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Language Markers of Student Beliefs Signal College Success

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Abstract

Can we detect students' hidden beliefs about fitting in at college in ways that predict academic success and inequality? Using computational language-based measures, we analyzed 25,000 pre-college essays from students at 23 U.S. colleges to infer two beliefs about belonging. One belief—simple optimism—reflects confidence in a smooth college transition without acknowledging potential challenges. The other—a process-oriented perspective—acknowledges potential struggles but represents them as common and temporary. Students from socially disadvantaged backgrounds more often expressed simple optimism and less often the process-oriented view. These patterns mattered: simple optimism predicted lower grades and rates of full-time enrollment through the first year of college, whereas a process-oriented view predicted higher GPA and persistence, controlling for academic preparation, among other factors. A short social-belonging exercise shifted students' language toward the process-oriented perspective by 25 percentage points, reducing differences by disadvantaged status. These findings suggest that latent beliefs about belonging are evident in everyday language and predict student outcomes, offering a tool for education leaders to better understand their students and support college success.

Keywords: natural language processing; college transition; belonging; process-oriented perspective; optimism

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Introduction

"Enjoy every minute of your college experience"[1]

- A Message from the President, Clemson University

"You belong here, and you can flourish"[2]

- Office of the President, University of Oregon

Many students receive enthusiastic, optimistic messages like these from college leaders, parents and peers assuring them about positive experiences and outcomes in college. These well-intentioned messages are meant to motivate students to thrive. Indeed, optimism among students is associated with self-efficacy, improved well-being and satisfaction[3,4]. Yet, it is unclear whether a general, forward-looking assurance about success is optimal to best support students through college—particularly those who face entrenched structural and social barriers.

College success remains a critical pathway to upward mobility for millions of Americans, but one with persistent inequities in access and outcomes[5,6]. These inequities stem from both structural factors[7–10], and psychological dimensions of the college experience[11–14]. Central among these psychological dimensions is a sense of belonging, which we define as the relationship between a person and a context: the fit, or potential fit, between who one is and what a context permits or seems to permit[15]. Belonging is experienced as a feeling of being included, valued, respected, and able to contribute to the setting.

In college, a sense of belonging strongly predicts students' health, well-being, persistence, and academic performance[15–21]. One reason belonging matters is because it helps students develop the social and academic integration in college that is essential for persistence and success[22]. Yet a robust literature in sociology and in social and cultural psychology shows that students from groups historically disadvantaged in higher education often encounter additional challenges to developing this crucial sense of belonging[23–27], facing the question: "Can people like me belong here?"[28]. This perspective can turn everyday challenges into perceived evidence of a general lack of belonging, leading students from disadvantaged backgrounds to disengage from school, thereby perpetuating inequality in college outcomes[28–32].

What beliefs serve students best to develop a sense of belonging and integrate in college? In the present study, we focus on two beliefs: simple optimism and a process-oriented perspective.

We define simple optimism as the expectation of personal belongingness without anticipating potential for normative belonging-relevant adversities. For example, an incoming college student may anticipate an easy experience making friends without considering the challenges posed by a large, unfamiliar, and diverse social milieu. We investigate simple optimism, rather than general optimism, for three reasons. First, general optimism is widespread, especially among students starting college[33,34]. Second, although optimism may confer benefits as compared to pessimistic ways of thinking in many settings[35,36], because few students begin college pessimistic, the operating question does not concern optimism versus pessimism but

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what form of optimism best serves students. It is not clear that simple optimism will do so. Indeed, an extensive body of research finds that unfounded and unrealistic optimism can be maladaptive[37–39], including in higher education[40–42]. For instance, laboratory studies reveal that simple and inflated praise may undermine resilience when challenges arise[43,44] whereas opportunities to observe the process by which others have gained success can help[45]. Third, after applying our codebook and further investigating the annotated data simple optimism emerged as a construct of interest due to its prevalence (observed in about one fifth of essays).

