Age Cohort Variability in Conceptual Complexity and Concreteness: The Case of Ecological and Technological Concepts

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Abstract

Concepts are flexible and vary depending on multiple factors. Here, we investigate age cohort conceptual variations using the two domains of ecology (e.g., "deforestation") and technology (e.g., "web") as case examples. 320 Italian older adults (>64 years) evaluated 50 concepts per domain across 39 semantic dimensions. Their ratings were compared with those of younger adults (18–35 years) reported in Falcinelli et al. (2024a). Results revealed clear generational differences: representations were more complex and concrete for ecological concepts in older adults, and for technological concepts in younger adults. Additionally, older adults showed greater personal experience with ecological topics, while younger adults reported higher familiarity with technology. Theoretically, our findings support evidence regarding differences in conceptualizations across age cohorts. Scientifically, the resulting O-TECo database provides the first semantic norms tailored to older adults. Societally, results highlight the importance of age-tailored interventions in these two crucial fields.

Keywords: ecological concepts; technological concepts; older adults; younger adults; conceptual complexity; conceptual abstractness.

Introduction

Concepts are fundamental to human functioning, as they represent the basic units of knowledge that people use in their everyday life to construct thoughts and act. Although being relatively stable, concepts are not static (Reilly et al., 2025) but are intrinsically flexible. Studies show that categories can be dynamically constructed to address momentary goals (ad hoc categories; Barsalou, 1983) and that conceptualizations vary in relation to societal factors. For instance, representations can differ across people with distinct linguistic and cultural backgrounds (e.g., Mazzuca et al., 2024; van Putten et al., 2020), and domain knowledge can be reorganized due to societal events, as it was during the COVID-19 pandemic, which reshaped people's understanding of diseases (Mazzuca et al., 2021, 2022).

Conceptual representations can also vary as a function of people's characteristics. One of them is the expertise: compared to laypeople, experts tend to represent their expertise domain less abstractly, with more detailed features and richer in emotional and interoceptive components (Falcinelli et al., 2024b, c; Falcinelli et al., 2025; Mazzuca et al., 2025; Tanaka & Taylor, 1991; Villani et al., 2022).

Another important source of variability is age. Previous research documents age-related differences in the quantity (Dubossarsky et al., 2017), structure (Cosgrove et al., 2021), and content (Vignando et al., 2018) of knowledge related to a conceptual domain. In addition, recent studies indicate that both younger and older adults update their conceptual knowledge to remain aligned with environmental changes; however, this requires a higher processing effort in older adults (Cain & Ryskin, 2025; Li & Siew, 2022).

Importantly, conceptual variability is not uniform across domains. Abstract concepts (e.g., "freedom"), for example, which usually lack a single physical referent, are more variable across individuals and contexts than concrete ones (e.g., "table") (Borghi, 2022; Borghi & Mazzuca, 2023; Davis et al., 2020; Kemmerer, 2023). Their conceptualization also changes across the lifespan. For instance, while networks (i.e., word associations) of concrete words become poorer, less interconnected, and more segregated with age, networks of abstract words remain largely preserved (Cosgrove et al., 2026).

Our study aims to further investigate age cohort variations in conceptual representations by focusing on two domains particularly salient in contemporary Western societies: ecology (e.g., "deforestation") and technology (e.g., "web").

We chose these concepts for two main reasons. First, the ecological and technological domains have undergone significant transformations in recent decades, likely influencing how people think about and interact with the natural environment. Research suggests that these changes affect generations differently (e.g., ecology: APA, 2018; Pihkala, 2020; technology: Lozano-Blasco et al., 2022), and that older and younger adults relate to these domains in distinct ways (e.g., ecology: Ágoston et al., 2024; López-Mosquera et al., 2015; Scott et al., 2015; Wang et al., 2021; technology: Hunsaker & Hargittai, 2018; Olson et al., 2011)—an aspect which also affect the concreteness of related representations (Falcinelli et al., 2024b; Falcinelli et al., 2025).

