

The Paradox of Modern Love: Why Romantic Signals Decline in Developed Societies

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Abstract

Converging evidence shows that the cultural importance of romantic love has increased dramatically with societal development; it now serves as a primary criterion for choosing partners, a foundation for family formation, and a pervasive theme in cultural production. Yet here we show that this rise does not continue indefinitely: romantic love peaks and then declines at the highest levels of development. This rise-and-fall pattern emerges both cross-nationally (9,474 participants across 45 countries) and diachronically (automatic annotations of 13,409 U.S. movies, 1971–2020). This poses a puzzle: if romantic love sustains long-term pair-bonds, and if safer, more affluent environments make such bonds more viable, why would love decline where it should thrive? We resolve this paradox by proposing that what declines is not love itself, but the need to signal it. Using a formal model and cross-national analyses ($N=7,333$ and $84,382$), we show that when long-term commitment becomes common, overt romantic signaling becomes unnecessary and even counterproductive: the most committed individuals benefit from not signaling, because doing so would reveal that they expected the relationship to need reassurance. In affluent societies, love becomes quieter not because bonds are weaker, but because they are more secure.

Introduction

Romantic love is commonly understood as a psychological mechanism whose primary function is to sustain long-term pair-bonding and cooperative parenting (Fletcher et al., 2015). By motivating individuals to form stable relationships over extended time horizons, romantic love increases the likelihood that offspring receive sustained care and investment (Quinlan, 2007; Kowal et al., 2019; Conroy-Beam et al., 2015; Walter et al., 2024).

From this functional perspective, the benefits of romantic love should scale positively with societal development. Why? When material needs are secure and the future is less uncertain, long-term investments become more worthwhile (Boon-Falleur et al., 2025; Mell et al., 2021; Pepper & Nettle, 2017), and individuals develop longer time horizons (Bulley & Pepper, 2017;

Griskevicius et al., 2011; Sunde et al., 2022). Therefore, durable pair-bonds should be especially advantageous in such environments (Li & Zheng, 2021; see Boon-Falleur et al., 2025).

Consistent with this hypothesis, evidence from literary history, quantitative text analysis and econometric methods show that societal development is associated with and causally increases references to romantic love over historical time. This pattern holds across European and non-European cultures alike, including the Arab world, Persia, India, China and Japan (Baumard et al., 2022; Zhong et al., 2023, 2025; Samani et al., 2025). Synchronic evidence points in the same direction: a cross-cultural survey of 9,474 participants across 45 countries reports higher levels of intimacy, passion, and commitment in societies with higher Human Development Index (HDI) (Sorokowski et al., 2023). Together, historical analyses and contemporary cross-cultural surveys converge on the same conclusion: romantic love increases as societies become more secure.

Yet this relationship may not continue indefinitely. Recent cross-national data suggest that reports of romantic love peak and then decline in the most developed societies (Sorokowski et al., 2023). This quantitative trend resonates with a familiar everyday experience: in affluent societies, overt romantic demonstrations often produce discomfort rather than admiration. Grand declarations and conspicuous devotion are frequently perceived as excessive, eliciting the awkwardness commonly labeled ‘cheesy’. Dowd and Pallotta (2000) documented a related shift in Hollywood cinema, showing that sincere romantic dramas have progressively given way to ironic romantic comedies, as though idealized love can no longer be portrayed without self-conscious distance. Giddens (1992) similarly argued that idealized romantic love is increasingly replaced by less demonstrative forms of intimacy in modern societies.

This poses a puzzle for functional accounts of love. If romantic love is a mechanism designed to sustain long-term pair-bonds, and if safer, more affluent environments make such bonds more viable, why would love decline in the very societies where it should thrive?

We propose that this paradox arises from a change in the adaptive value of romantic signals. Expressions of romantic love signal commitment, but they also reveal something about the sender’s expectations: specifically, how much reassurance they believe the relationship requires. In environments where trust is uncertain and long-term commitment cannot be taken for granted, overt romantic signals serve a clear function: they reduce doubt, align expectations, and stabilize cooperation. In contrast, in high-trust environments where commitment is increasingly presumed rather than negotiated, the same signals can acquire a different meaning. Rather than reassuring, they may imply that the sender believes reassurance is still necessary, that the relationship is fragile, uncertain, or insufficiently secure.

Under these conditions, romantic signaling could become counterproductive. When individuals anticipate the possibility of deep, low-maintenance cooperation (i.e., relationships that operate without constant reassurance) overt signals may force a reclassification of the relationship into a lower-trust mode, with shorter-term benefits. This reclassification carries an opportunity cost: what appeared to be a high-trust, high-cooperation relationship is downgraded to one requiring explicit proof and more direct reciprocation. The signal becomes aversive not because it indicates low commitment, but because it eliminates the possibility of an even more secure, long-term, effortless bond.

In this paper, we formalize this intuition and test some of its empirical implications. We first establish that romantic content in U.S. film production follows a rise-and-fall trajectory over the past five decades, confirming diachronically the cross-national pattern suggested by Sorokowski et al. (2023). We then present a model of cooperative signaling in which romantic expressions convey both commitment and beliefs about partner trust, predicting that overt signaling becomes unnecessary and even aversive in high-trust environments. We then test these predictions using converging evidence from cultural time series, cross-national survey data, and behavioral indicators of relationship stability. Across these domains, we show that as socio-economic development increases, infidelity becomes less common, and ostensive romantic signaling declines while core pair-bonding motivations remain significantly more stable. Together, these findings suggest that the apparent decline of romantic love in affluent societies reflects not weaker bonds, but stronger ones: relationships that no longer require reassurance and short-term reciprocation to endure.

Study 1: Romantic expression rises and falls in U.S. film history

Aim

The cross-national evidence reported by Sorokowski et al. (2023) reveals a non-monotonic relationship between socio-economic development and romantic expression across societies. However, cross-sectional data cannot rule out that this pattern reflects stable cultural differences between countries rather than a developmental trajectory. To assess whether the rise-and-fall pattern also characterizes historical change within a single society, we analyze cultural production over time using a pre-registered, diachronic approach.

Cultural artifacts offer a valuable window into collective psychological orientations: they reflect the concerns, ideals, and emotional expectations of their audiences, and their production responds to demand-side pressures that track population-level preferences (Baumard et al., 2023). We focus on narrative fiction films, which are particularly well-suited to this approach because romantic content is both frequent and naturally variable, and because large annotated corpora are available.

Methods

Dataset

We analyzed a corpus of U.S. feature films released between 1971 and 2020. The initial dataset comprised 13,415 films; after exclusions (films for which the language model returned no valid score), the final analytic sample included 13,409 films. The dataset was deposited on OSF at the time of pre-registration (<https://osf.io/84k6w/>)

Measures

Following the protocol recommended by Dubourg et al. (2024), we obtained LLM-generated annotations of two love-related constructs for every film in the corpus: a broad General Love score and a stricter Romantic Love score. We used the API of GPT-4 with a temperature of 0, providing the following standardized prompts (with [Title] replaced by the film title).