We define a process-oriented perspective as recognizing that belonging-relevant adversities are common and temporary in nature. This is an optimistic perspective because it represents struggles as shared (and thus one's own struggles are not due to deficiencies in the self) and as likely to improve. For example, an incoming college student may worry about making friends, but think that all students are "in the same boat." They may further believe that this worry will pass with time as they become more familiar with their new social environment. We investigate this process-oriented perspective because decades of psychological research rooted in attribution theory[46–48] has demonstrated it to be adaptive, including in education settings[49,50]. This evidence is causal: by experimentally targeting the two components of the perspective—commonality and temporariness—researchers have shown them to be both manipulable and beneficial across a wide range of contexts and outcomes, including college achievement and persistence[28–32,51,52]. Importantly, the deep history of research on process-oriented beliefs points to the value of integrating common and temporary attributions for adversity. With only the belief that belonging-relevant adversity is common, students might think this is permanent, perhaps due to deficiencies of the context. With only the belief that belonging-relevant adversity is temporary, students might think there is something particularly wrong with them and/or their social identity group or its fit with the college context, even if this is temporary. Although the joint belief in the commonality and temporariness of adversity is optimal, the two constructs are also distinct. This said, it is not the case that the absence of one theme in a student essay necessarily means the student rejects that theme; it may just go unsaid, for instance if the essay simply emphasizes the other theme. Accordingly, we investigate the two themes together and separately.

Despite the demonstrated importance of process-oriented beliefs[45], the field lacks robust, unobtrusive measures of these beliefs in student behavior. Such measures are necessary to create diagnostics on perspectives students bring to college and to design responsive interventions.

Past research has documented intergroup inequality in critical beliefs in education using in-depth interviews and self-report surveys[11,28,32,53,54]. In the context of belonging, researchers have measured outcome beliefs (e.g., "I feel like I belong"[16,55]), anticipated belonging[56], the perceived contingency of belonging (i.e., belonging uncertainty, e.g., "When something bad happens, I feel that maybe I don't belong at [school name]"[28,32]), and the day-to-day link between setbacks and feelings of non-belonging[28,30–32]. In addition to the burdensomeness of these methods, fixed-choice surveys limit what students can or will report. They may also be affected by social desirability and changing reference frames[57–60], which can mask or inflate

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observed differences. Distal outcomes such as GPA do not substitute: they unfold slowly and are confounded by many factors. A scalable tool is needed to assess whether students hold the belief that belonging challenges are both normal and temporary.

The primary goal of this preregistered study is to provide scalable, proximal measures of these key beliefs. To do so, we leverage essays students wrote anticipating their experience in college before beginning college. While these essays are also constrained by what students choose to express, they can surface spontaneous beliefs and, since they are already collected as part of an intervention exercise, offer an efficient secondary data source. Analyzing essays written by 25,000 students randomized to an active control or treatment condition of a social-belonging intervention[55] conducted across 23 colleges and universities in the United States and Canada, we develop computational measures of simple optimism and a process-oriented perspective. We (i) test for intergroup inequality in students' spontaneous expressions in the active control condition of a nationally representative intervention; (ii) assess their predictive relationship with critical markers of progress through the first year of college (full-time completion rates, grade point average [GPA]); and (iii) evaluate whether the social-belonging intervention reduces inequality in these beliefs. Our approach, summarized in Fig. 1, largely follows research questions and analytic methods documented in our preregistration (any deviations are reported in Tables S1-S2).

Our work makes two primary contributions. First, we provide an unobtrusive, cost-effective approach that can be integrated into open-ended writing exercises, serving as a diagnostic tool for understanding student beliefs and designing responsive interventions. For example, if institutional leaders observe non-optimal beliefs in specific student groups they can create tailored responses to support students in normalizing and embracing challenges. Second, our study contributes large-scale evidence that students' conceptual models of the college transition differ by social advantage and carry significant implications for student success.

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[INSERT FIGURE 1]

Methods

Data

Source Data. We used data from the College Transition Collaborative's social-belonging intervention[55], which included 25,000 students enrolled in 23 colleges: 22 in the United States (US) and 1 in Canada. The US institutions in the sample reasonably generalize to 749 4-year institutions in the US. Students were randomized to a social-belonging or active control exercise in the summer before their first year (see Supplementary Note 1). Both conditions included stories from older students about college. However, the treatment condition focused on social adjustments in college, offering a process-oriented perspective for understanding challenges to

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belonging, whereas the control condition focused on adjustment to the physical environment, including the campus, region, and weather. Both included "saying-is-believing" exercises: essays that encouraged students to reflect on the condition-specific message and its relevance to themselves.[28,52,61]

Importantly, the content and structure of the control condition permit students to articulate a process-oriented perspective about the college transition but does not specifically encourage this view. Thus, it allows us to assess intergroup inequality in this way of thinking absent treatment; the condition comparison allows us to assess whether and to what extent this shifts with the social-belonging exercise.

The essays were linked to students' background information (high school standardized test scores, gender, race/ethnicity, first generation status, among others) as well as their academic outcomes, including GPA and completion of the first year of college at full-time status. Secondary analysis of data for this study was approved by Stanford University's Institutional Review Board.

