DE GRUYTER MOUTON Linguistics 2025; 63(2): 511–555

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The role of environmental ethics and sustainability in research ethics for linguistics: what is currently available in terms of guidance and how might that be improved?

https://doi.org/10.1515/ling-2023-0203
Received October 11, 2023; accepted January 24, 2025; published online March 14, 2025

Abstract: Ecological sustainability has become a central concern in academic and political discourse and should be considered in research ethics guidelines. However, despite growing environmental awareness, current research ethics guidelines overlook the environmental impacts of academic activities such as travel, lab-based research, and high-performance computing. We argue that it is now imperative to incorporate environmental ethics in these guidelines, aligning them with the 17 sustainable development goals (SDGs) of the UN. Drawing on empirical impact studies, we propose both general recommendations applicable across disciplines and specific guidance for linguistic research that involves high-performance computing, laboratory research, and fieldwork. We also discuss how environmental issues can be addressed in ecolinguistics, linguistics teaching, outreach, and knowledge transfer. In our recommendations, we focus on researchers' responsible use of natural resources in academic practices, including travel, conferences, events, laboratory work, and institutional operations.

Keywords: computational linguistics; ecolinguistics; environmental ethics; research ethics; SDGs

1 Introduction

Since the 1960s and 1970s, pollution, climate change, the loss of biodiversity, and other degradations to our natural environment have made ecological sustainability

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an intensely discussed topic in society, politics, and academia. In the resulting sustainability research, it soon became obvious that social and economic development are inextricably linked to ecological sustainability. As a result, several fields – including economics, psychology, sociology, and linguistics – have witnessed an "ecological turn". However, we will show that concerns about ecological sustainability are still not sufficiently reflected in research ethics guidelines. Hence, we will argue for the inclusion of environmental ethics into such guidelines, and we will offer evidence-based recommendations for an extension of research ethics that can be applied to a broad range of fields, including linguistics. We will also discuss specific environmental issues in linguistic research that should be considered in research ethics guidelines for these disciplines.

In Section 2, we will provide the background for our discussion by briefly describing the rise of environmental science, activism, and ethics in the 1960s and the resulting shift from anthropocentric to ecocentric approaches in environmental ethics.

In Section 3, we will discuss how the mounting evidence for environmental degradation and human effects on climate change has led to the current UN agenda for sustainable development and its 17 goals for sustainable development that were agreed on in 2015. We will also discuss the first reflections of this agenda in research ethics guidelines, but we will show that the vast majority of these guidelines still do not refer to the environmental impact of everyday research activities.

Faced with the observed gap in research ethics guidelines, we will present general observations about current research practices and recommendations for making them more sustainable in all fields of science (Section 4). Our suggestions are based on studies of the environmental impact of academic activities, existing guidelines in other fields, and examples of good practice. Our focus is on researchers' use of natural resources related to (i) travel, conferences, and events (Section 4.1), and (ii) labs, offices, and institutions (Section 4.2). These suggestions are intended to improve ethics guidelines for linguistics but could also be applied to ethics guidelines for other academic disciplines.

Section 5 will complement this set of general observations and recommendations by focusing on specific environmental issues connected to research practices in several sub-disciplines of linguistics: corpus linguistics, computational linguistics, and large language models (Section 5.1), lab-based linguistic disciplines like phonetics and psycho- and neuro-linguistics (Section 5.2), linguistic fieldwork (Section 5.3), and ecolinguistics (Section 5.4). We will also discuss recommendations for teaching and knowledge transfer events (Section 5.5).

In Section 6, we will summarize our findings and arguments and discuss potential further steps.

2 The rise of environmental science, activism, and ethics

In the 1960s and 1970s, a growing number of researchers recognized that technology, industry, economic expansion, and population growth were having a negative impact on our natural environment – and that human beings might one day destroy their own environment and hence the basis for their own life. Three seminal publications resulting from this "environmental turn" were:

– Rachel Carson's ([1962] 2009) book *Silent Spring*, which showed that the widespread use of chemical pesticides posed a serious threat to public health and wildlife,
– Paul Ehrlich's (1968) book *The Population Bomb*, which discussed the negative effects of the growing human population on the planet's resources, and
– the 1972 *Limits to Growth* report of the Club of Rome, with computer simulations of exponential economic and population growth in a world with finite resources (Meadows et al. 1972).

In the following decades, environmental research reports showed alarming developments with respect to climate change, environmental pollution and degradation, and the dramatic loss of biodiversity. These books and reports have inspired:

– films and documentaries, such as *An Inconvenient Truth* (2006),
– eco-activist organizations and grass-roots movements, such as *Greenpeace*, *World Wide Fund for Nature* (WWF, founded 1961 as *World Wildlife Fund*), or *Fridays for Future*,
– governmental and UN organizations, for instance the US Environmental Protection Agency, founded in 1970, the UN Environment Programme (UNEP), created in 1972, and the Intergovernmental Panel on Climate Change (IPCC), established in 1988, as well as,
– treaties and resolutions at national and international levels, such as the so-called "Paris Agreement", a legally binding international treaty on climate change, adopted by 196 Parties in Paris in 2015 (see Appendix A in Supplementary material for all links).

Both "environmental ethics" and "environmental philosophy" refer to philosophical sub-disciplines that emerged around 1970 (see Belshaw 2001 for overviews, as well as the journals *Environmental Ethics*, launched in 1979, and *The Trumpeter: Journal of Ecosophy*, launched in 1983). Environmental philosophers (i) focus on the natural environment and humans' place within it, (ii) try to define what we actually mean by terms like "nature" and "environment" and (iii) discuss the value and role of plants, animals, and humans within nature.

Environmental ethics combines ethics and environmental philosophy, asks how humans should behave with respect to their non-human environment, and is characterized by a debate between three approaches (see Attfield 2019; Benson 2000; Brennan and Lo 2022; DesJardins 2013; Gardiner and Thompson 2016; Hale et al. 2022; Rolston 2020): anthropocentric or human-centered approaches, also called human supremacy or human exceptionalism approaches, consider humans to be separate from nature and superior to it. For proponents of such approaches, humans are the most important or critical element in any given situation and should hence always be their own primary concern, while any other entities – such as animals, plants, or minerals – are viewed as mere resources for humans. Thus, for them, nature's value is instrumental, i.e., dependent on the needs and values of humans. In contrast, biocentric or life-centered approaches attribute intrinsic value to life and living beings, regardless of their instrumental value for humans. Ecocentric or nature-centered approaches go one step further and attribute intrinsic value to all of nature, including non-living things, independently of human values. Assigning intrinsic value to non-human entities is motivated by the lack of existential distinctions between human and non-human nature in biocentric and ecocentric approaches: it makes it impossible to justify assigning higher intrinsic values to humans than to non-human natural entities.

Anthropocentric approaches are widespread in "traditional" Western ethics, with Aristotle in Greek antiquity and Rene Descartes or Francis Bacon in the 17th century as prime examples. The establishment of environmental ethics as a (sub)-discipline, however, went hand in hand with a growing interest in biocentric and ecocentric approaches. This was, in part, fueled by some philosophers arguing that anthropocentric thinking contributed to the current ecological crisis by legitimizing the overexploitation of nature and viewing it as a mere resource for humans (see e.g., the seminal work by White 1967 as well as Bourdeau 2004 for discussion).

The debates between anthropocentric, biocentric, and ecocentric approaches to environmental ethics are still ongoing. However, as the negative effects of environmental degradation on humans grow, the three approaches have started to converge in their support for environmental protection – even if they do this for entirely different reasons. This has also led to new variants of ethical approaches, for instance prudential anthropocentrism, where moral duties and obligations towards non-human beings and our ecological environment are derived from our direct duties and obligations to humans, who are, after all, affected by environmental degradation (see e.g., Light and Katz 1996; Norton 1991).

3 Sustainability and current research ethics guidelines

In order to see whether current research ethics guidelines reflect the move from anthropocentric to biocentric approaches, we reviewed the current research ethics literature, in particular the list of ethics resources, statements, and codes of conduct in Appendices B to D in Supplementary material as well as recent overview articles, (chapters of) handbooks and textbooks on research ethics (in linguistics) and environmental ethics (Attfield 2019; Benson 2000; Brennan and Lo 2022; Calicott and Frodeman 2008; D'Arcy and Bender 2023; DesJardins 2013; Gardiner and Thompson 2016; Hale et al. 2022; Hourdequin 2024; Mallinson 2018; Rice 2011a, 2011b; Rolston 2020; Schücklenk and Ashcroft 2000; Weinbaum et al. 2019). We also conducted Google, Google Scholar, ERIC, and Linguist List archive searches, using the following search terms: "ethics statement" "linguistic society", "ethics statement" "linguistic association", "environmental impact of research"; "ecological impact of research"; and "footprint of research".

We found that research ethics guidelines in Appendix C in Supplementary material were extended step by step to cover (i) individual participants (cf. the Nuremberg Code of 1947 and the Geneva Declaration for the Medical Profession from 1948), (ii) (Indigenous) communities (see e.g., the 1988 Statement of Ethics for the American Folklore Society, the 1998 Code of Ethics of the American Anthropological Association, and the Linguistic Society of America's Ethics Statement of 2009), (iii) all individuals and institutions involved in the research process (see e.g., the 2010 Singapore Statement on Research Integrity, the 2011 European Code of Conduct for Research Integrity, and the Linguistic Society of America's Revised Ethics Statement of 2019). However, even the most recent ethics guidelines for linguistics research do not seem to consider the effects of research on non-human and ecological environments. The studies that refer to these effects are usually studies that:

– employ experiments with animals,
– involve toxic substances or data collection processes that could directly harm the natural environment, e.g., collecting samples of endangered plants in the wild, or
– could produce results with negative environmental impacts, e.g., by leading to the development of environmentally damaging products or industrial processes.