Second, ecological and technological concepts can be considered *hybrid* in terms of abstractness: although they often refer to concrete entities (e.g., "factory", "computer"), people think that they share several properties with abstract concepts (Falcinelli et al., 2024a, b; Falcinelli et al., 2025). This evidence is consistent with similar findings documenting a mixed characterization for different conceptual kinds (e.g., gender: Mazzuca et al., 2020, 2024;

In G. Boleda, I. Dautriche, M. Maldonado, C. Saldana and T. Torrent (Eds.), *Proceedings of the 48th Annual Conference of the Cognitive Science Society*

odor: Majid et al., 2018). These studies reveal that the stronger experience within a domain makes its representation less abstract. We are therefore interested in understanding whether different experiences, including age, may influence the degree of abstractness and related dimensions in conceptualizations. To capture these aspects, we used ratings, a reliable (Corneille & Gawronski, 2024) and widely used method for investigating conceptual representations (e.g., Brysbaert et al., 2014; Lynott & Connell, 2013; Lynott et al., 2020; Villani et al., 2019) that also shows convergence in results with more implicit measures (e.g., reaction times, Falcinelli et al., 2024b; 2025).

In our study, we employ evaluations to investigate various dimensions to determine whether and how the representation of ecological and technological concepts differs between younger and older adults. To this end, we replicate and extend a previous rating study by Falcinelli et al. (2024a), in which participants—mostly younger adults—evaluated a pool of concepts, including ecological and technological, on multiple dimensions (N = 39). We adopted the same methodology, word set, and semantic dimensions, but we collected new data from older adults (aged >64). To allow comparisons, we contrasted our older adults' ratings with existing data from younger adults (aged 18-35; Falcinelli et al., 2024a), using Partial Least Squares Discriminant Analyses (PLS-DAs; Barker & Rayens, 2003; Nguyen & Rocke, 2002). This multivariate dimensionality-reduction technique allowed us to identify which semantic dimensions most strongly characterize each age cohort within each domain, offering a novel approach to studying semantic organization.

Beyond its theoretical contribution, our work extends the TECo database (Falcinelli et al., 2024a) by providing several semantic norms for these new concepts specifically tailored to older adults—the O-TECo database.

Method

Participants

Based on Falcinelli et al. (2024a), we enrolled 20 participants to gain evaluations on each word and semantic dimension. We recruited participants via word-of-mouth or by sponsoring surveys on social media. The inclusion criteria were being Italian native speakers aged 64 or older.

Our final sample consisted of 320 older adults (231 females, M_{age} = 70.71; SD_{age} = 5.25; $Range_{age}$ = 64 - 94), all Caucasian and residents of Italy.

Materials

Target words

The stimulus set consisted of Italian target words including ecological and technological concepts (n = 50 each). Ecological concepts comprised terms indicating climate change phenomena (e.g., *global warming, greenhouse effect, ozone hole*) or their causes (e.g., *deforestation, industrial drain, pollution*). Technological concepts encompassed words mainly referring to devices and software commonly used for online communication and interaction (e.g., *computer, multimedia, Internet*).

Semantic dimensions

Dimensions (N = 39) were the same as in Falcinelli et al. 2024a. We divided them into distinct groups (henceforth, "spheres"), based on previous literature investigating their relevance to define abstractness.

Abstractness sphere. This sphere included dimensions typically used to distinguish between abstract and concrete concepts. They are: Concreteness~Abstractness, capturing how concrete-abstract a concept is perceived to be (Paivio et al., 1988; Paivio, 1990); Imageability (Paivio et al., 1988; Paivio, 1990) and Context Availability (Schwanenflugel et al., 1992), referring respectively to the ease with which a concept evokes mental images and can be associated with contextual information; Body-Object Interaction, assessing the easiness to physically interact with a concept's referent (Bennett et al., 2011; Tillotson et al., 2008); Familiarity, indexing the perceived knowledge of a concept (Barca et al., 2002); two acquisition-related measures—Age of Acquisition (Gilhooly & Logie, 1980) and Modality of Acquisition (Wauters et al., 2003)—capturing when and how (i.e., mainly through sensorimotor~linguistic experiences) a concept has been learned; Frequency, reflecting estimated word usage in spoken and written language (Laudanna & Burani, 1995); and Easiness of Providing a Definition, measuring how easily participants feel they can define a concept (Falcinelli et al., 2024a).

In line with Multiple Representation Views, according to which multiple components (e.g., emotional, inner, metacognitive, sensorimotor, sociopolitical) concur in conceptual representation (Barsalou et al., 2018; Borghi, 2022, 2023; Conca et al., 2021; Crutch et al., 2013; Diveica et al., 2025; Dove, 2022; Pexman et al., 2023; Reilly et al., 2025), we included additional spheres to capture the extent to which concepts evoke different kinds of experiences.

