THE UNIVERSAL DECAY OF HUMAN COLLECTIVE MEMORY

C. Candia-Castro-Vallejos, C. Jara-Figueroa, Carlos Rodriguez-Sickert, Albert-László Barabási, César A. Hidalgo

Collective Learning Group, MIT Media Lab, Massachusetts Institute of Technology, Cambridge, United States
Network Science Institute, Northeastern University, Boston, MA 02115, USA
Centro de Investigación en Complejidad Social (CICS), Facultad de Gobierno, Universidad del Desarrollo, Santiago, Chile

ccandiav@mit.edu

Pablo Neruda

"Es tan corto el amor y tan largo el olvido"
"Love is so short forgetting is so long"

ABSTRACT

The literature on human collective memory proposes that memory decays through two mechanisms, one involving communicative memory--the memory sustained by oral communication--and another involving cultural memory--the memory sustained by the physical recording of information. Yet, there is no statistical evidence supporting the decay of collective memory through these two mechanisms, or exploring the universality of the decay function. Here, we use time series data on papers and patents' citations, and on the popularity of songs, movies, and biographies, to test the hypotheses that the decay of human collective memory involves the decay of communicative and cultural memory, and that the decay function is universal. We derive a mathematical model from first principles by formalizing these two mechanisms and we compare the bi-exponential function, predicted by this model, with other decay functions proposed in the literature. Our results support the hypotheses that the decay of human collective memory involves the combined decay of communicative and cultural memory, and that the decay function is universal across multiple cultural domains. These findings allow us to explain the dynamics of the attention received by a piece of cultural content during its lifetime, and suggest that the dynamics of human collective memory follows a universal decay mechanism.