There are only very few types of linguistic studies that fit these criteria, for instance animal communication experiments (cf. Kaufman et al. 2021; Kulick 2017; Tomasello and Call 2019) or some types of neurolinguistic studies that involve potentially harmful chemicals. These studies are governed by laws and regulations for animal or environmental protection and typically not discussed in detail in ethics statements for linguists or other fields.

In other words, the ethics guidelines reviewed so far reflect an anthropocentric or biocentric view of scientific practices. However, as we will show in the following, there are some initial signs of the beginning of a shift to a more ecocentric or nature-centered approach to research ethics – or at least a prudential anthropocentric approach (see Section 2). This shift is linked to international initiatives for sustainable development.

Just as social issues have been at the core of previous and current research ethics guidelines, social issues were the focus in early initiatives for sustainable development, which mostly tried to address poverty and hunger in the Global South. However, the increasing discussions about pollution, climate change, the loss of biodiversity, and other degradations to our natural environment made ecological sustainability an intensely discussed topic in society, politics, and academia. Moreover, a growing number of empirical studies have demonstrated that ecological sustainability is inextricably linked to the sustainability of our social and economic development (see Section 2 and Section 5.4 for references). In 1987, the Brundtland Report recognized these links and argued for a more sustainable form of human development, i.e., "development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs" (see Appendix E in Supplementary material, no page).

At the 1992 Earth Summit in Rio de Janeiro, Brazil, world leaders suggested a new approach to development that integrates economic, social, and ecological sustainability (see Du Pisani 2006 for a historic review of the concept of sustainable development). In 2015, more than 178 countries adopted Agenda 21, "a comprehensive plan of action to be taken globally, nationally and locally by organizations of the UN System, Governments, and Major Groups in every area in which human impacts on the environment" (see Agenda 21 in Appendix E in Supplementary material). This plan inspired the UN World Decade for Education for Sustainable Development (2005–2014) and extensive consultations and a participatory and consultative process involving governments, civil society, the private sector, and other stakeholders. The 17 sustainable development goals (SDGs) depicted in Figure 1 were the outcome of this process in 2015 and announced by the UN General Assembly (see Appendix E in Supplementary material).

In our view, the SDGs are more advanced than current ethics research guidelines when it comes to their response to the growing ecological crisis and its links to social and economic issues. Thus, the SDGs can serve as an inspiration for the development

Figure 1: The 17 UN Goals for Sustainable Development (SDGs, https://unric.org/en/sdgs-sustainable-development-goals-un-visuals/).

of improved research ethics guidelines. This would align the development of research ethics guidelines with the international sustainability movement – just as earlier guidelines were improved by aligning with movements for human rights, Indigenous rights, and equality (captured in the socially focused goals discussed in previous sections).

Some of the 17 SDGs are linked to our development as social beings within local, national, and international communities, e.g., goals related to economic or social development, such as quality education (SDG 4), gender equality (SDG 5), decent work (SDG 8), reduced inequalities (SDG 10). Most ethics principles in current ethics guidelines relate to these SDGs, in particular requirements to treat everyone involved in the research process fairly and equally and to provide appropriate working conditions. The remaining SDGs are linked to environmental sustainability and our development as physical beings on earth:

(1) SDGs and Environmental Aspects of Sustainability

- We must combat climate change (SDG 13) while ensuring energy consumption (SDG 7).
- We need measures to make consumption and production more responsible (SDG 12); We must reduce pollution, waste, and habitat destruction to ensure access to clean water (SDG 6), and to protect life below water (SDG 14) and on land (SDG 15).

Some of the recent research integrity guidelines contain general references to the environment, such as the reference to “respect for colleagues, research participants, research subjects, society, ecosystems, cultural heritage, and the environment" in the 2023 European Code of Conduct for Research Integrity (Appendix C1 in Supplementary material). There are also a few papers calling for the inclusion of environmental issues in ethics statements, for instance, a paper by Samuel and Richie (2023) from the field of health research. Moreover, we have found some declarations on sustainability ethics and science, which focus on the topics addressed by science and its results, see Appendix B in Supplementary material. However, none of these documents nor the ethics statements in Appendix C in Supplementary material discuss measures to limit the environmental impacts of "everyday" (linguistic) research activities, such as flying to conferences or field sites or using energy to store and process data. The Marie Skłodowska-Curie Actions: Green Charta (see Appendix E in Supplementary material) contains general guidelines for ecological sustainability that will be applied to the projects funded by this program. However, this statement is not a general research ethics guideline for researchers and still quite general in its recommendations.

We think that this situation is about to change for two main reasons. On the one hand, most researchers are also educators – as teachers or via their contribution to knowledge transfer activities. In this role, they have become exposed to the idea of education for sustainable development and may have already been asked to incorporate sustainability in their own educational activities. On the other hand, ecoactivism groups outside of academia (see Section 2), combined with researchers' own awareness of environmental degradation, inspired some researchers to become ecoactivists in their professional capacity – and not just as members of the public. One of the inspirations for larger-scale academic ecoactivism were the climate strikes by Greta Thunberg and the Fridays for Future movement that demanded the implementation of the 2015 Paris Climate Agreement. This led to the creation of the Scientists for Future movement. In their 2019 statement, Scientists for Future listed core empirical findings of climate research and argued that the Fridays for Future protests for more climate protection are justified (see Appendix A in Supplementary material).

Mariette et al. (2022) acknowledge this growing awareness and argue for researchers to assess their own environmental impact even though the direct contribution of research to national greenhouse gas emissions is probably relatively small: Firstly, academia plays a role in producing and imparting knowledge on climate change and its impacts. Secondly, scientists actively contribute to public debates around climate change mitigation and adaptation and hence their consistency and credibility is often scrutinized. Thirdly, the carbon footprint of academics is likely above the per capita median value in their countries of residence (cf. Fox et al. 2009; Spinellis and Louridas 2013; and other references cited in Mariette et al. 2022).

Thus, taken together, there are quite a few reasons why academics should be aware of the environmental impact of their research. They should also be motivated to minimize it – and to consider it in future research ethics guidelines. Therefore, we argue that it is time to include environmental ethics in research ethics guidelines. In the following, we will provide an evidence-based foundation for such endeavors: Section 4 focuses on general observations and recommendations, e.g., for travel or office work, that apply to all fields of research. In Section 5, we will discuss the ecological impact and potential of individual linguistic sub-disciplines that could be reflected in specific ethics guidelines for linguistic research.

4 Current research practices and sustainability recommendations for all fields of research

The empirical observations reported in this section use a growing number of tools for assessing environmental impacts (see Cox et al. 2018; Mariette et al. 2022; Palmieri et al. 2023; Valls-Val and Bovea 2021). The recommendations are based on the resources in Appendices G to J in Supplementary material, the scoping review by Leochico et al. (2021), and the publications cited in this section.

The main aim of this section is to reflect on and inform current and future practices in linguistics research based on observations and recommendations that are in use in linguistics itself and in other fields. Thus, the observations and recommendations in this section are not discipline-specific and could be the basis for sections on environmental ethics in research ethics documents for a broad range of fields. When it comes to best practice examples, we have, however, chosen examples from linguistics and related fields. For a discussion of more linguistics-specific environmental issues and practical recommendations, see Section 5, where we will consider a set of linguistic sub-disciplines where more specific environmental issues arise and recommendations were made.

As the observations and recommendations in our paper are meant to be the basis for the development of future research ethics guidelines, we have included both more “obvious” recommendations such as the reduction in air travel as well as less well-known recommendations, such as replacing connecting flights with direct flights, changing conference locations, or the use of hub-models for hybrid conferences. Note that even the more “obvious” recommendations have faced criticisms, e.g., by opponents arguing that (air) travel cannot be reduced without negatively affecting young researchers’ careers. Hence, we have combined our recommendations with empirical observations that can be employed to counter such arguments.

4.1 Travel, conferences, and other events

4.1.1 Observations

O-01: Travel is a major contributor to the environmental impact of academic work and results in above-average emissions levels for academics
In pre-pandemic times, the contributions of academic travel to overall emissions of academics were substantial and raised academics' average per capita emissions levels above that of the average individual in their respective countries of residence – even for academics with otherwise low-emissions lifestyles (cf. Nursey-Bray et al. 2019 for Australia; Achten et al. 2013 for Belgium; Cluzel et al. 2020 for France; Reyes-García et al. 2022 for Spain; Ciers et al. 2018 for Switzerland; and Astudillo and AzariJafari 2018, Fox et al. 2009; Klöwer et al. 2020 for the US). For instance, 59 % of researchers surveyed in Adelaide, Australia, said they were concerned about the climate impacts of academic plane travel, but 72 % of them had used planes for overseas business trips at least once in 2017, with 33 % traveling once, 15 % twice, 8 % three times, and 10 % more than five times (Nursey-Bray et al. 2019). Moreover, 85 % of participants flew domestically every year. Even conservationists are not exempt from frequent flying: Fox and 12 US fellow conservation scientists (2009) showed that their own flight emissions accounted for two-thirds of their carbon footprint. Moreover, while lower-carbon lifestyle choices reduced their non-flying private carbon footprint by 16 % compared to the average American, their total emissions were still double the American average and more than ten-times the global average. Achten et al. (2013) attributed 74 % of the total life-cycle carbon footprint of an environmental science PhD student in Belgium to travel and commuting, and just 26 % to office, internet, printing, and food. With respect to the institutional perspective, a sustainability audit at a US university found that nearly 30 % of the CO_2 footprint of its entire campus in 2014 resulted from air travel (Hiltner, n.d.: https://hiltner.english.ucsb.edu/index.php/ncnc-guide/). For a large astronomy meeting in France, Burtscher et al. (2020) found that the CO_2 footprint of the virtual 2020 meeting in pandemic times was ca. 3,000 times smaller than the in-person meeting in 2019.