For General Love: “Rate the significance of love in each movie on a scale from 0 to 10, where 0 represents a complete absence or irrelevance of love, and 10 indicates that love is central and extremely relevant. Focus exclusively on the presence and impact of love between partners, setting aside other forms of love or relationships such as familial bonds or friendships. Provide a very brief justification. You must write the score after / SCORE = / at the end, with no text nor symbol after. If you don't know the movie, score NA. The movie is: [Title].”

For Romantic Love: “Romantic love is defined as an all-consuming type of love, which is unconditional and enduring, capable of overcoming challenges and standing the test of time. Rate the significance of romantic love in each movie on a scale from 0 to 10, where 0 represents a complete absence or irrelevance of romantic love, and 10 indicates that romantic love is central and extremely relevant. Focus exclusively on the presence and impact of romantic love between partners, setting aside other forms of love or relationships such as familial bonds or friendships. Provide a very brief justification. You must write the score after / SCORE = / at the end, with no text nor symbol after. If you don't know the movie, score NA. The movie is: [Title].”

For each of the two annotations, the numeric score was parsed from the model’s response using regular expressions. The accompanying justification was retained as the text preceding the SCORE marker. Films for which the LLM declined to rate (e.g., “I don’t know this movie”, or responses requesting disambiguation) were assigned a missing score. After parsing, a valid General Love score was available for 12,505 films (93.2 % of the corpus) and a valid Romantic Love score for 12,369 films (92.2 %). All subsequent analyses use these two analytic samples.

Validity check

The external validity of each score was tested using the IMDb Romance genre tag as an independent ground-truth label. We compared the mean score between films tagged as Romance and films not tagged as Romance using Welch’s two-sample t-test (two-sided). The pre-registration specified that the temporal analyses would be conducted only if the average score of Romance-tagged films was significantly higher than that of non-Romance films ($p < .05$, one-sided direction pre-specified) on both outcomes; failure would be interpreted as a compromise of external validity and would stop further hypothesis testing.

Statistical analysis

To test the pre-registered prediction of a temporal decline in romantic expression (Sorokowski et al., 2023), we fit four ordinary least squares regression models per outcome, consistent with the pre-registered analysis plan:

(M1) a linear model with release year as the sole predictor, (M2) a linear model additionally controlling for the number of films released in the same year (`n_movies_year`, a production-volume control), (M3) a quadratic model including both a linear and a squared year term, and (M4) a quadratic model with the production-volume control.

In all four models, year was mean-centered and z-scored so that the linear and quadratic coefficients are interpretable as standardized betas; the squared term and the production-volume

control were also z-scored for comparability. The production-volume control was computed as the within-sample count of films per release year, following the pre-registration. Standardizing the predictors does not affect AIC ranking or inferential statistics.

Model selection followed the pre-registered rule: we retained and interpreted the model with the lowest AIC. The pre-registered hypothesis was that (i) if a linear model was selected, the coefficient of year would be negative and significant, or (ii) if a quadratic model was selected, the coefficient of year² would be negative and significant. Inference was based on two-sided t-tests of the fixed effects, and 95 % confidence intervals were obtained from the model-based standard errors (no correction for multiple comparisons was applied because the two outcomes are treated as a primary pre-registered test and a replication, respectively). All analyses were conducted in R version 2025.09.1+401 using base regression functions.

Results

Before testing the focal hypothesis, we verified that the LLM-derived scores behaved as expected: films tagged by IMDb as belonging to the Romance genre should score substantially higher than non-Romance films. A Welch two-sample t-test confirmed this pre-registered expectation, with Romance films scoring on average 3.95 points higher than non-Romance films on the 0–10 scale ($M_{\text{Romance}} = 6.76$, $SD = 2.46$, $n = 2,079$; $M_{\text{non-Romance}} = 2.80$, $SD = 2.57$, $n = 10,290$; $t(2,532) = 67.63$, $p < .001$). The scores therefore meet the pre-registered validity criterion and we proceeded with the diachronic analysis.

Following the pre-registered analysis plan, we fit four OLS regression models predicting the Romantic Love Score. Both quadratic models clearly outperformed their linear counterparts ($AIC_{\text{linear}} = 57,423.18$; $AIC_{\text{linear+control}} = 57,412.00$; $AIC_{\text{quadratic}} = 57,354.74$; $AIC_{\text{quadratic+control}} = 57,351.73$), with the quadratic-with-control model providing the best fit. Compared to the simple linear model, this represents a reduction of $\Delta AIC = 71.45$, indicating overwhelming support for a non-monotonic specification (relative likelihood $< 10^{-15}$).

In the best-fitting model, the quadratic term for year was negative and significant (unstandardized $b = -1.05 \times 10^{-3}$, $SE = 1.32 \times 10^{-4}$, $t = -7.90$, $p < .001$, 95 % CI $[-1.30 \times 10^{-3}, -7.86 \times 10^{-4}]$; standardized $\beta = -0.20$, 95 % CI $[-0.25, -0.15]$), confirming the pre-registered prediction of a curvilinear, rise-and-fall trajectory. The linear year term remained positive ($b = 1.25 \times 10^{-2}$, $SE = 3.98 \times 10^{-3}$, $t = 3.14$, $p = .002$, $\beta = 0.17$), consistent with a concave pattern that crests within the observation window. The control for the yearly number of films released was small but significant ($b = -1.03 \times 10^{-3}$, $SE = 4.61 \times 10^{-4}$, $t = -2.24$, $p = .025$, $\beta = -0.11$), and its inclusion left the quadratic year term essentially unchanged, indicating that the rise-and-fall of romantic content is not an artifact of the increasing supply of films produced over time.

The fitted trajectory confirms the predicted pattern: romantic content rose across the 1970s and 1980s, peaked in the mid-1990s to early 2000s, and declined thereafter, returning by the late 2010s to levels comparable to those of the early 1980s (Fig. 1C).

The same analytic pipeline applied to a more general score of romantic love ($n = 12,505$ films) yielded a virtually identical pattern. The validity check again passed ($M_{\text{Romance}} = 7.08$ vs. $M_{\text{non-Romance}} = 2.89$; $t(2,654) = 71.37$, $p < .001$), the quadratic-with-control model again provided the

best fit ($AIC_{\text{linear}} = 59,726.31$; $AIC_{\text{linear+control}} = 59,718.12$; $AIC_{\text{quadratic}} = 59,653.35$; $AIC_{\text{quadratic+control}} = 59,652.30$; ΔAIC vs. linear = 74.01), and the quadratic year term was negative and even stronger than for romantic love ($b = -1.16 \times 10^{-3}$, $SE = 1.40 \times 10^{-4}$, $t = -8.24$, $p < .001$, $\beta = -0.22$, 95 % CI $[-0.27, -0.17]$). The convergence of the two operationalizations indicates that the diachronic rise-and-fall generalizes across narrower and broader definitions of love in cultural production.

These results provide the first diachronic evidence that romantic expression in cultural production follows a non-monotonic path, rising with societal development and declining at the highest levels. The convergence between the cross-national survey pattern reported by Sorokowski et al. (2023) and our within-society cultural time series strengthens the case that this pattern reflects a systematic shift in the function or valuation of romantic signals, rather than idiosyncratic cultural trends or stable between-country differences.