MECHANISMS OF FORGETTING
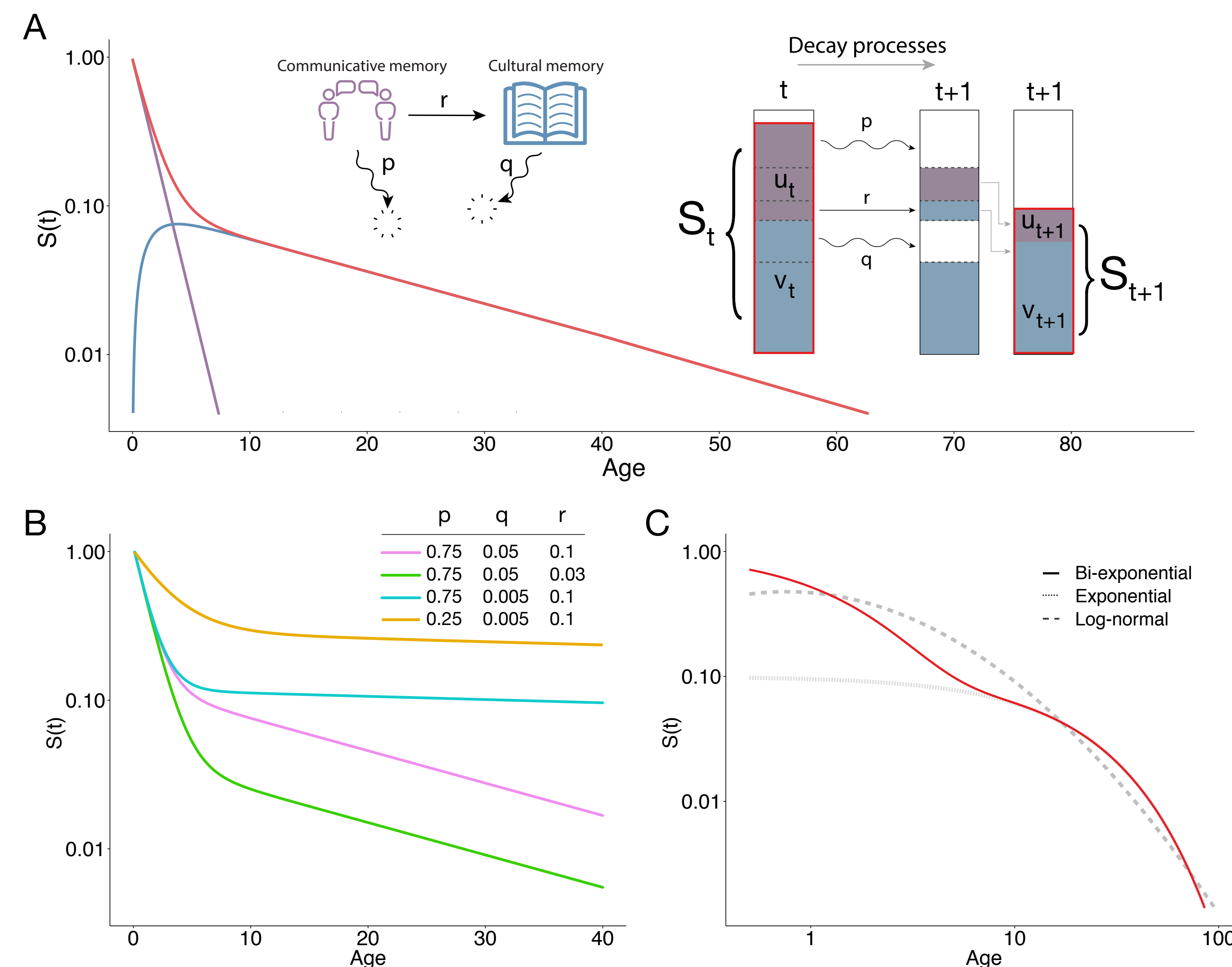
Modelling collective memory. A) The red curve shows the bi-exponential function predicted by our model in log-lin scale. The light-blue and light-green curves show the two exponential of communicative and cultural memory. The inset illustrates the basic mechanics of the model. At any time point t the total memory is the sum of communicative memory