

Historical Dynamics and Cultural Associations of Relational Norms in American and Chinese Political Discourse

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Research Article

Keywords: historical psychology, relationships, cultural values, sentence embeddings

Posted Date: October 13th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-11342307/v1>

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Additional Declarations: The authors declare no competing interests.

Historical Dynamics and Cultural Associations of Relational Norms in American and Chinese Political Discourse

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Abstract

Cooperative expectations can vary across relationships (e.g. between supervisors and employees versus close friends). Such ‘relational norms’ specify which cooperative functions – ways of coordinating mutually beneficial behavior – are expected within different kinds of relationships. These relational norms are embedded within broader cultural contexts, yet little is known about how they change over time, including in relation to broader cultural shifts in values such as collectivism or cultural tightness/looseness. Here, we used computational text analysis to measure discourse related to four forms of cooperation – care, hierarchy, transaction and mating – in two historical corpora: U.S. Congressional speeches (1879-2022) and China’s *People’s Daily* newspaper (1946-2021). For each year, we quantified the semantic similarity of corpus sentences to technical descriptions of each cooperative function both across the full corpora as well as in discourse specifically related to relational contexts. We then tested temporal associations between these trajectories and linguistic indicators of broader changes in the cultural values of individualism-collectivism and tightness-looseness. Relationship-specific analyses showed that associations with cultural values varied across relational contexts: In the United States, past cultural value indicators more often improved prediction of subsequent cooperative function discourse within public relationships, particularly boss-employee and teacher-student relationships. In China, predictive associations occurred in both temporal directions across a broader range of relationships and frequently involved collectivism. These findings suggest that broad cultural change may be expressed differently across relationships, highlighting norms governing relational context as an important level for understanding cultural change.

Keywords: historical psychology, relationships, cultural values, sentence embeddings

Significance statement

Relationships differ in socially endorsed expectations about how people should and should not cooperate. These ‘relational norms’ exist within broader, dynamic cultural and social contexts, raising the question of whether they also change as those contexts change over time. Using two corpora of political discourse from the United States and China, we trace how discourse surrounding these expectations within each country shift historically and how they relate to broader cultural values (individualism, collectivism, tightness, looseness). Our findings show that the temporal relationships between broader cultural values and cooperative expectations differ across relationships vary across relational context, as well as between the two corpora, highlighting the importance of examining cultural change through specific socio-relational contexts, rather than through only society-wide patterns.

Introduction

Social norms govern actions and expectations between individuals. As the relationship between two individuals differs, the social norms governing the interaction between them can also vary markedly. For instance, dropping everything to help someone dealing with a personal problem may be expected of a parent, partner, or adult child, but far less so of a coworker or acquaintance (1). At the same time, conceptions of relationships and their accompanying expectations are also deeply embedded in broader cultural contexts (2, 3). While research suggests that people across cultures represent relationships on shared dimensions (e.g. how formal or unequal relationships are), the positions of particular relationships along these dimensions can differ across cultures (for instance, a sibling relationship may involve more hierarchy in certain cultures than others) (4). Yet, cultures are themselves dynamic, changing alongside broader shifts in values, institutions, and socioeconomic conditions (5), raising the possibility that the expectations attached to particular relationships may shift with them. For example, in Western societies, doctor-patient relationships have shifted from more ‘paternalistic’ models, in which physicians exercised greater authority over patients, toward models placing greater emphasis on patient autonomy and shared decision-making (6). A historical perspective is therefore important for understanding the obligations and expectations in different relationships, as culturally patterned psychological constructs may shift in meaning and prominence over time (7–10). Tracing relationship-specific expectations over time can reveal whether broader cultural shifts are reflected differently across particular domains of social life.

Relationship theories have long proposed that recurring interpersonal contexts create distinct coordination problems and corresponding norms and motives (11–14). For instance, a parent is expected to care for a child in ways that could be deemed inappropriate for a stranger (15). Recent work formalizes these differences in terms of cooperative functions: solutions to recurrent coordination problems in our species (1, 11, 16). These cooperative functions – care (providing/receiving support according to need and ability), hierarchy (coordinating behavior between individuals with unequal authority), transaction (balancing benefits and obligations through contingent exchange), and mating (establishing and maintaining sexual partnerships) – are expected to be served (or not served) by different relationships to different degrees: for instance, in parent-child relationships, care is strongly prescribed, whereas mating is strongly proscribed; in romantic relationships, care and mating are both strongly prescribed. The strength of these patterns of prescriptions and proscriptions across these functions constitutes the *relational norms* of a given relationship.

These relational norms are not random or arbitrary; rather, they are adapted to broader cultural systems. Recent evidence suggests that people across cultures represent different relationship categories along shared dimensions, such as equality and closeness, but that there remains substantial cultural variability in how *particular* relationships are understood within those dimensions (4, 17). For instance, public relationships (i.e., structured by formal

organizational roles, such as boss-employee or teacher-student (4)) were more variable along these dimensions across cultures and time, whereas familial and romantic relationships showed more consistency. This variability raises the possibility that some relationships, as well as some cooperative functions associated with them, may be more historically variable than others. This historical perspective allows us to examine a temporal ordering question, of whether broader cultural shifts precede changes in relational norms or vice versa, something that cannot be assessed using contemporaneous cross-cultural data alone.

One potential source of this variation is broader change in cultural values. Here, we focus on two widely studied cultural dimensions: individualism-collectivism, concerning the relative emphasis on personal autonomy versus interdependence (18, 19), and tightness-looseness, concerning the strength of social norms and tolerance for deviance (20, 21). Both dimensions have been shown to shift substantially over historical time alongside broader changes in socioeconomic conditions and social organization. For example, some theorists propose that shifts towards urbanized, commercially organized societies foster individualistic values (22). Indeed, empirical research has documented increases in individualistic practices and values across most of 78 societies over a 5 decade period, primarily associated with socioeconomic development (5). Complementary analyses of historical corpora from the nineteenth to twenty-first century have found linguistic shifts toward individualism in the US and the United Kingdom (23), as well as China in the latter half of the 20th century (24). Historical change has also been documented for tightness-looseness, including evidence of steady decline of tightness between 1800 and 2000 in the United States (25).

These broad changes in cultural values may have different implications for specific forms of social behavior. Individualism has been associated with overall greater affection-related language in both Chinese and American books from 1960 to 2008 (26). Yet, the relationship between cultural values for social norms may importantly depend on context: although individualism is associated with more permissiveness overall, it is also associated with stricter responses to behavior that is perceived to be inconsiderate to others (27). Thus, broad cultural shifts may not translate into uniform changes in perception across social life. Because different relationships involve distinct expectations surrounding care, hierarchy, mating, and transaction, the same cultural shift may have different implications across relational contexts. Examining expectations related to cooperative functions within particular relationships therefore allows a more fine-grained account of cultural change, revealing whether, and how, broad cultural shifts are reflected in changing perceptions of interpersonal obligations. A central question, then, is whether broad cultural shifts translate uniformly across social relationships, or whether their implications depend on the particular relationship and cooperative function involved.

To investigate these questions, we use two distinct historical corpora of formal political discourse: U.S. Congressional Speeches and China's *People's Daily* newspaper, building on

computational approaches to quantifying historical cultural change (28). Historical psychology approaches emphasize the importance of understanding psychological processes within the particular contexts in which they unfold (9, 29). As the U.S. and China differ significantly in cultural values (30), historical traditions (31, 32), and political organization (33), we analyze these two corpora separately, and do not make direct quantitative comparisons between them. Instead, we treat them as two distinct historical contexts in which to examine how cooperative function discourse and broader cultural values change together over time.

