Supplementary information: simulation details for BAH submission

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In order to test our hypothesis we use a computational simulation informed by the best currently available anthropological and archaeological data, basing our analysis to a large degree on (Bowles, 2009). We consider a population of N tribes, with M_i members in each tribe i (for simplicity, $\forall_i$ M_i is the same and will be referred to as M). A tribe member is marked as h_{ij}, meaning the member j of tribe i. A member is assumed to carry a vocal infant ($h = 1$) or non-vocal infant ($h = 0$). While this ignores the graded nature of the vocalizing characteristic, it is typical of modeling based on the Price equation.

The 'strength' of a tribe S is directly related to the proportion of extremely vocal infants λ, thus:

$$S(tribe_i) \equiv \lambda(tribe_i) \equiv \sum_{j=1}^{M} h_{ij} \tag{1}$$

This corresponds to the intuitive idea on which the more crying babies tribe-members bring into battle with them, the stronger they are.

We will simulate the population as it changes over G generations, where in each generation each tribe has a chance k of being engaged in violent conflict with another tribe. We will use $k = 0.28$, again see (Bowles, 2009) for details.

If a violent conflict takes place between tribes A and B, the strength of both groups is estimated and the winner is established by the following equation:

$$P(A = winner) = \frac{S(A)}{S(A) + S(B)} \tag{2}$$

Again reflecting a rather intuitive notion. If a tribe loses a conflict it is eliminated and repopulated with M new members, where the value h of each new member is drawn from a Bernoulli with parameter $p = S(winner)$, thus reflecting the spread of the winner's genes (encoding the level of distress signaling) into the new population.

Without any additional parameters, this state of affairs would lead to every tribe quickly becoming armed with as many vocal infants as possible. However, while infant distress signaling is beneficial on a group selection level in case of conflict, it is not necessarily beneficial on an individual level. At each generation for each tribe member h there is a chance of infanticide, proportional to some general 'unbearableness' parameter θ.

That is, for each generation g, if a tribe member is carrying a vocal infant ($h_{ij} = 1$) then there is a probability θ that h_{ij} will delete its vocal infant, setting $h_{ij} = 0$

In our simulations we are interested in two things: (i) The change in the proportion of vocal infants (λ) over time given violent conflict, and (ii) The effect of different values of 'unbearableness' (θ) on λ.

We assessed this by varying θ between 0 and 1 in steps of 0.025, and for each value of θ running forward a tribal population of $N = 100$ and $M = 30$ for $G = 300$ generations. This number of generations corresponds to a reasonable time frame for human ancestor development, and also allowed for stabilization of the population. We assessed the population of vocal infants by calculating the mean of λ over the entire tribal population, in the last 20 generations. This also gave us a approximation of $var(\lambda)$ once it had stabilized. In Fig. 1 we show the results of these simulations. Fig. 1.a shows some example runs of the simulation for different values of θ. As can be seen, for low values of θ (black line), the proportion of the population armed with vocal infants rises towards a high-value fairly quickly. For high values of θ (dark gray bottom line) we find the population of vocal infants crashes to 0 and stays there after a certain number of generations. Fig. 1.b shows the ultimate stable relative proportion of vocal infants after a large number of generations, for different values of 'unbearableness.' Unsurprisingly there is an inverse relation between the two. This also gives us a prediction - if we knew the actual value of θ we could predict the expected proportion of vocal infants in the population.

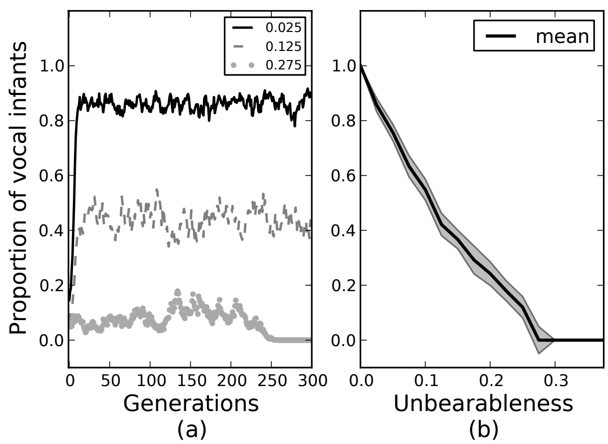

Figure 1: **(a)** Simulation runs for exemplary values of θ, **(b)** Predicted stable proportion of vocal infants given θ. The gray overlay shows a deviation of one σ

We can use the estimated rate of infanticide during the Paleolithic period as proxy for θ. According to (Williamson, 1978), the infanticide rate was 15-20%, which means we predict a extremely vocal infant population of about 20-35%, which is indeed in line with the actual estimated frequency of infantile colic.

References

Bowles, S. (2009). Did warfare among ancestral hunter-gatherers affect the evolution of human social behaviors? *Science*, *324*(5932), 1293–1298.

Williamson, L. (1978). Infanticide: an anthropological analysis. *Infanticide and the Value of Life*, 61–75.