u and cultural memory v. Both communicate and cultural memory decay with their own respective decay rates p and q. B) The bi-exponential model (Eq. 1) for various parameters p, q, and r, can account for a wide range of decays. C) Comparison between the bi-exponential model (in red), and the exponential and log-normal models in log-log scale.
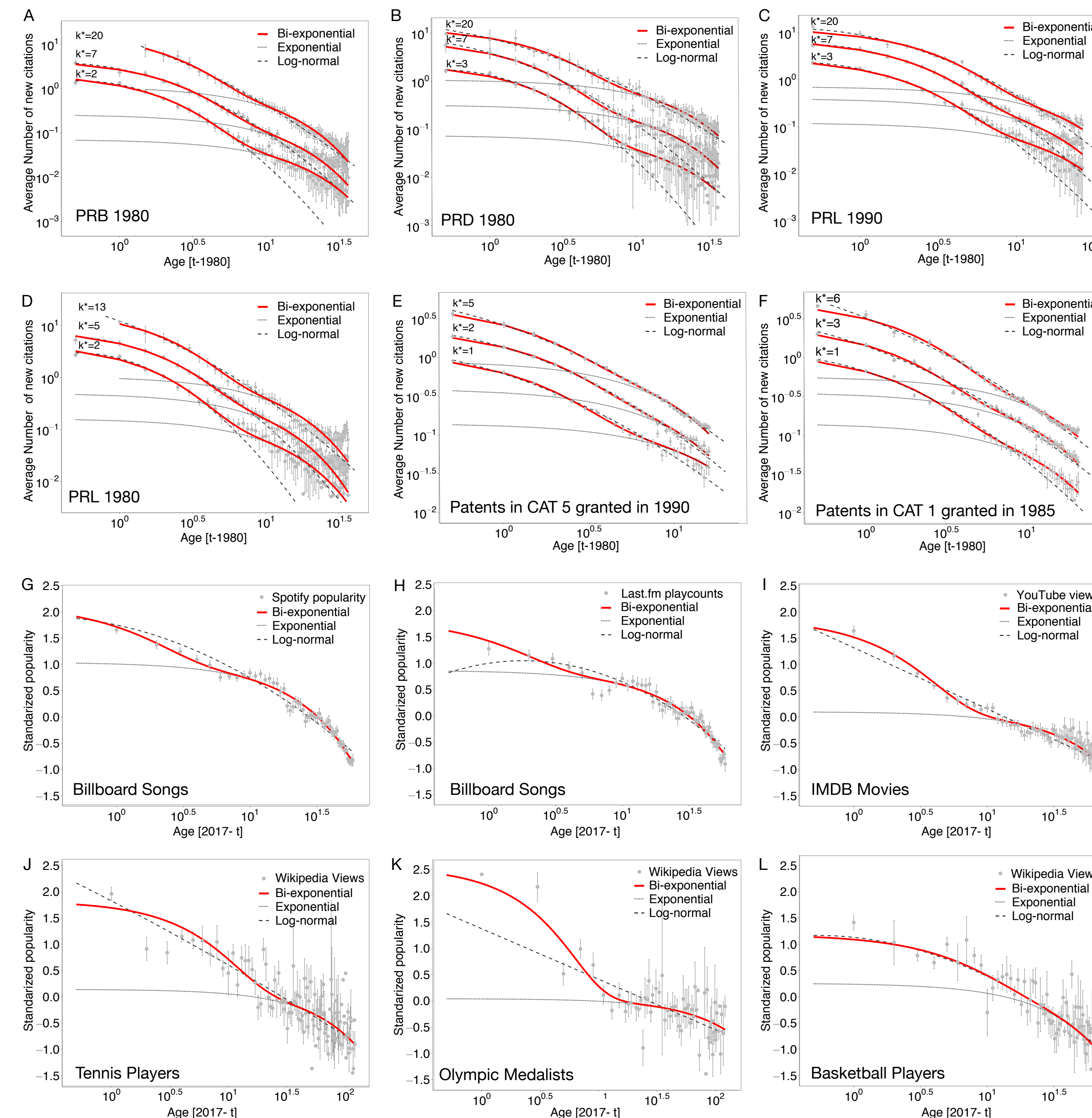
$$u(t) = Ne^{-(p+r)t}$$