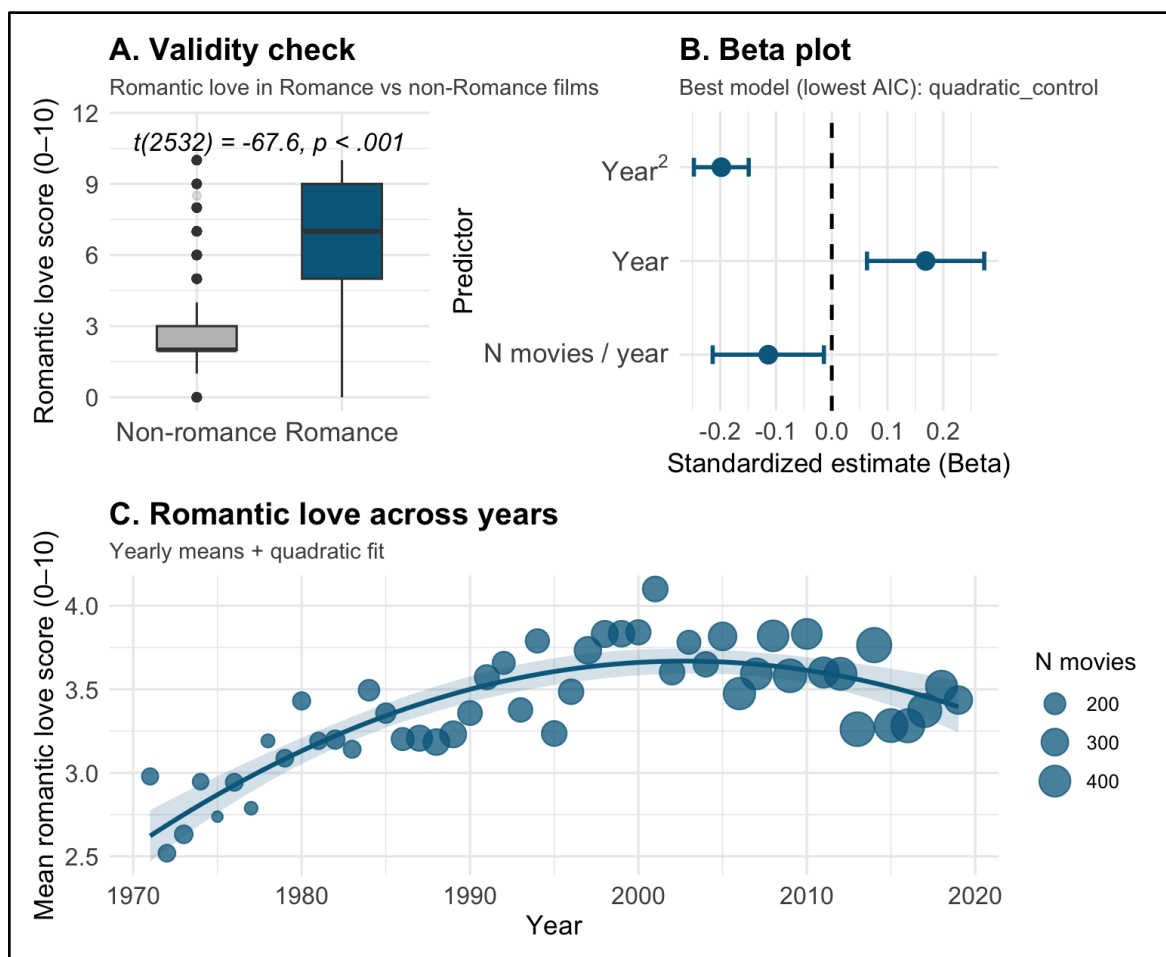


Figure 1. Romantic love in English-language cinema rises and then decreases. **A.** Validity check: distribution of romantic love scores (0–10) in Romance-genre films (blue, $n = 2,069$) versus non-Romance films (grey, $n = 10,300$). Welch two-sample t-test, $t(2,532) = -67.6$, $p < 0.001$, Cohen’s $d = 1.94$, confirming that the GPT-4 annotation successfully recovers the genre signal. **B.** Standardized fixed-effect estimates (β) with 95% confidence intervals from the best-fitting model of romantic-love score on release year (AIC-selected: quadratic + control for yearly sample size). $Year^2$ is negative and Year positive, indicating a rise-and-fall trajectory. Dots are point estimates; whiskers are 95% CIs. **C.** Yearly mean romantic love score across release years (each dot = one year, size proportional to the number of films in that year, $n = 50$ years, 1970–2019; years with fewer than 100 films removed). The blue line is the fitted quadratic trend with 95% confidence band. All analyses are pre-registered.

Study 2: A model of commitment signaling under uncertainty

Aim

To clarify the mechanism underlying the paradox described above, we introduce a formal model (detailed in Method and Supplementary Note 1). The goal of the model is not to reproduce the full complexity of romantic relationships, but to isolate a minimal set of assumptions under which signals of commitment can become counterproductive.

Model

We develop a model of costly signaling in cooperative relationships, building on a framework in which cooperation serves as a signal of time preferences (Lie-Panis & André, 2022; Lie-Panis & Hilbe, 2026). Full details and derivations are provided in Supplementary Note 1.

Players

We consider a long-lived signaler matched with a short-lived chooser. The signaler's discount factor δ is privately known and takes one of three values: $\delta_L < \delta_M < \delta_H$, corresponding to low, medium, and high-patience types, drawn with probabilities p_L , p_M , and p_H . The chooser is either high-trust (probability q_H) or low-trust (probability $q_L = 1 - q_H$).

Matching

With probability r , matching is assortative: high-patience signalers are paired with high-trust choosers, while other signalers are paired with low-trust choosers. With probability $1 - r$, matching is random. As a result, high-trust choosers hold more favorable prior beliefs about signaler patience than low-trust choosers.

Timing

The game has three phases. In Phase 1, the signaler privately observes their type and decides whether to pay cost $k > 0$ to send a signal. In Phase 2, the signaler is matched with a chooser, who observes the signaling decision, permanently sets the level of cooperation—high or low—and decides whether to extend trust. In Phase 3, the signaler and chooser play an infinitely repeated trust game at the chosen level: in each round, the chooser decides whether to trust the signaler; if trusted, the signaler decides whether to reciprocate or cheat.

Cooperation levels

Cooperation can occur at two levels, reflected in trust game payoffs. At level $l \in \{L, H\}$, trust costs the chooser $\gamma_l > 0$ and earns the signaler $b_l > 0$; reciprocation costs the signaler $c_l > 0$ and earns the chooser $\beta_l > 0$. Mutual cooperation is net beneficial for both players ($\gamma_l < \beta_l$, $c_l < b_l$), and payoffs are larger at the high level ($\gamma_L < \gamma_H$, $\beta_L < \beta_H$, $c_L < c_H$, $b_L < b_H$).

Successful cooperation is more beneficial at the higher level for both players ($b_L - c_L < b_H - c_H$, $\beta_L - \gamma_L < \beta_H - \gamma_H$), but harder to sustain, with reciprocation requiring more patience ($c_L / b_L < c_H / b_H$) and trust requiring more favorable beliefs ($\gamma_L / \beta_L < \gamma_H / \beta_H$).

