Publizierbarer Endbericht

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A) Project data

General overview	
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B) Project overview

1 Kurzfassung

Motivation und Methoden

Persönliche klimarelevante Aktivitäten beeinflussen sich gegenseitig und stehen in einem Spannungsverhältnis zueinander. Eine Verhaltensänderung in einem Bereich kann daher nachfolgende Veränderungen in anderen Bereichen anstoßen. SPILLOVER begleitete junge Österreicherinnen und Österreicher in der konstitutiven biographischen Phase vor, während und nach dem letzten Schuljahr, um zu untersuchen, wo und warum Spillover entsteht und wie positiver Spillover gefördert werden kann. Das Projekt verfolgte einerseits, wie klimarelevante Konsumaktivitäten und -präferenzen junger ÖsterreicherInnen entstehen und sich verändern. Andererseits entwickelte das Projekt ein Lernprogramm, in dem junge Menschen ihr eigenes Konsumverhalten reflektieren können.

SPILLOVER verfolgte MaturantInnen während des biografischen Übergangs nach dem Verlassen der Schule in einer zweiwelligen Längsschnittstudie. Die erste Erhebungswelle (n=502) wurde während des letzten Schuljahres abgeschlossen; zum Zeitpunkt der zweiten Welle (n=165) hatten die männlichen Teilnehmer ihren Wehr-/Zivildienst beendet und alle TeilnehmerInnen hatten einen Ausbildungs- oder Berufsweg eingeschlagen. Die Covid-19-Pandemie seit März 2020 brachte zahlreiche Einschränkungen für das Projekt mit sich.

Hauptergebnisse und Schlussfolgerungen

Wirksamkeitsüberzeugungen im Umgang mit der COVID19-Pandemie werden auf die Wirksamkeit in Bezug auf die Klimakrise übertragen, und die Übertragung der partizipativen Wirksamkeit wird durch die wahrgenommene Ähnlichkeit der beiden Krisen moderiert. Die Erfahrung von erfolgreichem individuellen und kollektiven Handeln während der COVID19-Pandemie scheint das Vertrauen in den Umgang mit dem Klimawandel zu stärken.

Kompensatorische grüne Überzeugungen (Compensatory Green Beliefs, CGBs) bezeichnen die Überzeugung, dass nicht-nachhaltige Verhaltensweisen durch andere nachhaltige Verhaltensweisen kompensiert werden können. Wir schlagen vor, zwischen wirksamen, normativen und allgemeinen Überzeugungen (ECGBs, NCGBs, GCGBs) zu unterscheiden. ECGBs beziehen sich auf die effektive Kompensation früherer Versäumnisse. NCGBs bezeichnen das Gefühl, moralisch verpflichtet zu sein, Wiedergutmachung zu leisten. GCGBs beziehen sich auf den Ausgleich von nicht spezifizierten Anstrengungen im Gesamtkonsum. Wir bestätigen eine Drei-Faktoren-Struktur von CGBs. NCGBs sind positiv mit umweltfreundlichen Werten sowie persönlichen und sozialen Normen verbunden, während GCGBs negativ mit diesen Faktoren assoziiert sind. NCGBs zeigen eine hohe zeitliche Stabilität über ein Jahr. CGBs müssen nicht destruktiv sein, da NCGBs zu nachhaltigem Handeln anregen können.

Die mentalen Modelle von Laien über klimarelevante Verhaltensweisen leiten die Übertragung von Verhaltensweisen zwischen verschiedenen Kontexten. Wir analysierten Daten zur wahrgenommenen Ähnlichkeit zwischen 22 klimarelevanten Verhaltensweisen, die in einer offenen Kartensortieraufgabe erhoben wurden. Fünf postulierte Kategorisierungen nach Bereich, Ort, Auswirkung, Schwierigkeit und Häufigkeit werden konfirmatorisch auf ihre Übereinstimmung mit den beobachteten Ähnlichkeitsmustern getestet. Die beste Anpassung wird für die Nullhypothese der zufälligen Zuordnung gefunden. Die Bereichskategorisierung passt am nächstbesten, gefolgt von Auswirkung, Häufigkeit, Schwierigkeit und Ort. In den mentalen Modellen von Laien werden Verhaltensweisen konsistent gruppiert, die mit Abfall und politischem Engagement zu tun haben. Verhaltensweisen mit hoher Klimawirkung und schwierig auszuführende Verhaltensweisen, heben sich von anderen, weniger extremen Verhaltensweisen ab. Die mentalen Modelle werden nicht durch persönliche Normen, Kompetenzen und Umweltwissen beeinflusst. Die wahrgenommene Ähnlichkeit zeigt Ansatzpunkte für die gemeinsame Förderung mehrerer klimafreundlicher Verhaltensweisen.

Wir vergleichen verschiedene Maße für klimarelevantes Verhalten: ein Wirkungsmaß durch Berechnung der (objektiven) Treibhausgasemissionen der TeilnehmerInnen, ein hybrides Maß durch Kombination des Wirkungsmaßes mit Aussagen über das eigene klimarelevante Verhalten und ein Absichtsmaß, welches sich ausschließlich auf die Aussagen der TeilnehmerInnen stützt. Die Maße korrelieren stark mit dem Kleiderkauf, schwach mit der Ernährung und der Mobilität und gar nicht mit dem Heizen. Dies lässt den Schluss zu, dass Auswirkung und Absicht unterschiedliche Aspekte des klimabezogenen Verhaltens widerspiegeln und dass junge Erwachsene, die sich selbst als klimafreundlich einschätzen, einen ähnlichen oder sogar höheren objektiven CO2-Fußabdruck haben könnten als ihre weniger engagierten AltersgenossInnen. Der Zusammenhang zwischen Wirkungsmaß und Absichtsmaß ist in Konsumbereichen mit hoher Strukturabhängigkeit geringer. Soziodemografische Aspekte erklären vorrangig Wirkungmaße und psychologische Variablen erklären vorrangig Absichtsmaße; hybride Maße liegen dazwischen. Die Verwendung hybrider Maße, die sowohl die Wirkung als auch die Absicht widerspiegeln, könnte dazu beitragen, sowohl Struktur- als auch Kulturmerkmale in die Forschung einzubeziehen.

Die entwickelten Lernmodule sind in einen Rahmen eingebettet, der einen ständigen Dialog mit den SchülerInnen sowie die Bewertung ihrer Gedanken, Lernerfahrungen und möglichen Konzeptänderungen im Hinblick auf nachhaltigen Konsum und Spillover-Effekte ermöglicht. Das Lernprogramm befasst sich nicht nur mit dem Verhalten der SchülerInnen in einzelnen Konsumbereichen und Aktivitäten, sondern ermöglicht es den SchülerInnen auch, ein Bewusstsein für die gegenseitigen Einflüsse von Verhaltensweisen innerhalb und zwischen den Konsumbereichen zu entwickeln. Die konzipierten Lernmodule bilden die Grundlage für die Integration in den Unterricht, wobei die Prinzipien der Bildung für nachhaltige Entwicklung und der Klimabildung berücksichtigt werden.

2 Executive Summary

Project rationale and methods

Personal activities incurring greenhouse gas emissions interact, influence and trade off against each other. Behavioural change in one domain may therefore act as a seed for following changes in other domains. SPILLOVER accompanied young Austrians in the constitutive biographical phase before, during and after their final schoolyear in order to assess where and why spillover emerges, and how positive spillover may be encouraged. On the one hand, the project tracked how climate-related consumption activities and preferences of young Austrians persist, are rearranged and modified over time. On the other hand, the project co-designed a learning programme to empower young people to reflect and revise their own consumption patterns.

SPILLOVER tracked senior students during their biographical change of leaving school in a two-wave longitudinal survey. The first survey wave (n=502) was completed during their final schoolyear; by the time of the second wave (n=165), male participants had concluded their military/civil service and all participants had taken up an educational or occupational path. The Covid-19 pandemic since March 2020 posed multiple restrictions for the project.

Main findings and discussion

We asked how efficacy beliefs in dealing with the COVID19 pandemic transferred to efficacy beliefs regarding the climate crisis among Austrian high school students before and after the lockdown. COVID19-related efficacy beliefs are transferred to climate-related counterparts over time, and the transfer of participatory efficacy is moderated by perceived similarity of the two crises. Experiencing successful individual and collective action during the COVID19 pandemic seems to inspire confidence in dealing with climate change.

Compensatory Green Beliefs (CGBs) denote beliefs that unsustainable behaviours can be compensated for by performing other sustainable behaviours. We propose to differentiate between efficacy, normative and general beliefs (ECGBs, NCGBs, GCGBs). ECGBs refer to effectively offsetting previous lapses. NCGBs denote feeling morally obliged to make amends. GCGBs refer to trading off unspecified efforts in overall consumption. We find a three-factor structure of CGBs. ECGBs, NCGBs, and GCGBs intercorrelate moderately, indicating their status as different constructs. NCGBs are positively associated with pro-environmental values, and personal and social norms, whereas GCGBs are negatively associated with these factors. CGBs, in particular NCGBs, have unique explanatory power for sustainable behaviours. NCGBs show high temporal stability over one year. CGBs need not be destructive, as NCGBs may encourage sustainable action. Persuasive messages could be tailored to specific CGBs in specific behavioural domains.

