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Semantic Network Analysis of Bioethics and Postmaterialism: Conceptual Structures, Discursive Centralities, and Value Orientations

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Abstract

This study examines the semantic structures underlying contemporary debates on bioethics and postmaterialism through the application of semantic network analysis. Drawing on textual corpora composed of academic publications, policy documents, and normative statements, the research identifies key concepts, relational patterns, and discursive centralities that articulate ethical reasoning beyond materialist frameworks. The analysis reveals how postmaterialist values—such as autonomy, quality of life, environmental responsibility, and human dignity—are interconnected with bioethical principles including justice, beneficence, non-maleficence, and responsibility. Network metrics such as centrality, density, and modularity are employed to detect dominant nodes, peripheral concepts, and thematic clusters, highlighting the transition from utilitarian and resource-centered ethics toward value-based and reflexive moral discourses. The findings suggest that bioethics operates as a semantic bridge between scientific rationality and postmaterialist value orientations, reinforcing its role in guiding decision-making in health, technology, and sustainability contexts. The study contributes methodologically by demonstrating the usefulness of semantic network analysis for mapping ethical paradigms and substantively by clarifying the conceptual convergence between bioethics and postmaterialism.

Keywords: semantic network analysis; bioethics; postmaterialism; ethical discourse; value systems; conceptual networks

Introduction

Research on semantic network analysis (SNA) as a tool for exploring conceptual structures in ethics has expanded significantly in the last decade. Early work by Liu and Xu demonstrated that network methods can uncover latent patterns in philosophical discourse by mapping term co-occurrences and identifying central concepts that traditional content analysis overlooks [17]. Similarly, Smith et al. applied SNA to moral philosophy texts to reveal how different ethical frameworks cluster around distinct semantic communities, thereby validating the method's utility in distinguishing normative from descriptive vocabularies [26]. These foundational studies established methodological benchmarks for employing semantic networks in ethical scholarship. In the context of bioethics, network approaches have been used to trace how core principles such as autonomy, justice, beneficence, and non-maleficence interrelate across policy statements and academic debates. For example, García and Fernández applied SNA to analyze international bioethics guidelines, revealing that autonomy consistently occupies a central node connecting patient rights to broader social values, while justice often mediates between

resource allocation and equity discourse [9]. Their results showed that semantic prominence correlates with normative salience in bioethical debates, suggesting that network centrality measures can serve as proxies for ethical priority in policy texts.

Parallel to this, the literature on postmaterialism, derived from Inglehart's value theory, emphasizes the shift from materialist concerns (economic and physical security) to postmaterialist values (self-expression and quality of life) in modern societies [13,21]. Although primarily studied through survey research, recent efforts have begun integrating computational textual methods to explore postmaterialist value articulation in public discourse. Martínez and Pérez used SNA to map postmaterialist rhetoric in environmental and health communications, identifying clusters of terms that reflected emergent postmaterialist concerns such as sustainability and participatory ethics [19]. Their study illustrates how semantic network structures can operationalize abstract value dimensions in text corpora.

Despite these advances, few studies have explicitly connected bioethical discourse with postmaterialist value systems using network analysis. A notable exception is the work of Turner and Ali, who

investigated semantic linkages between human dignity, sustainability, and technological ethics in debates on genetic modification. Their network analysis revealed an intertwined semantic space where postmaterialist values amplified traditional bioethical concerns about human autonomy and well-being [28]. This integrative approach suggests a convergence of ethical and value frameworks in contemporary normative debates, yet the literature remains emergent and fragmented.

Methodologically, researchers have noted challenges in applying SNA to ethical and value discourse. Issues such as corpus selection, term disambiguation, and network thresholding affect the interpretability of results [12]. Advances in natural language processing and dynamic network modeling promise to address some of these limitations, enabling longitudinal analyses that can track changes in ethical discourse over time [6]. These methodological refinements underscore the evolving nature of semantic network analysis as both a theoretical and practical tool in interdisciplinary research.

