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# Cohort differences in attitudes toward sexual orientation: the formative political climate as a socializing agent

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**Introduction:** Why do cohorts differ in their attitudes toward sexual orientation and what is the role of societal values during formative years? We investigate whether discontinuities in the prevailing values of equality and tradition in a person's formative years impinge on their attitudes toward sexual orientation as adults.

**Methods:** We test this by integrating historical political data from the Manifesto Project Dataset with contemporary micro-data on attitudes toward sexual orientation from 10 rounds of the European Social Survey (2002-2020) across 13 cohorts in 13 European countries.

**Results and discussion:** Using hierarchical age-period-cohort analysis with synthetic age cohorts, we find if the value of equality is politically diffuse, it can have a socializing effect. We find that the individuals who came of age during a period when political values of equality were more dominant are more tolerant of gays and lesbians. On the other hand, we do not find any evidence that individuals who experience youth during a time of more traditional political values have more negative opinions about different sexual orientations. Overall, these findings suggest that cohorts adopt distinct patterns of attitudes toward gays and lesbians as a result of a collective process of socialization during their impressionable years.

## KEYWORDS

attitudes toward sexual orientation, political socialization, values, age cohort analysis, Europe

## Introduction

### Background

In the last 30 years, attitudes toward different sexual orientations<sup>1</sup> have rapidly become more tolerant around the world. Some attribute this to a by-product of economic growth and the expansion of post-materialist values (Andersen and Fetner, 2008) and declining religiosity (Sherkat et al., 2011), increasing education levels in society (Loftus, 2001) and the media visibility of gays and lesbians (Schiappa et al., 2006).

There is clear evidence that younger people are more tolerant of gays and lesbians than older people (Halman and van Ingen, 2015; Dotti Sani and Quaranta, 2020), a pattern that is common regarding shifting social issues. For this reason, including age as a demographic variable in cross-sectional research without distinguishing the meaning of age from other temporal phenomena obscures important social dynamics in attitudes. Attitudinal differences between the old and the young are not necessarily due to aging, in

<sup>1</sup> We avoid the use of the terms homosexuality and homosexuals to be consistent with the current inclusive language about people belonging to sexual minorities following the most recent APA guidelines: <https://apastyle.apa.org/style-grammar-guidelines/bias-free-language/sexual-orientation>.

other words, the process of becoming older. Rather, the age of a person holds different substantive meanings (Riley, 1973, 1987; Kertzer, 1983). In addition to their placement along the lifecycle, a person's age also indicates their birth year, which carries its social significance. Birth cohorts, individuals born around the same time, can experience different socializations through a unique sequence of events and circumstances which have long-lasting impacts on their socio-political attitudes (Inglehart, 1977).

There is an existing debate about whether this growing liberalization of attitudes toward gay and lesbian people is due to a period effect or a cohort effect. A period effect refers to an underlying general trend toward more tolerant attitudes for all of society which are often driven by events or institutional change. In the case of a period effect, a trend is observable if there is a consistent worsening or improvement of attitudes vis-à-vis a given issue. This can occur for two reasons: either because people change their opinions or because the composition of the population changes, such as through the mechanism of cohort replacement. Thus far, there is evidence of both period and cohort effects (Treas, 2002; Ruel and Campbell, 2006; Andersen and Fetner, 2008; Sherkat et al., 2011; Sheoran et al., 2012; Pampel, 2016). Baunach (2011) decomposes this trend and finds that while two-thirds of the changes in the United States are due to intracohort aging (individuals changing their views), one-third are due to a cohort effect.

Scholars have been more recently interested in explaining what appears to be a non-linear trend of attitudes across cohorts. Recent research shows a fluctuating or inconsistent trend of cohort effects, implying that this is not simply due solely to a period or aging effect. Younger cohorts tend to be less politically tolerant than baby boomers and what seems to be a general increase in approval of same-sex relationships may simply be an artifact of baby-boomers making up a larger portion of the general population (Schwadel and Garneau, 2014). In a recent study, Ekstam (2021) finds discontinuities in the pattern of adjacent cohorts and suggests that this is due to the effects of different political socialization of cohorts, who come of age in different formative contexts. At present, much of the existing attention in the socialization of attitudes toward same-sex relationships has been toward micro-socializing factors such as religion or education or macro-socializing factors such as legislation for same-sex relationships (for a discussion see Dotti Sani and Quaranta, 2020).