Laypeople's mental representations of climate-relevant behaviours guide the transfer of behaviours between contexts, which is necessary for broad lifestyle changes to reduce overall carbon emissions. We use data on perceived similarity

between 22 climate-relevant behaviours collected in an open card sorting task. Five posited categorisations by domain, location, impact, difficulty and frequency are tested in a confirmatory approach for their fit to the observed similarity patterns. By analysing co-occurrence matrices, edit distances and similarity indices, the best fit is found for the null hypothesis of random assignment. Ranking by test statistics shows that the domain categorisation fits next best, followed by impact, frequency, difficulty and location. Waste and advocacy behaviours emerge consistently in lay mental models. Behaviours with a high carbon footprint and difficult behaviours that are performed by few other people stand out from other, less extreme behaviours. Categorisation fit is not moderated by personal norms, competencies and environmental knowledge. Perceived similarity shows entry points for promoting multiple climate-friendly behaviours together.

We compare different measures of climate-relevant behaviour: an impact measure by calculating (objective) greenhouse gas emissions of the participants, a hybrid measure by combining the impact measure with statements about the own climate-related behaviour, and an intent measure relying solely on the statements of the participants. Measures correlate strongly in the domain of buying clothes, weakly for diet and mobility and do not correlate for heating. This allows the conclusion that impact and intent are a reflection of different aspects of climate-related behaviour and that young adults who consider themselves as climate-friendly might have similar or even higher objective carbon footprints than their less-engaged peers. The association between impact and intent is smaller in consumption domains with high structural dependency. Sociodemographic aspects mainly predict impact measures and psychological variables mainly predict intent measures, whereas hybrid measures stand in between. The composition of hybrid variants, reflecting impact as well as behaviour, might help to incorporate structure as well as culture into research.

The learning modules developed are embedded in a framework, which enables a constant dialogue with the pupils as well as assessing their thoughts, learning experiences, and possible concept changes with regard to sustainable consumption and spillover effects. The learning program not only addresses pupil behaviour in single consumption domains and activities, but also allows pupils to develop awareness of the mutual influences of behaviours within and across consumption domains. The designed learning modules form the basis for the integration into the classroom, with the principles of Education for Sustainable Development and Climate Education in mind.

3 Motivation and objectives

Personal activities incurring greenhouse gas emissions interact, influence and trade off against each other. Behavioural change in one domain may therefore act as a seed for following changes in other domains. Undertaking a certain consumption activity may infect consumption in other domains, also known as spillover or rebound effects (Crompton & Thogersen 2009, Santarius & Soland 2018). This may cut both ways: for instance, eating less meat may encourage a person to take up even more ambitious behaviours like cycling to school, or may be used to justify carbon-intensive consumption like going on holiday by air travel. Thus, instigating low carbon transformation at the level of individual consumers requires a detailed and holistic understanding how and why particular consumption activities bleed into other domains.

Young people currently entering adulthood will shape the overall footprint of the Austrian populace in the coming decades, as the consumer preferences they are used and socialised to now will fully play out once they settle down, take up work, found families, etc. (Haustein et al. 2009, Klöckner & Matthies 2012). Thus, leveraging the full potential of spillover for promoting low carbon transformation requires empowering future consumers to deliberate and balance their carbon impact across multiple domains.

SPILLOVER accompanied young Austrians in the constitutive biographical phase before, during and after their final schoolyear in order to assess where and why spillover emerges, and how positive spillover may be encouraged. On the one hand, the project tracked how climate-related consumption activities and preferences of young Austrians persist, are rearranged and modified over time. On the other hand, the project co-designed a learning programme to empower young people to reflect and revise their own consumption patterns. SPILLOVER derived entry points for targeted interventions to trigger cascading effects across consumption domains: Ideally, shifting a few anchor activities or beliefs introduces a momentum of change, which carries over to a broad range of other activities or beliefs.

The great challenge of low carbon transformation calls for fundamental changes in private consumption patterns. Citizen engagement needs to extend from sporadic activities to a comprehensive restructuring and downscaling spanning across multiple consumption domains. SPILLOVER investigated how behavioural change in one domain may act as a seed for following changes in other domains. Therein, the project put young adults on centre stage, as they are the decision makers and consumers of tomorrow whose actions will determine the future carbon emissions caused by private consumption.

Original objectives and research questions as planned in the project proposal:

- Which activities advance or limit other private consumption and public engagement as spillover within and between consumption domains unfolds dynamically over time? Which psychological and social mechanisms govern spillover?
- How can young people be encouraged to reflect their own consumption patterns? In how far do they translate those reflections into real-world behavioural change?

Revised objectives and research questions as developed due to pandemic-related project restrictions:

- How do climate-related beliefs, intentions and behaviours compensate or trade off against each other? Which factors influence these processes?
- How can critical biographical phases, the transition to adulthood or the experience of a pandemic, influence climate-related beliefs and behaviours? How can this be leveraged in education for sustainable development?

The Covid-19 pandemic since March 2020 had multiple implications for the project: repeated school closures restricted SPILLOVER's contact with teachers and students; the shifting of in-school teaching to homeschooling restricted the design, deployment and testing of learning materials; schools were less able to cooperate with SPILLOVER because they struggled with maintaining regular teaching and had little capacities for extracurricular activities; the transitional biographical phase after leaving school was confounded with the overall coping of the Austrian society with the pandemic. However, as a positive side-effect, an additional survey wave with 113 respondents allowed pre/post analysis of the first Covid-19 lockdown in March to May 2020.

4 Content and results

Note: This report features selected core findings and excerpts from the scientific publications produced during the project (see Section 9). For more detailed information and comprehensive results, please refer to the respective publications and to the project website https://spillover.joanneum.at/.

4.1 Stability in climate-relevant beliefs and behaviours

We observe virtually no change in climate-relevant beliefs and behaviours from t1 to t2. T-tests show minimal change in mean indices (each index aggregates 3-4 items) for norms and efficacy beliefs (Figure 1 next page), self-reported behaviours (Figure 2) and public engagement (Figure 3). Regression models show that mean change is hardly moderated by the occurrence of life events. However, as a quite obvious effect, transport mode choice shifts to cycling and walking if students relocate by moving out of the parental home and entering academic education. Autoregressive cross-lagged models between norms, efficacy beliefs and those behaviours with a strong normative underpinning (food, waste separation, household energy consumption) show high stability over time, but cannot discern causal direction between factors. High stability, or put differently, the absence of change despite a biographical transition among the surveyed students, means there remains only very few variance at t2 to be explained by e.g. spillover mechanisms. Few variance consequently means small potential effect sizes, which would require a much larger sample for statistical confirmation.

We can exclude several methodological reasons for this overall null finding. The multi-item scales feature measurement invariance over time. Similar sample distribution in both survey waves by socio-economic status of parents and by gender precludes self-selection bias. Participants indeed experienced multiple life events, despite the COVID19 pandemic restrictions, and rated the pandemic's influence on their life course fairly low. Selected $p<.05$ results have minimal effect sizes and seem to come from cumulative alpha error. However, the small longitudinal sample lacks statistical power.