Sensorimotor & Experiential sphere. This sphere included Perceptual Strength, assessing the degree to which a concept can be experienced via the five sensory modalities (hearing, taste, touch, smell, and vision; Connell & Lynott, 2012, 2014; Lynott & Connell, 2013); Action Effectors, measuring the involvement of specific body parts (feet/legs, hands/arms, mouth/throat, and torso; Lynott et al., 2020); and Personal Experience, indicating the extent to which a concept is perceived as directly experienceable (Falcinelli et al., 2024a).

Emotional & Inner sphere. This sphere comprised Interoception, reflecting the degree to which a concept evokes bodily internal states (Connell et al., 2018; Villani et al., 2021); Metacognition, indexing the extent to which a concept triggers cognitive or mental processes (Villani et al., 2019); Emotionality, measuring the emotional content associated with a concept (Ponari et al., 2018; Vigliocco et al., 2014); and Valence, Dominance, and Arousal, referring respectively to emotional tone, perceived control over the referent, and the level of activation elicited by the word (Montefinese et al., 2014).

Metacognitive sphere. This sphere encompassed Word Confidence and Confidence in Experts (Mazzuca et al., 2022), capturing, respectively, the self and field experts knowledge of a concept; and Social Metacognition and Expert Social Metacognition, reflecting the extent to which individuals feel the need to rely on generic others or field experts, respectively, to understand a conceptual meaning (Borghi, 2022; Falcinelli et al., 2024a).

Sociopolitical sphere. This sphere comprised Social Valence, assessing the extent to which a concept evokes social situations (Diveica et al., 2023; Pexman et al., 2023); two pragmatic–communicative dimensions—Easiness to Start a Conversation and Openness to Negotiation—capturing a concept's potential to initiate discussion and its perceived negotiability (Fini et al., 2023); and Political Relevance, measuring the extent to which a concept may elicit public or societal debate (Falcinelli et al., 2024a; Mazzuca & Santarelli, 2023).

Impact sphere. It included the perceived influence of a concept on individuals' lives, including Perceived Impact in the Past, Present, and Future (Falcinelli et al., 2024a), and Perceived Distance, reflecting the psychological closeness-distance felt toward it (Mazzuca et al., 2022).

Naturalness~Artificiality sphere. It comprised the perceived Scientificity of a concept and also its Naturalness–Artificiality, assessing whether a concept is conceived mainly as natural or artificial (Falcinelli et al., 2024a; Forde & Humphreys, 2005).

The instructions for dimensions are available at the OSF repository (https://doi.org/10.17605/OSF.IO/BAXC8).

Procedure

The study was approved by the Ethics Committee of the Department of Dynamic and Clinical Psychology, and Health Studies, Sapienza University of Rome (Prot. n. 000147 - 04/02/2022). We implemented 16 Qualtrics surveys, each compiled by an independent sample of 20 older adults. In each survey, we asked participants to evaluate all target words on, on average, two semantic dimensions using 7-point Likert scales (Falcinelli et al., 2024a; see also Villani et al., 2019). In the last section of the survey, they provided their socio-demographic information (e.g., age, sex, education). Each compilation took on average 1.5 hours.

Data Analysis

We pre-processed and analyzed data using RStudio (R-Core Team, 2019, version 4.2.2).

O-TECo database. After ensuring high reliability of our ratings (Cronbach's alpha: .90 to 1.00 - Cronbach, 1951), we created the O-TECo database by calculating the mean and standard deviation for each word and dimension. The database is publicly available at the OSF repository (https://doi.org/10.17605/OSF.IO/BAXC8).

Samples selection. We extracted data on younger adults from Falcinelli et al. (2024a) by selecting participants aged ≤ 35 years (see Falcinelli et al., 2024b; Falcinelli et al., 2025). For older adults (aged ≥ 64), we extracted the same number of ratings per word per dimension as for younger adults by retaining only evaluations from the oldest participants in our study, to maximize the age gap between cohorts. To better characterize our samples, we also examined whether older and younger adults differed in their personal experiences and familiarity with ecological and technological concepts. To this end, we run two separate ordinal regression mixed models ("ordinal" R's package - Christensen, 2022), featuring ratings on the target dimension as a dependent variable, the interaction between Age Cohort (Older, Younger) and Concept Type (Ecological, Technological) as a fixed factor, and Target Word and Participants as random intercepts. We determined the significance of the interaction through a Type III ANOVA ("RVAideMemoire" R's package - Hervé, 2022) with *p*-values calculated using Wald's Chi-squared tests, and we performed contrasts across conditions with Tukey's adjustments for multiple comparisons ("emmeans" R's package - Lenth, 2023).