## This study

This article addresses the question of why cohorts differ in their attitudes toward gays and lesbians by investigating the role of contextual values during formative years. It is well established that ideas and values that are part of the zeitgeist of a cohort's youth have a formative impact on their worldviews throughout their adulthood (Ryder, 1965). According to the "impressionable years" argument, socio-political orientations are acquired during young adulthood. During youth, people experience a window of "plasticity" while they transition from adolescence to young adulthood as they engage for the first time with the social and political world around them (Marsh, 1971; Niemi and Sobieszek,

1977; Hanks, 1981; Sapiro, 2004; Neundorff et al., 2013). According to this view, a person's orientations are then crystallized and remain remarkably persistent as the person grows older. As a result, attitudes and values become more deeply entrenched and become more stable over the lifetime (Sears, 1981; Jennings and Gregory, 1984; Stoker and Jennings, 1995; Visser and Krosnick, 1998; Lewis-Beck, 2009). Following this reasoning, symbolic predispositions toward different sexual orientations formed in young adulthood are then solidified throughout the individual's life course. So, after the critical period of young adulthood, we would then not expect a person's biological age to be a factor in underlying their attitude and preferences.

While much emphasis has been placed on "landmark events" (in other words, exogenous shocks) and how they leave a mark on political socialization (see Sears and Valentino, 1997), there is now growing attention to more subtle shifts in the political values can have lasting effects (Grasso, 2014). For instance, in their study of attitudes toward immigration, Jeannet and Dražanová (2023), analyze the role of the political climate during formative years as a socializing agent in a person's political life. They define political climate as "the normative principles, beliefs, ideals, and values that prevail in the political zeitgeist" during a person's impressionable years [Jeannet and Dražanová, 2023, p. 6].

Similar to attitudes toward immigration, attitudes toward different sexual orientations are strongly related to human values. Values represent a person's fundamental priorities and as such underlie and motivate attitudes (Davidov et al., 2008). Schwartz (1994) offers a framework of certain basic values which are universal and generally explain the inevitable human tension between an openness to pursuing change and an inclination toward conservation. Kuntz et al. (2015) examine the relationship between attitudes toward gays and lesbians and Schwartz (1994)'s human values, finding a positive association between Schwartz's values of universalism and acceptance, while values of tradition lead to the opposite outcome. According to Schwartz (1994) tradition is "respect, commitment, and acceptance of the customs and ideas that traditional culture or religion provide" whereas universalism is "understanding, appreciation, tolerance and protection for the welfare of all people and nature" (Schwartz, 1994, p. 35). While Schwartz names his value concept "universalism", it is clear from its definition that it is tapping into the importance of equality in society.

What is the mechanism between these values and attitudes toward gays and lesbians? The value of tradition underlies disapproval of different sexual orientations which are often perceived as a threat to "traditional family values" and accepting them would imply a perceived abandonment of tradition that such individuals hold dear. Therefore, individuals who hold tradition as a strong value can be more motivated to oppose the disruption of the status quo as sexual mores shift (Kuntz et al., 2015). On the other hand, universalism values, such as egalitarianism, foster the approval of different sexual orientations by prioritizing "tolerance and acceptance of those who differ from oneself, understanding rather than rejecting those with unconventional lifestyles". Universalism values emphasize equal opportunities for all (Kuntz et al., 2015, p. 122).

While the work of [Kuntz et al. \(2015\)](#) examined the relationship between a person's contemporary values and their attitudes, our argument does not dispute this. Instead, this article offers a different investigation and contribution. We consider the role of the formative value context, during a person's coming-of-age period, and test whether this has an impact on the attitudes toward different sexual orientations when they are adults.