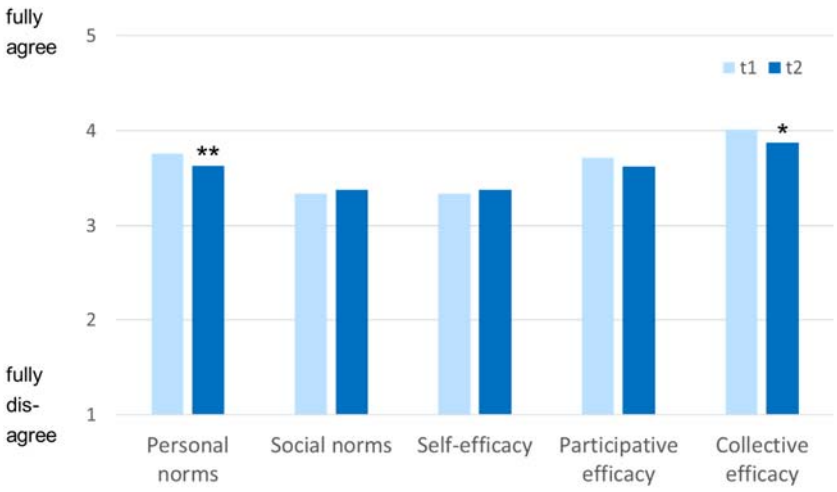

Figure 1. Minimal change in mean indices: Beliefs

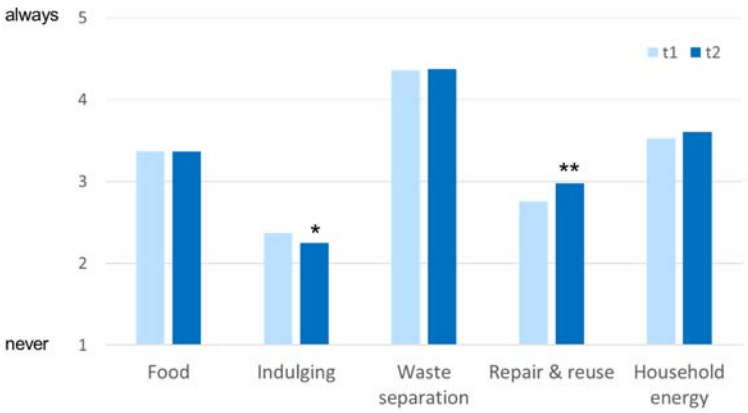

Figure 1. Minimal change in mean indices: Self-reported behaviours

Figure 3. Minimal change in mean indices: Self-reported public engagement

4.2 Transfer of efficacy beliefs from the Covid19 pandemic to the climate crisis

We analyze whether COVID19-related efficacy beliefs directly inform corresponding climate-related efficacy beliefs; in other words, we test for their positive association. Therein, we take up the argumentation that the pandemic experience demonstrated individual and collective capabilities that may transfer to coping with the climate crisis (Lehmann et al., 2021; Reese et al., 2020; Lauren et al., 2019). Second, we explore mechanisms, conditions, and behavioral effects related with the transfer of efficacy beliefs. We test a moderation model in which the effect of COVID19-related efficacy beliefs on climate-related efficacy beliefs is assumed to depend on the perceived similarity of the two crises. We thus refer to our two overarching research questions, that is to say, the assumed positive relationship between COVID19-related and climate-related efficacy beliefs, and that transfer of efficacy beliefs is more likely between contexts perceived as similar.

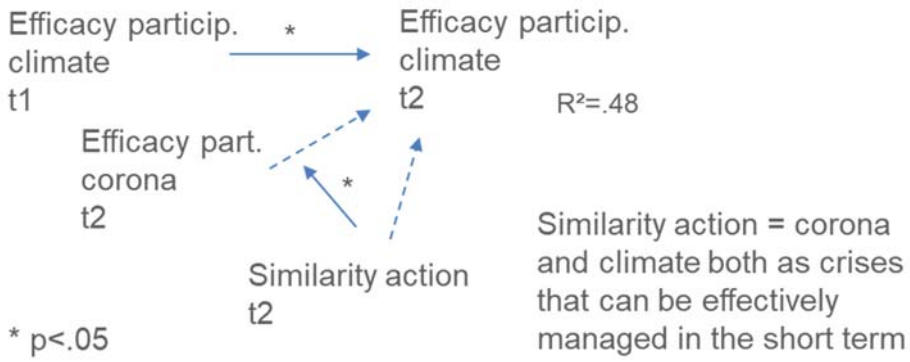

Figure 4. Moderation model for the transfer of efficacy beliefs, on the example of participatory efficacy.

We find a unique, statistically significant direct transfer effect of COVID19-related self-efficacy onto its climate-related self-efficacy counterpart, above and beyond the stability of climate-related efficacy between t1 and t2. The same unique direct transfer effect between the two crises is found for positive and negative efficacy affect. However, direct transfer of participatory efficacy is not statistically confirmed (it is fully moderated by similarity of action though; see below). Direct transfer is also not statistically significant in collective efficacy. Throughout, all five climate-related efficacy beliefs show high stability over the course of three months from t1 to t2. Both stability and direct transfer effects are fairly constant in size across the various efficacy beliefs; direct transfer amounts to about a third to a half of the stability effects.

Second, we are interested in the role of perceived similarity between the two crises. Similarity of threat is positively associated with self-efficacy, participatory

efficacy and positive efficacy affect. This effect tends to be slightly weaker than the direct transfer of efficacy beliefs. Contrary to assumptions, no statistically significant interaction of similarity of threat and COVID-related efficacy beliefs on the climate-related counterparts is found. Similarity of action is not associated with any climate-related efficacy beliefs; however, similarity of action moderates the transfer of participatory efficacy. The unique simple effect of COVID19-related participatory efficacy is not statistically significant; thus, the influence of COVID19-related participatory efficacy fully depends on similarity of action. This indicates that the learning of participatory efficacy beliefs requires a perceived similar context of the COVID19 and the climate crisis.

Despite its small sample size, we confirm the transfer of self-efficacy beliefs and efficacy affect from the COVID19 to the climate crisis. The direct impacts of COVID19-related efficacy and similarity are about a third to a half of the stability of climate-related efficacy. This suggests that efficacy beliefs are indeed changeable and fluid – presumably because the exceptional disruption of the national lockdown provided almost daily action-oriented feedback on the perceived capability of coping with an existential crisis. Regarding our second research question, similarity as a favorable condition for the transfer of efficacy beliefs is only confirmed as a significant interaction between similarity of action and participatory efficacy.

4.3 Efficacy, Normative and General Compensatory Green Beliefs

Compensatory green beliefs (CGBs) denote beliefs that the impact of unsustainable behaviors can be partially or fully compensated for by performing other more sustainable behaviors (Kaklamanou et al., 2015; Holmgren et al., 2018). The concept of compensatory beliefs originates from health research reflecting the premise of different actions contributing to and trading off towards an overall outcome such as 'I may eat this piece of cake now because I will exercise this evening' aimed at watching one's weight (Knäuper et al., 2004). In the domain of environmental protection, CGBs are enacted to protect someone's environmental credentials or to alleviate negative feelings after giving in to temptation and acting against personal standards for protecting the environment (Byrka & Kaminska, 2015; Hope et al., 2018).

Under the umbrella term of CGBs, previous studies measured three different dimensions of CGBs: efficacy, normative and general CGBs. Efficacy compensatory green beliefs (ECGBs) refer to effectively offsetting previous lapses by specific actions (X can compensate for Y; e.g. 'Not using a dishwasher can compensate for taking longer showers,' Kaklamanou et al., 2015). Normative compensatory green beliefs (NCGBs) denote the perceived moral obligation to make amends by performing specific more sustainable behaviors (If I do X I should do Y; e.g. 'If you do not reuse plastic bags, you should use public transportation,' Byrka & Kaminska, 2015). General compensatory green beliefs (GCGBs) refer to a holistic

perspective on trading off unspecified efforts in overall consumption, similar to mental accounting (e.g. 'Doing some things that are positive for the environment means I am allowed to do other things that are less environmentally friendly,' Capstick et al. 2019).

Compensatory Green Beliefs		
X can compensate for Y	If I do X I should do Y	Unspecific trade-off
"Walking to the supermarket **can compensate** for buying highly packaged food." (Kaklamanou et al. 2015)	"If you use a car with high fuel consumption, in winter **you should** keep the heat on so that you do not have to wear a sweater." (Byrka & Kaminska 2015)	"Doing some things that are positive for the environment means I am allowed to do other things that are less environmentally friendly." (Capstick et al. 2019)
Efficacy beliefs	**Normative beliefs**	**General beliefs**

Figure 5. Differentiating compensatory green beliefs.

Mean scores show endorsement of NCGBs and ECGBs in the mid-range of the five-step response scale. Respondents slightly favor compensatory beliefs referring to household energy consumption (hot water use, disconnecting electrical devices) over beliefs referring to transport. Confirmatory factor analysis corroborates the three-dimensional structure of normative, efficacy, and general CGBs as interrelated but separate factors. CGBs are moderately correlated but do not overlap with environmental knowledge, personal and social norms and pro-environmental values. NCGBs correlate positively (r=.32 to r=.49) and GCGBs correlate negatively (r=-.35 to r=-.39) with pro-environmental norms and values. ECGBs are practically unrelated to pro-environmental norms and values; the r=.16 correlation of EGCB with personal norms is presumably a spurious finding arising from a linear combination of the ECGB-NCGB and NCGB-personal norms correlations. Both in ECGBs and GCGBs, weaker compensatory beliefs are associated with a higher level of environmental knowledge (r=-.12 and r=-.16). Being literate about the actual energy consumption and carbon emissions of everyday activities seems to correct an overly optimistic mindset that minor adjustments in daily consumption suffice to balance the personal carbon footprint.

In most behavioral domains, CGBs increase explained variance R^2 by a third when controlling for the influence of environmental knowledge, personal norms, social norms, and pro-environmental values. NCGBs stand out, as they significantly promote sustainable behavior in four out of five domains (β=.22 to β=.36). NCGBs

show the strongest effect on energy use (β=.36), most likely because the NCGB1 and NCGB4 items directly refer to household energy consumption. The unique effect of NCGBs additional to the influence of personal and social norms underscores that NCGBs imply a perceived moral obligation beyond common normative expectations. ECGBs diminish pro-environmental action by advancing carbon-intensive indulging behaviors (β=.23). That ECGBs particularly influence the indulging domain could indicate the compensatory premise of allowing oneself indulgence as unsustainable lapses may be easily corrected by subsequent minor adjustments. GCGBs do not significantly influence any domain of sustainable behavior, presumably because general CGBs do not refer to specific behaviors as normative and efficacy CGBs do.