Semantic network analysis (SNA) has increasingly been adopted across disciplines as a quantitative–qualitative hybrid method for uncovering the structural relationships among concepts embedded in textual data. In social sciences, SNA has been applied to explore how values and norms are linguistically articulated within cultural narratives [5]. By representing words or concepts as nodes and their co-occurrences as links, researchers can identify not only the prominence of individual terms but also the structural dynamics of broader conceptual systems [3]. Within ethics research, work by Costa and Silva demonstrated that semantic networks can effectively map moral frameworks in large corpora, revealing how ethical concepts cluster around competing normative paradigms [4]. Their findings suggest that SNA provides a replicable method for exploring philosophical and ethical instantiations in textual discourse, enabling comparisons across genres and contexts [4]. Parallel efforts by Nguyen et al. applied network visualization to analyze public health narratives, focusing on how ethical language is mobilized in policy debates about vaccination, autonomy, and collective responsibility [20]. These studies collectively underscore the capability of network methods to trace normative linkages that might remain opaque under traditional qualitative coding.

The methodological versatility of semantic network analysis has also been acknowledged in computational linguistics, where term co-occurrence models have been used to infer thematic cohesion and conceptual proximity in multidisciplinary texts [16]. Specifically, Li and Zhang demonstrated that semantic network metrics such as betweenness centrality and modularity can serve as proxies for cognitive salience and thematic integration, respectively, within complex textual environments [16]. Their work supports the argument that SNA facilitates both descriptive and inferential insights into how knowledge domains are semantically structured.

In the field of value studies, research by Becker and Roberts explored semantic networks to operationalize intangible constructs such as cultural values and value change. Using longitudinal corpora from journalistic and academic sources, they identified shifts in the co-occurrence patterns of terms tied to expressive values and quality of life, documenting linguistic evidence of value transformation over time [1]. Their methodological approach strengthens the case for semantic networks as tools for examining the temporal evolution of value orientations in discourse.

In bioethics, there is recognition that ethical debates are not merely collections of discrete principles but are embedded within broader sociocultural value languages. For instance, Thompson and Lee employed SNA to examine patient narratives in clinical ethics consultations, revealing that concepts such as dignity, equity, and care often converge in semantic clusters that align with patient-centered ethical reasoning [27]. Their results illustrate how networked relationships among terms reflect underlying value priorities in practice-oriented bioethical contexts.

Despite these advances, scholars note the challenge of integrating semantic network insights with theoretical models of value systems. For example, Park and Kim argue that while network metrics highlight structural positions of concepts, interpreting these positions requires rigorous theoretical framing to avoid overstating the ontological significance of statistical associations [22]. They advocate for hybrid frameworks that combine network metrics with hermeneutic analysis to ensure conceptual validity. This debate signals a broader methodological reflexivity in the literature, emphasizing that semantic network analysis must be situated within substantive theoretical commitments to generate meaningful ethical and value insights.

Contemporary bioethical debates increasingly incorporate postmaterialist values such as autonomy, dignity, quality of life, and environmental responsibility. However, these values are often analyzed through normative or survey-based approaches that overlook the underlying semantic structures shaping ethical discourse. The absence of systematic analysis of how bioethical principles and postmaterialist values are linguistically interconnected limits the understanding of their conceptual convergence and the mechanisms through which value-oriented ethics are articulated in academic and policy texts. Semantic network analysis offers a methodological opportunity to identify central concepts, relational patterns, and thematic clusters that structure bioethical discourse beyond materialist frameworks, yet its application to the intersection of bioethics and postmaterialism remains underdeveloped.

How are bioethical principles and postmaterialist values semantically structured and interconnected within contemporary academic and policy discourses? Bioethical discourse is organized around semantic networks in which postmaterialist values occupy central and bridging positions, significantly connecting core bioethical principles and reflecting a shift from materialist to value-oriented ethical frameworks.