Note that academics' travel is not limited to travel for research purposes. Due to the international nature of research teams and the often multi-national families and private networks of many academics, they often travel to visit family, partners, or spouses – even when they are from the country where their institution is based. See Reyes-García et al. (2022) for an impact assessment that suggests that simply only hiring academics from one region does not necessarily guarantee an overall reduction of travel, as academics are often part of internationally oriented communities with personal ties abroad.

O-02: Environmental concerns do not simply translate into reductions in the frequency of flights

In a pre-pandemic study, for instance, only 59 % of researchers surveyed in Adelaide, Australia, said they were concerned about the climate impacts of academic plane travel; and even those researchers were often flying for work (Nursey-Bray et al. 2019). In a more recent US focus group study, many participants were aware of or concerned about their carbon footprint from traveling (Gundling et al. 2023). Nevertheless, few faculty members reported altering their travel plans for environmental reasons. Another recent study involving a survey and interviews at an Austrian university reveals some of the reasons for the disconnect between environmental attitudes and flying behavior (Schreuer et al. 2023). University staff were in principle supportive of measures to reduce academic flying, but also voiced concerns about the fairness and viability of some restrictive measures, in particular disincentives and caps on flying. In contrast, they largely supported bans on short-haul flights. University managers saw their options limited by the potential resistance and non-compliance of staff, as well as by framework conditions that are external to the university.

O-03: The main motivation for travel is the – unsubstantiated – belief that it is crucial for career progression

Surveys or interviews with academics from the previous decade suggest that they considered travel necessary for career progression. For instance, Nursey-Bray et al. (2019) observed “that, while many academics were worried about climate change, very few were willing to change their current practice and travel less because they are not institutionally incentivized to do so. There is a fear of not flying: plane travel is perceived as a key driver for career progression, and this is an ongoing barrier to pro-environmental behavior” (2019: 1). Note, however, that even before the increase in online networking opportunities, conference travel was not associated with metrics of academic productivity, including hIa (h-index adjusted for academic age and discipline) or with being at an early career stage, where networking was important for obtaining employment or promotions (Wynes et al. 2019). Moreover, some studies suggest that travel emissions are actually higher for more advanced researchers than for early career researchers (Ciers et al. 2018). This suggests that the networking effects of conferences on early career progression might be overestimated, especially as virtual conferences and social media have made online networking easier and networking opportunities via social media are increasing.

O-04 The popularity of a conference location does not seem to be associated with travel distance and some popular conference destinations are difficult to reach with direct flights

Conference locations are typically not chosen with the goal of minimizing travel. For instance, Spinellis and Louridas (2013) report that none of the low-carbon-emissions locations they observed in their study appear in the list of the ten most popular locations, while Honolulu was very popular despite being the eighth worst destination from a CO_2 emissions perspective – and typically only reachable via connecting flights. Moreover, they show that the US as a conference-hosting country has made a high contribution to overall emissions, with the West Coast and Hawaii leading in these two aspects. Klöwer et al. (2020) demonstrated that moving a San Francisco conference to Chicago in the middle of the US would reduce emissions by 12 %, while moving it to Hawaii would increase them by 42 %.

O-05: "Next Generation" hub-models for hybrid conferences reduce long-distance and air travel and widen access

Recent years have brought about a growing number of conference types (Fraser et al. 2016; Parncutt et al. 2021; Tao et al. 2021; see Section 4.1.5 for examples):

- Virtual conferences center on live or recorded video presentations, combined with text-based discussion forums, social meetings in virtual worlds or online groups, or social media hashtags for conference information and discussion.
- Hybrid conferences combine these virtual elements with in-person events.
- The "one hub and node" model features a central hub, a venue that hosts a small conference and streams the conference to nodes, smaller external venues, for instance at other universities, where smaller regional pools of delegates can meet, present, network, and attend the conference. Further delegates can attend virtually from anywhere.
- The "multihub and node" model involves the same hub elements as the "one hub and node" model, but additional hubs within the same time zone.
- The "multilateral hub and node" model resembles the "multihub and node" model, but with hubs in different time zones.

Hub-based conferences can be created by combining existing conferences with similar audiences that take place in different locations (Klöwer et al. 2020). The environmental impact of virtual or hybrid conferences can be substantially reduced by switching off listeners' video transmission whenever they are not speaking themselves (Reyes-García et al. 2022).

O-06: Academics can reduce the environmental impact of their travel by changing the way in which they travel

It is already well known that air travel leads to higher emissions than car travel, which in turn causes higher emissions than travel by trains or buses (see Astudillo and AzariJafari 2018). Nevertheless, inter-continental flights make up the most substantial proportion of emissions for many conferences (Klöwer et al. 2020). This was confirmed by Rissman and Jacobs (2020), who surveyed 489 scientists, mostly North American and European psychologists, neuroscientists, and linguists. These researchers primarily traveled by plane (54 %), and less frequently by car (12 %) or train (18 %). It is important to note that plane emissions are highest during takeoff and landing, making shorter or connecting flights a particularly bad option. For instance, in their survey of the 2017 American Center for Life Cycle Assessment Conference, Astudillo and AzariJafari (2018) report that connecting flights increased emissions up to 32 % compared to direct flights.

O-07: Combining emissions-reducing measures can lead to substantial reductions

An analysis of the last seven General Conferences of the European Consortium for Political Research, with up to 2,000 participants each, suggests that the travel-induced carbon footprint of one of these conferences amounted to the same amount of greenhouse gases as ca. 270 UK citizens emit in a whole year. However, by (i) selecting more centrally located conference venues, (ii) promoting more land-based travel, and (iii) attendance from distant locations using virtual options, the footprint could be reduced by 78–97 % (Bjørkdahl et al. 2022: 19).

O-08: Reducing the amount of animal products can reduce the environmental impact of conference meals

An analysis of the US National Health and Nutrition Examination Survey showed that the average carbon footprints of vegan and vegetarian diets were lower than those of the pescatarian and omnivore diets (O'Malley et al. 2023; see Clark et al. 2018 for a more extended discussion, including both the environmental and the health-benefits of meat-reduction). Similarly, Goldstein et al. (2016) calculated that a change to the vegetarian menu from an omnivorous diet could reduce greenhouse gas emissions from meals by 46 %. Moreover, in a recent conference analysis, non-vegetarian meals performed worse in all impact categories (including environmental toxins) and dominated most of the catering impacts (Neugebauer et al. 2020).

O-09: Many conferences produce unnecessary waste, including food and single-use plastics

Food waste from conferences is a general problem and part of an increasing international food waste problem (see e.g., Katsarova 2016; UNEP 2021). However, conferences differ with respect to the amount of single-use plastic for catering, for instance, cups, dishes, utensils, individual packages for milk and sugar (substitutes), teabags, water or juice bottles or cartons, individually wrapped snacks and sweets. Many conferences also still use printed handbooks, giveaways like bags and stationery, or conference merchandise like mugs or T-shirts. Some conferences use single-use “bioplastics” for utensils or cups. This term covers bio-based, bio-sourced, or plant-based polymers or biodegradable and compostable materials. However, the first type may divert land from food production and is often not recyclable in current recycling facilities, while compostable bioplastic typically only breaks down in industrial compost centers. It mostly ends up in landfill as it is usually not allowed to go into organic waste bins. Thus, bioplastics are currently not a solution to the waste problem (see e.g., Gibbens 2018).

O-10: Third-party sustainability certifications for Green Event Venues or Hotels can help you assess their environmental impact

There are several third-party sustainability certifications for environmentally friendly accommodation and venues with fair working conditions, see Appendix F in Supplementary material.

4.1.2 Recommendations for individual researchers or projects[1]

R-01: Reduce the number of trips, but maximize networking and knowledge exchange:

- Attend fewer in-person events and make use of other opportunities to network and share information (virtual conferences, social media, mailing lists, online meetup groups, etc.).
- Combine in-person conferences with other networking and training activities, for instance, teaching or academic visits in the same area, additional tutorials, workshops, or satellite events of the conference.

1 We have not recommended carbon-offsetting for (air) travel (see Umweltbundesamt 2020). It is often unclear whether the offsetting measures are “greenwashing” or actually produce significant and reliable carbon-emissions reductions (in particular for tree-planting projects where many trees later die due to neglect). Emissions reductions would have to be substantial to also cover the additional emissions that the carbon offsetting schemes themselves create through administration, websites, data analysis, advertising, etc. Directly supporting certified and effective environmental programs financially or through volunteering avoids this. Moreover, the act of offsetting might increase the acceptance of flying – and thus eventually lead to more flights (see Kerner and Brudermann 2021).

- Instead of several project members traveling to the same conference, distribute in-person conference attendance amongst members of a project team.
- Follow up on conference meetings with virtual meetings, ideally including other team members or supervisees.

R-02: Reduce the environmental impact of each trip:
- Make use of public transport or car-sharing for business travel whenever possible, especially for shorter distances.
- If flying is unavoidable, opt for direct flights instead of connecting flights.
- Select the most sustainable accommodation and meal options available.
- Bring your own reusable cups, containers, and utensils in case only single-use plastic is provided.
- Refuse promotional items and unnecessary stationery.