Samples comparison. To explore age cohort differences in the representation of ecological and technological concepts, we performed two separate multilevel Partial Least Squares Discriminant Analyses (PLS-DAs). PLS-DA is a multivariate technique that relates a set of predictor variables to a categorical outcome by coding group membership as binary variables (Pérez-Enciso & Tenenhaus, 2003). Similar to Principal Component Analysis, it reduces a high-dimensional dataset to a smaller set of latent components (PCs), but differently from it, PLS-DA uses class membership information to maximize separation between groups, allowing for classification (Barker & Rayens, 2003; Nguyen & Rocke, 2002; Botella et al., 2009; Christin et al., 2013; Tan et al., 2004). Latent components are linear combinations of the original semantic dimensions, and the first one (PC1) captures the main axis that best discriminates between targeted groups.

We ran multilevel PLS-DAs using the "mixOmics" R package (Rohart et al., 2017), including Dimensions ($N = 39$) as predictor variables, Age Cohort (Older, Younger adults) as a grouping factor, and Target Words as multilevel categorical variables. Each dimension was treated as a continuous numerical variable representing the standardized mean rating assigned to each word on that semantic scale. We selected the optimal number of PCs using classification-based criteria (*Maximum, Centroids,* and *Mahalanobis distances*). We then ran the final PLS-DAs on the identified PC(s), examined their variances, and assessed their roles in discriminating between the two age cohorts.

To investigate differences between older and younger adults in the complexity—i.e., richness and variety—and concreteness of their semantic representations of ecological and technological concepts, we then zoomed into each PC1 composition. In particular, we visually inspected how dimensions (specifically, those with a weight (W) equal to or over |.10|) and their subdivision into "spheres" contributed, in number and type, to both sides of the identified PC, each of which encompassed a prevalence of observations from an age cohort. The weights of the dimensions (W) reflect their contributions and directions to PC1, with higher absolute values indicating a stronger role in distinguishing between older and younger adults.

Results

Characterization of the compared samples of older and younger adults.

We compared data from 236 older (168 females, M_{age} = 71.99; SD_{age} = 5.13, $Range_{age}$ = 64 - 94) and 239 younger adults (162 females, M_{age} = 25.67; SD_{age} = 3.39, $Range_{age}$ = 18 - 35), all Italian native speakers, Caucasian, and living in Italy.

Both models on personal experience and familiarity returned a significant Age Cohort x Concept Type interaction (Personal Experience: $X^2(1) = 70.065$, $p < .0001$; Familiarity: $X^2(1) = 204.19$, $p < .0001$), revealing that older adults reported greater personal experience with ecological concepts, SE = 0.386, z = 2.471, $p = .013$, whereas younger adults were more familiar with technological concepts, SE = 0.576, z = 2.262, $p = .023$.

Age cohort differences in domains' semantic organization.

Among the 39 Principal Components extracted from the initial PLS-DAs, all indexes (i.e., *Maximum Distance, Centroids Distance*, and *Mahalanobis Distance*) suggested *one* as the best number of PCs to retain for both domains.

For ecological concepts, PC1 accounted for 41% of the total variance, whereas for technological concepts, it accounted for 43%. In both domains, the separation between older and younger adults fully accounted for PC1's organization (100%), with all older adults' concepts (arbitrarily) positioned on the left and all younger adults' on the right.

Ecological concepts (Figure 1, left)

Older adults' side of PC1 includes a larger number of dimensions (n = 29) than that of younger adults (n = 10), a broader range of spheres (all except the *metacognitive* one compared to younger adults' side which misses the *abstractness* and the *naturalness–artificiality* spheres) and a higher number of dimensions contributing to each sphere (e.g., within the *sensorimotor* sphere, seven dimensions for older adults vs. two for younger adults).

As for its composition, first, the older adults' side includes the full set of dimensions related to *abstractness*. Ecological concepts are principally described by older adults as strongly tied to situational contexts (Context Availability, W = −0.19), bodily interactions (Body–Object Interaction, W = −0.19), and mental imagery (Imageability, W = −0.10), are perceived as easy to define (Easiness of Providing a Definition, W = −0.16), and mainly acquired later in life (Age of Acquisition, W = −0.19). Moreover, older adults describe ecological concepts as highly personal experienced (Personal Experience, W = −0.21) through all bodily effectors (mouth/throat: W = −0.23; feet/legs: W = −0.20; hands/arms: W = −0.17; torso: W = −0.16), and also with the vision sensory modality (W = −0.11) (*sensorimotor & experiential* sphere).