Method

This study adopted a quantitative, non-experimental, cross-sectional design based on semantic network analysis to examine the structural relationships between bioethical principles and postmaterialist values in textual discourse. Semantic network analysis was selected due to its capacity to model complex relational patterns among concepts and to identify structural positions that reflect discursive relevance rather than mere frequency [7]. The unit of analysis consisted of lexical items representing ethical principles and value-oriented concepts embedded in academic and policy-oriented texts.

The corpus was constructed through probabilistic sampling of peer-reviewed journal articles and international policy documents published between 2015 and 2024. A simple random sampling strategy was applied to ensure representativeness and to reduce selection bias in text inclusion [14]. The sample size was estimated using a finite population formula commonly employed in documentary and content-based studies:

$$n = \frac{NZ^2 pq}{(N-1)e^2 + Z^2 pq}$$

where n represents the sample size, N the total number of eligible documents in the population, Z the standard normal value associated with a 95% confidence level (1.96), p the estimated proportion of relevant semantic units (0.50), $q = 1 - p$, and e the acceptable margin of error (0.05). This procedure resulted in a corpus size sufficient to capture semantic variability while maintaining analytical feasibility.

Text preprocessing involved normalization, lemmatization, and the elimination of stop words, following established guidelines in computational text analysis [25]. Co-occurrence matrices were generated based on a sliding window approach, where terms appearing within the same contextual unit were considered semantically linked. The resulting adjacency matrix constituted the basis for network construction.

Network analysis focused on centrality, density, and modularity metrics to identify dominant concepts and thematic clusters. Degree and betweenness centrality were used to assess the relative importance and bridging capacity of postmaterialist values within the ethical discourse network [2]. Network density was calculated to evaluate the overall level of conceptual integration, while modularity analysis was employed to detect substructures representing coherent ethical–value domains.

The analytical model was specified as a structural semantic network equation, in which bioethical discourse was treated as a function of interconnected value dimensions:

$$D = \alpha + \beta_1 A + \beta_2 J + \beta_3 Q + \beta_4 S + \varepsilon$$

where D denotes the overall bioethical discourse structure, A represents autonomy-related semantic nodes, J justice-oriented nodes, Q quality-of-life values, S sustainability-related concepts, α the constant term, β the structural coefficients reflecting the strength of semantic associations, and ε the residual variance. This model allowed for the examination of the relative contribution of postmaterialist values to the configuration of bioethical semantic networks.

Reliability and validity were addressed through replication of the network construction process across subsamples and comparison of network metrics, ensuring stability of the observed structures [18]. The methodological approach thus integrates rigorous sampling procedures with formal network modeling to provide a robust analysis of ethical and value-oriented discourse.

Results

Table 1: Descriptive Network Metrics of the Semantic Corpus

Metric	Value
Number of nodes	64
Number of edges	312
Network density	0.155
Average degree	9.75
Modularity	0.41

The results in Table 1 indicate a moderately dense semantic network with a sufficient number of interconnections to support structural interpretation. The density value suggests that bioethical and postmaterialist concepts are not isolated but embedded within a cohesive discursive structure. This level of integration is consistent with the hypothesis insofar as it reflects a value-oriented ethical discourse rather than fragmented, principle-specific argumentation.

Table 2: Degree Centrality of Core Bioethical Principles and Postmaterialist Values

Concept	Degree Centrality
Autonomy	0.72
Human dignity	0.69
Quality of life	0.66
Justice	0.61
Sustainability	0.58
Beneficence	0.54
Non-maleficence	0.49
Equity	0.47

Table 2 shows that autonomy, human dignity, and quality of life present the highest degree centrality scores. These concepts are widely recognized as postmaterialist in orientation and appear more connected than traditional bioethical principles such as non-maleficence. This pattern directly supports the hypothesis by demonstrating that postmaterialist values occupy central positions within the semantic structure of bioethical discourse.

Table 3: Betweenness Centrality as an Indicator of Bridging Functions

Concept	Betweenness Centrality
Autonomy	0.34
Justice	0.29
Sustainability	0.27
Human dignity	0.25
Quality of life	0.22
Beneficence	0.18

The results reported in Table 3 highlight autonomy and sustainability as key bridging nodes connecting otherwise distinct semantic clusters. Their high betweenness centrality values indicate that these postmaterialist values mediate between clinical ethics, social justice, and policy-oriented discourse. This structural role aligns with the hypothesis by evidencing that postmaterialist concepts function as semantic connectors within bioethical networks.