## Hypotheses

Based on existing research and the theoretical tenets of the Impressionable Years argument, we formulate the following hypotheses:

*Hypothesis 1: Individuals belonging to an age-cohort that experienced a formative climate where the value of equality was heightened are significantly more likely to express tolerance for gays and lesbians than individuals belonging to other cohorts.*

*Hypothesis 2: Individuals belonging to an age-cohort that experienced a formative climate where the value of tradition was heightened are significantly less likely to express tolerance for gays and lesbians than individuals belonging to other cohorts.*

Some scholars dispute the notion of “impressionable years”, instead positing a lifelong openness model to public opinion ([Franklin and Jackson, 1983](#); [Franklin, 1984](#)). According to this view, opinions remain open even after youth and political socialization can occur even later in life, for instance, due to personal experiences. We choose not to derive competing hypotheses based on this theoretical perspective because in our view, it is not applicable to the formation of attitudes toward sexual orientation. This is because such attitudes are symbolic political issues, as they are more ideological or affective in nature rather than economic ([Sears, 1983](#)). Symbolic political issues are highly stable over a lifetime and less affected by life experiences ([Alwin and Krosnick, 1991](#); [Jeannet, 2018](#); [Peterson et al., 2020](#)).

We apply the expectations of political socialization theory to test the above-formulated hypotheses during the years 2002–2020 in 13 European countries. Firstly, the findings offer an empirical contribution to the burgeoning scholarship on attitudes toward people of different sexual orientations and other stigmatized groups. Yet the findings are also useful for understanding the socializing agents in the formation of political tolerance. Political tolerance is a broader concept that refers to the willingness to “extend civil liberties to political outgroups” ([Karpov, 2002](#), p. 267). This study chooses to focus on Europe for several reasons. The first is that most of the existing work has focused on social change in attitudes toward gays and lesbians in the United States (notable exceptions are [Dotti Sani and Quaranta, 2022](#)), particularly when it pertains to the study of cohort effects. Secondly, Europe offers a natural setting for a double-comparative design that cross-classifies cohorts and countries over time. This allows us to observe cohorts aging in different contexts, with different period effects.

## Materials and methods

### Sample

The analysis relies on the European Social Survey (ESS), rounds 1 (2002) to 10 (2020). We use 13 countries that have participated in at least five rounds of the survey: Austria, Belgium, Switzerland, Germany, Denmark, Finland, France, Great Britain, Ireland, Italy, Netherlands, Norway, and Sweden.<sup>2</sup> Following standard practice in cohort analysis, we group individuals into cohorts based on five-year birth intervals. We, therefore, have 14 cohorts and 206,906 respondents in total.

### Dependent variable

The dependent variable measures the extent to which respondents agree with the statement that “gay men and lesbians should be free to live their own life as they wish”. The response categories are ordinal and range from 1 (agree strongly) to 5 (disagree strongly). We recorded the variable so that higher numbers mean more positive attitudes.<sup>3</sup> This survey item has been frequently used as an indicator of attitudes toward gays and lesbians in extant research ([van den Akker et al., 2013](#); [Abou-Chadi and Finnigan, 2019](#); [Dotti Sani and Quaranta, 2020, 2022](#)).

### Independent variables

For our two independent variables, we rely on data from The Manifesto Project, a widely used data set that includes a coded content analysis of party manifestos since 1945. Using this data, we measure the two values of equality and tradition as the share of quasi-sentences calculated as a fraction of the overall number of allocated codes per manifesto ([Volkens et al., 2018](#)). We conceive of the principle of equality as a positive view of social justice and the need people to be treated fairly. “This includes references to topics such as special protection for underprivileged social groups, removal of class barriers, need for fair distribution of resources and the end of racial or sexual discrimination” ([Volkens et al., 2018](#), p. 17). On the other hand, the principle of tradition is coded as positive or favorable mentions of traditional and/or religious moral values. “This includes references to topics such as prohibition, censorship and suppression of immorality and unseemly behavior, maintenance and stability of the traditional family as a value, and support for the role of religious institutions in state and society” ([Volkens et al., 2018](#), p. 19).

Borrowing a similar approach by [Jeannet and Dražanová \(2023\)](#), we compute annual measures by country from the manifesto data. We do this by weighting the share of votes that

<sup>2</sup> Our selection of countries is restricted to European countries which were participatory democracies during the formative years of the oldest cohort in the sample (1949–1953).