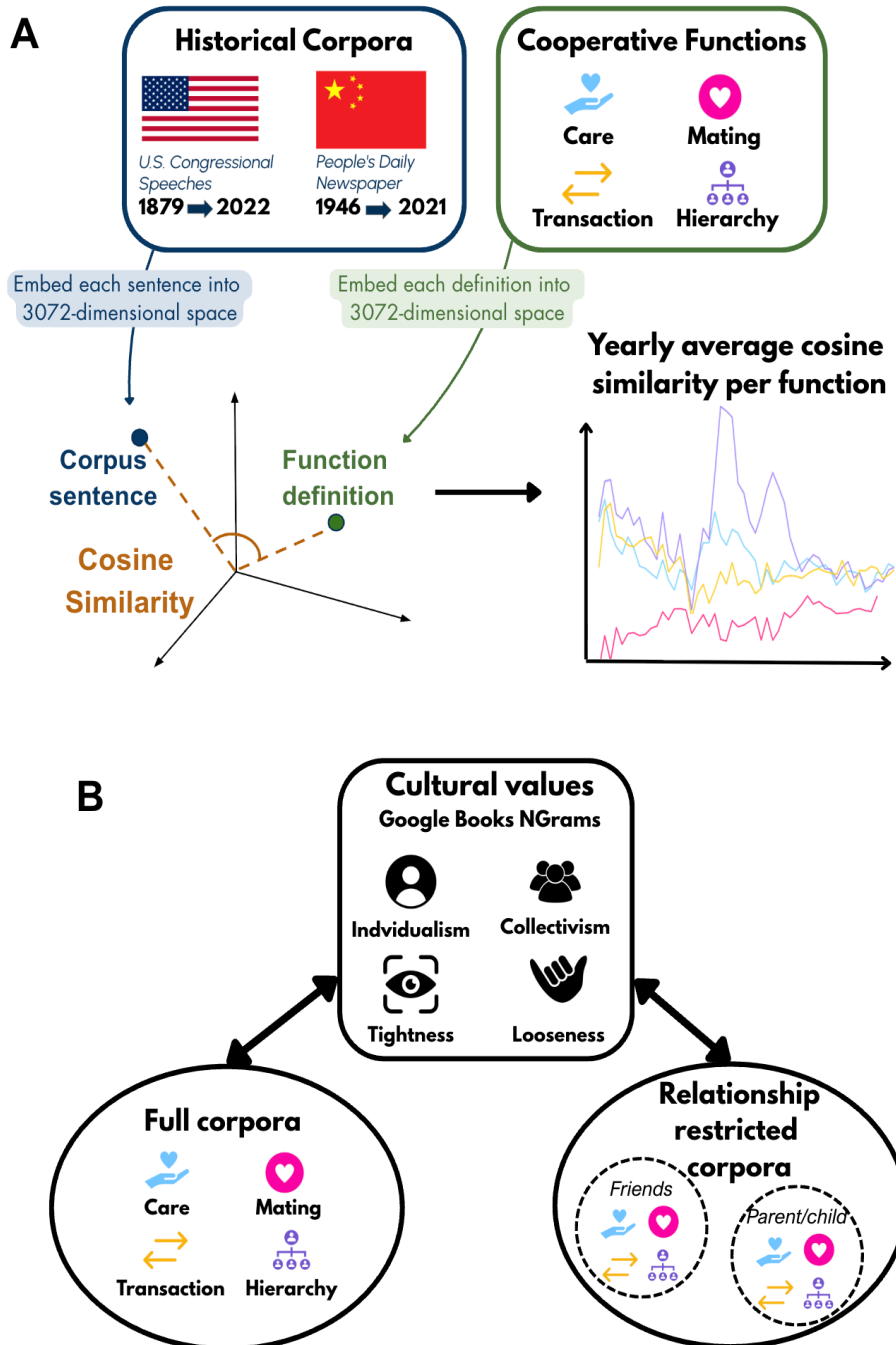
We use sentence embeddings to estimate the semantic similarity of sentences to descriptions of the four cooperative functions (care, hierarchy, mating, and transaction), and construct annual time series from the resulting scores. Importantly, these scores index the prominence of discourse semantically related to each function; they do not indicate whether the function is endorsed, prescribed, proscribed, or criticized, and thus should be interpreted as measures of discursive prominence rather than the direction of the underlying relational norm.

We first examine the historical prominence of these functions across political discourse as a whole, to obtain a broader picture of which cooperative functions have been emphasized over time, and identify likely historical change points in their trajectories. Next, we investigate how these corpus-wide trajectories of care, hierarchy, transaction and mating are temporally associated with historical indicators of individualism, collectivism, tightness, and looseness. We focus on these cultural dimensions as they are related to autonomy and interpersonal obligation, as well as how strongly social norms are enforced. Both may therefore influence the forms of cooperation that are emphasized. Because different cooperative functions solve different social problems (16), we do not expect these cultural dimensions to map uniformly onto care, hierarchy, transaction, and mating. Accordingly, we had several theory-guided expectations: first, tightness and looseness may be related to hierarchy and mating, given their links to authority and the regulation of sexual behavior (21, 34), second, collectivism may be particularly relevant to care and transaction, as it relates to obligations to others and interdependence (31).

Our central analysis then asks whether the temporal relationships between cooperative function discourse and cultural value indicators differ across relational contexts. Whereas much historical work has traced society-level constructs such as individualism-collectivism or tightness-looseness (5, 25), relational norms concern what forms of cooperation are expected within particular interpersonal relationships. We therefore examine the historical prominence of each cooperative function within discourse about specific familial, romantic, and public (e.g., boss-employee or teacher-student) relationships and their temporal associations with broader cultural values. This allows us to test whether cultural change is expressed uniformly across social life or instead through changes in the obligations attached to particular relationships. In doing so, we use relational norms as a more fine-grained level for understanding how broad cultural change maps onto interpersonal social life.

Figure 1. Overview of approach.

A) Sentences from U.S. Congressional Speeches and China's People's Daily newspaper, and, in parallel, descriptions of four cooperative functions (care, hierarchy, mating, and transaction) were embedded into a 3072-dimensional semantic space. Cosine similarity between corpus sentence and function embeddings was calculated and averaged annually to construct historical time series for each cooperative function. **B)** Main analyses were conducted at two levels: first, across the full corpora to examine overall changes in **cooperative function** discourse, and second, within relationship-specific texts identified through lexical filtering to investigate changes in **relational norms**. At both levels, we examined historical trajectories and their temporal associations with cultural-value indicators (individualism, collectivism, tightness, and looseness) derived from Google Books Ngrams.



Results

Reliability and validity of function sentences

Before our main analyses examining changes in cooperative function discourse, we assessed the the reliability of our annual scores, which varied by function but were moderately to highly reliable, with ICCs 0.63-0.94 in the U.S. corpus and 0.77-0.84 in the Chinese corpus (Supplementary Table S1), indicating broadly consistent trajectories.

To assess construct validity, trained research assistants (3 for the U.S. corpus, 2 for the Chinese corpus) rated sentences sampled from high, middle, and low cosine-similarity ranges while blind to their similarity scores (Supplementary Table S2). Each sentence's consensus rating was the majority vote across raters, and there was strong inter-rater agreement: $\kappa = .84-.88$. Cosine similarity strongly discriminated sentences rated as clearly expressing care, hierarchy, or transaction from other sentences in these samples (AUC = .95-1.00 across functions and corpora). Discrimination for mating was similarly strong in the U.S. (AUC = .99) but slightly lower in China (AUC = .86). Table 1 shows sentences with high similarity scores from each corpus.

Table 1. Example sentences with high similarity scores for each function from each corpus.

Function	Representative sentence (U.S. Congressional Speeches)	Representative sentence (China's <i>People's Daily</i> Newspaper)
Care	"Their thoughtful acts of kindness are unlimited and they are always at the side of a family member, friend or neighbor in need of assistance." (1997)	遇到一方有所需要，另一方即打破界限，尽力支援。 (<i>Whenever one side is in need, the other breaks down boundaries to provide all-out support.</i>) (1959)
Hierarchy	"If one is at the top, one is in charge and one is accountable for whatever happens throughout the ranks." (1997)	应正确处理权力与责任的关系，级别越高、权力越大，越应更多地承担社会责任、更好地为人民服务； (<i>Power and responsibility should be handled correctly: the higher the rank and the greater the power, the more social responsibility one should bear and the better one should serve the people;</i>) (2010)
Transaction	"This is an equal value exchange that benefits both parties." (1995)	怎样把互利问题解决好？(<i>How can the question of mutual benefit be handled well?</i>) (1978)
Mating	"It is in nature that we find that men and women come together to have children and in the process of having the children, the sexual acts that caused the children create bonds that cause the couples to stay together." (2004)	两人第一次见面就发生了性关系，并形成了长期的包养关系。(The two had sex the first time they met and formed a long-term paid-companion relationship.) (2014)