R-03: Raise awareness of the environmental impact of academic conferences:
- Discuss environmental issues in your project meetings, committees, teaching, and supervision.
- Use impact assessment tools for your own travel and inform others about them.
- Use conference feedback forms or committee memberships to point out more sustainable options.

4.1.3 Recommendations for universities, research institutes, and funders

R-04: Incentivize networking, collaborations, and the Open Access dissemination of research results instead of in-person conference attendance or research trips:
- Support virtual or hybrid conferences and recommend minimal use of video transmission.
- Improve training for non-travel forms of collaboration and networking, such as social media.
- Provide infrastructure for virtual meetings.
- Raise awareness of teaching exchange and mobility programs that allow researchers to combine several events in one trip to make each trip more effective for networking.
- Treat virtual conference presentations as equal to in-person presentations in evaluations.
- Incentivize attendance at regional conferences.

R-05: Incentivize researchers to select environmentally friendly options:
- Allow researchers to select the most environmentally friendly travel options even if they are not the cheapest options and may extend travel times.

- Make it easier for researchers to be reimbursed for the combination of several events or visits in one trip, especially if there is a short gap between events.
- Produce or demand information on the environmental impact of conferences that you host or fund (including both emissions and waste).

R-06: Raise awareness of the environmental impact of traveling:
- Offer sustainability training and recommendations as part of the onboarding process and as part of newsletters and continuing professional development.
- Make tools for environmental impact assessment accessible to individual researchers, projects, or departments and incentivize their use.

4.1.4 Recommendations for event organizers

R-07: Select the format of your conference with the environmental impact in mind:
- Switch from annual conferences to biannual or triannual conferences.
- Choose a hybrid or virtual format for all conferences or alternate between virtual and hybrid formats, with a hybrid format every two or three years.
- Combine two or more conferences in a sequence or add tutorials, workshops, or other events to your conference to avoid the need for separate trips.
- Consider hub-and-node models, collaborating with other event organizers.
- Archive digital conference content long term and make it Open Access to increase dissemination (e.g., via YouTube videos).

R-08: Select locations and venues with the environmental impact in mind:
- Model delegates' journeys, based on previous conferences and minimize travel distances for the expected audience.
- Choose locations that are easy to reach by public transport and direct flights.
- Alternate conference locations between different regions.
- Select venues and accommodation with third-party sustainability certifications (see Appendix F in Supplementary material) where possible.

R-09: Support environmentally friendly travel to and at your location:
- Encourage ride-shares and travel groups for public transport and provide online tools or social media hashtags for groups to form.
- Offer or promote accommodation in the venue itself, in walking distance, or reachable by public transport.
- Promote walking (and support networking) by offering meeting points and walk-with-me ambassadors for the way from accommodation to venue.
- Offer (mini) buses for transport if public transport is not ideal.

- Provide information about local public transport.
- Discourage car travel wherever possible and choose venues with electric charging points.

R-10: Raise awareness about the environmental impact of travel and provide information:
- Make participants aware that connecting flights tend to cause more emissions than direct flights.
- Provide information about websites that make trip planning and ticket buying easier for long-distance trips by train.
- Offer information about local transport options and waste disposal options.

R-11: Lower the environmental impact of conference meals for in-person events:
- Choose organic, local, seasonal food.
- Offer (only) vegan or vegetarian food.
- Provide tap water or, if necessary, water dispensers instead of bottled drinks.
- Donate leftovers to charity or encourage participants to bring containers and take home leftovers.

R-12: Refuse, Reduce, Reuse, Recycle, Rot (=compost):
- Offer recycling sorting stations and containers for compostable food waste in all meeting spaces.
- Reduce waste by providing reusable name tags, conference signs or banners (name of conference only, not year or specific topics), dishes and utensils instead of single-use (plastic) materials, etc.
- Avoid plastic packaging and other plastic items (e.g., teabags with plastic coating).
- Use paper products made from recycled fibers.
- Encourage sustainable practices among presenters and exhibitors, such as digital handouts or posters instead of printed materials.
- Do not provide conference packs with promotional materials, printed flyers, handbooks, and stationery.
- Do not offer merchandise, such as bags, T-shirts, mugs, or pins.

4.1.5 Best practice examples

- Though many conferences have gone back to in-person formats and abandoned online or hybrid formats a few years after the Covid pandemic, several linguistic conferences have taken measures to reduce (air) travel, for instance:

- The *Congress of the International Association for Child Language* (IASCL, https://www.childlanguage.org/) has always been triannual, with diverse locations, mostly in North America and Europe, but also in Asia.
- The *Conference on Architectures and Mechanisms of Language Processing* (AMLAP http://amlap.org/) is now complemented by its Asian equivalent, which provides an incentive for scholars to avoid long flights from Asia to Europe or vice versa.
- *The Boston Conference for Language Development* (BUCLD, https://www.bu.edu/bucld/) takes place every year, but now in a hybrid format.
- *The International Conference on Language Documentation & Conservation* (https://ling.lll.hawaii.edu/sites/icldc/about/) is organized by the University of Hawaii, which participants typically reach by (connecting) flights. However, the conference organizers take several measures to reduce travel: the conference only takes place every two years, combines it events with related conferences and events so that researchers can use one trip for multiple events. In 2021 and 2023, the conference was virtual.
- An example of a multilateral hub-and-node conference is the *Sustainability Research + Innovation Congress 2023*, which offered a main conference in Panama, combined with an Open Day and an idea market, plus satellite events in African and Asian hubs, with all main parts of the event in hybrid format. The 2025 congress will take place in Chicago, with an African satellite event (https://sricongress.org/).
- The *International Conference on Environmental Psychology* (ICEP) 2025 combines several measures to reduce carbon emissions and waste: "By informing our guests about the sustainable options for traveling to Lithuania and locally, by serving environmentally friendly meals (vegan, vegetarian from local producers when possible), by reducing waste to a minimum and if impossible providing recycling facilities, by refusing bottled water, we will celebrate the values of the ICEP community and the host organisation" (https://www.icep2025.com/conference/welcome/).
- In 2002, German Scientists for Future asked researchers to sign a voluntary commitment to avoid short-haul flights (<1,000 km) if the journey can be carried out in a maximum of 12 h using alternative means of transport.
- Smaller conferences often make use of university dining halls, which have already implemented measures to reduce their environmental impact. For instance, the Free University of Berlin now has a dining hall with exclusively vegetarian and vegan food. The dishes are organic, seasonal, and local (https://www.fu-berlin.de/en/sites/nachhaltigkeit/handlungsfelder/campus/ernaehrung/index.html).

4.2 Labs, servers, data centers, offices, and institutions

4.2.1 Observations

O-11: The increased use of labs, data centers, data-intensive computational methods, and AI requires growing amounts of energy and other resources and leads to an increasing amount of (e-)waste

A combination of recent developments has substantially increased the amount of energy, electronic equipment, and other resources used (or wasted) in the research process:

– Researchers now often work with large-scale datasets (Big Data) that require extensive processing power to analyze, often using cloud computing, high-performance computing clusters, or distributed systems. This type of work often involves training AI models, machine learning, data mining, and simulations, which consumes massive amounts of electricity and hardware (see e.g., Luccioni et al. 2024 and references cited there).
– We can observe an increased use of digital tools, media, and methods, not just in the "hard" sciences, but also in the humanities (e.g., databases and automatic analysis or annotation of texts and media in the "digital humanities"; cf. Hawkins 2022) and in the social sciences (e.g., reaction-time, eye-tracking or neuro-imaging experiments in psychology, linguistics, or sociology).
– Datacenter emissions are already substantial and continue to grow. They include *operational emissions* – resulting from the use and cooling of machines as well as power distribution overheads – and *embodied emissions*, which arise from the design and manufacturing of computing systems (see Eilam et al. 2024 and references cited there).

O-12: Environmental concerns do not simply translate into reductions in energy consumption for laboratories, data centers, offices, and institutions

For instance, in interviews with UK health researchers, Samuel (2023) discusses studies making this observation and found that researchers wanted to address the environmental impact of their data- and storage-intensive research, reflected on how they could do so in alignment with their own research aims, but prioritized their own research whenever tensions emerged.

O-13: Sharing equipment and facilities can reduce the environmental impact of research labs

Given the growing importance of lab-based research in linguistics, it is worth noting that researchers can benefit from shared facilities (SF), see Strom et al. (2020: 335):

- Investment in SFs results in long-term benefits to the university through the recruitment of talent and to the community as a driver of economic growth by enabling and sustaining a startup culture.
- Dedicated space housing both routine and cutting-edge instrumentation, and managed by engaged staff, are the fundamental components of a sustainable SF.
- Expert and service-oriented staff members are critical for a first-rate SF; they require and warrant the largest investment from stakeholders.
- SFs play a significant role in the training and education of the future workforce, and in the process, build a mutually beneficial relationship between the university and industry.
- The impact of SFs can be maximized through investment in instrumentation databases such as MRFN.org, as well as by advertising, community outreach, and effective university and state policies that provide funding, foster connections, and promote initiatives supporting the SFs.

O-14: The amount of paper used in academia is still very high and may be associated with additional travel to transport documents

Despite efforts to make labs and offices paperless, paper use is still considerable. For instance, Macaulay et al. (2022) surveyed 50 offices in an unnamed African university considered representative for the region. They found that 6,888 reams of paper were consumed annually (equivalent to ca. 413 trees), even though administrative staff members were Information Communication Technology certified and generally informed about the advantages of going paperless. Similarly, Zella (2016) reported that the paper used for one semester at the Mwalimu Nyerere Memorial Academy in Zanzibar equaled about 27 trees. Similar results were found in studies for other countries, which also demonstrated that paper use is associated with travel in paper procurement, and often also with the postal or in-person distribution of print documents. For instance, Chakladar et al. (2011) studied all applications to a single Health Research Ethics Committee in southern England over one year. For 2009, 68 trials were submitted, with a paper consumption of 176,150 sheets of A4 paper (879 kg), equivalent to an estimated 11.5 million sheets (88 tons, 2,100 trees) per year for the entire UK. In addition, energy was used in paper procurement and the postal distribution of documents.