Other parameter assumptions

We assume that signaler types span both thresholds ($\delta_L < c_L / b_L < \delta_M < c_H / b_H < \delta_H$), leading them to adopt different behaviors in equilibrium, with low-patience types cheating regardless of level or reputation, medium-patience types reciprocating at the low level and cheating at the high level, and high-patience types always reciprocating trust. We also assume that the signaling costs are sufficient to deter low-patience signalers in and of themselves ($k > \delta_L b_L$); that is, even in the absence of social benefits coming from not sending the signal (i.e., attracting the trust of high-trust choosers in the aversive signaling equilibrium).

Reputations

The signaler has two observable attributes: their signaling decision (sent or did not send, fixed after Phase 1), and their trust game reputation, reflecting their last reciprocation decision: good if they last reciprocated, bad if they last defected, unknown if they have never been trusted. The chooser observes both when deciding whether to extend trust.

Strategies

A chooser strategy specifies what level of cooperation to initially choose, as a function of their type (high-trust or low-trust) and the signaler's initial signaling decision (sent or did not send); and whether to extend trust, as a function of own chooser type, the level of cooperation, and the signaler's full reputation. A signaler strategy specifies whether to reciprocate trust, as a function of own signaler type (high-, medium-, or low-patience), the level of cooperation, and own current reputation.

Equilibrium analysis

We study Perfect Bayesian Equilibria in pure strategies (Fudenberg & Tirole, 1991). PBE is the standard solution concept for sequential games with incomplete information, and aligns with evolutionary simulations in related settings (Hoffman et al., 2018; Lie-Panis & Hilbe, 2026).

We focus on the following strategy profile, which we call the aversive signaling equilibrium: (1) Medium-patience signalers initially send the signal, low and high-patience signalers do not send. (2) When faced with a sender, both high and low-trust choosers set the level of cooperation at low and extend trust. When faced with a non-sender, high-trust choosers set the level of cooperation at high and extend trust, while low-trust choosers set the level of cooperation at low and distrust. (3) Subsequently, all choosers trust based on trust game reputation only, trusting signalers with good reputation and distrusting those with bad reputation regardless of initial signaling decision. Signaler reciprocation behavior is a function of own type and cooperation level, as detailed above.

We derive five conditions that are jointly necessary and sufficient for the aversive signaling equilibrium to exist (Supplementary Note 1, conditions 3.3–3.7).

To characterize the equilibrium domain (Figure 2.C.), we adopt a binomial parametrization that reduces both signaler and chooser types distributions to a single parameter $\mu \in (0, 1)$, capturing both the level of patience and trust in the shared population: $p_H = q_H = \mu^2$, $p_M = 2\mu(1 - \mu)$, $p_L = q_L = (1 - \mu)^2$. We assume symmetric payoffs ($\gamma_i = c_i$, $\beta_i = b_i$) and fix the high-level surplus at $b_H - c_H = s(b_L - c_L)$, with $s = 3/2$. We evaluate the five equilibrium conditions on a grid over μ and c_H/b_H . Other parameters: $\delta = (1/8, 1/2, 7/8)$, $c_L = 2/5$, $b_L = 1$, $r = 7/10$, $k = 1/4$.

Result

The model captures two adaptive problems that arise in any relationship built on mutual cooperation. First, individuals must attract and maintain trust, bearing the immediate costs of cooperation to build a reputation that sustains the relationship over time. Second, they must decide whether to extend trust, predicting their partner's future behavior based on incomplete information. In the model, these problems are separated into two roles: a signaler, who manages their reputation by deciding whether to reciprocate trust, and a chooser, who decides whether and how much to trust based on what they observe. The signaler's willingness to reciprocate depends on their patience: how much they value future interactions relative to the immediate cost of cooperating. More patient signalers reciprocate trust because the long-term benefits of maintaining trust outweigh the short-term savings from cheating. The chooser's challenge is to identify such partners, using the information available to them: the signaler's past reciprocation behavior, their signaling decisions, and the chooser's prior beliefs about the kind of partner they are likely to encounter.

Cooperation can occur at two levels. The high level is more rewarding for both partners when it succeeds, but harder to sustain, requiring more patience from the signaler and more favorable beliefs from the chooser. Signalers belong to one of three types, reflecting different levels of patience and reciprocation: low-patience types always cheat, medium-patience types reciprocate trust only at the low level, and high-patience types always reciprocate.

Choosers are either high-trust or low-trust. This distinction arises entirely from assortative matching: patient signalers are more likely to be paired with high-trust choosers, so that high-trust choosers have reason to be more optimistic about the signaler's patience. Before interaction, the signaler may choose to send a costly signal: a visible gesture that reveals information to the chooser but does not change the signaler's type. After observing whether a signal was sent, the chooser permanently sets the level of cooperation and decides whether to extend trust.

We show that this model admits an equilibrium in which signaling is aversive to high-trust choosers, represented in Figure 2.A-B. In this equilibrium, only medium-patience signalers send the signal. Choosers interpret the signal accordingly: a signaler who sends reveals that they can sustain only low-level cooperation, so both chooser types set the level at low and

trust. A signaler who does not send is ambiguous: they are either low or high patience. Low-trust choosers, who tend to be matched with less patient signalers, resolve this ambiguity unfavorably and distrust entirely. High-trust choosers resolve it favorably: they set the level at high and trust.

The signal is aversive to high-trust choosers because of what it reveals about the signaler's beliefs. Sending the signal communicates an expectation that the partner needs reassurance—that the relationship is uncertain enough to require explicit demonstration. By the model's matching assumption, this expectation is correlated with the signaler's own patience: patient signalers, who tend to be matched with high-trust choosers, expect their partner to extend high-level trust without reassurance, while less patient signalers expect the opposite. From the high-trust chooser's side, this is why receiving a signal is bad news: they were predisposed to expect a patient partner, and the signal reveals instead one who is cooperative but only at a basic level—willing to sustain the relationship, but not to invest in it fully.

Figure 2.C shows the parameter combinations for which the aversive signaling equilibrium exists. The vertical axis varies the difficulty of cooperation: the cost-to-benefit ratio of high-level reciprocation and high-level trust. The horizontal axis captures population patience, by varying a single parameter that determines both the prevalence of patient signalers and of high-trust choosers. As population patience increases, the equilibrium becomes sustainable across a wider range of cooperation difficulties. This is primarily because higher patience makes it easier for high-trust choosers to justify extending high-level trust to non-senders: the more patient the population, the more confident they can be that a non-sender is high-patience rather than low-patience. At very high levels of population patience, however, the equilibrium disappears, because even low-trust choosers resolve the ambiguity of non-sending favorably and trust without needing a signal.