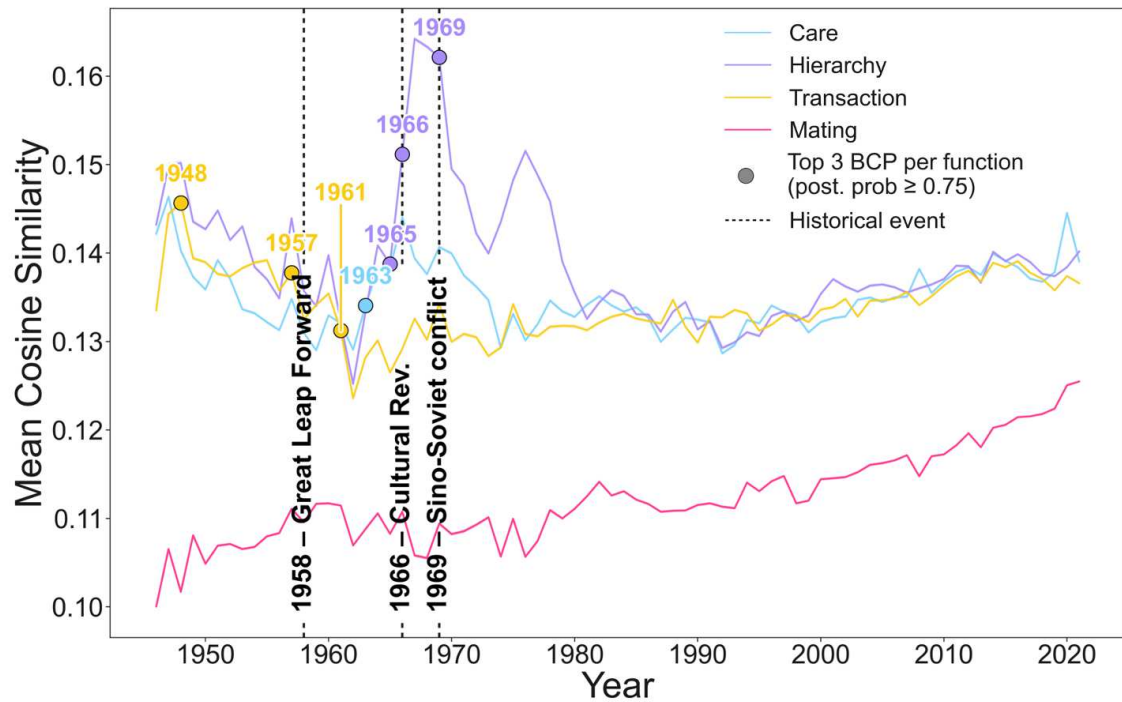
Historical trends of cooperative function discourse in both corpora

We first examined the trajectories of cooperative function discourse in the U.S. and Chinese corpora. Figure 2 shows the annual mean semantic similarity between corpus sentences and descriptions of care, hierarchy mating and transaction. Mating had the lowest annual similarity scores of the four functions but increased over time in both corpora. In the U.S., care showed a linearly increasing trend, while hierarchy discourse declined in later decades. In China, the representation of care and transaction initially declined before gradual increases, while hierarchy discourse showed strong fluctuations, especially during the 1960s.

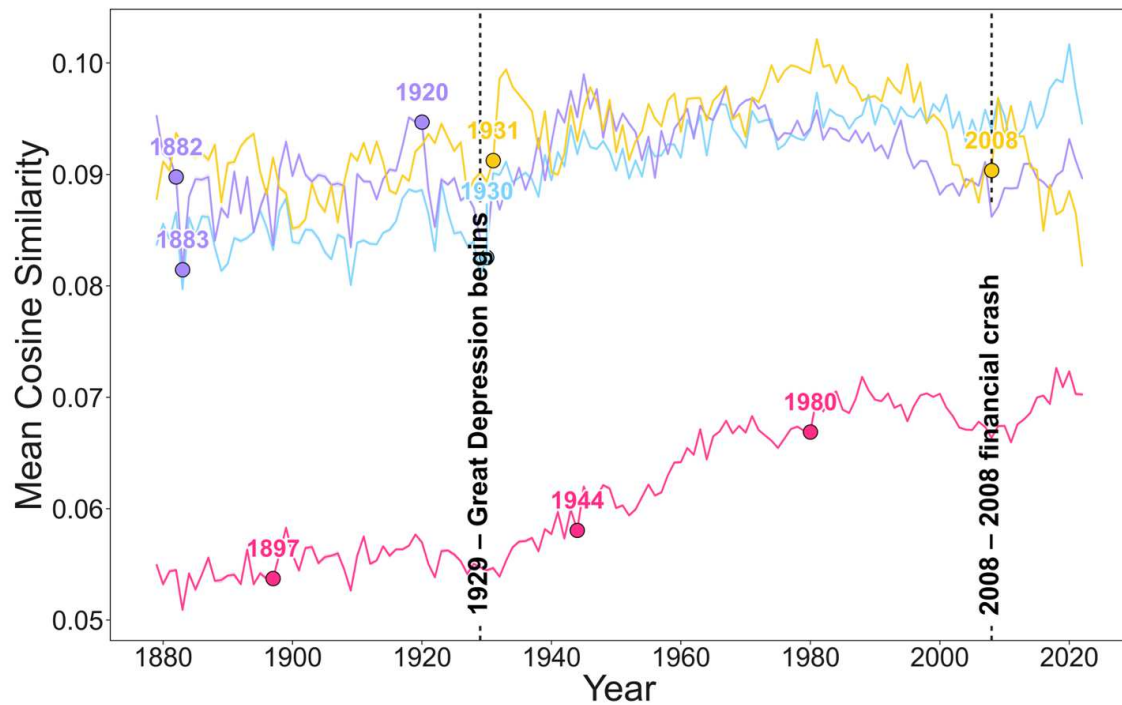
We then used Bayesian Change Point Detection (BCPD) to more precisely identify years in which these trajectories are likely to have shifted (Full list of change points with posterior probabilities > 0.75 in Supplementary Table S3). In the United States, rises in transaction discourse in 1931 (posterior probability = 0.99) and 2008 (0.86) coincide with economic downturns, including the Great Depression and the 2008 financial crisis. In China, matching visual trends, BCPD identified upward shifts in similarity to hierarchy in 1965 (0.97), 1966 (0.99), and a sharp decline in 1969 (1.00), coinciding with the beginning of the emergence and subsequent onset of the Cultural Revolution (1965-1966) and the Sino-Soviet border conflict (1969).

Figure 2. Historical changes in prevalence of cooperative functions in the American and Chinese corpora. Annual mean cosine similarity between corpus sentences and definitions of the four cooperative functions (care, hierarchy, mating, transaction) in China's *People's Daily* paper (Panel A) and U.S. Congressional Speeches (Panel B). Colored lines represent annual scores for each function, with care in blue, hierarchy in purple, transaction in yellow, and mating in pink. Colored circles indicate up to three Bayesian change points per function with posteriors of 0.75 or larger. Labels show the corresponding year and posterior probability. Dashed lines indicate selected historical events for reference.

A Historical change in cooperative function discourse (China)



B Historical change in cooperative function discourse (U.S.)



Corpus-wide temporal associations of cooperative functions with cultural values

Before examining particular relationships, we first tested temporal associations between cultural value indicators and cooperative function discourse across each corpus as a whole, providing a baseline for the relationship-specific analyses that follow. We used a three-stage procedure: first, to understand whether there were predictive temporal associations between cultural values and cooperative function discourse, we ran Granger causality tests in both directions between each of the four cooperative functions and each cultural value, using language/country matched Google Books NGrams (see Methods). Second, Granger models that survived FDR multiple comparison correction were carried forward into multi-lag ARIMAX models containing the full set of lagged predictor terms identified in the Granger analysis. Finally, to characterize the sign of each association, we refit a single-lag ARIMAX model using the peak lag identified in the Granger analysis. All ARIMAX models were fit with and without GDP per capita as a control variable. All significant Granger causality tests and corresponding ARIMAX models are in Table 2.

United States

In the U.S. corpus, changes in care and mating discourse in Congressional Speeches precede changes in linguistic indicators of cultural tightness ($q_{Care} = .046$, $q_{Mating} = .018$). These associations remained significant in the full set lag ARIMAX models with and without GDP per capita (Joint Wald $ps_{Care} \leq .44$; Joint Wald $ps_{Mating} < .001$). At the selected Granger peak lags, mating discourse was positively associated with subsequent tightness, at a lag of 5 years, meaning that changes in mating discourse preceded corresponding changes in tightness by approximately five years (lag 5, $\beta = .078$, $p = .016$; $\beta_{GDP-adjusted} = .163$, $p_{GDP-adjusted} = .001$). Care discourse was negatively associated with subsequent tightness (lag 4), but only significantly so once GDP was controlled ($\beta = -.089$, $p = .143$; $\beta_{GDP-adjusted} = -.148$, $p_{GDP-adjusted} = .005$). Residual autocorrelation remained in both models for both associations (Ljung–Box $p = .002-.007$), limiting robustness of these effects. No corpus-wide associations involving individualism, collectivism, or looseness were significant in Granger causality tests.