Analytic Sample. Our analytic sample included exactly 25,000 essays: 12,632 from the control condition and 12,368 from the treatment condition. Following the seminal publication from this research[55], we included data from only the control and standard treatment conditions, excluding data from a third experimental condition, which adapted belonging materials for each campus and was thus variant across campuses. By contrast, students within the control and standard treatment condition responded to the same experimental materials across institutions. The original data also included an "invalid essay" label, flagging essays shorter than 40 words or essays coded by research assistants as not meaningful. We filtered out these rows (9% of the original sample). The median length of retained essays was 108 words (mean=130.81, std=86.95).

We linked students' saying-is-believing essays to key measures of college progress, full-time enrollment and GPA over the first year of college, enabling tests of predictive validity. For the regression analyses, our sample size shrank by about 10% due to missing values for gender and high school test scores. Robustness checks using multiple imputation for these missing covariates indicate that results were substantively unchanged from complete-case estimates.

Computational Annotation of Essays

We used natural language processing to detect the presence or absence of simple optimism or a process-oriented perspective in the 25,000 saying-is-believing essays. We preregistered how the data were coded, the academic outcome measures, control variables and our key analyses (https://osf.io/adbg8/).

We used binary indicators to represent the presence of our focal constructs. We operationalize *simple optimism* as students' expressed anticipation that they will belong without recognizing that other students also have belonging concerns. We operationalize a process-oriented perspective as students' framing of belonging concerns as *common* and *temporary*. Although *commonality* and *temporariness* are often studied jointly, they are also conceptually

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distinct. We conducted all primary analyses treating them separately in the main text and replicated joint analyses in Fig. S1.

Manual coding. We developed a codebook, iterating through nine versions, grounded in psychological theory on optimism and attribution (see Introduction) and subtle language patterns observed in our data (e.g., the types of belonging concerns that students mentioned; see Supplementary Note 2). The codebook included the following constructs: *optimism* (rated on a three-point scale), *commonality* (dichotomous judgment) and *temporariness* (dichotomous judgment). The scales of judgment (dichotomous versus trichotomous) were developed after multiple rounds of protocol testing, during which we observed that optimism was better captured with more gradations than commonality and temporariness. These gradations seemed to represent qualitatively distinct essays, so we used a more leveled scale to capture these differences (see Supplementary Note 2 for examples). *Simple optimism* was derived later from *optimism* and *commonality* as discussed below. We did not develop a code for expressions of pessimism because this sentiment arose rarely in preliminary observations (essays that did not express optimism need not express pessimism). Although all constructs deal with belonging-relevant adversity, the word "belong(ing)" was not required for essays to be coded as containing one or more of the constructs. To do so would be unnecessarily restrictive; students often wrote about their relationship to or fit with the institution without using this word, instead describing feeling at home or "fitting in," for example.

Next, from 156 candidates, we selected six undergraduate student annotators who represented intersecting identities in terms of gender, race/ethnicity, first-generation status, thus helping ensure that these subjective constructs could be recognized and interpreted by people with relevant identity-based perspectives on recent, lived experiences of belonging in college[62,63]. After training the annotators coded a random sample of 1,200 essays.

Model training. We used the annotations as labels to train language model-based classifiers using supervised machine learning. Specifically, we fine-tuned RoBERTa models[64], which were pre-trained on vast amounts of text data to learn contextual representations of word meaning as features in the prediction model (see Supplementary Note 3 for hyperparameters). We used RoBERTa embeddings rather than simpler word-based features because the contextual representations capture meaning more accurately (with the ability to disambiguate word senses), especially in relatively short text. We decided to fine-tune RoBERTa rather than relying on prompting Large Language Models because this approach afforded greater control and reproducibility while being more cost-effective and privacy-preserving for sensitive student data.

Before training the models, we aggregated scores between the two raters of each essay. For dichotomous features (*commonality* and *temporariness*), we took the maximum of two raters' scores to be inclusive of different perspectives; that is, if either rater coded an essay as having a construct present, the essay was coded as *1*, otherwise *0* (taking the minimum instead of the maximum yields substantively the same conclusions, see Figs. S5-S7). For *optimism*, which

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was coded trichotomously, we took the mean of the two raters' scores. Next, we fine-tuned RoBERTa classifiers on the processed codes to predict scores for *optimism*, *commonality*, and *temporariness*. To evaluate model performance, we combined the held-out test sets in a five-fold cross-validation setup. Models agreed substantially with human judgments: *optimism* (Spearman $\rho = .70$, $p < .001$), *commonality* (precision = .77, recall = .80, F1 = .79), *temporariness* (precision = .79, recall = .87, F1 = .83). *Commonality* and *temporariness* showed a positive association but only moderately so (φ coefficient = .337, $p < .001$).