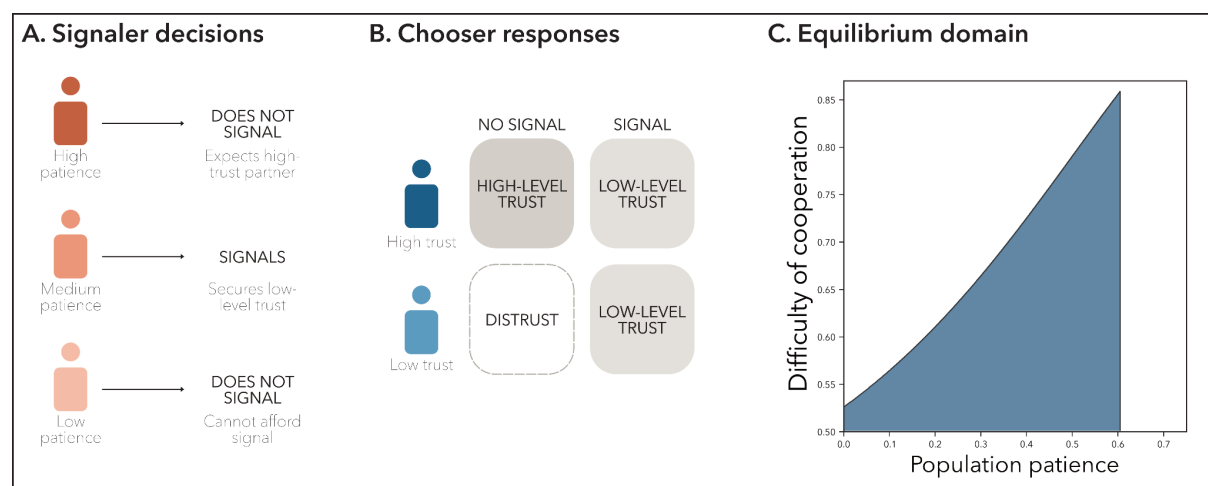


Figure 2. Aversive signaling equilibrium. **A.** Signaler decisions by type. Only medium-patience signalers signal, securing low-level cooperation from both chooser types. High-patience signalers do not signal because they expect a high-trust partner; low-patience signalers cannot afford the signal. **B.** Chooser responses to signalers and non-signalers. High-trust choosers extend high-level trust to non-signalers but downgrade to low-level trust upon receiving a signal. Low-trust choosers distrust non-signalers but upgrade to low-level trust upon receiving a signal. **C.** Domain of the aversive signaling equilibrium. The shaded region shows parameter combinations for which the

equilibrium exists, varying population patience (horizontal axis) and the difficulty of high-level cooperation (vertical axis). See Methods for parameter values.

The model thus identifies conditions under which the intuition motivating this paper holds: signaling can become counterproductive when long-term commitment is common, provided that committed and secure partners co-occur. This logic provides a unified explanation for why overt expressions of romantic love may decline in high-trust environments. Rather than indicating weaker commitment, reduced signaling reflects confidence that commitment no longer needs to be demonstrated. The model therefore predicts that socio-economic development, by reducing uncertainty about long-term commitment, should decrease the prevalence of overt romantic signaling. We test this prediction in the analyses that follow.

Study 3: Socio-economic development selectively reduces romantic signaling

Aim

The formal model developed above predicts not a generalized decline in romantic motivation, but a selective decline in commitment *signaling*. When long-term cooperation is uncertain, individuals benefit from emitting signals that reassure partners of their commitment. However, once long-term commitment becomes sufficiently common in the population, these signals lose their function and even become counterproductive. A critical empirical implication of this logic is that socio-economic development should selectively reduce expressions of love whose primary function is to signal commitment under uncertainty, while leaving intact (or even strengthening) other components of romantic relationships that directly sustain cooperation.

Testing this prediction raises an important measurement challenge. Romantic signaling is not directly observable in standard survey instruments: self-report scales typically measure subjective feelings or behaviors rather than their strategic or communicative function. Nevertheless, many expressions of romantic love plausibly function as signals, especially when they involve partner idealization, that is, portraying the partner or the relationship as uniquely valuable, irreplaceable, or central to one's life. Such expressions are costly in an informational sense: they publicly commit the individual to a specific partner, foreclose alternatives, and expose the individual to reputational or emotional loss if the relationship dissolves (Gelbart et al., 2025). For this reason, partner idealization has long been interpreted as a core ingredient of romantic signaling in both evolutionary and cultural accounts of love (Murray et al., 1996, 2011).

We therefore propose partner idealization as a theoretically grounded proxy for romantic signaling. Importantly, this proxy does not assume that all expressions of love are signals. Instead, it captures systematic variation in the extent to which specific expressions rely on idealization, which are precisely the features expected to decline when commitment becomes taken for granted.

Methods

Dataset and participants

We reanalyzed the large-scale cross-national dataset reported by Sorokowski et al. (2023), comprising 9,474 adults drawn from 45 countries across all inhabited continents. Participants completed the 45-item version of Sternberg's Triangular Love Scale and reported demographic information including age, gender, relationship length, and subjective socio-economic status. The final sample included only participants who indicated that they were currently involved in a romantic relationship (dating, engaged, or married), ensuring that all love ratings referred to an ongoing dyadic bond. After excluding rows with any missing covariate and countries not present in the HDI table, the analytic dataset comprised 324,931 item-level observations from 7,333 participants in 38 countries.

Measures

Romantic love was assessed using the 45-item version of Sternberg's Triangular Love Scale. Each item was rated on a Likert scale reflecting agreement or frequency. Rather than aggregating items into composite scores, we analyzed responses at the item level to preserve theoretically relevant variation.

Each of the 45 Sternberg items was independently rated on a 0–10 scale by four coders blind to the hypotheses, following a written rubric that operationalized “Partner Idealization” as “the extent to which the statement portrays the romantic partner as exceptional, uniquely fulfilling, or beyond ordinary limits”. The four ratings were averaged and rescaled to [0, 1] to form a single item-level PI score ($M = 0.36$, $SD = 0.21$). Inter-rater reliability was high ($ICC_{2k} = 0.88$, two-way random, absolute agreement).

Crucially for our purposes, the items vary widely in their degree of partner idealization. Some items strongly imply idealization and exclusivity (e.g., “Nothing is more important to me than my relationship”), others involve moderate idealization (e.g., “I find my partner very personally attractive”), and still others involve no idealization at all (e.g., “I give considerable emotional support to my partner”).

Country-level socio-economic conditions were indexed using the Human Development Index (HDI). Individual-level socio-economic status (SES) was measured via a self-report item assessing participants' perceived economic standing relative to others in their country.

Statistical analysis

The analysis and stopping rules were pre-registered. Observation ij (participant i , item j) was modelled as:

$$Y_{ij} = \beta_0 + \beta_1 PI + \beta_2 HDI_i + \beta_3 HDI_i^2 + \gamma_1 (HDI_i \times PI_{ij}) + \beta_4 SES_i + \beta_5 SES_i^2 + \gamma_2 (SES_i \times PI_{ij}) + \beta_6 Age_i + \beta_7 Gender_i + \gamma_3 (Gender_i \times PI_{ij}) + \beta_8 RelLength_i + \gamma_4 (RelLength_i \times PI_{ij}) + u_i + v_j + w_i + e_{ij}$$

with random intercepts u_i (participant), v_j (item) and w_i (country). Continuous predictors were z-scored before estimation so that fixed-effect coefficients are directly comparable in magnitude.