Older adults also conceive ecological concepts as highly emotionally charged (Emotionality, W = −0.19) and internally engaging, activating arousal (W = −0.21) and mental processes (Metacognition, W = −0.14) (*emotional & inner* sphere). In addition, older adults perceive ecological concepts as highly impactful, especially in their present and future lives (Perceived Impact in the Present, W = −0.24; Perceived Impact in the Future, W = −0.24), and also in their past, to a lesser extent (Perceived Impact in the Past, W = −0.14) (*impact* sphere).

Ecological concepts are also viewed by older adults as negotiable in their meaning (Openness to Negotiation, W = −0.22), socially relevant (Social Valence, W = −0.17), and good starting topics for conversations (Easiness to Start a Conversation, W = −0.11) (*sociopolitical* sphere). Finally, older adults tend to conceive these concepts as scientific (Scientificity, W = −0.16) and more closely associated with artificial than natural aspects (Naturalness–Artificiality, W = −0.15) (*naturalness~artificiality* sphere).

In contrast, younger adults' characterization of ecological concepts is mainly based on their political relevance (Political Relevance, W = 0.17) (*sociopolitical* sphere) and the psychological distance felt from these concepts (Perceived Distance, W = 0.23) (*impact* sphere). Additionally, younger adults report to experience these concepts mostly through sensory channels—particularly taste (W = 0.19) and touch (W = 0.12) (*sensorimotor & experiential* sphere)—, and their understanding of ecological concepts is strongly associated with deference to expert knowledge (Expert Social Metacognition, W = 0.22), trust in experts (Confidence in Experts, W = 0.11), and reliance on others more generally (Social Metacognition, W = 0.21) (*metacognitive* sphere).

Technological concepts (Figure 1, right)

The PC1 side associated with younger adults encompasses a larger number of contributing dimensions than that of older adults (n = 22 vs. n = 17). In addition, although both age cohorts draw on all conceptual spheres, younger adults show a more heterogeneous distribution of dimensions across spheres (e.g., within the *sensorimotor & experiential* sphere, seven dimensions contribute for younger adults vs. only three for older adults).

First, younger adults characterize technological concepts as familiar (Familiarity, W = 0.21) and easy to define (Easiness of Providing a Definition, W = 0.21) (*abstractness* sphere). They also report a strong sense of epistemic mastery, expressing high confidence both in their own understanding (Word Confidence, W = 0.23) and in experts' knowledge of technological concepts (Confidence in Experts, W = 0.17) (*metacognitive* sphere).

Moreover, younger adults emphasize bodily and sensory modalities associated with active manipulation: technological concepts are primarily experienced through the hands and arms (W = 0.20), the tactile modality (Touch, W = 0.16), and the torso (W = 0.13) (*sensorimotor & experiential*). Younger adults also describe technological concepts as positively valenced (Valence, W = 0.16) and engaging interoceptive awareness (Interoception, W = 0.22), arousal (W = 0.12), and mental processes (Metacognition, W = 0.16) (*emotional & inner* sphere).

In addition, younger adults conceive technological concepts as highly relevant in society (Social Valence, W = 0.14), suitable topics for initiating conversations (Easiness to Start a Conversation, W = 0.22) (*sociopolitical* sphere), and mark the impact they had in their past life (Perceived Impact in the Past, W = 0.16) (*impact* sphere). Finally, younger adults place great emphasis on the artificial nature of technological referents (Naturalness–Artificiality, W = 0.14).

Turning to older adults, they conceive technological concepts as mainly abstract (Concreteness–Abstractness, W = −0.19), despite stressing the possibility of physically interacting with their referents (Body–Object Interaction, W = −0.17). Older adults also perceive technological concepts as frequently encountered in everyday life (Frequency, W = −0.22), acquired later in life (Age of Acquisition, W = −0.23), and primarily through linguistic channels (Modality of Acquisition, W = −0.15) (*abstractness* sphere). In sensorimotor terms, older adults highlight the experienceability of technological concepts through the mouth and throat (W = −0.21) and the auditory channel (Hearing, W = −0.12).