<sup>3</sup> We treat the variable as continuous in our analysis.

the party has received in the country's last elections.<sup>4</sup> As we are interested in the individual's formative political environment, rather than the environment at the time of the survey, we assign individuals the values of tradition and equality when cohorts were between the ages of 18 and 23 by averaging the five years of each cohort.

We also include a series of controls using the European Social Survey based on individual-level characteristics which have been shown to be associated with attitudes toward sexual orientation in prior research. Individuals who are older, less educated and male tend to hold more negative attitudes (Schwadel and Garneau, 2014; Halman and van Ingen, 2015). We control for religiosity since individuals who are more religious tend to oppose same-sex relationships (Adamczyk and Pitt, 2009), living in an urban/rural area (Jakobsson et al., 2013), socio-economic position (Anderson and Fetner) by perceived income difficulties (Andersen and Fetner, 2008) and left-right self-positioning (Baunach, 2012).

Empirical evidence also shows that attitudes toward sexual orientation depend on context (Adamczyk and Pitt, 2009) and can vary cross-nationally (Dotti Sani and Quaranta, 2020). We, therefore, control for policy regulations such as gay marriage or the possibility for registered partnership based on Waaldijk (2020) data tracking the years when either registered partnership or same-sex marriage were introduced at the cohort and period level within each country, the percentage of university-educated people at the cohort and period level within each country and the level of unemployment at the cohort and period level within the country (Inglehart, 2008).

## Analytical strategy

Our empirical strategy employs hierarchical age-period-cohort regression analysis (HAPC) using repeated cross-sectional surveys (Zheng et al., 2011). HAPC analysis separates the three temporal phenomena of age, period (year of survey) and birth cohort (year of birth) effects using micro survey data (Yang and Land, 2013). It allows us to construct synthetic cohorts based on age groups where individuals are cross-classified by both country-period and country-cohort. By constructing cohorts, the age, period and cohort is no longer perfectly collinear. This is because one cannot derive the exact age of the respondent from the age and year, but only a range of possible ages. Similar approaches have been used in the study of cohort effects in public opinion (Smets and Neundorf, 2014; Gorodzeisky and Semyonov, 2018).

Following Jeannet and Dražanová (2023), we apply hierarchical three-level age-period-cohort models. In these models individuals are nested both within two second-level variables (country-cohort and country-period) as well as nested within countries since possible clustering at the country level might still occur.

<sup>4</sup> In the case of mixed electoral systems with a proportional and majoritarian component, we follow Jeannet and Dražanová (2023). We use the vote share in the proportional component. In the case of an electoral coalition where programs for all members of the coalition and the coalition were coded, we set the vote share to zero for the coalition program so that the sum of the share is not higher than 100 percent.

The models also include random effects for cohorts and periods. We assume that while age is related to biological processes of aging, cohort and period effects are the result of external influences and are to be considered as macro-level variables (Yang, 2008).

$$\text{The level-1 model is: } Y_{ijkc} = \beta_{0jkc} + \beta_1 X_{ijkc} + e_{ijkc} \quad (1)$$

where, within each country-cohort  $j$ , country-period  $k$  and country  $c$ , respondents' attitudes to sexual orientation ( $Y$ ) are a function of their individual characteristics (vector  $X$ ).  $\beta_{0jkc}$  is the mean of attitudes of individuals in country-cohort  $j$ , country-period  $k$ , and country  $c$ ,  $\beta_1$  is the level-1 fixed effects and  $e_{ijkc}$  is the random individual variation.

The level-2 model is:

$$\beta_{0jkc} = \gamma_{0jkc} + C_{0jc}Z_{jc} + K_{0kc}T_{kc} + \mu_{0jc} + \nu_{0kc} \quad (2)$$

where  $Z$  is a vector of country-cohort characteristics and  $T$  is a vector of country-period characteristics,  $\mu_{0jc}$  is the residual random effect of country-cohort  $j$ ,  $\nu_{0kc}$  is the residual random effect of country-period  $k$ . The level-3 model is:

$$\gamma_0 = x_{0c} + \omega_{0c} \quad (3)$$

where  $\omega_{0c}$  is the residual random effect of country  $c$ . In all three models (1), (2) and (3)  $\mu_{0j}$ ,  $\nu_{0k}$  and  $\omega_{0c}$  are assumed normally distributed with mean 0 and variance  $\tau_\mu$ ,  $\tau_\nu$  and  $\tau_\omega$  respectively.