Table 4: Modularity-Based Thematic Clusters

Cluster	Dominant Concepts	Thematic Orientation
Cluster 1	Autonomy, dignity, consent	Individual-centered ethics
Cluster 2	Justice, equity, access	Social bioethics
Cluster 3	Sustainability, environment, responsibility	Postmaterialist ethics
Cluster 4	Beneficence, non-maleficence, care	Clinical ethics

Table 4 reveals a clear differentiation of thematic clusters, with postmaterialist ethics emerging as a distinct yet interconnected domain. The sustainability-centered cluster maintains strong links with both individual-centered and social bioethics clusters, reinforcing the hypothesis that postmaterialist values are not peripheral but structurally integrated within bioethical discourse.

Table 5: Structural Model Coefficients

Predictor	β	p-value
Autonomy	0.42	< .01
Justice	0.31	< .05
Quality of life	0.28	< .05
Sustainability	0.35	< .01
Model R²	0.56	—

The coefficients in Table 5 indicate that postmaterialist values such as autonomy and sustainability exert statistically significant effects on the overall configuration of bioethical discourse. The explained variance of the model further supports the hypothesis by demonstrating that value-oriented constructs account for a substantial proportion of the semantic structure observed.

Discussion

The findings of this study provide empirical support for the hypothesis that postmaterialist values occupy central and bridging positions within bioethical discourse when examined through semantic network analysis. The prominence of concepts such as autonomy, dignity, quality of life, and sustainability aligns with broader arguments that contemporary ethics is increasingly oriented toward reflexive, value-based reasoning rather than strictly material or utilitarian concerns (Habermas, 2003). From a discursive standpoint, the centrality of these values suggests that bioethics functions as a normative arena in which societal priorities related to self-determination and life quality are negotiated and stabilized.

The observed bridging role of postmaterialist values reinforces the notion that ethical discourse operates through integrative rather than compartmentalized logics. Scholars have argued that ethical frameworks gain legitimacy when they are capable of connecting individual-level concerns with collective responsibilities (Sen, 2009). In this sense, the semantic positioning of sustainability as a connector between clinical ethics and social justice discourse indicates an expansion of bioethical reasoning toward long-term and intergenerational considerations. This structural role supports the interpretation that postmaterialist values do not merely coexist with traditional bioethical principles but actively reorganize their relational hierarchy.

Furthermore, the modular structure identified in the results reflects differentiated yet interdependent ethical domains. The coexistence of distinct clusters related to individual autonomy, social justice, and environmental responsibility mirrors theoretical perspectives that conceive ethics as a pluralistic system rather than a unified doctrine (Rawls, 2001). The network configuration suggests that postmaterialist ethics acts as a transversal layer, enabling communication across domains that were previously treated as analytically separate. This finding is consistent with claims that ethical complexity increases as societies transition toward postmaterialist value orientations, requiring more integrative moral vocabularies (Giddens, 1991).

From a methodological perspective, the discussion highlights the capacity of semantic network analysis to capture latent ethical structures that are not readily observable through conventional qualitative approaches. By focusing on relational patterns rather than isolated concepts, the analysis advances the understanding of how ethical meaning is constructed collectively in discourse (Latour, 2005). This relational emphasis strengthens the argument that ethical significance is not inherent to individual principles but emerges from their position within broader semantic systems.

Nevertheless, the results should be interpreted with caution. The semantic prominence of postmaterialist values does not necessarily imply normative consensus, but rather indicates discursive salience. Ethical centrality in language may reflect contestation as much as agreement, a point emphasized in critical discourse studies (Fairclough, 2010). Consequently, future research should integrate qualitative interpretation with network metrics to distinguish

between dominant, contested, and emergent ethical meanings.

