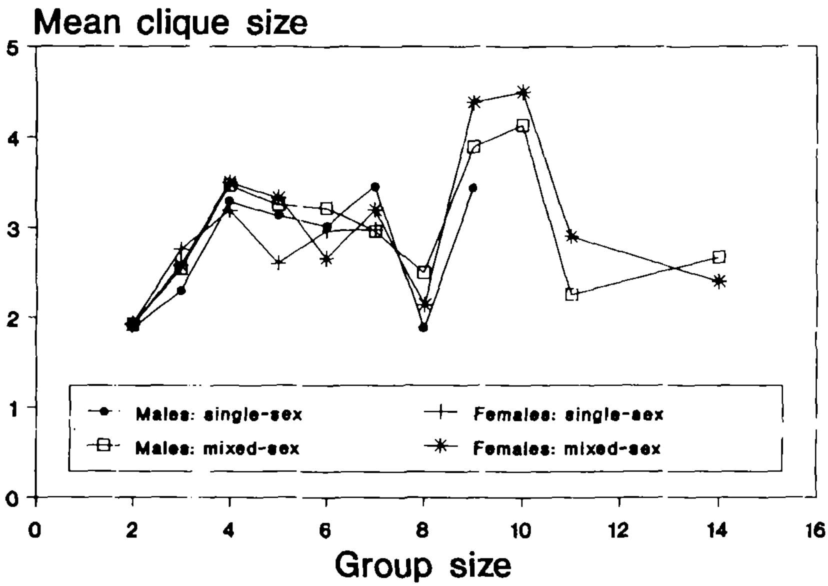

Figure 4. Mean clique size for males and females in same-sex and mixed sex groups plotted against the size of the social group for each of the two refectory samples. Individuals not taking part in a conversation were considered to be in cliques of size 1.

increases but eventually give up and settle back into cliques with four or fewer members.

A comparison of mean clique sizes for individual males and females failed to reveal any significant differences in the two samples for which clique composition by sex was available (Figure 4). This suggests that, in this context at least, cliques form at random with respect to sex. This result is supported by an analysis of the frequency with which the two sexes occur in single- and mixed-sex cliques within large (size > 4) groups: males do not occur disproportionately more often in all-male

Table 2. Frequencies of Males and Females in Single- and Mixed-sex Cliques within Large (size > 4) Mixed-sex Social Groups (RD sample only).

	Number of Individuals in:		
	Single-sex Cliques	*Mixed-sex Cliques*	*Total*
Males	42	106	148
Females	18	73	91

Table 3. Frequencies of Males and Females as Speaker and Listener in Mixed-sex Conversational Cliques in Social Groups with >4 Members (in RD sample only).

	Frequency of Occurrence		*Probability*
	Speaker	*Listener*	*of Speaking*
Males	28	76	0.269
Females	19	52	0.268

Table 4. Proportion of Male and Female Speakers in Mixed-sex Conversational Cliques as the Number of Conversations in the Surrounding Group Increases (RD sample only).

Number of Conversations in Group	*Male Speakers*	*Female Speakers*	*Male : Female Ratio*
1	51	53	0.962
2	22	9	2.444
3	10	7	1.429
4–5	4	1	4.000

cliques than females do in all-female cliques (Table 2: $\chi^2 = 2.176$, df = 1, $P < 0.1$).

No sex differences were apparent in the likelihood of speaking in large (size > 4) mixed-sex cliques (Table 3: $\chi^2 = 0.001$, df = 1, $P > 0.99$), indicating that females were not generally deterred from speaking by the presence of males in this population. However, in mixed-sex cliques, the probability of a female speaking drastically declined as the number of conversations in the group as a whole increased (Table 4: $\chi^2 = 7.359$, df = 3, $P = 0.06$). The ratio of male to female speakers varied from 0.96, when there was only one conversation in the group, to 4.0 when there were five.

DISCUSSION

The results suggest that, rather than increasing indefinitely as the number of people present increases, the size of a conversational clique has an upper limit. It seems likely that clique sizes are limited by the physical efficiency of speech production and detection, as Cohen (1971) suggested.

However, there may also be nonacoustical constraints on group size. Seeing the speaker facilitates both decoding of the speech signal and the regulation of turn-taking (Kendon 1967). Visual as well as auditory feedback is important in sustaining the flow of a conversation (Argyle et al. 1968) and in increasing the efficiency of information transfer (Leavitt and Mueller 1955). In large cliques, it becomes very difficult to monitor all the members visually. Furthermore, as a clique expands, the individuals immediately to the left and right of a given participant will be more and more visually occluded. The importance of this visual effect is confirmed by Steinzor (1955). He found that, in small groups, individuals are much more likely to follow (i.e., take the next conversational turn) a speaker opposite them whom they can fully see than one adjacent to them whom they cannot. Similarly, Sommer (1961) found that members of conversational dyads preferred to sit opposite each other so long as the seating arrangement enabled a distance of less than 2 m to be maintained.