China

In the Chinese analyses, several Granger causality tests survived multiple comparison correction, all involving the cultural values of collectivism or tightness. From cultural values to cooperative function discourse, collectivism indicators predicted subsequent changes in care ($q = .032$), hierarchy ($q < .001$) and transaction discourse ($q = .002$), while tightness predicted subsequent changes in transaction ($q = .007$) and mating discourse ($q = .042$). In the reverse direction, transaction discourse in turn predicted subsequent changes in collectivism ($q < .001$), and hierarchy discourse predicted subsequent changes in tightness ($q = .034$). Thus, transaction discourse and collectivism showed bidirectional temporal predictability.

All associations remained significant in basic ARIMAX models (joint Wald $ps \leq .004$), and all but one (tightness to mating, joint Wald $p = .125$) remained significant after controlling for GDP per capita (joint Wald $ps \leq .010$).

Several associations also had clear directions at the selected peak lag. Higher collectivism was associated with greater care five years later (lag 5, $\beta = .347, p = .001$; $\beta_{\text{GDP-adjusted}} = .337, p_{\text{GDP-adjusted}} < .001$) and a negative association with hierarchy discourse (lag 3, $\beta = -.223, p = .026$; $\beta_{\text{GDP-adjusted}} = -.246, p_{\text{GDP-adjusted}} = .016$). In the reverse direction, from cooperative function discourse to cultural values, results showed that hierarchy discourse positively predicted subsequent tightness (lag 3, $\beta = .231, p = .002$; $\beta_{\text{GDP-adjusted}} = .183, p_{\text{GDP-adjusted}} = .043$), and transaction discourse positively predicted subsequent collectivism (lag 1, $\beta = .485, p < .001$; $\beta_{\text{GDP-adjusted}} = .483, p_{\text{GDP-adjusted}} < .001$).

Thus, the corpus-wide Chinese results did not indicate a single relationship between cultural values and cooperation: collectivism, for example, was positively associated with subsequent care discourse but negatively associated with subsequent hierarchy discourse.

Summary of corpus-wide results

Together, these results suggest that associations between cooperative function discourse and cultural values varied strongly across both corpora and functions themselves. In the U.S. corpus, the only two significant associations involved tightness, although some temporal dependence remained unexplained by the models, reducing confidence in the robustness of these effects. The Chinese corpus showed a broader pattern involving both directions of temporal prediction: collectivism and tightness predicted subsequent changes in cooperative function discourse, while changes in cooperative function discourse also predicted subsequent collectivism and tightness. Importantly, these associations differed across functions. For example, in China, collectivism was positively associated with subsequent care discourse but negatively associated with subsequent hierarchy discourse. Thus, broader cultural-value indicators did not map uniformly onto different forms of cooperation. This heterogeneity motivates examining whether more systematic patterns emerge within particular relational contexts, where the same cooperative function may carry different normative significance.

Table 2. Significant Granger and ARIMAX associations between cooperative function discourse and cultural value

Corpus	Cooperative function	Cultural indicator	Predictive direction	Granger q	ARIMAX p	GDP-adjusted p	Peak lag (years)	β	GDP-adjusted β
U.S.	Care	Tightness	Function $\rightarrow$ cultural value	.046	.043†	.040†	4	-.089 <i>n.s.</i>	-.148**
U.S.	Mating	Tightness	Function $\rightarrow$ cultural value	.018	< .001†	< .001†	5	+.078*	+.163**
China	Care	Collectivism	Cultural value $\rightarrow$ function	.032	< .001	< .001	5	+.347**	+.337***
China	Hierarchy	Collectivism	Cultural value $\rightarrow$ function	< .001	< .001	.010	3	-.223*	-.246*
China	Hierarchy	Tightness	Function $\rightarrow$ cultural value	.034	.004	< .001†	3	+.231**	+.183*
China	Transaction	Collectivism	Cultural value $\rightarrow$ function	.002	.001	.002	5	+.136 <i>n.s.</i>	+.072 <i>n.s.</i>
China	Transaction	Collectivism	Function $\rightarrow$ cultural value	< .001	< .001	< .001	1	+.485***	+.483***
China	Transaction	Tightness	Cultural value $\rightarrow$ function	.007	< .001	< .001	2	-.105 <i>n.s.</i>	-.070 <i>n.s.</i>
China	Mating	Tightness	Cultural value $\rightarrow$ function	.042	.003	.125	2	-.173**	-.150**

Note. ARIMAX p and GDP-adjusted p are joint Wald tests of all lags. † Ljung–Box $p < .05$ for that model's residuals. β is the standardized coefficient at the peak lag, and p (β) tests the peak-lag single coefficient.

Relational norms across history: relationship-specific associations of cooperative functions with cultural values

To examine associations between cultural values and specific relational norms, we next narrowed the corpus to discourse about particular relationships to examine temporal associations between cultural values and cooperative functions (see individual relationship trajectory plots in SI, Fig. S1-S2). To do so, we used relationship-specific lexical terms to identify sentences in the corpora referring to particular relationships (close friends, doctor-patient, parent-child, teacher-student, romantic partners, neighbours, boss-employee and coworkers) and calculated annual cosine similarities with cooperative function sentences within each subset (see **Methods**). We then repeated the Granger causality, full-lag ARIMAX model, and peak-lag ARIMAX analyses for eight relationship categories. A full picture of the results can be found in Fig. 3; in text, for narrative clarity, we report on a select number of especially interesting patterns.

United States

In the United States, relationship-specific associations between cooperative function discourse and linguistic indicators of cultural values were concentrated in public relationships, particularly boss-employee and teacher student. Most involved cultural values preceding changes in cooperative function discourse (see **Fig. 3**).

From cultural values to cooperative functions. First, within boss-employee discourse, Granger tests showed that changes in the cultural values of individualism ($q < .001$) and looseness ($q = .009$) predicted care-related discourse in the corpus, with both associations remaining significant in the joint ARIMAX tests (Joint Wald $ps \leq .002$). At the selected peak lags, both associations were positive (individualism: $\beta = .048$, $p = .024$; $\beta_{\text{GDP-adjusted}} = .048$, $p_{\text{GDP-adjusted}} = .028$; looseness $\beta = .030$, $p = .032$; $\beta_{\text{GDP-adjusted}} = .027$, $p_{\text{GDP-adjusted}} = .209$). Collectivism similarly changes in hierarchy-related discourse ($q = .002$), with a positive peak-lag estimate ($\beta = .052$, $p = .011$; $\beta_{\text{GDP-adjusted}} = .041$, $p_{\text{GDP-adjusted}} = .057$). Tightness predicted mating discourse ($q = .034$), although its negative peak-lag estimate was not individually significant ($\beta = -.011$, $p = .773$; $\beta_{\text{GDP-adjusted}} = -.029$, $p_{\text{GDP-adjusted}} = .397$).

This suggests that increased individualism and looseness in broader culture were accompanied by more care-related discourse in the boss-employee relationship, while increases in collectivism predicted increased hierarchy discourse in this relationship. Note that these findings are agnostic as to whether care or hierarchy was increasingly prescribed or proscribed; rather, they indicate greater prominence of discourse related to these functions, without specifying whether that discourse endorsed, or criticized these functions in the boss-employee relationship.

In teacher-student discourse, multiple cultural indicators predicted changes in hierarchy-related discourse. Linguistic indicators of individualism, collectivism, and looseness, each

predicted subsequent changes in hierarchy ($q_{Individualism} = .025$; $q_{Collectivism} = .041$; $q_{Looseness} = .015$), with all three relationships remaining significant in the joint basic ARIMAX tests (Joint Wald $p_{Individualism} = .007$; $p_{Collectivism} = .035$; $p_{Looseness} = .002$), as well as the joint ARIMAX tests including GDP-per capita (Joint Wald $p_{Individualism} = .007$; $p_{Collectivism} = .005$; $p_{Looseness} = .002$). At the selected peak lags, coefficients were not individually significant. Thus, teacher-student hierarchy discourse showed reliable temporal associations with several cultural indicators, though the direction of these associations could not be robustly characterized.