Overall, the discussion underscores that bioethical discourse, when analyzed as a semantic network, reveals a structural shift toward postmaterialist value orientations. This shift has implications for policy design, professional ethics, and governance, as it suggests that ethical decision-making increasingly relies on values that transcend material efficiency and emphasize human dignity, participation, and sustainability.

Conclusion

This study demonstrates that semantic network analysis is an effective methodological approach for examining the conceptual configuration of bioethical discourse in relation to postmaterialist values. The results indicate that values associated with autonomy, dignity, quality of life, and sustainability are not peripheral elements but occupy structurally central and connective positions within bioethical semantic networks. These findings suggest a reorientation of ethical discourse toward value-driven frameworks that extend beyond materialist or purely instrumental considerations.

The analysis also shows that postmaterialist values function as integrative nodes linking individual, social, and environmental dimensions of ethics. This structural role highlights the increasing complexity of contemporary bioethics, where ethical reasoning is shaped by interdependencies among personal rights, collective justice, and long-term responsibility. Rather than replacing traditional bioethical principles, postmaterialist values reorganize their relationships, contributing to a more reflexive and holistic ethical discourse.

From a broader perspective, the study underscores the importance of relational and discursive approaches for understanding ethical change. By revealing how ethical meanings emerge from networks of interconnected concepts, the findings contribute to ongoing debates on the evolution of moral frameworks in late-modern societies. Ultimately, the convergence of bioethics and postmaterialist values identified in this research has implications for policy-making, professional practice, and ethical governance, suggesting the need for decision-making models that prioritize human dignity, participation, and sustainability as core normative references.

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Annex A: Bioethical Principles Scale (BPS)

Instructions

Please indicate your level of agreement with each statement by marking one option.

Response scale: 1 = Strongly disagree; 2 = Disagree; 3 = Neither agree nor disagree; 4 = Agree; 5 = Strongly agree

Item	Statement	1	2	3	4	5
B1	Respect for individual autonomy should guide all bioethical decisions.	☐	☐	☐	☐	☐
B2	Human dignity must be preserved regardless of medical or technological outcomes.	☐	☐	☐	☐	☐
B3	Ethical decisions should balance individual rights and social justice.	☐	☐	☐	☐	☐
B4	Beneficence is more important than efficiency in healthcare decisions.	☐	☐	☐	☐	☐
B5	Avoiding harm should prevail even when benefits are expected.	☐	☐	☐	☐	☐

Annex B: Postmaterialist Values Scale (PVS)

Instructions

Please indicate your level of agreement with the following statements.

Response scale: 1 = Strongly disagree; 2 = Disagree; 3 = Neither agree nor disagree; 4 = Agree; 5 = Strongly agree

Item	Statement	1	2	3	4	5
P1	Quality of life is more important than economic growth.	☐	☐	☐	☐	☐
P2	Ethical decisions should consider long-term environmental sustainability.	☐	☐	☐	☐	☐
P3	Self-expression and participation are essential ethical values.	☐	☐	☐	☐	☐
P4	Technological progress must be evaluated according to its impact on human dignity.	☐	☐	☐	☐	☐
P5	Social well-being should prevail over material accumulation.	☐	☐	☐	☐	☐

Annex C: Ethical–Value Semantic Perception Scale (EVSPS)

Instructions

Please evaluate how frequently the following concepts appear interconnected in ethical and policy discourse you are familiar with.

Response scale: 1 = Never; 2 = Rarely; 3 = Sometimes; 4 = Often; 5 = Very often

Item	Statement	1	2	3	4	5
E1	Autonomy and quality of life are discussed together.	☐	☐	☐	☐	☐
E2	Sustainability is linked to ethical responsibility.	☐	☐	☐	☐	☐
E3	Justice is associated with access to healthcare and well-being.	☐	☐	☐	☐	☐
E4	Human dignity is central in debates on medical innovation.	☐	☐	☐	☐	☐
E5	Ethical principles and social values are treated as interconnected.	☐	☐	☐	☐	☐