The two-wave longitudinal subsample illustrates substantial temporal stability of NCGBs but cannot determine causal directions between NCGBs and other factors. Both NCGBs and sustainable behaviors show high autoregressive effects, underscoring that NCGBs remain mostly unchanged (β=.47 to β=.54) and norms and behaviors are almost constant from t1 to t2 (β=.80 to β=.98). While it comes as no surprise that environmental beliefs and behaviors persist over time (Stern 2000, Verplanken & Orbell 2003), these high stabilities are still remarkable because of the substantial biographical change undergone by the study population of high school graduates. That NCGBs persist under changing circumstances speaks to their status as an enduring mindset.

Thus, in order to address conceptual ambiguity in previous research on compensatory green beliefs, we introduce a three-dimensional perspective. In our study sample, normative, efficacy, and general compensatory green beliefs can be differentiated among themselves (construct validity) and from the factors environmental knowledge, personal norms, social norms, and pro-environmental values (discriminant validity). CGBs, in particular NCGBs, have unique explanatory power for sustainable behaviors, above and beyond the norms, values, and knowledge factors (incremental validity). NCGBs hardly change over time, which supports their status as underlying, persistent beliefs (temporal stability).

4.4 Mental models from perceived similarity of climate-relevant behaviours

In the perspective of experts, scientists and policymakers, all climate-relevant behaviours are linked in that they all contribute to a person's carbon footprint. Laypeople however, or, those people who are expected to understand and act on their carbon footprint in their day-to-day lives, hardly hold an overarching mental concept that carbon-intensive and energy-consuming activities belong together (Truelove & Gillis 2018). Instead, laypeople form their mental representations by grouping behaviours that relate to the same practices and habits, that are performed with the same domestic appliances, or that hold the same meaning for themselves or a meaning shared with others (Gabe-Thomas et al. 2016; Doran, Böhm & Hanss 2018). The larger the discrepancy between expert and lay concepts

of how climate-relevant behaviours relate to each other, the harder it is for communicators to engage households in concerted and comprehensive action for reducing carbon emissions. Thus, the present paper investigates how laypeople perceive some behaviours as similar and other behaviours as dissimilar, and what their patterns of similarity between behaviours may tell about their underlying mental models.

Previous research points to underlying categorisations that guide why laypeople group some behaviours as similar and distinguish other behaviours as dissimilar: domain, location, impact, difficulty and frequency. The present paper operationalises

- the Domain categorisation with the four categories energy use & consumption, transport, waste and advocacy.
- the Location categorisation with the four categories indoor, outdoor, online and political space.
- the Impact categorisation via the shares of behaviours in the average carbon footprint with the four categories >10%, 5-10%, <5% and no direct impact. Carbon impacts are calculated by applying the ECHOES methodology to the study population (Bird et al. 2019).
- the Difficulty categorisation with four categories of 0-25%, 26-50%, 51-75% and 76-100% engagement probability. The higher the engagement probability, the less difficult the behaviour, as a higher percentage of people is likely to engage in that very behaviour. Engagement probabilities are derived from a General Ecological Behaviour attitude distribution.
- the Frequency categorisation with four factors as categories that are derived from a principal component analysis of self-reported behaviours.

Perceived similarity is elicited in an open sorting task of climate-relevant behaviours. Previous studies on perceived similarity are exploratory (Gabe-Thomas et al. 2016; Doran, Böhm & Hanss 2018; Kneebone, Fielding & Smith 2018). By contrast, the present paper tests confirmatorily how well the posited categorisations Domain, Location, Impact, Difficulty and Frequency fit to the similarity patterns between 22 climate-relevant behaviours.

Testing how well the similarity categorisations fit to the entire sample shows that the respondents do not seem to have a shared mental concept which climate-relevant behaviours belong together. The two null hypotheses assuming random assignment and stochastic independence, have the lowest Chi² test statistics and therefore fit best to the observed data. However, Chi² test statistics may still be compared to assess which posited categorisations fit better than others. Ranking the Chi² test statistics suggests that the Domain categorisation fits best, followed by Impact, and then with substantially higher Chi² values followed by Frequency, Difficulty and finally Location. Mean edit distances range from 7 to 10, meaning respondents would on average have to move 7 to 10 behaviours to another group in order to comply with the posited categorisation. The mean edit distances

replicate the ranking observed in the co-occurrence matrices, with Domain showing the best fit, followed by Impact, Frequency, Difficulty and finally Location with increasingly higher edit distances.

The highest similarity indices emerge in the waste category of the Domain categorisation (M=0.89) on the one hand; and the advocacy category in Domain (M=0.86), political space in Location (M=0.92), no direct impact in Impact (0.86) and high Difficulty (0-25%: M=0.62) on the other hand; advocacy, political space, no direct impact and high difficulty reach similarly high indices because they all include behaviours of political and civic engagement. These categories seem to reflect shared representations of related behaviours that most respondents hold. Interestingly, the high Impact (>10%: M=0.46) and the high Difficulty (0-25%: M=0.62) categories stand out against the other categories within Impact and Difficulty. Behaviours with a high carbon footprint (heating, flying, eating meat) and behaviours that are performed by few other people (buying organic food, various political and civic engagement behaviours) seem to stand out by being perceived as similar to other extreme behaviours yet distinct to less carbon intensive and less difficult behaviours. The moderator variables personal norms, competencies and environmental knowledge do not have any discernible effects on co-occurrence matrices, edit distances, and similarity indices.

4.5 Relationship and predictors of climate-relevant intent and climate impact.

We find several relevant results when comparing different methods of measuring climate-related behaviour: using objective data to calculate the GHG-emissions associated with a certain lifestyle domain (impact measure); combining objective data and statements about the own behaviour (hybrid measure); or using solely statements about the own behaviour (intent measure). We compared the results for these different measures in four lifestyle-domains: Diet, mobility, heating-behaviour and habits of buying clothes. The first three domains were chosen, because they are the lifestyle domains leading to the highest private GHG emissions (Bird et al., 2019). Buying of clothes was chosen as representative for consumption behaviour. Furthermore, we assume that the agency of students over these four domains is differently strong, leading potentially to different results. For diet and buying clothes we only calculated a hybrid and an intent measure, since a purely impact variant would require detailed data of what participants eat everyday and how much and what kind of clothes they buy during a year, which was not available.

Observing first the correlation between impact and the hybrid measure we found a very high correlation for mobility as well as for heating (mobility: $r=0.93$; $p<0.01$, $N=442$; heating: $r=0.99$, $p<0.01$, $N=272$). This picture changes if the impact respectively hybrid measure is compared to the intention measure: For mobility, we only found a small correlation for hybrid and intent ($r=0.21$, $p<0.01$, $N=442$) and even a smaller for impact and intent ($r=0.11$, $p<0.05$, $N=443$). For

heating the correlation between impact respectively hybrid and intent was not existent (r=-0.07, n.s., N=399 respectively r=-0.06, n.s., N=272). Diet showed a weak association between hybrid and intent (r=0.25, p<0.01, N=501) and buying clothes a high correlation (r=0.88, p<0.01, N=501).

Table 1. Pearson correlations between different measures of climate-related behaviour in four domains

BEHAVIOUR	PCC IMPACT-HYBRID	PCC IMPACT-INTENT	PCC HYBRID-INTENT
MOBILITY	.928** (N=442)	.107* (N=443)	.210** (N=442)
HEATING	.985** (N=272)	- .067 (N=339)	- .058 (N=272)
DIET	---	---	.246** (N=501)
BUYING CLOTHES	---	---	.876** (N=501)

* P < .05; ** p< .01. Lower intent score= more climate-friendly behaviour.

Looking at the predictors of the measures and beginning again with mobility, the pure impact model shows that especially sociodemographic variables are relevant, explaining around 16% of observed variance. Psychological variables do not lead to further variance explanation. In the hybrid model, we see a similar development, but the model including psychological variables increases explained variance by 5%. For the intent model, the sociodemographic variables have no relevant impact. Psychological variables can improve this model (although explained variance remains low).

For heating, explained variance for the impact and hybrid model is zero. The only exception is the model with sociodemographic and psychological variables for the intent-measure. There we see an influence of the psychological variables.

For diet, we see an influence in the hybrid measure of sociodemographic variables as well as of psychological variables, whereby especially the psychological variables improve variance resolution. The situation is different for the intent model: Variance resolution is clearly smaller and only existent in the model with sociodemographic and psychological variables.

For buying clothes, there is a similar effect for the hybrid as well as the intent measure: Sociodemographic variables improve variance resolution better than psychological variables.

4.6 Learning programme for behavioural spillover

The learning modules developed in the first project stage have been embedded in a framework, which enables a constant dialogue with the pupils as well as assessing their thoughts, learning experiences, and possible concept changes with regard to sustainable consumption and spillover effects. The learning program not only addresses pupil behavior in single consumption domains and activities, but

also allows pupils to develop awareness of the mutual influences of behaviors within and across consumption domains and, building on this, to build self-efficacy through their own genuine experiences. Ultimately, the changed behavior patterns should lead to a lower overall carbon footprint.