We have grand-mean centered all continuous individual, country-cohort and country-period level variables.

## Results

Table 1 shows as Model 0 a so-called null model, in order to partition the variance of our dependent variable of interest across the three levels. This model provides information on the variance components of attitudes toward sexual orientation at each level of analysis (Level 1—individual, Level 2—country-cohort, Level—country-period and Level 3—country). The null model includes only an intercept, country-cohort random effects, country-period random effects, country random effects and an individual-level residual error term. The overall mean attitude toward sexual orientation across all countries, all country-cohorts, all country-period and all respondents is estimated to be 4.17 on a scale of 1–5. Therefore, generally, attitudes toward gays and lesbians across an average individual are quite positive.

The null model simply decomposes the total variance in attitudes to sexual orientation into separate country-cohort, country-period, country and individual variance components.

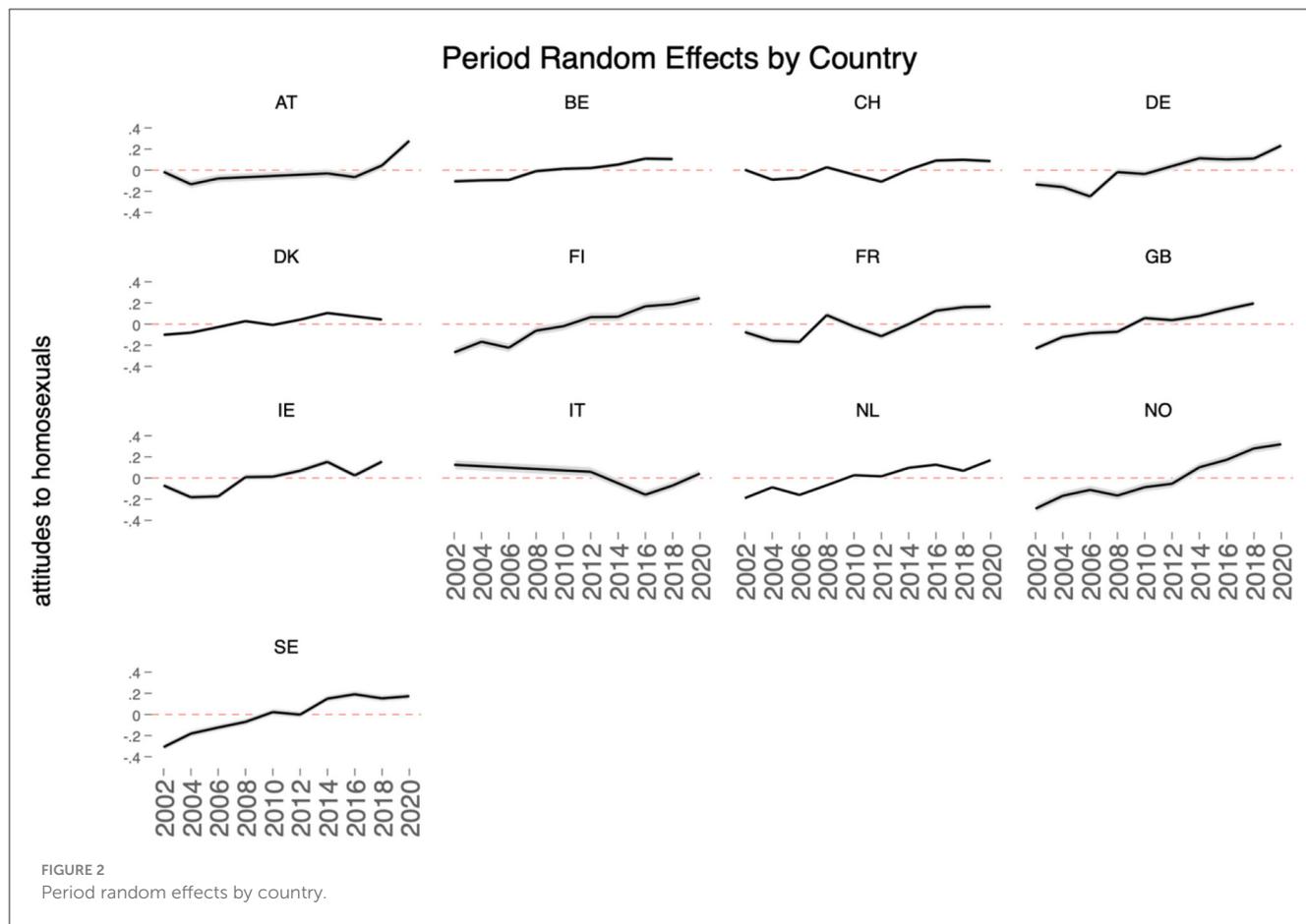
Having fitted the model, we can predict Best Linear Unbiased Predictions (BLUPs). We predict BLUPs for the country-cohort and country-period random effects from the unconditional model by country together with their associated standard errors. Figure 1 shows the country-cohort random effects for each country separately. As can be seen from the figure, there is variation between cohorts in their attitudes to gays and lesbians. In most countries, the general trend is that younger cohorts tend to have more positive attitudes toward different sexual orientations, but it