Paper consumption can be reduced comparatively easily. For instance, Shah et al. (2019) looked at selected higher education institutions in Oman and found high paper consumption but showed that changing printing preferences can save 44.8 % of economic and environmental resources. One might have hoped that paper use for academic administration would be reduced after the shift to digital processes during the Covid pandemic. However, this is not universally so.

O-15: The use of energy-efficient equipment and adopting appropriate default settings can lead to significant energy savings and make research (results) more accessible to communities

Laptops are not just useful for travel and meetings; they also use considerably less energy and fewer materials than desktop computers. If required, they can be supplemented with larger screens or keyboards – and still use less energy than a desktop computer with the same components. Nevertheless, many institutions still issue desktop computers as standard equipment, often complemented by laptops for meetings and travel, which consumes additional resources. In contrast, linguistics fieldworkers, who often have limited access to electricity, have started to use energy-efficient equipment like the Raspberry Pi, a small computer that can also serve as a Wi-Fi transmitter when there is no internet connection (see e.g., La Rosa and Thieberger 2020). This versatile device is used, for instance, to make video recordings from a hard drive available to the respective language communities. Community members can connect to the Raspberry Pi Wi-Fi and view the recordings on their mobile devices, such as phones. In addition to devices, settings for equipment are crucial for saving energy and other resources, take for instance double-sided printing or video streaming with the quality necessary for the task instead of the maximal quality.

O-16: Open Science can save energy and other resources, but it is often difficult to find data and other materials

Open Science practices can reduce redundant and unnecessary data collection as others can see and use what has already been done. For pre-registered reports, where the study plan is submitted for review before the actual study, reviewers can also evaluate the match between research questions and methods and request more targeted – and hence less resource-intensive – data collection procedures.

While storing data, stimulus materials or code available via archives can avoid unnecessary work and energy consumption, even publicly available data sets can be hard to find due to the growing number of archives. Moreover, many sets of data and materials are still "dark data", i.e., not publicly accessible, but hidden in researchers' offices or university storerooms (Shembera and Durán 2020).

O-17: Third-party sustainability certifications for green labs and for office-related products can help researchers from all disciplines to assess and reduce the environmental impact of their lab work

In addition to third-party sustainability certifications for a broad range of products, there are also certifications for environmentally friendly labs that consider the use of energy, water, waste, and other resources as well as the potential toxicity of cleaning products and lab chemicals (see Appendix G in Supplementary material). These certifications involve recommendations for improvement and were originally developed for the natural sciences, where they are now used by a growing number of labs. They are, however, still uncommon in linguistics, even though most of the criteria applied for certification would also be relevant for linguistic labs that make use of the equipment described in O-11.

O-18: Environmental concerns are not (yet) routinely considered in institutional procedures, such as procurement or ethics review procedures

As sustainability criteria tend not to be part of a university's procurement policies, it can be quite difficult to buy a more sustainable product if a less sustainable alternative is cheaper. Moreover, buying second-hand products, for example, office furniture or toys for studies with child participants, is typically also difficult administratively unless they are sold via companies like Amazon. At the same time, ethics reviews do not involve questions about minimizing the environmental impact of research projects. For instance, researchers may need to demonstrate that the stimulus or participant reward materials for their project are appropriate for the respective age range or culture. However, researchers are typically not asked about the environmental impact of these materials or the working conditions under which they are produced. While most universities now have standardized recycling procedures for technical equipment that make extra statements superfluous, the same is not true for stimulus or office materials. Similarly, researchers who are planning energy-intensive natural language processing studies mostly do not have to explain how they intend to minimize energy consumption.

O-19: Some measures can only be implemented at the institutional level and a growing number of universities follow a whole-institution approach to sustainability

There are some measures that only an academic institution – and not individual researchers – can implement in an ecologically sustainable way, for instance:

- creating, developing, and maintaining buildings and grounds,
- developing and implementing purchasing and management procedures,
- providing institutional support and coordinating efforts through dedicated funds, positions, or departments, such as sustainability officers,
- providing institution-wide sustainability training for both administrative and research staff,
- creating institution-wide targets and implementing the corresponding progress reviews,
- developing comprehensive strategies and awareness campaigns to foster desired practices across all aspects of the organization or institution.

Thus, sustainability recommendations need to extend to the institutional level. This has been recognized by universities that take a whole-institution approach and embed sustainability into all aspects of an institution's operations, making sustainability an integral part of the institution's culture, decision-making processes, and long-term planning. Universities following such an integrated approach have also created a range of networks and resources to support it (see Appendix H in Supplementary material).

4.2.2 Recommendations for individual researchers or projects

R-13: Reduce the energy consumption of your work:

- Select energy-efficient equipment as far as possible within institutional constraints.
- Select energy-efficient settings for equipment.
- Avoid unnecessary use of energy (e.g., pictures in email-signatures, cc-ing others in emails that do not immediately concern them, sending large documents as email attachments and not deleting them).
- Store data that is infrequently accessed on hardware that remains switched off most of the time, such as external hard drives, powered-down computers or tape libraries.
- Write efficient code that minimizes the energy required for processing.
- Switch off equipment that is not in use.
- Switch off the heating and close windows when away from the office.
- Switch off video or reduce video quality when only listening in larger virtual meetings or conferences.

R-14: Buy sustainable products whenever possible:

- Wherever possible, restrict your purchases to products with third-party sustainability certification (see Appendix G in Supplementary material), in particular for:
- equipment,
- stationary,
- furniture, and
- stimulus materials.
- If no certified products are available, use criteria employed for sustainability certifications, such as low-energy consumption ratings.

R-15: Refuse, Reduce, Reuse, Recycle, Rot (=compost):

- Share or reuse computer hardware, other equipment or furniture.

- Offer and use recycling sorting stations and containers for compostable food waste in all your lab and office rooms.
- For meetings and breaks, reduce waste by providing reusable dishes and utensils instead of single-use (plastic) materials.
- Avoid plastic packaging and other plastic items for meetings (e.g., teabags with plastic coating).
- Use products made from recycled materials (for instance stationery).
- Encourage sustainable practices for meetings, such as digital handouts instead of printed materials or using tap water and unpackaged local organic fruit instead of bottled water and pre-packed snacks and sweets.
- Limit the use of printed promotional single-use materials, flyers, handbooks, and stationery.
- Do not offer single-use or plastic-based rewards for study participation.

R-16: Make use of internal sustainability surveys for your lab(s) or offices:
- Conduct internal sustainability surveys with your team, focusing on the areas covered by sustainability lab certifications (see Appendix G in Supplementary material), in particular:
- energy,
- stationary,
- water,
- waste and recycling, and
- lab chemicals (if used).
- Implement measures yourself or negotiate with your institution's administration.

R-17: If you conduct lab-based research, obtain third-party sustainability certifications for your lab:
- Evaluate which certification is best suited for your lab or already used within your institution.
- Obtain the selected third-party sustainability certifications for your lab.
- Implement recommendations made as part of the certification process.

R-18: Practice Open Science:
- Publish data, stimuli, scripts, and other materials from your studies, wherever possible.
- Publish Open Access.
- Preregister your studies, wherever possible.
- Reuse data for new questions.
- Make dark data available.

- Reuse existing data and make new annotations or analyses available to the original researchers and archives if possible.

R-19: Raise awareness of the environmental impact of academic labs and offices:

- Include team members and students in lab or office surveys.
- Ask administrators responsible for procurement for sustainable alternatives if they are not already in use or available in the provided catalogs.
- Display third-party lab certifications and include them in reports, publications, or webpages.

4.2.3 Recommendations for universities, research institutes, and funders

R-20: Reduce the consumption of (non-renewable) energy in laboratories, data centers, data-intensive computing methods, and AI:

- Develop and implement policies for energy efficiency: guidelines for the procurement of energy-efficient equipment, policies for working from home and closing of buildings during holiday periods, policies for setting equipment and software defaults to energy-efficient settings (e.g., stripping off email attachments when saving emails in send folders) etc.
- Select green electricity providers with renewable energy sources.
- Improve insulation and install state-of-the-art heating systems to reduce energy use for heating.
- Consider energy use when building new facilities.
- Create your own renewable energy on campus (e.g., via solar panels on buildings).

R-21: Establish sustainable procurement:

- Buy products with third-party sustainability certifications whenever possible.
- Preferably use suppliers with third-party sustainability certifications.
- Preferably use suppliers that offer an end-of-life takeback program.
- Add sustainability as a criterion for selecting products or suppliers so that it is possible to order a more sustainable product even if it is not the cheapest option.

R-22: Refuse, Reduce, Reuse, Recycle, Rot: create systems for waste reduction:

- Create and maintain systems for sharing and re-using computer hardware, other equipment or furniture.
- Offer recycling sorting stations in all buildings.
- Provide composting opportunities for food waste from tea kitchens or cafeterias.
- Do not provide unnecessary stationery (e.g., calendars, business cards, or promotional materials that were not specifically requested).