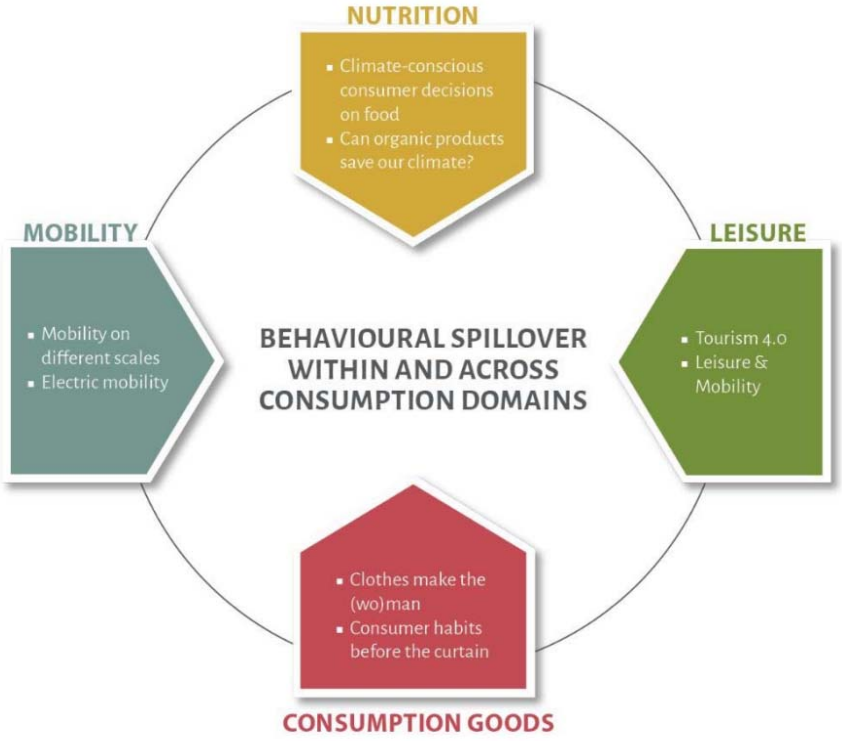

Figure 6. Topics addressed in learning modules

In addition, the learning program includes educational background information and suggestions for dealing with other real-life projects. The learning program goes far beyond the design of individual lessons, and makes suggestions for a more in-depth examination of a main topic in the classroom or a project week. The learning program builds on the principles of moderate constructivism, conceptual change, and research-based learning and aims to be brought to live together with experts, students and teachers (inter- and transdisciplinary approaches). Thus, the learning program is to be understood as a suggestion or opportunity to deal more intensively with the topic of spillover in different subjects at school. The designed learning modules form the basis for the integration into the classroom, with the principles of Education for Sustainable Development and Climate Education in mind. In addition to the individual modules, the learning program includes suggestions for the integration into school within the framework of up to 12 lessons or a project week and subsequent real-life projects. The individual modules are underpinned by the claim to further develop, implement, and evaluate them in the

sense of peer-to-peer learning by students for students. The complete learning program is available to teachers of all subjects via the project website.

Following the finding from survey wave 2 of relatively little attitudinal and behavioral change, semi-structured focus groups confronted students with their absent change and asked for their explanations. The students claim a self-image as climate conscious people, and have undertaken short-term, occasional experiments including eating vegan or buying second-hand clothing during the year between wave 1 and 2. However, they describe the changing habits as still „in progress", and they expect substantial changes to take longer than one year. The school as an institution still seems to have a marginal influence on the development of competences in the fields of climate change and sustainability. Overall, Education for Sustainable Development played a subordinate role in the respondents' school experiences, regardless of which school or type of school they attended and region they lived in.

5 Conclusions and recommendations

5.1 Leverage efficacy beliefs formed during the pandemic

We find empirical support that COVID19-related efficacy beliefs directly affect their respective climate-related counterparts, even when controlling for climate-related self-identity or the stability of climate-related efficacy beliefs over time. Our results support corresponding theoretical assumptions expressed at the beginning of the pandemic (Lehmann et al., 2021; Reese et al., 2020), and extend previous empirical evidence on possible efficacy transfer (Lucarelli et al., 2020; Meijers et al. 2021). Our results are less clear regarding the mechanisms, conditions, and behavioral effects of this efficacy transfer. We find evidence of partial mediation of the effect of COVID19-related efficacy on private behavior and policy support via climate-related efficacy, and of a moderator effect of perceived similarity.

When the COVID19 pandemic forced governments to implement swift and radical measures, many voices argued that this might provide a blueprint and door opener for ambitious climate action once the pandemic declined (e.g., Lehmann et al., 2021; Reese et al., 2020). Developing an individual and collective sense of capability to achieve a common goal, be it overcoming the pandemic or reaching the 1.5℃ climate target, could be one of the many possible lessons humanity may take from COVID19. Our results suggest that if the lockdown in the spring of 2020 was experienced as a successful strategy of crisis management, efficacy beliefs for combating climate change increased. Efficacy beliefs are hard to increase in laboratory environments (Hamann & Reese, 2020), and it seems to take substantial interventions to change ingrained beliefs such as a coaching weekend program (Hamann et al., 2021) or even a pandemic lockdown. The regression coefficients observed in our studies are rather small in magnitude, though, so we do not expect massive turnarounds in consumer lifestyles and climate policy acceptance. Moreover, most transfer effects found encompass self-centered

efficacy beliefs, so we assume that the pandemic triggers individual rather than collective climate action. Last but not least, it should be kept in mind that transfer functions in both ways – experiences of success may carry over to other contexts as well as experiences of failure, as indicated by the positive sign of our regression coefficients.

5.2 Promote normative compensatory green beliefs

In our study sample, normative, efficacy, and general compensatory green beliefs can be differentiated among themselves (construct validity) and from the factors environmental knowledge, personal norms, social norms, and pro-environmental values (discriminant validity). CGBs, in particular NCGBs, have unique explanatory power for sustainable behaviors, above and beyond the norms, values, and knowledge factors (incremental validity). NCGBs hardly change over time, which supports their status as underlying, persistent beliefs (temporal stability).

With regard to promoting sustainable behavior in persuasive interventions, the results indicate both a constructive and a destructive facet of compensatory green beliefs. Normative CGBs encourage sustainable behavior; this constructive facet emerges most strongly in waste separation and energy use. General CGBs and, in a less pronounced way, efficacy CGBs inhibit sustainable behavior; this destructive facet appears most strongly in indulging and repair and reuse behaviors. People who reflect on their unsustainable behavior are more likely to be persuaded to change their behavior (Hope et al., 2018). Persuasive messages could be tailored to normative or efficacy CGBs depending on the specific behavioral domains targeted. Compensatory beliefs are discussed as a spillover mechanism (Nash et al., 2017); thus, making NCGBs salient may inhibit negative spillover. Judging from the discriminant validity correlations, NCGBs could be advanced by appealing to personal and social norms and pro-environmental values. ECGBs and GCGBs reflect how compensatory beliefs function as a mechanism for coping or even self-deception – if someone wants to relieve their bad conscience, they have to convince themself that their compensatory actions actually suffice to correct their lapse, even if this belief is inconsistent with common sense or carbon footprint calculations. Environmental knowledge is negatively associated with ECGBs and GCGBs, presumably because knowing the facts about real-world carbon impacts makes it hard to uphold erroneous beliefs. Thus, educating individuals on the actual carbon impact of their actions, for instance by product labeling, could help in debunking compensatory fallacy and could support realistic mental accounting of personal contributions to climate protection.

5.3 Account for mental models in persuasive interventions

We compared similarity patterns observed in an open card sorting task, which assigned 22 climate-relevant behaviours to four groups, to five posited categorisations. Across the three complementary analytical approaches of co-occurrence matrices, edit distances and similarity indices, the best fit is found for

the null hypotheses of stochastic independence and random assignment, suggesting there is no common structure to the respondents' sorting and thus no shared mental concept of similarity held by all respondents.

However, some categories of behaviours perceived as similar emerge. Organising behaviours in a Domain taxonomy seems to best represent how people mentally structure their everyday actions. Within the Domain categorisation, waste behaviours and advocacy behaviours each seem to belong together in laypeople's mental models. Higher similarity in behaviours that have high climate Impact, high Difficulty and are performed with similar Frequency, points to an interesting avenue for future research to explore how this congruence could be used to motivate broad behavioural change.

Perceived similarity is also relevant for designing green marketing efforts that aim to encourage lifestyle changes, which span several climate-relevant behaviours. Perceived similarity indicates how consumers arrange behaviours in their mental space and therefore shows entry points for promoting multiple climate-friendly behaviours together (Bernard, Ryan & Borgatti 2009; Thogersen 2004; Kneebone et al. 2018). Persuasive messages for broad lifestyle change make more sense to consumers if they address those bundles of behaviours, which go together in consumers' mental representations (Gabe-Thomas et al. 2016). Understanding where lay and expert taxonomies diverge allows taking dedicated steps to correct lay misperceptions (Doran, Böhm & Hanss 2018).

