# CS 109 Challenge: Cultural Survival Through Immigration (my family edition)

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**Introduction/Background:**

My family, like many others, has a long line of immigration. My great grandparents came from the Veneto part of Italy to Brazil where they raised my grandma, influenced by both Italian and Brazilian culture because of her parents/location. She learned Veneto which is a dialect that mixes both Portuguese and Italian. My mom grew up learning some Veneto in Brazil and later immigrated to the United States where her children (me!) learned Portuguese and English, with a couple words in Veneto mixed in. This history led me to wonder:

**How does cultural knowledge survive (or die) as it passes through generations of immigrant families, and what factors determine transmission success?**

I started with interviewing the three generations in my family in order to collect information and find potential traditions to track. After interviewing my sister (3rd generation, representing me/my generation), my mom (2nd generation), my grandma (1st generation), and with second-hand information about my great grandma (0th generation), I chose 5 traditions to model as random variables. Based on the responses from the interviews I determined (an educated guess) initial strength parameters for each of the traditions as well as presumed decay rates after comparing the interview responses between generations.

Each tradition $T$ is modeled with:

- **Initial strength**: $S_0 \in [0, 1]$
- **Decay rate**: $\lambda \in R^+$

$$P_{\text{survive}}(g) = S_0 \cdot e^{-\lambda g}$$

Table 1: Tradition Parameters

| Tradition | $S_0$ | $\lambda$ |
|---|---|---|
| Veneto Dialect | 0.9 | 0.3 |
| Italian Recipes | 0.8 | 0.2 |
| Choral Singing | 0.6 | 0.4 |
| Family Eating | 0.9 | 0.15 |
| Catholic Traditions | 0.7 | 0.25 |

For $n$ children, transmission follows a binomial distribution:

$$X \sim \text{Binom}(n, p = P_{\text{survive}}(g))$$

Expected number of cultural offspring:

$$E[X] = n \cdot P_{\text{survive}}(g)$$

Variance:

$$\text{Var}(X) = n \cdot P_{\text{survive}}(g) \cdot (1 - P_{\text{survive}}(g))$$

To determine how a cultural tradition gets passed down to the next generation I used a Binomial Distribution. Each child has some probability $P_{\text{survive}}$(g) of inheriting the tradition (such as speaking the Veneto dialect) based on the generation g (like great-grandma = 0, grandma = 1, etc.) and the tradition's decay rate λ and initial strength $S_0$. Each child is an independent Bernoulli trial: They either inherit the tradition (success, X=1) or don't (failure, X=0).

In calculating the Expected Value, I computed the average number of children expected to inherit the tradition which indicates the tradition's "cultural fitness" in that generation. Calculating the Variance quantifies how much randomness exists in the transmission process: The binomial model shows how traditions might fade (e.g., if E[X]<1 E[X]<1, the tradition is likely to die out).

Then, I analyzed two key aspects of cultural transmission using probability theory. First, I quantified the variability in tradition preservation by calculating the variance in the

For $k$ traditions with survival probabilities $p_1, \ldots, p_k$:

$$P_{\text{all survive}} = \prod_{i=1}^{k} p_i$$

Conditional probability:

$$P(\text{Recipes}|\text{Dialect}) = \frac{P(\text{Recipes} \cap \text{Dialect})}{P(\text{Dialect})}$$

number of children who inherit each tradition, using the formula Var(X) = n·p·(1-p), where p represents the generation-dependent survival probability P□$_{urvive}$(g). This variance measure reveals how consistently traditions are passed down (high variance indicates greater unpredictability in cultural preservation). Second, I examined how traditions interact by computing both joint survival probabilities (the likelihood that multiple traditions all persist simultaneously) and conditional probabilities (such as the probability that Italian recipes survive given that the Veneto dialect persists). This helps identify whether the loss of one tradition might accelerate the decline of others, providing insight into cultural resilience.

$$H(X) = -\sum_{i=1}^{n} p(x_i)\log_2 p(x_i)$$

Information loss between generations:

$$\Delta H = H_{\text{parent}} - H_{\text{child}}$$

I then extended the probabilistic framework by introducing entropy to quantify the uncertainty in cultural transmission across generations. Now, entropy isn't a core CS109 topic!! However, it builds on the probability foundations by operating on the same discrete distributions we've studied for random variables. For each tradition, I calculated H(X) = -Σ p(x)log$_2$p(x), measuring how much information is lost as practices fade over time. Unlike variance which measures spread, entropy directly captures information decay which is crucial for understanding which traditions are most vulnerable to being lost. The model assumes traditions are independent (consistent with earlier joint probability calculations), which allows entropy to identify high value preservation targets. This information theory perspective complements the binomial transmission analysis by adding a dimension of cultural information content that simple survival probabilities can't reveal.

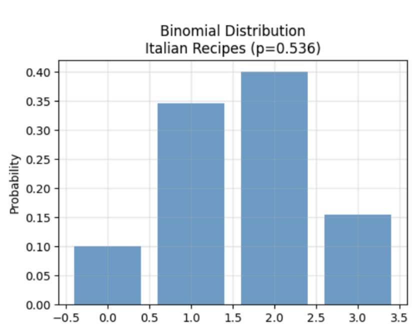
After programming this concept (code included at end), I was able to get numeric results for the survival probabilities by generation as well as the expected cultural offspring.

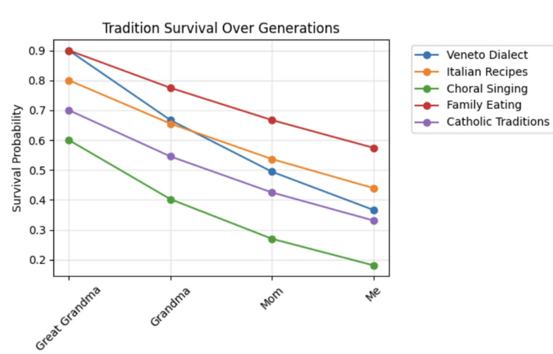
**Some key findings:** Food traditions (λ=0.2) survived best, reflecting their strong role in cultural identity and daily practice. In contrast, language (λ=0.3) faded fastest (a common pattern in immigrant communities). The chance of keeping multiple traditions together dropped sharply each generation. These findings confirm that without active preservation efforts language, among other core cultural aspects, is at risk of disappearing within a few generations.

| Tradition | Great-Grandma | Grandma | Mom | Me | Next Gen |
|---|---|---|---|---|---|
| Veneto Dialect | 0.900 | 0.666 | 0.407 | 0.223 | 0.135 |
| Italian Recipes | 0.800 | 0.670 | 0.535 | 0.423 | 0.335 |
| Family Eating | 0.900 | 0.798 | 0.698 | 0.606 | 0.527 |

For $n = 2$ children in current generation:

$$E[\text{Veneto Dialect}] = 0.446$$
$$E[\text{Italian Recipes}] = 0.846$$
$$\text{Cov}(\text{Dialect, Recipes}) = 0.034$$



**A Broader Scope:**

This model can be directly applied to other topics outside of my family with real and important data such as: 1.) Endangered language preservation by quantifying transmission rates and predicting extinction timelines, 2.) Immigrant assimilation studies through comparative analysis of tradition decay rates ($\lambda$) across different communities, and 3.) Digital archiving by prioritizing high-risk traditions (low $S_0$, high $\lambda$) for AI preservation and creating predictive simulations of cultural loss. The joint probability calculations enable targeted interventions for interconnected traditions, while entropy metrics identify which elements contain the most cultural information worth saving.