From cooperative functions to cultural values. In the reverse, function discourse-to-cultural value direction, six of the eight significant Granger tests involved the relationship of romantic partners (for details, see Figure 3). However, residual autocorrelation (Ljung-Box tests $p < .05$) was present in all eight of the function to cultural value ARIMAX models, meaning the models' error structures did not fully capture the temporal dependence even in the associations that passed the joint Wald test. We therefore treat these findings as less robust and do not interpret them further here.

China

In China, associations between cooperative function discourse and linguistic indicators of cultural values were distributed across a wider range of relationships (**Fig. 3**), but two recurring patterns stood out.

From cultural values to cooperative functions. First, linguistic indicators of collectivism predicted hierarchy-related discourse in parent-child ($q = .042$) and teacher-student contexts ($q = .001$). Both associations remained significant in the joint Wald tests before and after GDP adjustment (parent-child: $p < .001$, $p_{GDP-adjusted} = .005$; teacher-student: $p < .001$, $p_{GDP-adjusted} = .011$). At the selected peak lags, the coefficients were negative, suggesting that higher collectivism was followed by less hierarchy-related discourse in both relationships (parent-child, lag 1: $\beta = -.271$, $p < .001$; $\beta_{GDP-adjusted} = -.262$, $p_{GDP-adjusted} = .005$; teacher-student, lag 6: $\beta = -.235$, $p = .051$; $\beta_{GDP-adjusted} = -.235$, $p_{GDP-adjusted} = .014$). Notably, this predictive direction and sign of the peak-lag coefficient were consistent with those of the corpus-wide association between collectivism and hierarchy discourse in China.

From cooperative functions to cultural values. Second, in the reverse direction, from function discourse to cultural values, transaction discourse concerning close friends and coworkers positively predicted subsequent linguistic indicators of collectivism at a lag of one year ($q_{friends} = .018$, $q_{coworkers} = .014$; basic joint Wald $p_{friends} = .001$, $p_{coworkers} = .001$; GDP-adjusted joint Wald $p_{friends} = .002$, $p_{coworkers} = .001$; $\beta_{friends} = .283$, $p_{friends} = .001$; $\beta_{coworkers} = .298$, $p_{coworkers} = .002$; $\beta_{friends-GDP-adjusted} = .297$, $p_{friends-GDP-adjusted} = .002$; $\beta_{coworkers-GDP-adjusted} = .321$, $p_{coworkers-GDP-adjusted} = .001$). Interestingly again, these patterns paralleled the corpus-wide transaction to collectivism association.

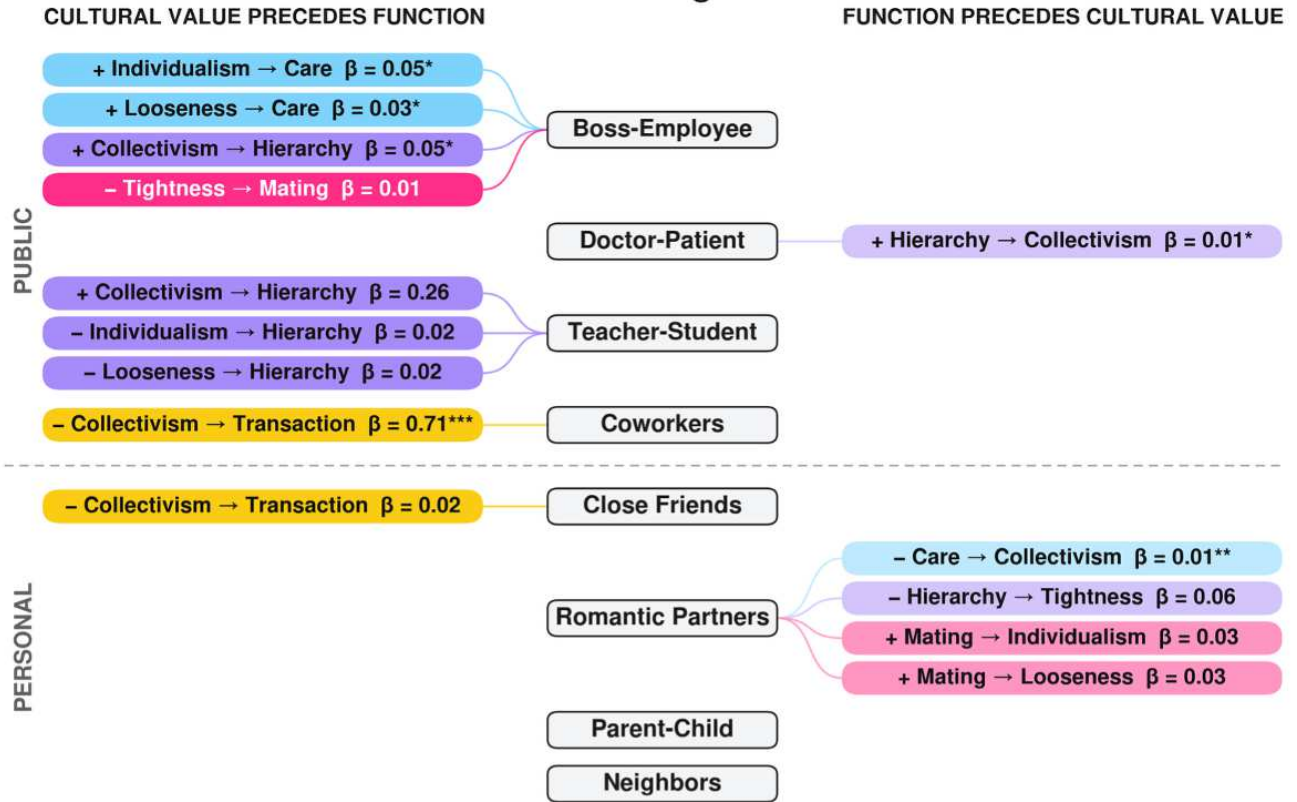
Summary of relationship-specific results

Taken together, the relationship-specific analyses revealed distinct patterns across the two countries. In the United States, associations from cultural values to cooperative function discourse were concentrated in public relationships, particularly boss-employee and teacher-student contexts, whereas associations from cooperative functions to cultural values primarily involved romantic partners, although, robustness tests showing remaining unexplained temporal dependence limits confidence in these US function-to-culture models. In China, associations were distributed across a wider range of relationships, with recurring patterns in which collectivism preceded subsequent hierarchy discourse, while transaction and mating discourse preceded subsequent collectivism. These findings suggest that corpus-wide associations do not necessarily generalize uniformly across relationship contexts.

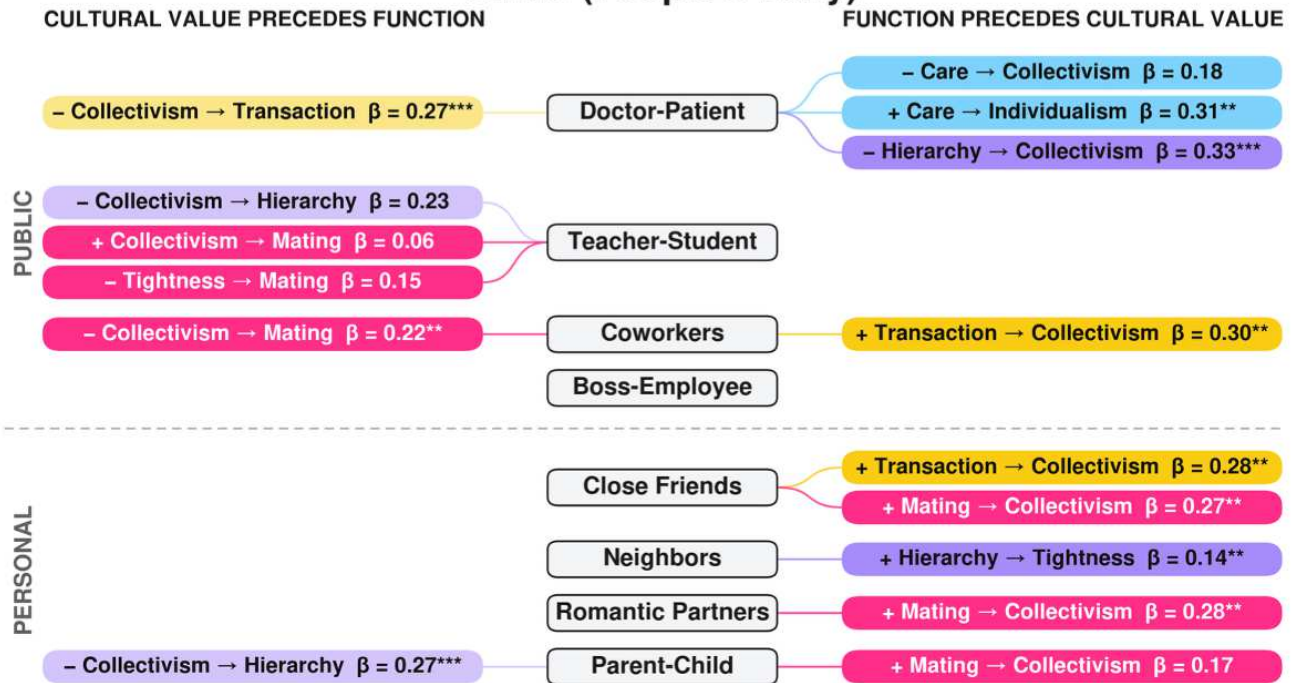
Figure 3. Relationship-level associations between cooperative function discourse and cultural values in the U.S. Congressional Record (top) and People's Daily (bottom).