5.4 Differentiate between intent, hybrid and impact footprint measures

Regarding the comparison of the different measures of climate-relevant behaviour we can conclude that correlations between impact, hybrid and intent measures are limited. Correlations heavily depend on the domain under investigation: We discovered a strong correlation in the domain of buying clothes, a small one for diet and mobility and no correlation for heating. This allows the conclusion that impact and intent are a reflection of different aspects of climate-related behaviour and that young adults who consider themselves as climate-friendly might have similar or even higher objective impacts on the climate as their peers not caring so much, a conclusion that is also drawn by other researchers (e.g. Moser & Kleinhückelkotten, 2019). We can further conclude that the correlation between impact and intent is connected with the structural dependencies of certain lifestyle domains: In case of a high structural dependency (as for heating and- to a lesser degree- mobility), the association is smaller than for domains with less structural dependency (diet and buying clothes).

The conclusion of a systematic difference between impact and intent is supported by the investigation of their predictors: We can conclude that sociodemographic aspects mainly predict impact measures and psychological variables mainly predict intent measures, whereas hybrid measures stand in between. One explanation for this might be that impact measures reflect stronger structural conditions in the

living space of people and intent measures reflect a general cultural climate or self-perception. Both aspects have important implications for practice, therefore the composition of hybrid variants, reflecting impact as well as behaviour, might help to incorporate structure as well as culture into research.

5.5 Outlook for future research

It should be noted that the learning program is designed in the sense of Education for Sustainable Development cannot and must not provide any "ready-made model solutions". An essential part of such a concept is the creation of learning opportunities in the joint process between teachers, experts and students. This learning program is not a static concept with ready-made instructions, but rather a companion who wants to encourage further development and the active implementation of one's own ideas. In this sense, the teaching units designed by the students are put up for discussion and further developed or modified within the framework of the learning program and can be implemented in a different form than the present one. Based on the findings from the questionnaire surveys and the subsequent focus group interviews, the fact that very little Education for Sustainable Development is currently implemented in Austrian schools should be further investigated in the future.

We observe high stability in beliefs and behaviours during the biographical transition after leaving school. We may exclude various methodological reasons for this null finding. As directions for future research, we may speculate on potential conceptual reasons for this absence of change: Behavioural change might take longer than one year, even if this year marks a clear biographical transition. Students might still experiment with their consumption patterns and their incremental changes might be too small to register in common survey formats. Socialisation could already be completed by the final schoolyear. Life events may only impact behaviours, if the opportunities and constraints by the built environment change as well. Students might need strong intentions for change in order to fully leverage biographical transitions.

Since our data collection after the first COVID19 infection wave, the world has seen several successive waves. We may only speculate how individual and societal efficacy transfer processes from COVID19 have been continuing. Monitoring the development with longitudinal studies is neccessary to obtain greater clarity. Several parallel processes might shape how efficacy beliefs evolve(d) over the course of the pandemic: A (further) decrease in public acceptance of radical governmental measures could undermine perceived collective efficacy to combat climate change. As the immediate COVID19 threat fades into the background, the experiences and lessons gained from the pandemic might, as well, and climate-related efficacy beliefs could fall back to pre-pandemic levels. Or, contrariwise, as COVID19 becomes a less pressing concern, citizens might (again) become more willing to engage with comprehensive state action for protecting the climate.

For the majority of climate-relevant behaviours no clear mental concepts can be confirmed that tie these behaviours together. The absence of moderator effects further underlines that there does not seem to be a commonly shared mental representation, not even among subgroups of the population. The substantial inter-individual differences which behaviours are perceived as similar merit more detailed research, for instance using qualitative methods or participatory observations.

Regarding the measurement of climate-relevant behaviour, future research needs to be aware that results might change fundamentally whether intent or impact measures are used. Researcher should reflect already in the research design why they chose an impact or intent measure, or use a hybrid approach. Judging from the small correlation between impact and intent, even climate-conscious young adults might not be fully aware of what aspects of their lifestyles produce the greatest climate-impact. A more in-depth engagement with climate-change related topics, as developed in the project, therefore seems as an important component to achieve future GHG emission reductions.

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C) Project details

7 Methods and concepts

7.1 Survey of students before and after leaving high school

SPILLOVER tracked senior students during their biographical change of leaving school in a two-wave longitudinal survey. The first survey wave was completed during their final schoolyear; by the time of the second wave, male participants had concluded their military/civil service and all participants had taken up an educational or occupational path. Both survey waves applied the same questionnaire. The questionnaire included items on climate-related behaviours; and a range of psychological and social factors as spillover mechanisms to explain the degree and direction of behavioural change between first and second wave.

Standardized self-completion questionnaires were distributed from February to May 2020. Data collection was implemented as an online survey using the open source software Limesurvey hosted on a dedicated, local JR server. Students completed the questionnaire in the classroom during school hours, using the school's computers or their own electronic devices. A project team member was present on-site in the classroom for oversight and clarification. Implementation of the questionnaire as a web form allowed to gather data without later manual data entry and reduced the risk of data transition errors. However, Covid-19 school closures commenced shortly after the wave 1 data collection had started at the end of February 2020. Already fixed dates for classroom surveys had to be cancelled on short notice, and data collection had to shift to an entirely online survey. Teachers distributed an email invitation to the online survey and up to two reminders to their respective students who completed the questionnaire as a homeschooling exercise. Having implemented the questionnaire in an online format from the onset greatly facilitated this process. In total, wave 1 resulted in valid responses from 502 students.

While the pandemic severely impeded the wave 1 data collection, it also provided the opportunity for tracking attitudes and beliefs before and after the first national lockdown. When school quarantine was announced in mid-March 2020, in-classroom data collection had already been completed in six schools in Styria. Students from these six schools were approached in May 2020, after quarantine rules had been relieved, in an additional survey wave (nicknamed "wave 1.5", because the original project design planned for only two waves), resulting in a longitudinal sample of n=113 responses.

One year later, in March to April 2021, those 336 students who had agreed to participate in a follow-up survey were approached again. These students received an email invitation to an online questionnaire and three reminder emails, plus a reminder text message if they had provided a mobile phone number. Students were offered participation in a lottery of gift vouchers (8 x 50 Euro) as an incentive

to take part in the survey. In total, 49% of the respondents who had provided valid contact data participated in the follow-up survey, yielding a longitudinal sample of n=165 cases.

During the year between the first survey wave in 2020 (t1) and the second survey wave in 2021 (t2), the respondents experienced a formative biographical phase wherein several life events coincided: high school graduation (98.6% experienced this life event), moving out of the parental home (36.0%), doing military/civil service (29.5%; compulsory for able-bodied male citizens), taking up gainful employment (51.1%), and/or entering academic education (57.6%). Respondents experienced on average 2.73 life events (SD=0.85).

Table 2. Composition of the wave 1, wave 1.5 and wave 2 samples

Characteristic	Wave 1		Wave 1.5		Wave 2	
	n	valid %	n	valid %	n	valid %
Total	502	100.0	113	100.0	165	100.0
Surveyed in classroom	319	63.5	113	100.0	97	58.8
Surveyed online	183	36.5	0	0.0	68	41.2
Styria	453	90.2	113	113	153	92.7
Tyrol	49	9.8	0	0.0	12	7.3
Female	241	51.6	60	53.1	95	57.6
Male	222	47.5	53	46.9	70	42.4
Age 16-17 years	130	27.8	39	34.5	0	0
Age 18 years	217	46.5	50	44.2	38	27.5
Age 19 years	103	22.1	22	19.5	67	48.6
Age 20-22 years	17	3.6	2	1.8	33	23.9