The model was fitted with `lmerTest::lmer` (REML) in R 4.3, and 95% confidence intervals were obtained by parametric bootstrap (1,000 simulations, `bootMer` with `use.u = FALSE`). In case of a singular random-effect structure, we pre-committed to iteratively removing the random effect with the smallest variance component until convergence. The two pre-registered focal effects were γ_1 ($\text{PI} \times \text{HDI}$) and γ_2 ($\text{PI} \times \text{SES}$); both were predicted to be negative and significant.

To corroborate the LMER estimates against alternative assumptions, we re-fit the same fixed-effect specification in Python (NumPy 1.26) as an OLS on the standardized design matrix, and computed 95% cluster-robust confidence intervals at the participant level using both the sandwich estimator (CR1) and a non-parametric cluster bootstrap (500 replications resampling participants). Point estimates from the LMER, OLS, CR1, and cluster bootstrap were all within 0.01 SD of each other, confirming that the main interaction results are not driven by specific modelling choices. Results reported in the main text correspond to the pre-registered LMER.

Effects are reported as standardized β coefficients with 95% confidence intervals and two-tailed p -values against the null of no effect. The complete coefficient table is available in Supplementary Table S4 and on the project OSF repository (<https://osf.io/84k6w/>)

Results

Before turning to the formal statistical model, we illustrate the core pattern at the country level. We split the 45 Sternberg items into high- and low-idealization groups based on their PI scores, computed the mean endorsement of each group per country, and plotted both against HDI (Fig. X). The two trajectories diverge strikingly. Endorsement of low-idealization items (i.e., those describing concrete relational behaviors such as emotional support or shared decision-making) rises steadily with development. Endorsement of high-idealization items (i.e., those portraying the partner as exceptional or irreplaceable) rises at low-to-moderate levels of HDI but then declines at the highest levels, producing the same rise-and-fall pattern observed in U.S. film production (Study 1). This divergence is precisely what the model predicts: development does not reduce love globally, but selectively attenuates its signaling component.

To confirm this pattern statistically, we moved beyond the binary split and exploited the continuous variation in PI across all 45 items. As pre-registered, we modeled each participant's response to each item (324,931 item-level observations from 7,333 participants in 38 countries) as a function of the item's PI score, the participant's country-level HDI and individual-level SES, and their interactions, with random intercepts for participant, item, and country (see Methods for the full specification).

The key prediction is that the effect of development on love scores should depend on how idealizing the item is. This is captured by the $\text{PI} \times \text{HDI}$ interaction. As predicted, this interaction was negative and significant ($\beta = -0.05$, $p < .001$): the more an item implies partner idealization, the more its endorsement declines with development. A parallel effect emerged at the individual level ($\text{PI} \times \text{SES}$: $\beta = -0.01$, $p < .001$): within countries, more affluent individuals selectively endorsed idealizing items less.

Crucially, development did not reduce love scores uniformly. Both HDI and SES showed positive main effects at low-to-moderate levels, with negative quadratic terms (HDI^2 : $\beta = -0.06$, $p < .001$; SES^2 : $\beta = -0.02$, $p < .001$), confirming that the rise-and-fall pattern reported by Sorokowski et al. is driven specifically by signaling-heavy items. Items low in idealization showed stable or increasing endorsement across the full range of development. Additional covariates (age, gender, relationship length) and their interactions with PI are reported in Supplementary Table S4.

These results provide strong support for the model's central prediction. Socio-economic development does not reduce romantic love globally. Instead, it selectively attenuates signaling-based expressions of love. As long-term commitment becomes increasingly secure, overt idealization loses its functional value. Love does not disappear; it becomes 'quieter'.

Interestingly, these results are in line with the diachronic pattern observed in Study 1. In Figure 3, the inflection point (where endorsement of idealizing items begins to decline) falls in the HDI range of approximately 0.7 to 0.85. The United States crossed this range between the mid-1970s and the early 1990s, which corresponds closely to the period in which romantic content in U.S. films peaks before declining (Figure 1). This temporal alignment strengthens the case that the two patterns reflect the same underlying process: as societies move through a critical range of development, the adaptive value of romantic signaling shifts, and cultural production tracks this shift.

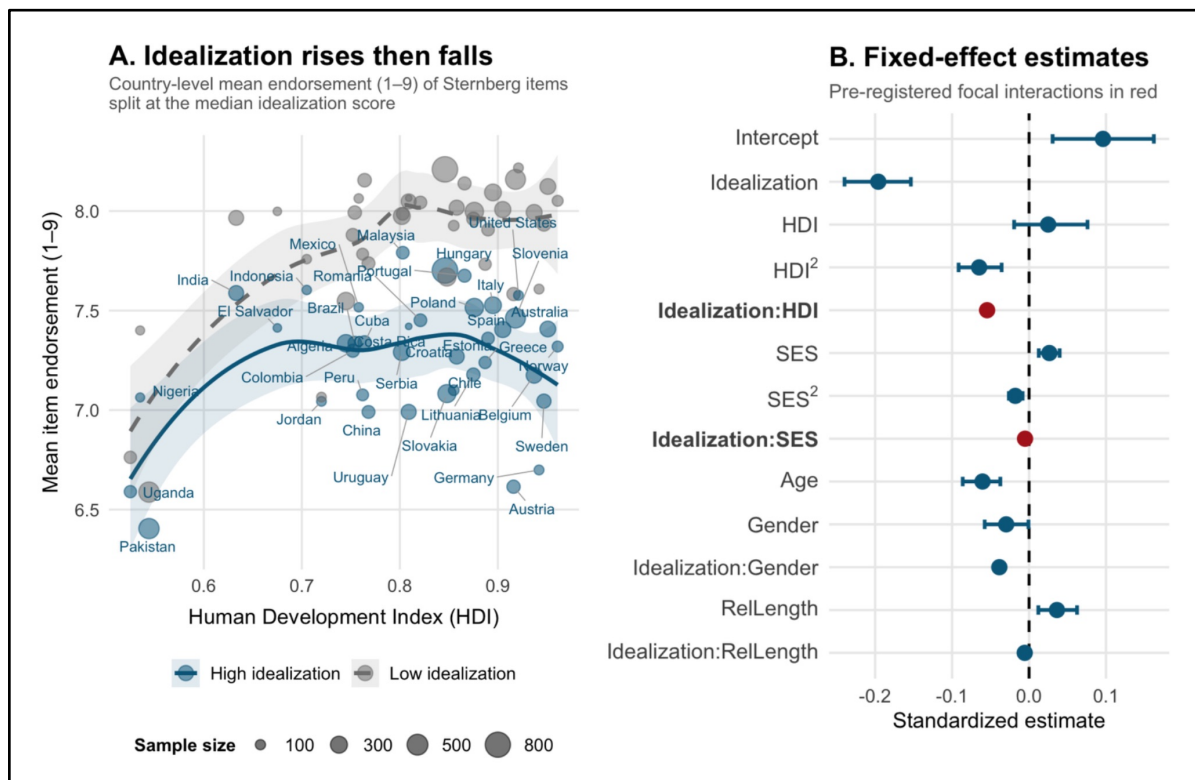


Figure 3. Socio-economic development selectively reduces idealizing expressions of love. **A.** Country-level mean endorsement (1–9) of items from the 45-item Sternberg Triangular Love Scale, plotted against the country's Human Development Index (HDI). Items are split at the empirical median idealization score (0.25): high-idealizing items in blue, low-idealizing items in grey. Each dot is one country ($n = 38$ countries; bubble size proportional to the number of participants per country, range 100–800). Lines are LOESS fits with 95% confidence bands.