- Offer reusable dishes and utensils instead of single-use (plastic) materials in cafeterias.
- Avoid plastic packaging and other plastic items (e.g., teabags with plastic coating).
- Minimize the use of promotional materials and merchandise.
- Use reusable promotional material and signposting wherever possible (e.g., arrows pointing to conference rooms with a particular number instead of the same signs with the name of the specific conference).
- Use paper products and other products made from recycled materials whenever this alternative exists.
- Set equipment up to reduce waste (e.g., double-sided printing as the default option for printers, energy-saving default settings for computers, etc.).

R-23: Raise awareness:
- Provide information about more sustainable equipment and office material options and encourage researchers to use them.
- Promote and incentivize recycling.
- Ask researchers to declare their sustainability efforts in publications or grant proposals (for examples, see Grogan et al. 2021).

R-24: Establish a whole-institution approach to sustainable development:
- Develop a university-wide sustainability policy and implement it.
- Integrate sustainable development in all aspects of your management plans.
- Incentivize, reward, recognize, and share sustainable practices.
- Make use of third-party sustainability certifications (see Appendix F and Appendix G in Supplementary material).
- Establish regular sustainability reports.
- Join a network of institutions with a whole-institution approach to sustainable development (see Appendix H in Supplementary material).

4.2.4 Best practice examples

- The Max Planck Institute for Psycholinguistics in Nijmegen (Netherlands) has a broad range of shared equipment and labs: a virtual reality lab, a baby lab, behavioral labs with sound-proof rooms, an EEG lab, eye-tracking labs, a gesture lab with multiple cameras, and a molecular biology lab (https://www.mpi.nl/research-facilities). Similarly, all researchers of the Collaborative Research Centre (SFB) “Prominence in Language” at the University of Cologne, which is funded by the German Research Foundation, have access to several shared experimental labs (https://sslac.uni-koeln.de/research-infrastructure/experimental-resources).

- Stimulus databases, such as the IRIS database for second-language acquisition researchers and the fieldwork stimulus database of the Max-Planck Institute for Psycholinguistics simplify the process of finding stimuli (for links to these and other stimulus archives, see https://experimentalfieldlinguistics.wordpress.com/experimental-materials/). However, both are designed for specific audiences, even though the stimuli they contain can be employed by a broader range of users.
- The CHILDES child language database contains several sets of formerly "dark data" that were later (transcribed and) digitized (https://childes.talkbank.org/access/).
- Some universities have internal opt-in "marketplace" mailing lists that allow employees to sell, buy, or swap second-hand items for professional or private purposes.
- Sonja Eisenbeiß has developed a toolkit for the creation of language games (https://languagegamesforall.wordpress.com/examples-of-games/). This toolkit involves (mostly second-hand) Lego, re-used ID-holders, felt mats, and pockets with hook-and-loop fasteners (partially made from second-hand or dead-stock materials). The toolkit has been used to create many different elicitation games in studies with children and adults. It has also been employed as a teaching tool in linguistics and language courses. The materials were created together with students and other staff members, which helped them acquire sewing and craft skills for upcycling projects. Some of the creation sessions were held in collaboration with the local repair café in a public library. Once the toolkit was available, no further toys had to be purchased for staff or student language acquisition projects associated with the lab. There was also no need for picture lamination anymore. The toolkit has also been used in other institutions and in psycholinguistic fieldwork.
- In our current psycholinguistic study, we departed from the traditional approach in child language research, which typically uses plastic toys or laminated pictures as stimulus materials and plastic stickers as rewards for participation (Torregrossa et al. 2025). Instead, as part of the experiment, the children created their own "board game" using colored pens and envelopes made from recycled paper. They could decorate the "board" with compostable stickers they were given. They could also take it home, along with a wooden die that could be used for this and other games. This proved to be at least as motivating as conventional rewards.
- Leuphana University in Lüneburg, Germany has been an early adopter and a successful example of the whole-institution approach (see Opel et al. 2017).

5 Specific environmental issues in linguistic research

The previous section focused on discipline-independent observations and recommendations for sustainable research and best practice examples from linguistics and related fields. We will now point out more specific environmental discussions and recommendations for some linguistic sub-disciplines: corpus linguistics, computational linguistics, and large language models (Section 5.1), lab-based linguistics (Section 5.2), linguistic fieldwork (Section 5.3), and ecolinguistics (Section 5.4). Moreover, we will compare these discipline-specific recommendations with our more general recommendations in Section 4. Note that the recommendations that we found were not part of research ethics guidelines, but separate documents, published in the form of journal articles and not as official recommendations by a professional organization for linguistics. Finally, we will look at the role that ecological sustainability could play in linguistics teaching and knowledge transfer (Section 5.5).

5.1 Corpus linguistics, computational linguistics, and large language models

Corpus and computational linguistics – in particular work on or with large language models – involve high-performance computing (HPC). Thus, it is particularly urgent for researchers in these fields to reduce their increasingly high consumption of energy and other resources for computing. Moreover, they need to be aware that their development of new corpora, large language models, or natural language processing software will encourage others to use them – and consume even more energy and resources. Faced with this situation, Lannelongue et al. (2024) made ten suggestions for individual researchers in the field of computing:

(2) Ten rules for computing (adapted from Lannelongue et al. 2024)
1. Calculate the carbon footprint of your work.
2. Include the carbon footprint in your cost-benefit analysis.
3. Keep, repair, and reuse devices to minimize electronic waste.
4. Choose your computing facility.
5. Choose your hardware carefully.
6. Increase efficiency of the code.
7. Be a frugal analyst.
8. Releasing a new software? Make its hardware requirements and carbon footprint clear.
9. Be aware of unanticipated consequences of improved software efficiency.

10. Offset your carbon footprint.

Some of these rules are covered by our own general recommendations in Section 4, in particular Rules 1 (cf. R-16), 3 (cf. R-22), and 5 (cf. R-14 and R-21). Rule 2 was not specifically discussed in Section 4, but it might be useful as a recommendation for HPC fields, such as corpus and computer linguistics and the development of large language models. Note that Rule 4 is a useful addition to guidelines in HPC fields, but might not be applicable for fields that are less computation intensive as researchers in such fields typically rely on facilities provided by their institution. Rules 6 to 9 are formulated in a discipline-specific way but could be viewed as a way of adapting our energy consumption recommendations R-13 and R-20 to HPC fields. Rule 10 was not included in our recommendation due to the problems associated with carbon offsetting; see footnote 2 and the discussion by Lannelongue et al. (2024).

Individual researchers in HPC fields are limited by the decisions and frameworks of their institutions. Furthermore, individuals need to collaborate in sustainability efforts. Hence, Lannelongue et al. (2023) suggested the following set of GREENER principles that acknowledge this need for collaborative efforts:

(3) The GREENER principles (adapted from Lannelongue et al. 2023)

1. Governance:
All actors in computational research have a key role to play and can lead the efforts towards sustainable computing.

2. Responsibility:
Embracing both individual and institutional responsibility regarding the environmental impacts of research. This involves being transparent about these and initiating bold initiatives to reduce them.

3. Estimation:
Monitoring environmental impacts to identify inefficiencies and opportunities for improvement.

4. Energy and embodied impacts:
Minimizing energy needs of computations and favoring low-carbon energy sources, while also considering the broader environmental impacts (e.g., water usage, mining of raw materials, etc.).

5. New collaborations:
Cooperating to leverage low-carbon infrastructures, facilitate equitable access to low-carbon computation, and limit wasted resources.

6. Education:
Training all stakeholders to be aware of the sustainability challenges of HPC and to be equipped with the skills to tackle them.

7. Research:
Dedicating research efforts to green computing to improve our understanding of power usage, support sustainable software engineering, and enable energy-efficient research.

The GREENER principles 1 to 6 are similar to our recommendations for individuals and institutions in Sections 4.2.2Sections .2 and 4.2.3, in particular R-24, which recommends a whole-institution approach to sustainability. In contrast, Principle 7 is clearly discipline-specific and could hence be added to discipline-specific ethics guidelines.

Note that there are additional considerations for researchers creating large data sets, such as corpora. In particular, these researchers also have to deal with the tension between energy-efficient storage and the FAIR principles for Open Data that require data to be Findable, Accessible, Interoperable, and Reusable (see Wilkinson et al. 2016 and Appendix C1 in Supplementary material). One of the crucial challenges here is to appropriately treat two different data types: (i) “warm data” that will need to be accessed on a more or less frequent basis and (ii) “deep freeze” data that needs to be preserved, but not accessed on a regular basis, for instance uncompressed original video data or raw data sets that were used to create annotated published corpora (see Blasi-James 2024 for discussion). Specifically, researchers need to limit constantly active storage solutions with their high energy consumption to “warm data”, while “deep freeze” data should be stored using external hard drives, tape libraries, or optical storage technologies that consume less electricity and do not wear out as quickly as servers that are running all the time. Making such data storage decisions needs to be discussed with all stakeholders. Moreover, ecological sustainability needs to be weighed against the FAIR principles in these discussions. Thus, appropriate recommendations would be useful in discipline-specific ethics guidelines.

5.2 Lab-based linguistics

A growing number of linguists use labs with energy- and resource-intensive methods, and sometimes laboratory chemicals as well:

– Psycho- and neuro-linguists often employ ventilated and air-conditioned sound-proof booths, eye-trackers, motion-trackers, virtual world setups, EEG-machines, or brain scanners. Their studies also frequently involve the recording,

transcription, annotation, and analysis of video or audio data, which requires recording equipment.
– Phoneticians investigate articulatory and acoustic processes with audio recording equipment and potentially other tools, such as ultrasound tongue imaging or electromagnetic articulography.
– Some linguists carry out collaborative lab work with geneticists or molecular biology laboratories to investigate the origins of language and the genetic basis for our language abilities.
– Stimulus creation and data analysis for lab-based research often require HPC, for instance intensive natural language processing or automatically annotating and analyzing large collections of videos.