We derived *simple optimism* from two automated measures: *optimism* (trichotomous between 0-2) and the binary *commonality* measure. We assigned essays a code of *1* that had a score of *1* or higher on the *optimism* scale and a score of *0* for *commonality*. We focused on *commonality* (rather than *temporariness*) because it was clearly conceptually distinct from simple optimism (see codebook in Supplementary Note 2) and also less often present. However, our results do not change substantively by adding "temporariness=0" to the definition of *simple optimism* (Fig. S8).

Finally, we applied the computational models to derive annotations for all 25,000 essays, which form the basis of primary analyses.

Identifying Language Markers of the Three Constructs

To confirm the validity of our methods, beyond the substantial agreement between the automated and human codes, we sought to investigate whether the computational predictions captured the key constructs: *simple optimism*, *commonality* and *temporariness*. These exploratory analyses were not included in the preregistration (see Tables S1-S2), but are meant to complement our preregistered measure validation question. Machine-learning models based on contextual representations are non-trivial to inspect directly; instead, we chose a straightforward language analysis method widely used in prior work ("differential language analysis"[65,66]) to determine the words and phrases that statistically distinguish essays automatically coded for the target constructs from those without.

In this approach, for all essays that contained at least 50 words (n = 21,189), we independently regressed the relative frequency of 5,218 language features (words and phrases) against the machine-learning predicted constructs, controlling for gender and high school test scores. We determined significance of association for each feature via a two-tailed significance test with $p < .05$, with p-values controlled for multiple comparisons using Benjamini-Hochberg (see Supplementary Note 4 for full details). We complemented this "open-vocabulary approach" with a "closed vocabulary" dictionary-based approach, in which we analogously regressed the relative frequency of occurrence of 73 psychological dictionaries (LIWC[67]) against the predicted outcomes (using the same essays, covariates and *p* correction).

Analytic Approach

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The preregistration specified a measure-development and validation question, which we report in the preceding section. Our study now focuses on substantive, theory-focused questions, which we label as exploratory given that they were not preregistered (see Tables S1-S2 for rationale):

- EQ1 (Descriptive prevalence): How often do essays express each construct, and how do rates differ across student groups?
- EQ2 (Predictive validity): How do essay-based measures relate to first-year outcomes (GPA, full-time completion rate)?
- EQ3 (Convergent validity): Does the treatment shift the prevalence of key constructs in theoretically expected directions?

Descriptive analyses (EQ1 and EQ2). Our descriptive analyses quantified how often essays expressed three coded constructs—(i) *simple optimism*, (ii) the *commonality* of belonging concerns, and (iii) the *temporariness* of those concerns, comparing subgroups by disadvantaged status. We grouped data by social identity groups that are advantaged or disadvantaged in predominantly white post-secondary contexts, a binary variable defined in prior work[30,55,56] as all white and Asian continuing-generation students versus all Black, Latinx and Native students and all first-generation students. We conceptualize the latter group as facing group-based disadvantage within mainstream college contexts (not as disadvantaged in general). We ran two sets of Pearson chi-square (χ^2) tests of independence: (a) within the control arm to characterize baseline differences and (b) between treatment and control arms to assess treatment-related shifts in frequencies. Control-only comparisons used n = 12,632 essays; between-condition comparisons used n = 25,000 (adding 12,368 treatment essays). χ^2 tests are appropriate for categorical outcomes with independent observations; expected cell counts exceeded 5 throughout, so large-sample χ^2 assumptions were met and normality was not required. All tests were two-tailed with $\alpha = .05$.

Regression analyses (EQ2). Our preregistered ordinary least squares (OLS) regression analyses estimated associations between a process-oriented perspective and student outcomes; we additionally consider *simple optimism* (post-hoc) given its theoretical importance and as a contrast to a process-oriented perspective. The preregistration (dated May 25, 2023) can be found at https://osf.io/adbg8, which specifies the outcomes and covariates; while the way in which we derived a the process-oriented perspective construct is underspecified in the preregistration, Figs. S1-S8 demonstrate that results are robust to pre-processing decisions. See Tables S1-S2 for more details.

We used outcome variables according to how they were processed in the original dataset[55]. These were: first-year full-time completion (binary variable, indicating whether the student completed all terms in their first academic year at full-time status) and first-year weighted GPA (continuous variable, representing the average GPA point value of courses taken in the first year weighted by the number of credits each course conferred).