Endorsement of low-idealization items rises monotonically with HDI, whereas endorsement of high-idealizing items rises at low-to-moderate HDI but declines at the highest levels, reproducing the rise-and-fall pattern observed diachronically in U.S. cinema (Study 1, Fig. 1) and predicted by the model (Study 2, Fig. 2). **B.** Standardized fixed-effect estimates (β) with 95% confidence intervals from the pre-registered linear mixed-effects model predicting item-level endorsement ($n = 324,931$ observations from 7,333 participants in 38 countries; random intercepts for participant, item, and country; 95% CIs from a 1,000-replication parametric bootstrap). The two pre-registered focal interactions (Idealization $\times$ HDI and Idealization $\times$ SES, in red) are both negative and significant, indicating that more developed countries and more affluent individuals selectively endorse idealizing items less. Continuous predictors are z-scored. Reference category for Gender = Man. Full coefficient table in Supplementary Table S4.

The cross-national data also reveal informative residual variation. At the highest levels of HDI, countries diverge: Germanic and Scandinavian societies (Germany, Austria, Sweden, Norway) fall well below the regression line, displaying the strongest reduction in idealizing expressions, while Anglo-Saxon countries (United States, Australia) fall above it, maintaining relatively high levels of romantic idealization for their level of development. This pattern is consistent with the model's logic. What drives the decline of romantic signaling is not development per se, but the prevalence of interpersonal trust and long-term cooperation. Scandinavian and Germanic societies are characterized by unusually high levels of generalized trust (among the highest in the world; Delhey & Newton, 2005) whereas Anglo-Saxon societies, despite comparable HDI, display lower levels of interpersonal trust. If trust, rather than HDI alone, is the relevant ecological variable, then countries with higher trust should reach the signaling threshold earlier, and reduce romantic idealization more sharply. The residual pattern is precisely what this predicts: HDI is an imperfect proxy for the model's theoretical variable, and the deviations point in the expected direction.

These results offer a reinterpretation of recent findings suggesting that romantic love declines in modern societies. Rather than indicating a reduction in pair-bonding motivation, the observed decline appears to be driven by a subset of expressions that function primarily as commitment signals under uncertainty. When aggregated into composite scores, as in standard uses of the Triangular Love Scale, this selective decline can misleadingly appear as a global reduction in love intensity. An item-level analysis shows that the rise-and-fall pattern reported by Sorokowski and colleagues is not uniform across expressions of love. Items that strongly imply partner idealization decline sharply with development, whereas items low in idealization remain stable or increase. This pattern aligns closely with the model's predictions and suggests that some widely used self-report measures conflate signaling strategies with underlying relational motivation.

Study 3: Socio-economic development predicts lower infidelity

Aim

A central claim of the model is that the value of romantic signaling depends nonlinearly on the prevalence of long-term commitment in the population. When defection is common, even highly committed individuals must signal to avoid being mistaken for opportunistic types, because choosers cannot safely assume commitment in the absence of explicit reassurance. By contrast, once a sufficiently large share of individuals reliably sustain long-term exclusive cooperation, the informational environment changes. At that point, choosers can reasonably treat non-signaling as evidence of commitment rather than as a risk, allowing highly cooperative individuals to refrain

from signaling without incurring coordination costs. In this sense, the decline of romantic signaling requires a threshold condition: long-term commitment must be common enough that trust becomes the default.

Before signaling strategies can change, a threshold must be reached in which long-term commitment is sufficiently common to be taken for granted. We operationalize this threshold as the average prevalence of fidelity within a society: when most individuals reliably sustain exclusive relationships, choosers can infer commitment without requiring explicit reassurance. In other words, only once infidelity becomes sufficiently rare can non-signaling emerge as a stable strategy for highly committed individuals. We test this first-step prediction by examining whether socio-economic development is associated with lower rates of infidelity.

Method

Participants and materials

We analyzed data from a large international online survey on mating and relationship behavior. After restricting to participants with complete responses on the variables of interest (country of residence, perceived socio-economic status, age, gender, and the infidelity items), the analytic sample comprised 84,382 adults from 160 countries. Participants self-reported whether they had engaged in any form of infidelity in their current or most recent relationship (binary: 0 = no, 1 = yes). Country-level human development was quantified using the most recent available value of the UN Human Development Index (HDI) for each country.

Statistical analysis

The focal test was conducted at two complementary levels.

At the country level, we aggregated individual responses by country of residence and computed, for each country, the mean proportion of respondents reporting any infidelity. All 160 countries present in the dataset after HDI harmonization were retained, without any minimum-sample-size cutoff. The association between HDI and mean infidelity was quantified with a Pearson correlation and displayed in Fig. 4 as a scatter plot with country labels and a (non-weighted) linear regression line with a 95% confidence band. Labels were placed using `ggrepel` with a maximum-overlap rule; countries whose labels could not be placed without excessive crowding were left unlabeled, but the underlying data point is still shown.

At the individual level, we fitted a generalized linear mixed-effects model with a binomial likelihood and a logit link, with reported infidelity as the outcome, standardized HDI, SES, age, and gender as fixed effects, and a random intercept for country of residence:

$$\text{logit}(P(\text{infidelity} = 1)) = \beta_0 + \beta_1 \cdot \text{HDI} + \beta_2 \cdot \text{SES} + \beta_3 \cdot \text{Age} + \beta_4 \cdot \text{Gender} + u_{\text{country}}$$

The model was estimated with `lme4::glmer` (R 4.3) using the `bobyqa` optimizer. Continuous predictors were z-scored so that fixed-effect coefficients are directly interpretable on the standardized log-odds scale, and are also reported as odds ratios per one-standard-deviation increase in the predictor.

Reporting

This study was not pre-registered, and the analysis is therefore reported as a directional confirmation of a hypothesis derived from the theoretical model. Full data-processing code, country-name harmonization rules, and the figure-generating script are available on the project OSF repository.

Results

At the country level, HDI and the mean share of respondents reporting any form of infidelity were negatively correlated across all 160 countries in our dataset (Pearson $r = -0.16$, 95% CI $[-0.31, -0.01]$, $p = .040$). The effect is modest in magnitude, as expected when averaging a noisy binary outcome over highly heterogeneous country-level sample sizes, some of which are very small, but the direction is the one predicted by the model.