Thus there appear to be significant costs to maintaining large clique size in terms of the processing effort required to follow and maintain the flow of speech. Furthermore, the average interaction rate of each individual will tend to decline as clique size increases: Figure 5 shows that,

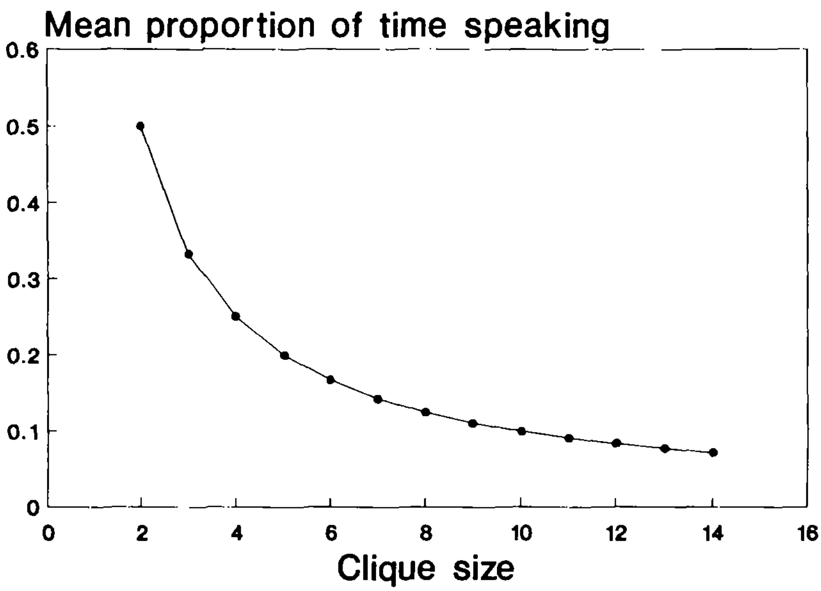

Figure 5. Mean proportion of time that would be spent speaking by any one individual if the members of conversational cliques of different sizes shared speaking time equally.

if conversation time is shared equally, the average proportion of all conversational turns taken by any one individual rapidly approaches an asymptotic minimum of 5–10% once clique size exceeds 4–6 individuals. As a result, the benefits of participation may be expected to decline proportionately. When an individual's absolute interaction rate becomes too low, continuing to attend to the conversation may cease being worth his or her while.

We thus conclude that a maximum clique size of around four is an inherent property of human speech mechanisms. However, a number of possible objections to the conclusion that the limit has any significance for the social functioning of language must be discussed.

One objection is that the limit may be a simple product of the noise levels in the environment in which the observations were made. Whilst this is to some extent true, the major source of environmental ambient noise was the conversations of other people (see also Legget and Northwood 1960). Thus, the clique size was not driven by special external factors, but by the dynamics of the group itself. We therefore find it implausible that the limit should be atypical of large aggregations of people in any noisy environment. The remarkable convergence of the mean clique sizes of the other samples with that of sample DN, collected in different settings, reinforces this point.

A second objection is that we have only looked at one type of speech event. Human language also permits such forms as the lecture and the sermon, which enable interaction with a larger number of people. Under these conditions, many hundreds of listeners can attend to a single speaker. There are, however, reasons for thinking that spontaneous conversation has a special evolutionary significance. Spontaneous conversation is *locally managed*—that is, the interactants themselves determine the speaker's turn-taking and turn-type, as well as the subject of discourse, as the conversation goes on (Phillips 1976). In contrast, other speech events, such as a lecture or play, require quite complex interactional norms that must be set up in advance. For example, the audience of a lecture must adopt a convention suspending their right to speak in order to achieve a certain, rather specialized type of information transfer. It seems unlikely that structurally managed speech events like lectures could develop in the absence of a prior system of communication that allows cultural rules to be established. They are also unnecessary in any system that is not informationally quite complex. We thus suggest that they are derivative of locally managed conversations.

A third possible restriction on the generality of these results may be the existence of cross-cultural variation in voice loudness and interpersonal spacing. If the simultaneous maintenance of two or three relationships is a necessary feature of conversation, then in those cultures where the interaction distance is great, voice loudness should also be great so that constant clique sizes may be maintained. Watson (1970) collected data on voice loudness and interpersonal distance for 110 males of various nationalities. The effects of cultural group on both variables were highly significant. However, there was a weak tendency for those groups who stood closer together to speak *more* loudly than those who did not. One possibility is that, owing to a difference of discriminability between languages, different groups need to behave differently with respect to space and volume to service the same number of relationships.

Finally, the tendency for women to act as listeners more often in conversations with men has been noted on a number of occasions and is usually attributed to cultural influences requiring women to behave modestly and submissively. However, the phenomenon may have a simple acoustic explanation. As the number of conversations going on in the group increases, so too does the local ambient noise level. Female voices have a threshold for intelligibility against background noise which is about 5dB lower than that of male voices (Cohen 1971). It would therefore become more costly for women to speak intelligibly as local ambient noise increases. Females are known to tolerate a lower level of ambient noise than males before they show stress and impaired performance on tests (Laaksonen and Dornic 1990). Some evidence in support of this suggestion comes from the fact that while women and men are equally likely to act as speaker in groups of two (dyads), women increasingly adopt the role of listener as the size of the surrounding group (and hence the ambient noise level) increases (and the detectability of their voices declines) (see Table 4).

The existence of sexual dimorphism with respect to speech is due to the male's lower larynx. In many bird and mammal species, sound-pitch is used to infer the size of the caller and functions as a conventional means of settling male-male conflicts (Morton 1977). Any male with a disproportionately long supralaryngeal tract would have larger apparent size, and accordingly would tend to be more successful (Ohala 1983). The tendency for females to listen rather than speak under high ambient noise levels may thus be a by-product of the fact that male voices have been under greater selection pressure for pitch and volume. This raises the question of why equal pressures have not acted on the female voice. A detailed answer to this question is beyond the scope of this paper, but one possibility is that females have no intrinsic interest in competing with males in conversational groups because male behaviour in such contexts is largely related to advertising their qualities as prospective mates. Only if females had been selected to compete with males in conversational contexts, rather than interact primarily with other females, would there have been a benefit to offset the cost of enlarging the vocal tract. Males, on the other hand, would quickly become locked into an evolutionary arms race over vocal tract size if they were competing amongst themselves for the attention of females.

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