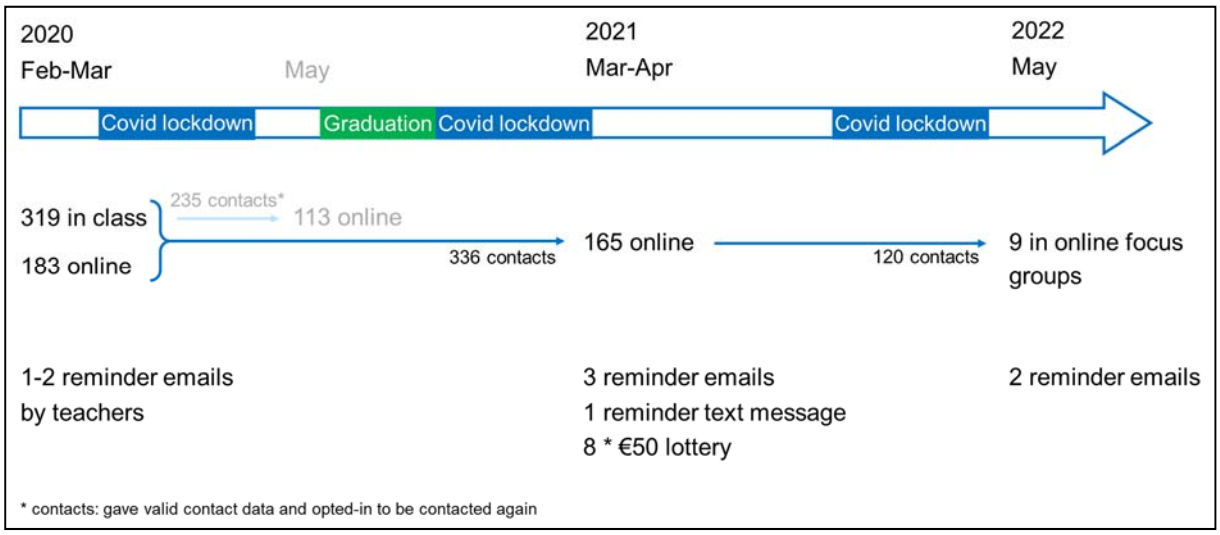

Figure 7. Survey timeline and sample sizes

7.2 Development and implementation of the learning programme

In the school year 2019/2020, three pilot classes in Tyrol (two at the HBLFA Kematen, one at the BG/BRG Reithmannstraße) participated in the two semester pilot phase. During the winter semester 2019/2020, there were three in-school attendance dates for each pilot class: the first appointment served as an introduction to the project, the following two were research workshops. The first workshop comprised an introduction to the topic of sustainable consumption and spillover, the identification of fields of interest, and the derivation of an individual scientific research question on a specific sub-area (e.g. mobility, housing, nutrition, information, leisure, consumer goods). The selection of a certain consumption domain by each group was based on individual preferences due to the completion of the Climate Lifestyle Check footprint calculator by JR (https://www.lifestylecheck.at/). At the end of the first workshop, the students were given a set of tasks which they had to implement as homework and in class until the second workshop. These tasks guided them to further specify, and ultimately answer their own research questions. At the end of the winter semester 2019/2020, the students presented their preliminary research results during the second workshop, and received suggestions from their class teachers and the project team from the University of Innsbruck.

In the summer semester 2020, parallel to the activities in the pilot classes, the university course 'Climate Change Education for Sustainable Consumption' at the University of Innsbruck required university students to design and implement a 1-2 hour teaching unit, therein integrating the research projects of the school students from the pilot classes. Over the summer semester, several (virtual) meetings of all protagonists (university students, course director Lukas Fritz, pilot class teachers, school students; in different constellations) took place, including a large workshop in May 2020. Subsequently, the students worked on the feedback given and submitted the lesson plans by mid-June 2020. Example lessons were implemented from mid-June until the end of the semester, largely via e-teaching online.

In the 2020/2021 winter semester, the learning programs developed by students, teachers and pupils were supposed to be implemented in the pilot schools and in other schools. Due to the corona pandemic, however, school visits by people from outside the school were not allowed by the respective state authorities. This unexpected situation did not change during the whole school year 2020/2021. As a consequence, the implementation did not take place as planned in the original research concept. This is why the existing learning modules were alternatively developed into a more extensive learning program.

In May 2022, 120 participants of survey wave 2, who had given their consent and contact data for a follow-up survey wave, were invited to participate in online focus groups. Twelve students agreed to discuss the overall finding of high stability in

climate related behaviours and beliefs in small groups of 2-4 students. Finally, nine people actually participated in four different online sessions.

7.3 Regression analysis of the transfer of efficacy beliefs

We calculated ten separate regression models each combining a specific efficacy belief (self, participatory, collective, positive affect, negative affect) with a specific similarity (threat, action). All models have the same structure, regressing climate-related efficacy beliefs at t2 on three predictors: (1) climate-related efficacy beliefs at t1 to control for the autoregressive effect and to show how stable efficacy beliefs are over time; (2) the counterpart COVID19-related efficacy at t2 to determine its unique additional effect and to show whether efficacy beliefs are directly transferred from COVID19 to climate; and (3) similarity to show whether the perceived attributes of the COVID19 crisis change climate-related efficacy. As a transfer of efficacy beliefs is more likely between similar contexts, the models include a COVID19-related efficacy x similarity interaction term to check for a moderator effect, in other words, whether transfer of efficacy beliefs is more pronounced the more similar both crises are perceived to be. This regression approach serves the dual purpose of showing the stability of climate-related efficacy beliefs, and analyzing how much of the individual variance left unexplained by stability can be traced back to the influence of COVID19-related efficacy beliefs.

The influence of climate-related efficacy at t1 may be interpreted as a common main effect; however, the influences of COVID19-related efficacy beliefs and similarity are conditional simple effects because these predictors are also included in the interaction term and are therefore mean-centered for clearer interpretation (Hayes 2018). All results are tested against $p < .05$ and $p < .01$ significance levels.

7.4 Validity analysis of compensatory green beliefs

The analysis proceeds in five steps: (1) We present descriptive statistics on NCGB and ECGB items to illustrate how strongly compensatory beliefs are endorsed in our study sample. Next, we employ confirmatory factor analysis to (2) ascertain the three-dimensional structure of normative, efficacy, and general CGBs we posit based on our review of previous CGB research (construct validity); and to (3) differentiate CGBs from the related but conceptually distinct factors environmental knowledge, personal norms, social norms and pro-environmental values (discriminant validity). Then, (4), structural equation models assess whether CGBs have additional, unique explanatory power for sustainable behaviors above and beyond environmental knowledge, personal norms, social norms, and pro-environmental values (incremental validity). In the final step (5), we calculate cross-lagged autoregressive models, in each model combining NCGBs with another normative or behavioral factor, in order to analyze temporal stability and the direction of causal effects. In step (5), we report the difference in the χ^2 model fit statistic between a restricted model that assumes equality of both cross-lagged path coefficients and an unrestricted model, where the two coefficients are

estimated freely; if the restricted model fits significantly worse, this indicates a direction of influence under the presumption that the time between cause (here: t1) and effect (here: t2) ascertains causal direction (Finkel, 1995).

Steps (1) to (4) use the one-wave cross-sectional data from n=502 cases at t1 only. Steps (1) to (3) use a reduced sample of 482 cases because 20 cases did not give any responses on the CGB variables. Step (5) uses the two-wave longitudinal data from n=145 cases at t1 and t2. The small longitudinal sample may, however, only yield tentative results, since it is presumably underpowered.

All structural equation models are calculated with raw data, using Full Information Maximum Likelihood (FIML) estimation with robust standard errors, and robust/scaled test statistics and fit indices to account for missing values and non-normality implemented. All results are tested against a $p<.05$ significance level.

7.5 Confirmatory analysis of perceived similarity

The unit of analysis are respondents, in contrast to the sorting studies by Gabe-Thomas et al. (2016) and Kneebone, Fielding & Smith (2018) who use the piles produced by respondents as unit of analysis. The observed similarity pattern (i.e. how each respondent placed behaviours in groups) is compared to five posited categorisations: Domain, Location, Impact, Difficulty and Frequency. All posited categorisations consist of four categories in order to conform with the group limit in the sorting task and to ensure equal probability of random assignment. The Domain, Location, Impact and Difficulty categorisations are derived from previous research. The Frequency categorisation uses the four factors with the highest eigenvalue in a principal component analysis of self-reported behavioural frequency.

The analysis adopts a confirmatory rationale and statistically tests how well posited categories fit to the observed responses. Co-occurrence matrices, edit distances and similarity indices are used to compare categorisations. These three approaches complement each other, as they test either entire categorisations (co-occurrence matrix, edit distance) or specific categories (similarity index), either for the entire sample (co-occurrence matrix) or within each respondent (edit distance, similarity index).

The *co-occurrence matrix* is organised as an item-by-item table with 22 rows and 22 columns. The entries in the matrix cells can range from 0 (no one considers the two behaviours as similar) to 364 (all respondents consider the two behaviours as similar). The observed co-occurrence matrix is available for the n=364 subsample who sorted all 22 behaviours and lists for all pairs of behaviours how many respondents assigned these two behaviours to the same group. The observed distribution in the co-occurrence matrix is compared to several expected distributions: Equal1, the null hypothesis of stochastic independence with the expected frequency in each cell calculated from the row sums and column sums of the observed matrix as in a common Chi^2 crosstabs test. Equal2, the null

hypothesis of equal distribution from random assignment with a 25% probability per group. The distributions as stated by the Domain, Location, Impact, Difficulty and Frequency categorisations.

The *edit distance* is a combinatorial function that shows how far apart a respondent's sort is from the posited categorisation. For each respondent, the edit distance gives the minimal number of behaviours they would have to move between groups in order to convert their sort to perfectly represent the posited categorisation. The edit distance is available for the n=364 subsample who sorted all 22 behaviours. This approach recognises that the groups the behaviours are sorted in are not independent from each other. The edit distance is averaged over all respondents and then tested for statistical significance via confidence intervals.