This figure shows associations of Granger causality tests which were FDR significant ($q < .05$), by relationship and direction of temporal precedence. Associations on the left indicate that changes in a cultural value preceded subsequent changes in cooperative function discourse; associations on the right indicate that changes in cooperative function discourse preceded subsequent changes in a cultural value. Colors denote the cooperative function involved, with pink indicating mating, blue indicating care, purple indicating hierarchy and yellow indicating transaction. Paler colors indicate models that failed the Ljung-Box residual autocorrelation test, meaning that the model residuals still contained systematic temporal dependence that the ARIMAX specification did not fully capture. These associations should therefore be interpreted more cautiously. The $\pm$ symbol indicates the sign of the association at the selected Granger peak lag, and β gives the absolute magnitude of the standardized coefficient from the single-lag ARIMAX model at that peak lag; asterisks indicate significance of the peak-lag coefficient ($*p < .05$, $**p < .01$, $***p < .001$).

U.S. Congress



China (People's Daily)



Discussion

In this study, we used historical corpora from the United States and China to examine changes in cooperative function discourse and their temporal associations with shifting cultural values. Building on approaches using historical texts and other cultural artifacts to investigate psychological change (35–37), we first examined discourse related to care, hierarchy, mating, and transaction across the entire corpora to characterize broad changes in the degree to which cooperative functions are emphasized in public discourse. We then examined discourse referring to particular relationships to investigate how these functions and their associations with cultural values varied across relational contexts.

First, historical trajectories of function discourse revealed changes in their prominence and trajectories. In both corpora, mating discourse grew in prominence over the course of the corpora years, while care, hierarchy and transaction followed more varied trajectories. In particular, in the Chinese corpus, discourse related to care, hierarchy and mating strongly fluctuate during turbulent moments in modern Chinese history (e.g. the Great Leap Forward and the Cultural Revolution). In the U.S., the most notable changes in transaction discourse coincided with economic downturns.. These divergent trajectories are consistent with accounts of cooperation as comprising multiple dissociable functions, rather than a single monolithic orientation (11, 38, 39).

Furthermore, the corpus-wide analyses linking cultural values to cooperative function discourse also suggest that associations between cultural values and social norms depend on the function, or type of collaboration, in question. These results also varied strongly across corpora. In China, collectivism appeared to positively precede changes in care and transaction, while negatively predicting hierarchy. Tightness also seemed to negatively precede subsequent mating discourse overall. However, in the United States, only two corpus wide effects remained, however residual autocorrelation limited confidence in the robustness of these findings. Taken together, these results suggest that broad cultural indicators do not have uniform temporal associations with different forms of cooperative discourse. This is consistent with research showing that historical changes in everyday norms can differ across behaviors rather than reflecting a single movement toward greater permissiveness or restriction (27). Yet the limited U.S. findings also raise a question about the level at which such associations become visible. These cooperative functions are known to be relationship-specific, with care being strongly important in close relationships, and hierarchy in boss-employee relationships (1, 40). Cultural values may thus be associated with care (or other cooperative function discourse) in *specific* relationships, rather than the corpus as a whole.

Indeed, when we examined relationship-specific associations between cultural values and cooperative function discourse, a more differentiated picture emerged. In the United States, a robust pattern emerged such that the most reliable associations were in the direction of culture

influencing relationship-specific discourse, and strongly concentrated in public relationships, particularly boss-employee, teacher-student, and coworkers. This complements past research finding that public relationship concepts exhibit greater cross-cultural variability than private or intimate relationship concepts (4). Our results further point to a selective mapping between cultural values and cooperative functions, specifically that individualism precedes changes in care discourse, whereas individualism, collectivism and looseness predicts changes in hierarchy discourse in teacher-student relationships. This work thus builds on prior findings of cultural variations in the descriptive conceptions of public relationships (4), by revealing the changes in obligations and expectations (relational norms) that underlie them.

In the Chinese corpus, we found a different set of associations. Rather than being concentrated in public relationships, associations were seen across almost all tested relational contexts, with collectivism involved in the majority of findings. Two patterns here emerged. First, broader, society-wide linguistic indicators of collectivism preceded changes in hierarchy discourse in both parent-child and teacher-student contexts, with negative peak-lag coefficients that mirrored the corpus-wide association. This may suggest that as broader collectivism (i.e., prioritization of group goals) (18, 19) declines, hierarchy may become an alternative means of organizing society, as hierarchy can provide a sense of structure under conditions of threatened control (41). Our results suggest this may be the case particularly in intergenerational formative relationships, such as parent-child and teacher-student, although this inference is speculative and further research is needed to support these ideas.

The second recurring pattern functioned in the opposite direction, whereby transaction discourse in close friends and coworkers predicted the cultural value of collectivism, with positive peak-lag coefficients in both contexts, again paralleling the corpus-wide association. This pattern is consistent with accounts of Chinese social relationships that emphasize reciprocal obligations and social exchange as important to maintaining enduring ties of Chinese (*guanxi*) (31, 42). From this perspective, transaction-related discourse may also reflect attention to reciprocal exchanges through which ongoing social ties are maintained. The positive lagged associations may suggest that drops in transaction discourse overall, as well as peer-to-peer relationships in particular, may predict subsequent declines in collectivism. This may reflect a weakening emphasis on reciprocal exchange as a basis for collective obligations, a mechanism that future research could test directly.

Overall, the relationship-specific findings revealed two key differences between the corpora; first in the kinds of relationships in which associations emerged and second, whether cultural values preceded cooperative function discourse or vice versa. In the United States, the most robust associations involved cultural values preceding cooperative function discourse and were concentrated in public relationships. In China, associations spanned a wider range of relationships, with substantial evidence both for cultural values preceding function discourse and for function discourse preceding cultural values. These contrasting patterns may reflect

differences in these societies themselves (e.g. social structures, economic conditions), or may reflect differences between the corpora (Congressional Speeches versus a newspaper).

The different relationships in which associations emerged may partly reflect differences in the *societies* themselves. In the United States, historical changes in occupational structure and employment relations may help explain why associations were concentrated in public relationships (43, 44). In China, the aforementioned importance of *guanxi* (31, 42) in social life may explain why associations between transaction and collectivism appeared across the Chinese corpora (45, 46), while this pattern was not seen in the United States. However, the patterns of difference concerning the directionality of associations may be better explained by the corpora themselves. In the United States, the most robust associations showed cultural values preceding changes in function discourse. This text is drawn from speeches made by elected officials, whose chief concern is responding to constituent demands; thus their speech may reflect concerns already present in broader culture. In China, however, associations were supported in both directions. Importantly, the *People's Daily* has been documented to be used not only to report current events, but to communicate official priorities, with its content shaped by government-led editorial decisions (47, 48). In this way, the dual directionality may reflect that the corpus not only *responds* to culture, but also *shapes* it.

More broadly, our findings illustrate why relational norms are useful for understanding cultural change historically. Rather than mapping uniformly onto social expectations, broader cultural values were associated with different cooperative expectations in different relational contexts. In the U.S. corpus, these associations were concentrated in public relationships (e.g., boss-employee and teacher-student), suggesting that historical shifts in cultural values may be especially visible in expectations surrounding formal social roles. In the Chinese corpus, collectivism was linked to hierarchy across parent-child and teacher-student relationships, while transaction and mating discourse in several relationships preceded subsequent changes in collectivism. These patterns suggest that cultural change may be expressed through specific relational obligations, such as how much hierarchy, care, or exchange is emphasized within particular relationships, rather than through uniform shifts in these expectations across relationships.