Older adults' representation of technological concepts is also characterized by a great reliance on others to understand technological meaning (Social Metacognition, W = −0.20) (*metacognitive* sphere). Older adults also stress the strong emotional charge associated with these concepts (Emotionality, W = −0.23) (*emotional & inner* sphere) and emphasize the negotiability of their meaning (Openness to Negotiation, W = −0.18) (*sociopolitical* sphere).

Finally, older adults consider technological concepts as highly impactful in their current (Perceived Impact in the Present, W = −0.16) and future lives (Perceived Impact in the Future, W = −0.19) (*impact* sphere), and they tend to conceive technological concepts as more closely associated with scientific knowledge (Scientificity, W = −0.19) (*naturalness–artificiality* sphere).

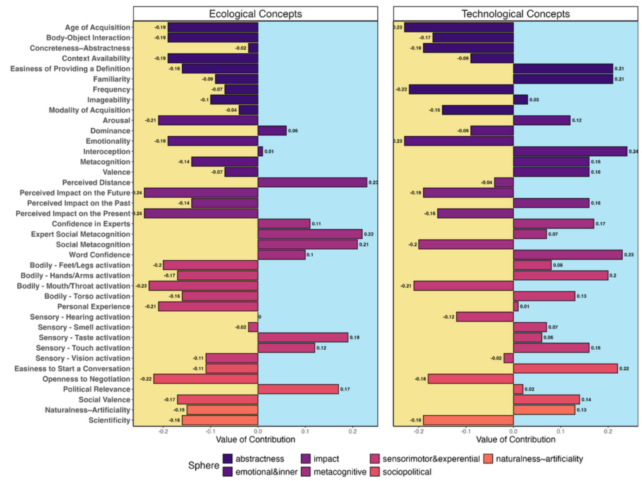

Figure 1: Contribution of dimensions to PC1 of Ecological (left) and Technological (right) concepts, along with their distinction into spheres (color-coded). The yellow background indicates the presence of all older adults' words in the negative pole of PC1, while the light-blue background indicates that all younger adults' words are in its positive side.

Discussion and Conclusion

Our results reveal clear age cohort differences in the semantic characterization of ecological and technological concepts.

In ecological concepts, older adults exhibit a richer and more multifaceted representation than younger adults. Their characterization draws on a larger number of dimensions overall and within each sphere, and spans almost all conceptual spheres, indicating a higher semantic complexity. Older adults conceive ecological concepts mainly with concrete features, such as the easiness in definition, mental imagery, contextual availability, bodily interaction, and high personal experienceability (Barsalou & Wiemer-Hastings, 2005; Bennett et al., 2011; Falcinelli et al., 2024a; Paivio, 1990; Schwanenflugel et al., 1992), suggesting strong experiential anchoring. This experience is primarily bodily, as older adults rate these concepts as involving all effectors and also the vision sensory modality (Lynott et al., 2020; Lynott & Connell, 2013), and they evaluate ecological issues as having a high perceived impact on their lives, especially in the present and future. At the same time, older adults also attribute to ecological concepts properties typically associated with abstractness: ecological concepts are perceived as activating emotional and inner (arousal, mental) processes and socially important, conversation-friendly, and negotiable in their meaning (Diveica et al., 2023, 2025; Fini et al., 2023; Ponari et al., 2018; Villani et al., 2019). Altogether, these aspects support their *hybrid* characterization of these concepts found in previous literature (Falcinelli et al., 2024a; Falcinelli et al., 2025).

In contrast, younger adults represent ecological concepts as less complex and, although similarly *hybrid* to older adults, as less concrete. Younger adults' characterization relies more strongly on ecological concepts' political relevance, on the psychological distance perceived from them, and on metacognitive aspects, including reliance on generic others and experts and trust in them for understanding their meaning—all typical properties of abstract concepts (Borghi, 2022; Falcinelli et al., 2024a; Mazzuca et al., 2022; Mazzuca & Santarelli, 2022). Sensorimotor grounding is present but limited primarily to sensory modalities, such as taste and touch, rather than to the engagement of bodily effectors, as for older adults. Altogether, this data suggests that younger adults' representation of ecological concepts is more distant and cognitively mediated, perhaps less embodied, in contrast with the more concrete, experience-rich, and personally and societally meaningful representation by older adults.