The individual-level analysis, which exploits the full 84,382-participant sample, provides a more powerful test and confirms the pattern. In a multilevel logistic regression with a random intercept for country ($\sigma^2 = 0.27$, $SD = 0.52$, $n = 84,382$ individuals nested within 160 countries), the focal effect of HDI was negative and significant on the log-odds of reporting any infidelity ($\beta = -0.13$, $SE = 0.04$, $z = -3.24$, $p = .001$; standardized), corresponding to an odds ratio of $OR = 0.88$, 95% CI $[0.81, 0.95]$ per one-standard-deviation increase in HDI. Controlling for age ($\beta = 0.33$, $z = 40.30$, $p < .001$), individual SES ($\beta = 0.04$, $z = 4.70$, $p < .001$), and gender ($\beta_{\text{male}} = -0.10$, $z = -6.10$, $p < .001$) did not alter the direction or significance of the focal effect. Age was by far the strongest individual-level predictor, with older participants reporting more lifetime infidelity, as expected from cumulative exposure. Importantly, individual SES displayed the opposite sign to HDI (positive rather than negative), indicating that the HDI effect cannot be reduced to affluence at the individual level; it operates specifically at the level of societal development.

Together, these results show that infidelity declines with country-level development, paralleling the moderation patterns documented in Study 3. As societies become more developed, people are not only more selective in which items of a love scale they endorse: they are also less likely to actually engage in extra-pair behavior. Both findings converge on the same interpretation: development reshapes romantic life by progressively removing the functional pressure for overt signals of partner commitment.

Discussion

The present work addressed a paradox at the intersection of evolutionary psychology, cultural change, and romantic behavior: why do expressions of romantic love peak and then decline in the most socio-economically developed societies, precisely where long-term commitment should be most advantageous? Across a formal model and multiple empirical tests, we show that this pattern does not reflect a weakening of pair-bonding motivations. Instead, it reflects a shift in the adaptive value of romantic signals: when long-term commitment becomes sufficiently prevalent, overt signaling becomes unnecessary and even counterproductive, because it reveals an expectation that the relationship requires reassurance.

A related logic appears in earlier models. In countersignaling models (Feltovich et al., 2002; Harbaugh & To, 2020), high types stay silent because receivers have access to additional information about them; signaling would then reveal a lack of confidence in this information. In the signal-burying model (Hoffman et al., 2018), high types pay the cost of a signal but conceal it, either because they expect their concealed signal to be revealed anyway, or because they prefer to be noticed only by receivers who care about distinguishing them from medium types. In both classes of model, what makes high types' behavior informative is the existence of an additional, observable source of information, or assumed differences in how different receiver and sender types value each other. Our model relies on a different mechanism: silence is informative because it reveals beliefs about the match itself, and these beliefs are correlated with type through assortment alone.

The empirical results closely track this logic. Socio-economic development predicts lower rates of infidelity, consistent with the first ecological condition of the model: trust and commitment must become widespread before signaling strategies can change. Once this threshold is reached, development selectively attenuates signaling-heavy expressions of love, while leaving intact—or even strengthening—non-signaling components such as emotional support and relational care.

An important implication of our account is that romantic signals do not merely lose relevance in affluent societies: they can become actively aversive. In high-trust environments, overt signaling may downgrade the perceived relationship by implying that reassurance is still required and long-term commitment is not secured. What might otherwise be interpreted as confidence and stability becomes reclassified as insecurity or short-termism. This reclassification carries an opportunity cost: it forecloses access to a high-trust, low-maintenance form of cooperation.

This logic helps explain a phenomenological shift that is difficult to account for using standard economic or sociological explanations alone. If romantic love were simply less necessary, one would expect indifference or attenuation. Instead, people often report discomfort, embarrassment, or social awkwardness in response to overt romantic displays. Our model predicts precisely this reaction: signals that were once reassuring become informative of miscalibration, and are therefore rejected.

Our account also offers a more precise alternative to existing sociological explanations of the same phenomenon. Several influential accounts have described the retreat of idealized romantic love in modern societies, attributing it to the rationalization of intimacy (Giddens, 1992), the demystification of romance under postmodernity (Dowd & Pallotta, 2000), the commodification of emotional life under capitalism (Illouz, 2012, 2019), or the liquefaction of social bonds in late modernity (Bauman, 2003). While these accounts capture the phenomenology of the shift, they share two limitations. First, they predict a general erosion of romantic attachment, yet our data show that non-idealizing expressions of love (e.g., emotional support, care, relational investment) remain stable or increase with development. The decline is selective, not global. Second, these accounts offer no mechanism that would explain *why* idealization specifically becomes aversive rather than merely irrelevant. Our model provides such a mechanism: signaling becomes counterproductive because it reveals an expectation of uncertainty that is inconsistent with the high-trust environment.

More broadly, these findings illustrate how ecological changes can alter the meaning of signals without altering their form. Romantic gestures, declarations, and idealization cues may persist, but their interpretation depends on background levels of trust. As environments become safer and cooperation more reliable, the same behaviors can reverse their informational valence. This logic likely extends beyond romantic relationships. Many domains of social life, from gift-giving to moral grandstanding, rely on signals whose value depends on background uncertainty. When trust is scarce, signals stabilize cooperation. When trust is abundant, signals can crowd out deeper forms of cooperation (Feltovich et al., 2002; Harbaugh & To, 2020). Romantic love offers a particularly clear case because the stakes of miscoordination are high and the signals are salient.

Several limitations warrant discussion. First, while we used multiple converging methods, our infidelity measure relies on self-report and may be affected by social desirability biases. However, such biases would need to vary systematically with HDI in a way that mimics the model's predictions, which seems unlikely. Second, while partner idealization is a theoretically grounded proxy for signaling, future work could test additional behavioral measures, such as public declarations, costly gifts, or social media displays. More generally, future research could examine within-society variation in trust environments, for instance across neighborhoods. The model predicts that signaling should re-emerge whenever trust becomes locally uncertain, even within otherwise affluent societies. Finally, our evidence remains correlational. Although the convergence of cross-national, longitudinal, and item-level patterns is consistent with the proposed signaling mechanism, direct experimental tests are needed to establish causality. Future work could manipulate trust environments and signal intensity in vignette or behavioral paradigms to test whether romantic signals indeed lose their reassuring function and acquire a counterproductive one when commitment is taken for granted.

More broadly, the same logic may extend to non-romantic forms of socialization. Many social bonds (e.g., friendships, kinship ties, patron–client relationships, professional alliances) are sustained by expressions of loyalty, devotion, or affection that function, at least in part, as costly signals of commitment. Cross-cultural variation in these expressions is striking: effusive declarations of friendship, elaborate kinship rituals, oaths of professional loyalty, and ostentatious displays of in-group devotion are far more prevalent in low-trust environments than in high-trust ones. Our framework offers a unified explanation: when background institutions and reputational systems make defection costly and cooperation predictable, overt signals of loyalty lose their informational function and may even signal that the relationship requires reassurance. The decline of overt romantic signaling in affluent societies may thus be one instance of a broader phenomenon in which high-trust environments selectively suppress the expressive forms of cooperation while preserving its substantive content.

Taken together, the present findings resolve an apparent evolutionary paradox. Romantic love does not fade in developed societies because bonds are weaker, but because they are stronger. As long-term commitment becomes common, reassurance becomes unnecessary, and signaling becomes costly. Love, in this sense, becomes quieter, not because it matters less, but because it can be taken for granted.

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