TABLE 1 Results of a hierarchical multilevel cross-classified model explaining cohort-differences in attitudes to different sexual orientation across 13 countries.

	Model 0		Model 1		Model 2		Model 3		Model 4	
	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.
Intercept	4.177***	(0.047)	4.019***	(0.038)	3.725***	(0.109)	3.761***	(0.109)	3.730***	(0.114)
<b>Individual-level</b>										
Age			−0.006***	(0.0003)	−0.006***	(0.0003)	−0.006***	(0.0003)	−0.008***	(0.0005)
University degree			0.180***	(0.0047)	0.180***	(0.0047)	0.180***	(0.005)	0.179***	(0.0047)
Female			0.243***	(0.0041)	0.243***	(0.0041)	0.243***	(0.004)	0.243***	(0.0041)
Urban residence			0.053***	(0.0044)	0.053***	(0.0044)	0.053***	(0.004)	0.053***	(0.0044)
Income difficulties			−0.116***	(0.0061)	−0.116***	(0.0061)	−0.116***	(0.006)	−0.116***	(0.0061)
Left-right scale			−0.046***	(0.0009)	−0.046***	(0.0009)	−0.046***	(0.0009)	−0.046***	(0.0009)
Religiosity			−0.055***	(0.0007)	−0.055***	(0.0007)	−0.055***	(0.0007)	−0.055***	(0.0007)
<b>Country-cohort level</b>										
Political climate of equality					0.008*	(0.003)			0.007*	(0.003)
Political climate of tradition							0.0002	(0.006)	−0.002	(0.006)
% of university educated									0.0001	(0.001)
Unemployment									−0.003	(0.003)
Marriage or reg. partner. access									−0.070***	(0.018)
<b>Country-period level</b>										
Political climate of equality					−0.00377	(0.00736)	−0.002	(0.007)	−0.003	(0.007)
Political climate of tradition					−0.0232	(0.0138)	−0.022	(0.013)	−0.024	(0.014)
% of university educated					0.00188	(0.00208)	0.002	(0.002)	0.00228	(0.002)
Unemployment					0.00234	(0.00705)	0.002	(0.007)	0.003	(0.007)
Marriage or reg. partner. access					0.192***	(0.0227)	0.192***	(0.023)	0.204***	(0.023)
<b>Random effect estimates</b>										
Country	0.024	(0.012)	0.015	(0.007)	0.007	(0.003)	0.008	(0.004)	0.008	(0.004)
Cohort (in country)	0.045	(0.005)	0.006	(0.0008)	0.006	(0.0008)	0.006	(0.0008)	0.005	(0.0007)
Period (in country)	0.019	(0.002)	0.026	(0.003)	0.013	(0.001)	0.013	(0.001)	0.014	(0.002)
Individual	0.835	(0.002)	0.747	(0.002)	0.747	(0.002)	0.747	(0.002)	0.747	(0.002)

\*\*\*p < 0.001, \*\*p < 0.01, \* p < 0.05; Level 1 N: 114,788; Level 2 Country-cohort N: 169; Level 2 Country-period N: 115; Level 3 Country-level.