For the *similarity index*, the raw data are recoded into binary variables for each pair of behaviours, coded 1 if these two behaviours are assigned to the (any) same group and coded 0 if they are assigned to (any) different groups. The similarity index is calculated by averaging the binary variables of all pairs of behaviours included in the posited category, resulting in a value between 1 and 0 for each respondent. Similarity indices are calculated for each category within the posited categorisation. The indices are available for the n=413 sample who at least partially completed the sorting task, because averaging within each category allows to correct for missing values. Moreover, averaging allows comparing categories comprising different numbers of behaviours. Testing for statistical significance is implemented via confidence intervals.

Potential *moderator effects* of personal norms, competencies and environmental knowledge are assessed by comparing the Chi² test statistics of two co-occurrence matrices obtained by splitting the sample by the median of the respective moderator variable; and by correlating edit distances and similarity indices with the moderator variables. Confidence intervals and significance tests use a significance level of $p<.05$.

7.6 Regression analysis of climate-relevant intent versus impact

For the comparison of impact and intent-measures of climate-relevant behaviour, we created three different measures: an impact measure by calculating (objective) greenhouse gas emissions of the participants, a hybrid measure by combining the impact measure with statements about the own climate-related behaviour and an intent measure (relying solely on the statements of the participants) using Pearson correlation.

For the impact measure of mobility, the average distance kilometres of using a certain mode of transportation was derived from the specifications of the participants. This value then was multiplied with a specific average emission factor for this mode of transportation (Bird et al., 2019), whereby for public transport emissions for metro travellers were excluded since in none of the cities under investigation a metro exists. The calculation of the hybrid measure was identical

with the impact variant, except for car transport. For car transport we used the answers on the questions "frequency of getting picked up" and "frequency of building car pools" to adjust the assumed average number of passengers for every car kilometre. For calculating intent we composed the mean of the two questions of frequency of getting picked up and frequency of building car pools.

For the impact calculation of heating, the basis of the calculation is the energy demand in mega joule per square meter for certain types of houses (single-family home; semi-detached home, terraced house and apartment house) (Austrian Energy Agency, 2015). This value is multiplied with the specific emission factor per mega joule for the relevant type of heating systems derived from the GEMIS database (IINAS, 2021). Then the result is multiplied by the living area of the home of the participant and divided by the number of persons living in the house. Again, the calculation of the hybrid variant is similar to the impact variant, except that the basic energy demand for the type of house is adjusted according to the behaviour of the respondent. The intent was calculated as the mean of the questions about heating behaviour.

For diet we had no possibility to calculate a pure impact related measure, since this would have required a detailed analysis of all the substances people eat. Base for the calculation of the hybrid measure of diet are the GHG emissions, calculated with the help of the GEMIS database (IINAS, 2021) of a purely vegetarian diet and of a diet including a maximum of meat. The intent measure again was calculated as the mean of the questions about frequency of certain dietary behaviours.

For buying clothes, we also had no pure impact calculation. The base for the hybrid measure is the average consumption of clothes per year in Austria multiplied with the average GHG-emissions for 1kg of processed cotton. This value is used if someone states to buy "sometimes" new clothes. If someone states to "always" buy new clothes, the emission factor is increased by 50 percent and if someone states he or she "never" buys new clothes, the factor is decreased by 50 percent. The resulting value then is corrected according to intentions for repairing clothes and buying used clothes. The intention measure again is composed as mean of the statements about frequency of the asked buying behaviours.

To find out if the different measures are predicted by different variables, we used two-block multilinear hierarchical regression models. In the first block of predictors, we included sociodemographic variables (gender, education of parents, average job position of parents, and rural or urban place of residence), in the second block psychological variables (self-efficacy, social norms, personal norms and environmental values). Our focus thereby is on the change in model fit and explanatory power when adding the second block.

8 Work and time schedule

The project SPILLOVER started in September 2019 and ended in May 2022 (project duration 33 months). It comprised of five interlocking work packages, each structured by tasks and methodological steps.

	2019				2020												2021												2022				
	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5
WP1: Project management	M 1.1			M 1.2			M 1.2			M 1.2			M 1.2 M 1.3			M 1.2			M 1.2			M 1.2			M 1.2			M 1.2			M 1.2		M 1.4
WP2: Scoping spillover					M 2.1 M 2.3									M 2.4																			
WP3: Understanding spillover						M 3.1				M 3.2				M 3.3								M 3.4								M 3.5			
WP4: Empowering spillover					M 4.1						M 4.2												M 4.3										
WP5: Dissemination	M 5.1	M 5.2											M 5.3																		M 5.4		M 5.5

MILESTONES

WP1
M1.1: Kick-off meeting
M1.2: Project team meetings
M1.3: Interim report to Climate & Energy Fund
M1.4: Final report to Climate & Energy Fund

WP2
M2.1: Set of consumption activities defined
M2.2: Omitted
M2.3: Contact list completed and school's schedule created
M2.4: Carbon footprint parameters compiled

WP3
M3.1: Questionnaire design completed
M3.2: Data management of first survey wave completed
M3.3: Preliminary analysis completed
M3.4: Data management of second survey wave completed
M3.5: Final longitudinal analysis completed

WP4
M4.1: Pilot-phase completed
M4.2: Conceptualisation of learning programme elements completed
M4.3: Implementation of the learning programme completed
M4.4: Omitted

WP5
M5.1: Dissemination plan to define communication channels for all target audiences developed
M5.2: Project website set up
M5.3: Intermediate revision and re-alignment of the dissemination plan completed
M5.4: Scientific publications submitted
M5.5: Teaching materials published

9 Publications and dissemination activities

All publications are linked and available at https://spillover.joanneum.at/.

Scientific publications	
Authors, title	*Available at*
Penker, M., Seebauer, S. 'I should' does not mean 'I can': Introducing Efficacy, Normative and General Compensatory Green Beliefs.	Spillover Working Paper No. 1
Moser, S., Seebauer, S. Has the COVID19 pandemic strengthened confidence in managing the climate crisis? Transfer of efficacy beliefs after experiencing lockdowns in Switzerland and Austria.	Spillover Working Paper No. 2
Seebauer, S. Deriving mental models from perceived similarity: Confirmatory testing of a card sorting task of climate-relevant behaviours.	Spillover Working Paper No. 3
Brenner-Fließer, M. Relationship and predictors of impact, hybrid and intent measures of climate-related behaviour in different lifestyle domains.	Spillover Working Paper No. 4
Scientific conferences	
Authors, title	*Presented at*
Oral presentations	
Moser, S., Seebauer, S. (2020). Aus der Corona-Krise für die Klimakrise lernen: Voraussetzungen für das Übertragen von Wirksamkeitsüberzeugungen aus dem Lock-Down auf die Bewältigung der Klimakrise.	*Netzwerktreffen Implikationen der Corona Krise für nachhaltige Entwicklung*, 29 Oct 2020, online.
Fritz, L., Brenner-Fließer, M., Schneeberger, A., Seebauer, S. (2020). Youth and Behavioural Spillover: Fundamentals, Competencies and Learning Programme for Lowering the Personal Carbon Footprint.	*18th Swiss Geoscience Meeting*, Nov 6-7, 2020, online.
Brenner-Fließer, M., Seebauer, S., Penker, M. (2021). Preaching water - drinking wine? Is political pro climate engagement of adolescents associated with a climate-friendly lifestyle?	*Conference of the European Sociological Association*, 31 Aug – 3 Sept, 2021, Barcelona.
Moser, S., Seebauer, S., Neubert, S. (2021). Learning from the Corona crisis: Transfer of efficacy beliefs on individual and public action from Covid-19 to the climate crisis.	*International Conference on Environmental Psychology*, 5-8 Oct, 2021, Siracusa.
Penker, M., Seebauer, S., Brenner-Fließer, M., Hadler, M. (2021). Should doesn't mean can. Introducing Normative Compensatory Green Beliefs for the Case of Austrian School Graduates.	*International Conference on Environmental Psychology*, 5-8 Oct, 2021, Siracusa.

Seebauer, S., Brenner-Fliesser, M., Pichler, L., Keller, L. (2022). If not now, then when? Unexpected stability in climate relevant behaviours and beliefs among young Austrians after leaving high school.	*CAST Moments of Change Symposium*, 13-14 Jun, 2022, London.
Poster presentations	
Seebauer, S., Brenner-Fließer, M., Fritz, L., Körfgen, A. (2020). Understanding and empowering spillover behaviour for low carbon consumption among young Austrians.	*Austrian Climate Day 2021*
Materials for professional and non-academic audiences	
Pichler, L., Keller, L. (2022). Lernprogramm Spillover	https://spillover.joanneum.at/info-schulen/
Seebauer, S., Sessig, E. (2020): Klimaverhalten und Einstellungen von Maturantinnen und Maturanten. (cross-sectional wave 1 results; one overall and eight school-specific factsheets)	https://spillover.joanneum.at/info-schulen/
Seebauer, S., Kofler, V. (2021): Veränderungen von Klimaverhalten und Einstellungen nach dem Schulabschluss. (longitudinal waves 1+2 results; one overall factsheet)	https://spillover.joanneum.at/info-schulen/

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