Limitations

Several limitations should be considered when interpreting these findings. First, although both corpora provide rich historical records, they represent formal, politically oriented discourse, rather than the full range of perspectives in either society, a limitation often noted in historical psychology research. To understand how relational obligations are understood to change over time, more diverse sources, including literature, diaries, letters, or other popular media (e.g., 40) should be used in future research.

Second, semantic similarity captures how closely the overall meaning of a sentence relates to our descriptions of each cooperative function, rather than whether it precisely matches the function's definition. Thus, sentences may score highly because they relate to some aspects of a function without precisely expressing all of its defining features. The resulting scores therefore indicate the prominence of function-related discourse, rather than the presence of a cooperative function in a strict definitional sense. Relatedly, semantic similarity does not capture whether these functions are endorsed, criticized, or practiced. For example, the increase in mating discourse in both corpora could reflect growing acceptance of sexual freedom, consistent with research documenting increasingly permissive sexual attitudes in the United States and China (50, 51). However, given the political nature of these two corpora, increased attention to sexual behavior could also accompany efforts to control it (see 43, 44). Given the apparent increase in mating discourse across both corpora, this appears a potentially fruitful avenue for future research.

Finally, although our analyses controlled for GDP per capita, other historical factors may have shaped both cultural values and cooperative function discourse. For instance, previous research has shown that changes in cultural values are related to socioeconomic structure, pathogen prevalence and secularism (44). Additionally, the economic systems in the United States and China were highly different across corpus time, with the US shifting within a broadly capitalist system, and China undergoing economic transformation especially as it transitioned into a more market-oriented economy in the 1980s. Future research should incorporate additional historical indicators and test whether the associations hold across alternative model specifications.

Conclusion

This study contributes to the growing field of historical psychology by tracing changes in cooperative function discourse and its associations with cultural values across relationships in the United States and China. Our findings suggest that cultural change should not be understood only at the level of society-wide shifts in values. Broader cultural value indicators were associated with different forms of cooperative discourse in different relationships, indicating that cultural change may be relationally differentiated rather than uniformly expressed across social life. We hope these findings provide a useful starting point for further research in psychology, history, and sociology on how cultural change relates to interpersonal relationships.

Methods

AI use statement

Claude Sonnet 5 (54) was used to assist with editing and organizing code and analysis scripts, including troubleshooting, suggesting revisions (especially to improve script clarity), and

organizing file versions to streamline their use and improve reproducibility. ChatGPT-5.6 Sol (50) was also used to help edit and streamline text drafted by the authors.

Historical text corpora and preprocessing

For this study, we use two historical corpora representing formal political discourse in the United States and China: the U.S. Congressional Record (1879-2022) and the People's Daily newspaper (1946-2021), which have been previously used in historical psychology papers (28, 55–58).

The U.S. Congressional record was drawn from Gentzkow et al., 2018 (59) and Aroyehun et al., 2025 (58) and following the latter's preprocessing steps, including the removal of procedural speeches using classifiers (56), as well as filtering of speeches with less than 11 tokens, and removal of duplicate entries. We then split speeches into sentences at periods, and verbless clauses (e.g., “Mr. President”) were merged with adjacent sentences (see SI Congressional Record Preprocessing and Supplementary Tables S5 and S6). The final dataset included 72,063,883 sentences, with an average length of 27.4 tokens. The *People's Daily*, the official daily outlet of the Chinese Communist Party, was drawn from Chen et al., 2024 (28). Although the record was generally high quality, we also preprocessed the data with several steps: we first deduplicated the data, removed sentences of less than 5 characters, removed photo credits, removed sentences that only contained dates, removed page markers, removed sentences without Chinese characters as well as null sentences (see Supplementary Table S7 for details on preprocessing procedures). Speeches were again into sentences at periods. The final dataset included 40,641,175 sentences, with an average length of 49 tokens.

Creation of function sentences

To operationalize the four cooperative functions of care, hierarchy, transaction, and mating, we developed a set of four anchor sentences for each function in English and Chinese. For each function, we first used verbatim brief definitions provided from previous research (16), and translated these into Mandarin Chinese. We then developed three additional definition sentences for each function (see Table 3), drawing on more extensive descriptions provided by Earp et al. (2026). Two researchers worked iteratively with each other, and used ChatGPT-5 to generate and refine alternative formulations. The additional sentences were designed to capture different facets of each cooperative function while varying the vocabulary and phrasing used to describe it (see 50, 51). Using multiple formulations also allowed us to assess whether the resulting historical trajectories were consistent across alternative descriptions of the same function.

Table 3. Cooperative function descriptions used in analyses.

Language	Care	Hierarchy	Transaction	Mating
English	Giving or receiving support based on need, without creating a debt	Coordinating behavior between people with unequal authority over one another	Balancing mutual benefits by keeping track of who owes what to whom	Establishing and maintaining a sexual partnership
English	Protecting another person's well-being through attentive and reliable support	Following established leadership roles when organizing shared behavior	Keeping cooperation fair through reciprocity, repayment, and balanced exchange	Forming and sustaining a committed sexual relationship with another person
English	Giving practical or emotional help without expecting repayment in return	Organizing collective action according to rank, status, and responsibility	Coordinating mutual gain by tracking contributions, obligations, and repayment	Attracting and retaining a partner for an ongoing sexual relationship
English	Providing dependable, unconditional assistance	Exercising greater decision-making authority over another person because of one's higher rank or position	Exchanging benefits in proportion to what each person contributes	Creating and preserving a stable romantic and sexual partnership
Chinese	根据需求给出或接受帮助和支持，不因此产生人情债	在权威、地位不平等的人之间协调行动	通过记录谁欠谁什么来平衡相互的利益	建立并维持性关系
Chinese	通过关切的和值得信赖的支持，保护另一个人的福祉	在有组织的协同行动中，遵从已确立的领导角色	通过互惠互利、偿付和对等的交换来维持合作的公平性	寻找并吸引一个可以发生性行为的性伴侣
Chinese	给予实践性的或情感性的支持，而不计较回报	根据级别、地位的高低和职责的不同来组织集体行为	通过记录各自的贡献、职责和偿付来协调相互的利益	与固定伴侣维持持续的性接触和肉体亲密关系
Chinese	提供值得信赖的、不讲条件的协助	因职级或职位较高，而对他人拥有更大的决策权	按照每人的贡献大小来分配利益	通过择偶和性关系来繁衍后代、延续血脉

Sentence embeddings

To quantify the prominence of each cooperative function in historical discourse, we used sentence embeddings to measure the semantic similarity between sentences in the two corpora and the function sentences described above. Unlike approaches that identify constructs through the frequency of predefined keywords (e.g., 12, 16), sentence embeddings represent the meaning of a sentence as a numerical vector, allowing us to assess similarity between expressions that use different vocabulary. We used OpenAI's *text-embedding-3-large* (62) model, which supports multilingual applications, to represent both corpus sentences and function sentences as 3072-dimensional vectors.

Cosine similarities and annual trajectories

To quantify the extent to which each corpus sentence expressed a given cooperative function, we calculated its semantic similarity to each function description in embedding space. Here, we use cosine similarity which has been increasingly applied in psychological and behavioral research to examine changing psychological constructs over time (28, 63). Before similarity was calculated, all 3072-dimensional embedding vectors were L2-normalized to unit length, following prior work emphasizing normalization as an important methodological consideration in sentence-embedding comparisons (Eger et al., 2019).

Each corpus sentence was compared separately with the four anchor formulations representing each cooperative function. For sentence i and function f , we calculated the mean cosine similarity across the four anchor formulations:

$$s_{if} = \frac{1}{4} \sum_{k=1}^4 \cos(e_i, a_{fk})$$

where s_{if} is the score of sentence i for cooperative function f , e_i is the embedding vector for sentence i , and a_{fk} is the embedding vector for the k th anchor formulation of function f . Thus, the four anchor-specific cosine similarities were calculated separately and then averaged to produce a single sentence-level score for each function. Higher values indicate greater semantic similarity between the corpus sentence and descriptions of that cooperative function.