Moreover, as the median age in the sample is 46 years old, this effect appears to be long-lasting. Interestingly, neither the political climate of tradition significantly negatively nor the political climate of equality significantly positively influence attitudes toward gays and lesbians at the country-period level in any of the models.<sup>5</sup>

## Discussion

To what extent do people’s current attitudes toward different sexual orientations reflect the values of the times they grew up in? Our results confirm previous studies showing that there is a cohort effect in attitudes toward same-sex relationships. We came to these conclusions by employing a double comparative design of cohorts in 13 countries (169 country-cohorts) that analyzes both contemporary micro-attitudinal data and historical macro-contextual data. Using hierarchical modeling in an age-period-cohort framework, we examined why attitudes toward gays and lesbians differ across age groups.

We have argued that one reason for this can be found in the macro-level socialization process which occurs during a person’s

youth. Overall, these findings suggest that cohorts adopt distinct patterns of attitudes toward different sexual orientations as a result of a collective process of political socialization during their impressionable years. We find that the individuals who came of age during a period when political values of equality were more dominant are more tolerant of other sexual orientations later in life. On the other hand, we do not find any evidence that individuals who experience youth during a time of more traditional political values have more negative opinions about gays and lesbians.

Our findings imply that if the value of equality is politically diffuse, it can have a socializing effect. As others such as Grasso et al. (2019) have argued, values that are dominant in the formative years can have a trickle-down socializing effect. Unlike primary socializing agents like the family or school, the formative political climate is an impersonal socializing agent that delivers mass messages about societal norms and principles. As such, the formative political climate can impress norms and values on younger people who come of age around the same time, regardless of socio-economic background.

## Limitations

The study has several limitations to consider. The first of these is the limited time span of our attitudinal microdata. The first round of the European Social Survey was in 2002

<sup>5</sup> In the existing literature, the empirical link between same sex legislation and tolerance for sex-same relationships is more tenuous than one might expect. For instance, Redman (2018) finds that the passing of same sex legislation intensifies support amongst individuals who were already tolerant but does not “re-educate” individuals or make acceptance more widespread.

and the last release was in 2020. This allows us to observe how cohorts age for 18 years. However, our study is not able to investigate how political values in a formative climate mature over three or four decades. Taking this into consideration we remain circumspect about our conclusions and abstain from generalizing about generations or inter-generational change and refer only to cohort change. Another limitation is not having sufficient historical control variables for unobservable macro-cultural aspects of society during an individual's formative years.

## Conclusions

We hope that the latter limitation can be overcome in future research. For instance, it would be worthwhile to examine how media stereotypes during a person's youth could also have a socializing effect. This line of research could be further motivated by the fact that voters often rely on stereotypes to generate their opinions by using them as heuristics. Influential individuals, such as openly gay politicians or celebrities during youth might also exert an influence. Other extensions of this study could explore whether the diffusion of equality in society during youth also has an impact on adult attitudes toward other potentially stigmatized groups such as ethnic minorities, transgender individuals, or disabled persons.

Our study does not assure that shifts in preferences for LGBT+ inclusion are genuine (Turnbull-Dugarte and Lopez Ortega, 2023). There are still widespread conspiracy beliefs relating to LGBTQ+ people (Salvati et al., 2023) as well as recent anti-LGBT policies and rhetoric across Europe. The importance of formative political context that we have demonstrated in our study thus implies that current events and political rhetoric are consequential for attitudes toward gays and lesbians in the future.

Cohort studies are important for understanding the temporal aspects of attitudes regarding different sexual orientations. If trends continue, we can expect increasing tolerance for sex-sex relationships in Europe. However, our study implies that if political values of equality today become less popular, this can harm political tolerance tomorrow. This could have serious consequences for

stigmatized groups and these reasons we urge social scientists to continue to study the socialization process in young cohorts.

## Data availability statement

Publicly available datasets were analyzed in this study. This data can be found here: <https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/IQFCFE>.

## Author contributions

A-MJ wrote the introduction and discussion. LD conducted the empirical analysis and wrote the results section. A-MJ and LD contributed to data collection and research design. All authors contributed to the article and approved the submitted version.

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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## Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpos.2023.1223274/full#supplementary-material>

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