$$v(t) = \frac{Nr}{p+r-q}\left(e^{-qt} - e^{-(p+r)t}\right)$$

$$S(t) = \frac{N}{p+r-q}\left[(p-q)e^{-(p+r)t} + re^{-qt}\right] \quad (1)$$

$$t_c = \frac{1}{p+r-q}\log\left(\frac{(p+r)(p-q)}{rq}\right) \quad (2)$$

DATA & RESULTS

The universal decay of collective memory. Average number of new citations received by All papers published in A) Physical Review B in 1980, B) Physical Review D in 1980, C) Physical Review Letters in 1990, D) Physical Review L in 1980, E) All Mechanical patents granted in 1990, and F) All Chemical patents granted in 1985.

Next, for cultural pieces we have the standardized popularity of G) Songs based on spotify's popularity index (y-axis) as a function of the date the song first appeared in the Billboard ranking (x-axis). H) Songs based on Last.fm's play counts (y-axis) as a function of the date the song first appeared in the Billboard ranking (x-axis). I) Movies based on YouTube's view counts (y-axis) as a function of the date the movie was released (x-axis). J) Tennis players based on Wikipedia's page views (y-axis) as a function of the date that the tennis player was included in the Top 600 International males singles tennis player (x-axis). K) Olympic medalist based on Wikipedia's page views (y-axis) as a function of the date of the middle of the career of the Olympic medalist. L) Basketball players based on Wikipedia's page views (y-axis) as a function of the date that the Basketball player starts his career (x-axis). Red lines show our bi-exponential model fit, the dashed lines and dotted lines show a log-normal decay and a exponential decay. Error bars represent standard errors.
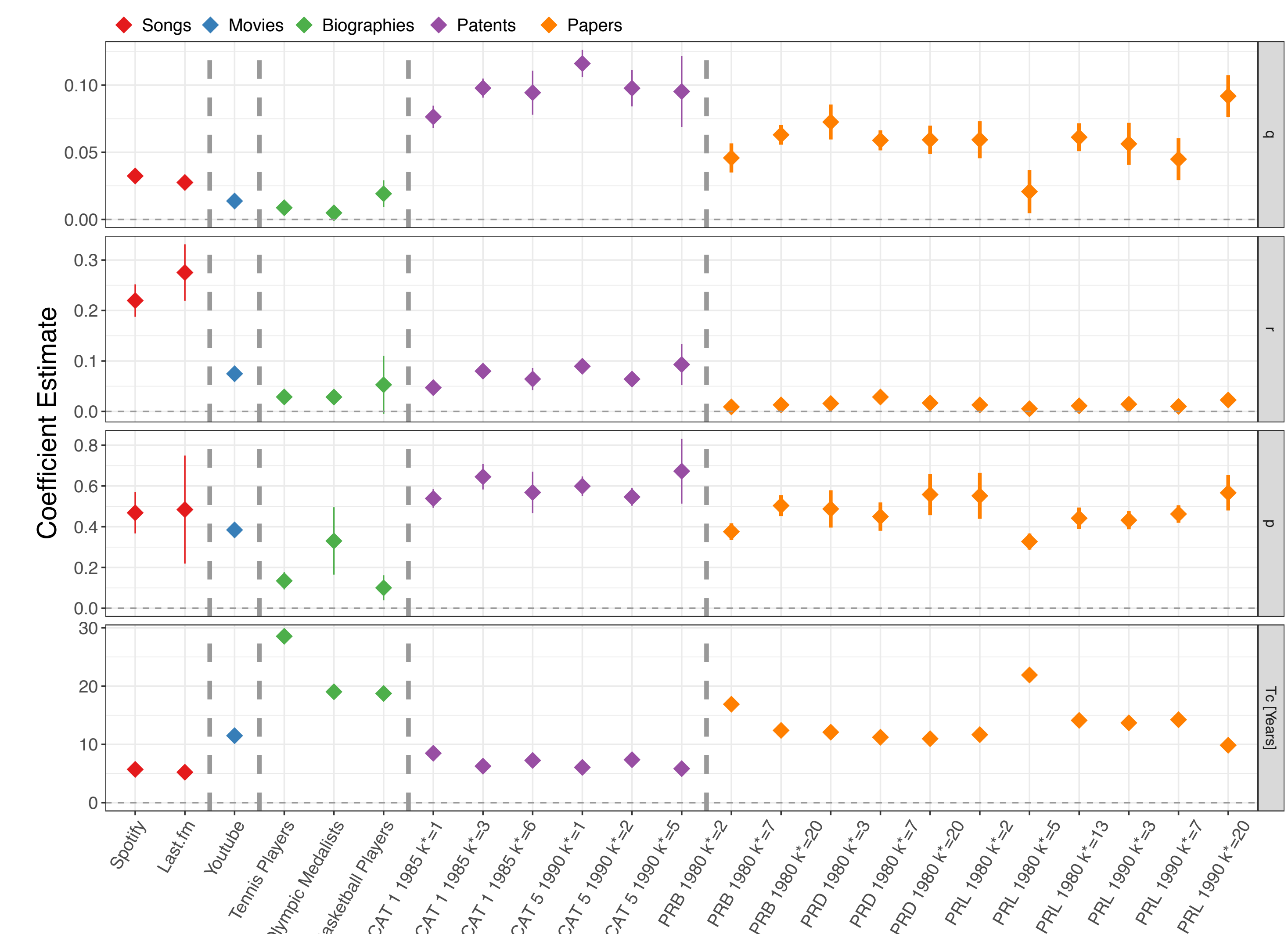
Model's parameters described by Eq. 1, and showed on figure 2. Each box correspond to a model's parameter and colors represent the type of cultural piece. The critical time, T_c, is calculated by Eq. 2, and it is measured in years. Bars represent the standard deviation of the coefficient estimation.

DISCUSSION

Here we show that this fast decay followed by a mild decline is a universal bi-exponential curve that can be derived from first principles from two concepts already in the literature on collective memory: the ideas of communicative and cultural memory. We show that this bi-exponential decay offers a more accurate description of the decay function than previously proposed models, validating these mechanisms, and also, that it produces parameters that can be readily interpretable.

Our results empirically validate the concepts of communicative and cultural memory and show that the decay of collective memory is universal across a variety of domains.