A BAD FEELING OR A BAD FILLING?
THE INFLUENCE OF SOCIAL NETWORK SIZE ON SPEECH PERCEPTION

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Infants and adults learn new phonological varieties better if they are exposed to multiple speakers rather than a single speaker during learning (Bradlow & Bent, 2008; Rost & McMurray, 2009, 2010;Lively, Logan & Pisoni, 1993). This multiple-speaker benefit is assumed to be due to the greater variability that exists in input from multiple compared to a single speaker. The studies here test (1) whether having a larger social network similarly facilitates phonological performance, and (2) what the underlying mechanism of this effect is.

In Study 1, 60 native Dutch speakers reported all their interactions for one typical week. Network Size was calculated as the number of different individuals participants interact with in a typical week. Amount of input was calculated as the number of hours of talk. Participants were then tested on transcription of *nonwords* in noise and on talker normalization. Additionally, participants were tested on a host of cognitive measures: WM, auditory STM, selective attention, and task switching. Results showed that, as predicted, participants with larger social networks were significantly better at speech perception in noise. Crucially, these findings held even after controlling for cognitive skills and for amount of input, indicating that the effect of social network size on speech perception is not due to a correlation between network size and cognitive abilities or amount of input. Study 1 then shows that interacting with multiple people boosts phonological performance even among adult native speakers. Social network size did not predict better talker normalization. It is unclear if this is because the two are not related, or because the tasks were not sensitive enough.

Study 2 used computational simulations with agent-based models to explore the mechanism underlying the effect of social network size on speech perception. Networks were created by randomly selecting people from a population speaking 12 Dutch vowels with a mean and SD as described in Pols, Tromp & Plomp (1973). During interactions, the agent met with a random member of her network and received one set of formants for each vowel. The agent stored these formant sets with their appropriate label. At test, the agent received sets of formants from members of the population that are not in her network, and needed to recognize them. Results showed that having a larger social network led to greater accuracy in phoneme categorization, replicating the behavioral results of Study 1. Interestingly, even though larger networks were also associated with greater variability, as reflected in larger SDs for vowel formants, variability did not predict performance. Instead, as Figure 1 illustrates, the benefit seemed to be due to the fact that input from smaller networks led to more separate clusters with unsampled areas between them, whereas input from larger networks covered the central areas of the vowels more fully. To test whether these distributional differences underlie the effect of network size, a novel measure of Beneficial Spread was created. This measure rewards for the 50^3Hz cubes within 1 SD of the vowel's center that are sampled, and penalizes for cubes that have samples from more than one vowel. This Beneficial Spread measure not only predicted performance, but more than fully mediated the effect of network size. In fact, a mediation test revealed that it explains 1.9 times the effect of network size. This is due to the fact that this measure explained both differences between agents with different network sizes, as well as differences between agents with the same network size. These analyses then show that having a larger social network boosts performance, but that this boost is not due to variability in terms of greater category variance, but to the smoother coverage of the central areas of the vowels.

Further simulations were run to explore how other properties of the network influence performance and modulate the effect of network size. In these simulations network size and network variability were manipulated orthogonally. These simulations again showed a positive effect of social network size on speech perception. Network variability was manipulated by controlling how similar or dissimilar to each other network members are. As before, variability did not boost performance, but, on the contrary, was found to lead to *worse* performance, the more so the larger the network was. The simulations also showed that the effect of network size is independent of amount of input. In contrast, the effect of network size is modulated by the ratio of intra- to inter-individual variability, such that having a larger social network is especially useful when speakers are consistent within themselves, and when the population is heterogeneous.

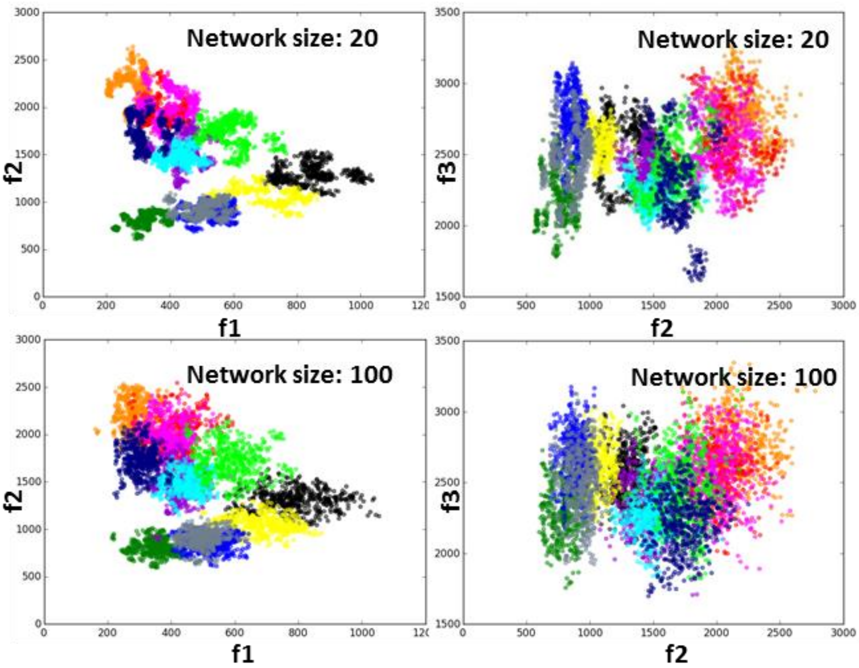

Figure 1. Illustration of typical input that agents with a network size of 20 (top row) and a network size of 100 (bottom row) receive. The 3-dimensional input (f1, f2, f3) is broken down to an f1 by f2 vowel map (left column) and an f2 by f3 vowel map (right column).

In all simulations reported so far, vowel recognition at test was done by matching the incoming input to the most similar stored token. To examine whether the pattern of results depends on this method of classification, all simulations were re-run with a vowel recognition algorithm that calculated the incoming token's probability of belonging to each category according to the category's distribution. All the previously reported results held except for one: increased variability no longer hurt performance, though it did not improve it either. Additionally, the agent in these simulations always performed about 5 percentage points worse than the agent in the simulations that recognized incoming input by matching it with the closest stored token.

Together, these studies show how having a larger social network leads to better speech perception by influencing the distribution of the input. They also show how other aspects of the network and environment, such as their heterogeneity, can modulate the magnitude of this effect. They thus show how aspects of our life-style can influence our linguistic performance.

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