Conversely, technological concepts exhibit an inverse age cohort pattern. Younger adults show a richer (i.e., more dimensions overall), more heterogeneous (i.e., more contributing dimensions within each sphere), and more concrete representation than older adults. As for typical concrete concepts (Barca et al., 2002; Falcinelli et al., 2024a; Mazzuca et al., 2022), technological concepts are described as familiar, easy to define, and younger adults feel high confidence in their own and field experts' understanding, indicating a strong sense of epistemic mastery. In addition, their representation is mainly grounded in active sensorimotor experiences, especially through the hands and touch, as is usually the case with concrete concepts (Lynott et al., 2020; Lynott & Connell, 2013). Also, the torso involvement is present, which might point to the inner (interoceptive, arousal) and positively valenced activations that technological concepts elicit in younger adults. These aspects, together with the activation of mental and cognitive processes, contribute to making younger adults' representations of technological concepts more similar to those of typical abstract concepts (Connell et al., 2018; Villani et al., 2019, 2021). Supporting this, as with abstract concepts, younger adults consider technological concepts highly important in society and suitable topics of conversation (Diveica et al., 2023, 2025; Fini et al., 2023), and they emphasize technology's impact on their past lives.

Older adults, by contrast, represent technological concepts in a less complex and more abstract manner. Their perception of technology relies more on mouth and hearing activations, which may allude to a more socially mediated way of experiencing their referents. In support of this, older adults perceive technological concepts as late acquired and mainly through verbal explanation. In addition, older adults report a high need for others to understand and negotiate their meaning, and consider ecological concepts as highly emotionally charged—all properties usually attributed to abstract concepts (Borghi, 2022; Fini et al., 2023; Diveica et al., 2025; Gilhooly & Logie, 1980; Ponari et al., 2018; Wauters et al., 2003)—, alongside a focus on technology's impact on their present and future lives. Finally, older adults also attribute to technological concepts some concrete features, such as the possibility to physically interact with their referents (Bennett et al., 2011) and the activation of sensorimotor components, although the specific parts involved—mouth, hearing—are usually linked to abstractness (Banks & Connell, 2023; Diveica et al., 2025). Altogether, as with ecological concepts, the characterization of technological concepts is *hybrid* for both age cohorts, but in this case, it appears more concrete in younger than in older adults (Falcinelli et al., 2024b).

Overall, our findings indicate that the complexity and concreteness of conceptual representations vary across age cohorts. At the same time, the inverse pattern of results we found for ecological and technological concepts across age cohorts suggests that variations may be domain-sensitive. Although not directly tested, results may be due to the intervention of additional interacting factors, such as the distinct life experiences of different age cohorts within each domain (e.g., Mazzuca et al., 2025; Villani et al., 2022). Indeed, our ordinal models showed that older adults reported greater experiential involvement with ecology than younger adults (López-Mosquera et al., 2015; Wang et al., 2021), whereas younger adults were more familiar with technological concepts (Hunsaker & Hargittai, 2018; Olson et al., 2011). One might think that divergences in ecological concepts' representation might reflect *qualitative* variations linked to the perceived presence/absence of personal experience within the domain, whereas differences for technological concepts could be associated with more *quantitative* aspects driven by different levels of familiarity with technology (e.g., frequency and continuity of use - Olson et al., 2011). However, further research is needed to clarify how experience-related factors shape age cohort differences in conceptualizations.

Importantly, our results should not be interpreted as stable or universal differences across age cohorts, as they offer a generational snapshot within the specific sociocultural context and historical period examined.

Theoretically, our data also supports multidimensional accounts on concepts (Barsalou et al., 2018; Borghi, 2022, 2023; Conca et al., 2021; Diveica et al., 2025; Dove, 2022; Pexman et al., 2023; Reilly et al., 2025), testifying that conceptual representations are complex and emerge from the integration of multiple components (e.g., emotional, inner, metacognitive, sensorimotor, sociopolitical).

Scientifically, the O-TECo database resulting from our study may serve as a useful tool for further research on aging, conceptual organization, and abstractness.

Socially, our results highlight the importance of tailoring communication, education, and policy strategies to different generations, especially in areas like environmental sustainability and technological innovation, where effective engagement also depends on how people represent and experience these domains.

Acknowledgments

The study was funded by Sapienza Excellent Projects, grant n. RG123188B09BDF14 - "*Ecological, Technological and Gender Concepts and Their Variations across the Lifespan*", P.I. Prof. Anna M. Borghi.

The Sponsors were not involved in all the steps of the experiment's execution and in the manuscript preparation.

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