In Section 4.2, we already presented general lab-related observations and recommendations, which could be included in ethics guidelines for a broad range of lab-based disciplines. However, we have also found recommendations specifically aimed at researchers in neuroscience labs. These are relevant for neurolinguistics labs. Rae et al. (2022) make general recommendations for the entire field of neuroscience,[2] adapted here:

1. Quantify:
Identify and evaluate the climate and ecological costs of your research. Push suppliers and manufacturers to evaluate and share the environmental impacts of their products via life-cycle assessments. The first step to action is often to understand the scale of impacts.

2. Laboratory Practices:
Integrate sustainable lab practices into your research. This includes but is not limited to increasing reuse of consumables, managing equipment in a more sustainable manner, and managing samples and chemical stockpiles. Ensure laboratory practices integrate quality control, to improve conditions for reproducible research. Consider doing this via an accreditation scheme such as LEAF.

3. Liquid helium for MRI and MEG scanners:
Helium is a by-product of fossil fuel extraction. Install a helium recycling tank for MEG to capture boil-off and support development of new non-helium methods such as OPM-MEG.

2 See Souter et al. (2023) for a set of similar recommendations with an even narrower focus: neuroimaging computing.

4. Computing demands for data analysis and modeling.
Run only analyses and models that you need to, optimize modeling to minimize energy costs, and avoid running jobs at peak times for energy demand.

5. Resource usage:
Consider carefully how much data to acquire, analyze, store, and share. Reduce storage of unnecessary files, regularly clean up data, remove intermediary processing stages, and consider how much needs to be stored long term.

6. Data sharing.
Where possible, use an Open Science repository that runs on renewable energy, such as the Open Science Framework.

7. Slow science.
Focus on quality over quantity, in line with “slow science” principles (Frith 2020).

8. Engage peers.
Raise awareness of impacts and contribute to community actions to establish best practices where this is currently unknown, such as through the Organization for Human Brain Mapping’s Sustainability and Environment Action Group. The ClimateActionNeuPsych Slack group provides a forum to discuss among colleagues and share best practices in, for example, teaching, conferences, laboratory practice, and institutional policy.

Some of these recommendations reflect our more general lab recommendations in Section 4.2, e.g., Rae et al.’s recommendations number 1 (R-16), 2 (R-17), 4 and 5 (R-13, R-20) as well as 6 (R-18). Recommendations 3 and 8 are formulated in a highly discipline-specific way, but they can be viewed as explications of our lab recommendations R-15/R-22 and R-19/R-23, respectively. Recommendation number 7 provides an interesting link between research integrity and the potential for the reduction of energy and resource consumption.

Note that Rae et al.’s first recommendation includes a call to push manufacturers of equipment for improvements. We did not find this in other sets of recommendations. This might be due to the fact that it is easier for such discussions to have an impact on manufacturers when very specialized manufacturers and high-cost equipment are concerned, as in neuroscience. Thus, this is a case of a recommendation that could be included in ethics guidelines for disciplines with such a scenario.

Note also that two aspects of lab-based linguistic studies are not covered in the recommendations presented above:

1. Lab-based linguistic studies with children often use plastic toys, stickers, and laminated paper for stimulus materials or rewards for participation. Many labs also give child or adult participants promotional items as rewards, such as mugs, T-shirts, pens, or small toys with the university or lab logo. Most of these items are unsustainably produced, unrecyclable, and will not be used for a longer term. Thus, our recommendation R-12 for the reduction or replacement of conference materials and merchandise and promotional materials could be extended to these items. See also our best practice examples in Section 4.2.4.
2. Both linguists and participants typically travel to the labs where the study is conducted. Here, our travel recommendations R-01 (reducing the number of trips) and R-02 (reducing the impact of each trip) could be adapted: firstly, researchers could reduce the number of trips (R-01) by employing (moderated) online-data collection methods. Such methods have shown their potential for psycholinguistics and phonetics research during the Covid pandemic, though some limitations remain (see Chuey et al. 2021, 2024; Rodd 2024 for discussion). Online-data collection is particularly helpful when there are only very few potential participants available, and participants do not all live in the same area as the researchers and their labs. This is often the case for studies on rare types of language or cognitive impairments. Secondly, when travel cannot be avoided (for instance in neurolinguistic studies), researchers could reduce the impact of individual trips, for instance through the use of public transport and ticket vouchers for participants.

5.3 Linguistic fieldwork

Online remote data collection might also help to reduce travel involved in linguistic fieldwork (see Leemann et al. 2020; Kostadinova and Gardner 2024 for discussion). Thus, it might be included as a suggested option in environmental sections of ethics guidelines for linguistic fieldwork in sociolinguistics, language documentation or description. However, collecting data online is not always an option due to a lack of internet access or the specific populations or methods involved.

An alternative is collaborative and participatory research where large parts of the project are designed, conducted and managed by locals. This can be supported by team meetings, training, and data collection sessions that are all conducted online. Sarvasy (2024) makes an interesting suggestion that takes this idea further and could make projects more collaborative and reduce travel at the same time, offering two recommendations, adapted here:

1. Grant proposal or ethics applications must state what proportion of the overall project funds will be distributed among local community members.

2. The travel costs for outsiders must be less than or equal to funds distributed within the local community (through fair payment, training, and capacity-building).

These recommendations would address social and ecological sustainability at the same time and could be added to ethics guidelines for disciplines that carry out linguistic (or other types of) fieldwork.

5.4 Ecolinguistics

Ecolinguistics, which has its roots in the "environmental turn" in the 1960s and 1970s (see Section 2), has been growing more rapidly since the 1990s, as evidenced by:

- an increasing number of introductory texts and overviews (e.g., Penz and Fill 2022; Steffensen 2024; Stibbe 2020 [2015]; Zhang 2022, and references cited there),
- two recent ecolinguistic book series (Bloomsbury: *Advances in Ecolinguistics*; Cambridge Scholars' Publishing: *Studies in Ecolinguistics*),
- a journal (*Language & Ecology*, see Appendix D in Supplementary material) and a special journal issue (e.g., vol. 8(2) of *Journal of World Languages*; 2022), and
- a growing number of professional organizations for ecolinguistics (see Appendix I in Supplementary material).

According to the webpage of the International Ecolinguistics Association, ecolinguistics "explores the role of language in the life-sustaining interactions of humans, other species and the physical environment" (cf. Appendix I in Supplementary material, no page number). Given this definition, one might expect this linguistic field to have environmental recommendations. However, the name "ecolinguistics" covers diverse approaches, which makes it understandable that there is no discipline-specific set of sustainability recommendations that covers all of these approaches. We will briefly discuss distinctions between approaches that are relevant for recommendations that could be included in discipline-specific research ethics guidelines.

According to the International Ecolinguistics Association webpage, ecolinguistics has two core aims: "The first aim is to develop linguistic theories which see humans not only as part of society, but also as part of the larger ecosystems that life depends on. The second aim is to show how linguistics can be used to address key ecological issues, from climate change and biodiversity loss to environmental justice".

Steffensen (2024) distinguishes four ecological approaches in current linguistics, based on citation and co-authorship analyses and cluster analyses for keywords in research articles:

1. *Language ecology* attends to the symbolic ecology of languages
2. The *sociocultural ecology of language* attends to language planning and learning and other sociocultural processes in educational and societal contexts
3. *Environmental ecolinguistics* attends to the entanglement of language and the ecosystemic surroundings of speakers
4. *Cognitive ecolinguistics* attends to how language affects human agents in ways that have environmental implications, be they destructive or beneficial (Steffensen 2024: 524).

Amongst these approaches, numbers 3 and 4 are the ones that focus on human languages and the actual physical and ecological environment, with approach 3 being more linked to the first aim mentioned on the International Ecolinguistics Association webpage, and approach 4 more closely associated with aim 2. Thus, we will look at these two aims and approaches and the studies they have inspired in turn.

First, we will consider studies that focus on the relationship between ecosystems and the language of the speakers in this environment. Such studies have observed close links between biodiversity and linguistic diversity, for instance correlations between a loss in biodiversity and language endangerment (for discussion, see e.g., Couee 2024; Dimmendaal 2008; Gorenflo et al. 2012; Gorenflo and Romaine 2021; Maffi 2001, 2005; Maffi and Woodley 2012; Mühlhäusler 2003; Skutnabb-Kangas 2003). This links language endangerment to the ecological SDGs, in particular those related to climate change (SDG 13), clean water (SDG 6), life below water (SDG 14), and on land (SDG 15).

Note, however, that the relationship between biological and linguistic richness is complex and we cannot simply interpret these correlations as one-directed causation. For instance, when natural habitats are destroyed, biodiversity is lost and people might move to larger cities, which might in turn lead to the loss of local Indigenous languages. At the same time, language endangerment can lead to a loss of cultural knowledge about the local natural environment and the traditional ways to preserve it. Language loss may also be associated with a loss of cultural practices that protect or support the community's natural environment. However, there are also factors related to globalization that cause losses in both biological and linguistic diversity. Thus, more research is needed to understand the complex web of causal links so that we can use this knowledge to prevent ecological degradation and language loss.

Nevertheless, the findings that exist so far allow us to derive a recommendation that could be added to research ethics guides for documentation and ecolinguistics projects – namely to include both ethnobotanic data and linguistic data in language documentation projects in order to provide the necessary information for "*bio-cultural diversity conservation*" (Maffi and Woodley 2012).