To construct historical trajectories, sentence-level scores were averaged within each year separately for each cooperative function.

$$\bar{s}_{ft} = \frac{1}{N_t} \sum_{i=1}^{N_t} s_{if}$$

where $\bar{s}_{ft}$ is the annual mean score for function f in year t , N_t is the total number of corpus sentences in that year, and s_{if} is the sentence-level function score defined above. Each sentence contributed equally to the annual mean, with no additional weighting by speech, speaker, article, or document. Higher annual values therefore indicate that the language appearing in a given year was, on average, more semantically similar to descriptions of the corresponding cooperative function.

Reliability of function sentences

To assess whether the historical trajectories were robust to the particular wording of the function descriptions, we evaluated agreement across the four formulations of each cooperative function. For each formulation, we first constructed a separate annual time series by averaging its cosine-similarity scores across all corpus sentences within each year. Reliability was then assessed separately for care, hierarchy, transaction, and mating, and separately for the U.S. and Chinese corpora. We calculated consistency-based intraclass correlation coefficients (ICCs) (64), treating years as targets and the four anchor formulations as raters. We report both the reliability of an individual anchor formulation, $ICC(C,1)$, and the reliability of the mean across the four formulations, $ICC(C,k)$ (65). The latter corresponds most directly to the measure used in the primary analyses, because the final sentence-level function score was obtained by averaging similarity scores across all four anchors. All subsequent analyses used the mean score across the four anchor formulations for each function.

Construct validity of cosine similarity scores

To assess whether the cosine-similarity scores identified sentences that clearly expressed the intended cooperative functions, we conducted a construct-validity analysis using sentences sampled from different regions of the score distribution. Validation was conducted separately for each cooperative function and corpus. For each corpus-by-function combination, we sampled 180 sentences: 60 from the extreme high end of the corpus-wide similarity-score distribution, 60 from the middle of the distribution (45th–55th percentile), and 60 from the lower end of the distribution (bottom 15th percentile). Sentences from the three groups were shuffled prior to evaluation. Five trained research assistants (3 native English speakers for the U.S. corpus; 2 native Chinese speakers for the Chinese corpus) evaluated each sentence while blind to their cosine similarity scores. Sentences were rated on a three-point scale indicating whether they expressed the target cooperative function: 0 = unrelated, 1 = tangential / ambiguous, and 2 = clearly expressed the construct. Ratings were conducted separately for care, hierarchy, transaction, and mating in each corpus.

We evaluated the correspondence between cosine-similarity scores and these blind ratings using three measures. Spearman's rho quantified the association between the ordinal ratings and similarity scores. A point-biserial Pearson correlation compared similarity scores with whether a sentence was rated as clearly expressing the construct (rating = 2 versus ratings = 0 or 1). Finally, area under the receiver operating characteristic curve (AUC) assessed how well the cosine similarities discriminated sentences rated as clearly expressing the target function from the remaining sentences.

Identifying relationship-specific discourse

To examine cooperative function discourse within specific relational contexts, we selected specific relationships based on analyses done in previous research, examining maximally different relationships based on their cooperative function profiles (16). We retained eight categories that could be identified with sufficient consistency in the historical corpora: doctor-patient, boss-employee, teacher-student, coworkers, neighbours, parent-child, romantic partners, and close friends. We removed relationships such as acquaintances and friends-with-benefits as we deemed them to not be reliably extractable or discussed in the corpus.

To identify discourse referring to particular interpersonal relationships, we used a lexical filtering procedure. For each retained relationship, we constructed a set of English and Chinese lexical role terms identifying references to either member of the relationship. English sentences were matched using word-boundary regular expressions, whereas Chinese sentences were matched using substring searches. The full list of search terms can be found in Supplementary Table S8.

We then applied additional exclusion to reduce systematic false positives. These removed usages such as congressional courtesy expressions (e.g., ‘my friend from [state]’), figurative kinship expressions (e.g., ‘founding fathers’), and idiomatic uses of relationship terms (e.g., ‘spin doctor’). Additional exclusions were applied to romantic-partner discourse: U.S. sentences containing ‘couple of’ were removed because couple frequently occurred as a quantity expression, and Chinese sentences containing 老太太 (‘old lady’) were removed because the string contains 太太 (‘wife’). Details on the distributions and numbers of sentences per relationship can be found in Supplementary Table S9.

Cultural Values

We obtained text-based measures of year by year fluctuations in individualism, collectivism tightness and looseness based on Google Ngram frequency data, used in past research on these same corpora (28). These measures were derived from Google Books Ngram word-frequency data using established English and Chinese dictionaries from prior historical psychology research. Individualism and collectivism were based on dictionaries from Greenfield (2013) (23) and Zeng and Greenfield (2015) (24), with the latter providing Chinese measures. Tightness and looseness were based on Jackson et al. (2019) (25), with Chinese versions following Chen et al., 2024 (28). For each construct, annual scores reflected the mean relative frequency of the corresponding dictionary terms in the relevant language corpus. The U.S. series were obtained from the current English Google Books Ngram corpus using a smoothing value of 3. For the Chinese Granger and ARIMAX analyses, we used the archived 2019 Google Books Ngram release, yielding a usable cultural-value series from 1950 through 2019.

GDP per capita

To control for broad changes in socioeconomic development, GDP was included as a covariate in adjusted ARIMAX models, following prior work examining cultural change across history (5, 28, 66). GDP per capita estimates were obtained from the Madison project database (67).

Analytic pipeline

Analyses were conducted separately for the U.S. and Chinese corpora, with the same analytical pipeline applied to corpus-wide and relationship-specific times series.

Bayesian change point detection

We used Bayesian change-point detection to identify points at which the mean level of each annual cooperative function time series was likely to have changed. Analyses were implemented using the package *bcp* (68) in R, which estimates the posterior probability that a change point occurred at each year using a Bayesian product-partition model (Barry & Hartigan, 1993; Erdman & Emerson, 2008).

Granger causality analyses

To examine temporal precedence between cultural values and cooperative function discourse, we conducted Granger-causality tests in both directions, using the *vars* package (69) in R. Granger tests assess whether the lagged value of one time series contains information that improves prediction of the outcome time series, beyond information contained in the outcome's own prior values. We corrected for multiple comparisons using the Benjamini–Hochberg FDR procedure, applying corrections separately within the individualism/collectivism and tightness/looseness predictor families for each cooperative function, and for each relationship-by-function combination in the relationship-specific analyses. Associations with FDR-adjusted $q < .05$ were carried forward to the ARIMAX analyses.

Multi-lag ARIMAX analyses

Associations that passed significance in the Granger tests, thus showing temporal precedence, were subsequently examined using autoregressive integrated moving-average models with exogenous predictors (ARIMAX). For each association, we fit a model containing the full set of lagged predictor terms identified by the Granger procedure and tested their joint contribution using a Wald test. A second specification additionally included log GDP per capita as an economic control. The ARIMAX joint-Wald p values were not subjected to an additional FDR correction because these models were applied only to associations that had already passed the FDR-corrected Granger screening stage.

Peak-lag ARIMAX analyses

To characterize the direction and magnitude of each association, we identified the peak lag, defined as the lag with the largest absolute z statistic among the predictor's coefficients in the Granger model. We then refit an ARIMAX model containing only that lag and report its standardized coefficient, together with the corresponding lag. The same peak lag was used in the GDP-adjusted model.

Residual autocorrelation was assessed for each ARIMAX model using the Ljung–Box test. Models with significant residual autocorrelation ($p < .05$) are flagged because remaining temporal dependence indicates that the fitted error structure did not fully account for autocorrelation in the series.

Acknowledgements

The authors thank Zixuan Qui, Ajoonee Sidhu, and Drake Zimmerman for manual coding of sentences.

Competing Interest

The authors declare no competing interests.

Data Availability

Data and analysis code are available at https://github.com/avamadesousa/RelationalNorms_Hist.

Funding

This research is funded by a University of California, Santa Barbara Office of Undergraduate Research and Creative Activities research grant awarded to S.T. A.Q.M.S. is supported by a Social Sciences and Humanities Recent Council of Canada Doctoral Fellowship, a Philanthropic Educational Organization Scholar Award and UC Santa Barbara Dissertation fellowship.

Author Contributions

H.Y., A.Q.M.S. and S.T. conceived the work. A.X.C., S.Z. and T.Q. obtained and cleaned corpus data. A.Q.M.S. lead main analyses, with support from S.T., S.Z., T.Q. and A.X.C. who wrote initial analysis code and provided feedback. A.Q.M.S. wrote the manuscript with feedback from all authors.

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