One could also recommend making this information as accessible as possible for all stakeholders. Indeed, some (eco)linguists use observations of links between biological and cultural diversity to argue for action and to highlight the need to consider ecological, sociocultural, and economic development together, in line with the UN Agenda 21. For instance, Gorenflo and Romaine investigated linguistic diversity and conservation opportunities at UNESCO World Heritage Sites in Africa and recommended the creation of Natural World Heritage Sites containing speakers of Indigenous languages as they "present opportunities to conserve both nature and culture in highly visible settings where maintaining natural systems may rely on functioning Indigenous cultural systems and vice versa" (Gorenflo and Romaine 2021: 1426).

Recommendations for research ethics guidelines could also be derived from the second aim of ecolinguistics – showing how language affects human agents in ways that have environmental implications. Studies of this type typically perform discourse analyses that can help us to (i) improve our argumentation for sustainability measures and (ii) understand why knowledge about environmental degradation does not necessarily lead to more sustainable behavior. This is crucial for quality education about environmental issues (SDG 4), in particular education for sustainable development.

5.5 Education for sustainable development in linguistics teaching and knowledge transfer

After discussing how linguists could address ecological issues in their research projects, we will now look at the role that ecological sustainability could play in linguistics teaching, outreach, and knowledge transfer. The background for our discussion are the 17 SDGs discussed in Section 3 and the initiatives related to Education for Sustainable Development (ESD) that started with the UN World Decade for ESD (2005–2014). ESD is starting to affect academic activities. Specifically, three ways of incorporating sustainability and implementing ESD have emerged, which we will illustrate with suggestions and examples:

– Incorporating topics related to social, economic, or ecological SDGs into the curriculum: In linguistics, this might mean that students in seminars on multilingualism and language contact discuss how these topics are related to initiatives to reduce inequality (SDG 10). For example, students may reflect on how using children's diverse linguistic background contributes to reducing inequalities in education (SDG 4). However, it could also mean that classes on language documentation could include discussions about the relationship between linguistic, cultural and ecological diversity and the threats they currently face. This would encourage discussions about a broad range of SDGs. One of us teaches classes about linguistic and educational support for children who need to learn the school language as a second or additional language. For this seminar, students in teaching degrees have to create teaching materials to support children's language learning in various school subjects. The future teachers can select topics for the school subjects they teach, but need to incorporate one or two SDGs.

- Enabling and fostering incidental learning about sustainability: In classes on linguistic analysis, students can be given texts to analyze that focus on sustainability topics. In this way, they can learn both linguistic analysis methods and something about sustainability. Moreover, one can use or develop materials that are explicitly designed for teaching linguistics, language, STEM, and sustainability at the same time. For instance, the Sprachspinat-concept developed by Eisenbeiß (2024) offers lists of plant names that can be used for language teaching, linguistic analysis tasks, or for quantitative and statistical analysis. This list has been used in university seminars on multilingualism, education, and statistics as well as in an outreach activity with children that focused on raising awareness of multilingualism and language structure (see e.g., Eisenbeiß and Torregrossa 2023).
- Using participatory teaching methods and skills training that help students become "change agents" that can bring about sustainable development: Sustainable development requires individuals that are equipped with the knowledge and skills required to bring about change. Thus, ESD employs participatory teaching methods. For instance, instead of giving students a fixed syllabus with a set of pre-chosen teaching materials, assignment or project topics, and assessment formats, students can be involved in the selection of course materials or assessment types and they can be supported in developing their own project ideas. They can also be shown how to use and produce Open Educational Resources (OERs) for their projects so that they experience contributing to SDG 4: Quality Education.

These three ways of implementing ESD in linguistics teaching and knowledge exchange could be incorporated into the teaching recommendations that are often part of professional ethics guidelines for linguists.

6 Discussion and concluding remarks

As our discussion in this paper has demonstrated, the public debate has become more attentive to environmental issues and the way in which humans' actions affect the environment. As a result, scientists have started to refer to environmental issues among the principles related to professional conduct. We noticed, however, that no exhaustive inventory of principles related to the protection of the environment is available at the moment. The main aim of this article was to provide evidence-based recommendations for individual researchers as well as universities, research institutes, and funders that can form the basis for the development of new environment-related guidelines.

The development of these guidelines is particularly needed because we often notice an incongruency between beliefs and practices among linguists (and scientists in general). As shown in Section 2, we have seen an increase in attention to environmental ethics since the 1970s. This presupposes a new ontological view of the relationship between humans, other species, and the physical environment, whereby humans are part of a larger ecosystem without being ascribed a central role in it anymore. Whereas it might be argued that this awareness was restricted to academic exchanges, some movements emerging in the following years had a global resonance, way beyond the academic debates. Let us only consider the climate strike movement started in 2018 by Greta Thunberg. This leads us to think that scientists (and people in general) cannot but be aware of the consequences of their actions on the environment. However, we noticed that this raised awareness is not reflected in scientists' research practices. In particular, there are no general guidelines for ecologically sustainable linguistic research practices. We have argued for the development of such guidelines in this paper and we hope that we can benefit from the insights of ecolinguistic discourse analysis in formulating and promoting such guidelines in a way that is convincing for others to conduct their research in a more ecologically sustainable way.

In a recent contribution, Malt and Majid (2023) write: "although individuals need accurate and complete enough information to understand the environmental impact of their actions, it is not always easy to get people that information because its processing is filtered through the lens of their beliefs, values and motivations" (Malt and Majid 2023: 345). If, for example, academics believe that traveling for meetings or conferences is fundamental for career progression (as noted in Section 4.1.1), they will be ready to give up knowledge about the impact of travel on the environment in favor of their beliefs concerning their career. In other words, their lack of action is motivated by their fear of being rejected from the academic community (see Malt and Majid 2023 for other examples of "fear of social rejection"). In addition to the conflict between environmental knowledge and individual beliefs, another reason that might motivate the lack of action is the idea that certain observations – as related, for instance to energy consumption in the labs – concern only researchers who conduct large-scale experiments, and not researchers of "smaller" fields like linguistics. However, natural language processing as well as psycho- and neurolinguistic experiments are associated with the consumption of a great amount of energy, as discussed in Section 5.1.

With regard to both of these issues, the last few years have witnessed a shift in researchers' mindsets, sometimes also supported by the institutions in which they work. As for their traveling behavior, the COVID-19 pandemic dramatically opened new scenarios that were not familiar before. For example, the organization of virtual conferences showed that networking in academia is possible also without traveling. This has led to a proliferation of virtual and hybrid conferences also after the emergency of the pandemic ended, as described in Section 4.1.1. Furthermore, there seems to be an increasing support by the institutions for scientists who are willing to reduce the environmental impact of their traveling as much as they can (see the links included in Appendix E in Supplementary material). As for energy consumption in the labs, the initiatives related to the creation of shared labs – as reviewed in Section 4.2 – suggest an increasing attention to the issue of energy consumption by the institutions. This increasing attention is also related to the recent energy crisis due to the Ukraine war and consequent sanctions on Russia by some Western countries. In the next few years, we will be able to understand the impact of this on people's awareness and behaviors with respect to energy consumption. We expect a new set of principles related to environmental issues to be included in reaction to these recent events, as has been shown above for other principles informing research practices.

In this article, we introduced guidelines and recommendations for individual researchers, institutions, and funders. However, we strongly believe that one core actor must be considered in the near future, namely professional organizations. Any field of study has its own methodology and research practices. Therefore, an exchange of methodological know-hows related to environmental issues seems to be necessary for the development of new guidelines and the introduction of innovative research practices. The methodological workshops organized at the moment in the field of linguistics concern experimental design, statistical analysis, or ethics guidelines related to participants, communities, research integrity, and professional conduct. In the near future, the environmental issues discussed in this article should be included in the content of these workshops. The workshop from which our paper originated is a first step towards this much needed involvement of professional organizations.

Acknowledgments: The seeds for this paper were planted during a collaboration between Sonja Eisenbeiß and members of the School of Language Literature and Culture Studies at Jawaharlal Nehru University, New Delhi. This collaboration led to many discussions about research and fieldwork ethics and the relationship between linguistics and ethnobotany, which influenced later research and teaching activities. We would like to thank the organizers of the Workshop on *Ethics in Linguistics* at the University of Leiden (2022) for inviting us and the attendees of this workshop for inspiring discussions. This gave us the motivation to finally write a paper about ecological issues in research ethics. We are also grateful for many discussions we had with the audiences of presentations that we gave at the University of Cologne – for the Mercator Institute for Literacy and Language Education, for the Institute for German Language and Literature (University of Cologne), and for the Nachhaltigkeitsforum (sustainability forum). We would also like to thank the members of the sustainability group of the SFB 1252 "Prominence in Language" at the University of Cologne as well as Teresa Barberio, Jürgen Bohnemeyer, Chris Bongartz, Birgit Hellwig, Evrim Kutlu, Bettina Landgraf, Andrea Listanti, Nicole Marx, and Leonie Twente for discussions about research ethics or comments on drafts. We have benefited from Marina Terkourafi's continuous support throughout the writing process and the thoughtful and constructive comments and suggestions of our three reviewers and the editors.
Research funding: Our work was supported by the German Research Foundation (DFG) via the Sonderforschungsbereich 1252 "Prominence in Language" and by the Mercator Foundation via the Mercator Institute for Literacy and Language Education at the University of Cologne. The UK-India collaboration that inspired our work in research ethics was supported by a UKIERI grant that enabled Sonja Eisenbeiß to work at Jawaharlal Nehru University for a month.

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Supplementary Material: This article contains supplementary material (https://doi.org/10.1515/ling-2023-0203).