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Since essay length is a key confounding variable in language studies (i.e., all language features are more likely to appear in longer writings), we controlled for the number of words in the essay. We additionally controlled for participant gender (based on self-report survey data and school-provided data, preferencing self-reported values) and high school standardized test score (ACT or SAT, converted to a common metric) as derived by Walton et al.[55]

Primary analyses were restricted to the control condition with covariates for essay word count, gender, and high school standardized test score. We also tested for interactions between constructs and disadvantaged-status to assess subgroup differences (parallel treatment-inclusive models are reported in Fig. S2). OLS yields unbiased estimates of average marginal effects only under standard conditions; for robustness, we therefore report heteroskedasticity-robust (Huber–White) standard errors. All tests were two-tailed with $\alpha = .05$. We conducted robustness tests, including removing all control variables (Fig. S3) and adding college as a fixed effect (Fig. S4). Predictive relationships with outcomes were similar if not stronger as in primary analyses.

In addition to our primary academic outcomes, we analyzed on an exploratory basis three constructs' association with the manipulation check from the original intervention study, students' self-reported anticipated growth in belonging. Results mirrored the academic patterns and are reported in Fig. S9.

Results

Language markers of a process-oriented perspective and simple optimism

The most significantly associated language features, with the highest beta values, are shown in Table 1 (words) and Table 2 (LIWC dictionaries). In general, we observed language patterns matching our theoretical understanding of the constructs, lending face validity to the automated coding. First, *simple optimism* was expressed as excitement and anticipation about the college experience (e.g., "excited," "forward," "new people," "ready," "great," "cannot wait to"), which was consistent with words in the LIWC "positive emotion" dictionary (as measured by correlation: $\beta = .26$ [.25, .27], $p < .001$).

Second, *commonality* was associated with words and phrases like "common," "common among," "everyone feels," "typically feel," and "not the only." This language is also reflected in the "cognitive processes" dictionary of LIWC ($\beta = .15$ [.13, .16]), which includes the use of more comparisons as a subdictionary ($\beta = .09$ [.08, .11], all ps $< .001$).

Third, language associations with *temporariness* were largely similar to those associated with *commonality*, except that they included more references to time ($\beta = 19$ [.18, .20], $p < .001$). Strongly associated words and phrases include "time," "eventually," "get used," "takes time," "after a while," and "first few."

Beyond these face-valid patterns, two other language patterns are noteworthy with regard to emotions and pronouns. First, while *simple optimism* was strongly associated with positive emotions ($\beta = 26$ [.25, .27]), essays with *commonality* were associated with negative emotions ($\beta = .14$ [.13, .15]), including anxiety ($\beta = .15$ [.14, .16], all ps $< .001$). This pattern is consistent

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with the inference that these essays anticipate the commonality of negative emotional experiences.

Second, differences in the use of pronouns are among the most well-studied language patterns[68]. Increased use of first-person singular pronouns ("I," "me," "mine"; LIWC *I* category) generally indicates increased attention on the self, often in a maladaptive or vulnerable fashion[69]. First-person plural pronouns ("we," "our"; LIWC *WE* category) indicate connection to a group, often in an adaptive fashion[70]. We observed essays with *simple optimism* to include notably more references to self (LIWC *I*: β = .28 [.27, .29]) and fewer "we" references (LIWC *WE*; β = -.11 [-.13, -.10], all *p*s < .001). *Commonality* and *temporariness* showed the opposite pattern, with more "we" (LIWC *WE*, β = .15 [.13, .16] and β = .11 [.10, .12], respectively) and fewer self references (LIWC *I*, β = -.18 [-.19, -.17] and β = -.19 [-.20, -.18], all *p*s < .001). Both *commonality* and *temporariness* were also more associated with social words (LIWC *Social*, β = .27 [.26, .28] and .19 [.18, .20], respectively, *p*s < .001), supporting the inference that both reflect a stronger social orientation.

These language patterns support the validity of the automated annotation of the three themes. They paint a picture in which essays coded as expressing *simple optimism* focus on the self and describe the college transition anticipating positive experiences, while essays coded as expressing *commonality* and *temporariness* understand the experience in the context of others', shared "we" identities, and stronger anticipation of negative experiences.

[INSERT TABLE 1]

[INSERT TABLE 2]

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EQ1 and EQ2: Prevalence of and group disparities in the expression of simple optimism and a process-oriented perspective and their predictive consequences

We examined writing from the control condition to understand inequality in students' spontaneous understandings of the college transition absent intervention and its predictive consequence. As expected, expressions of optimism in general were common: 80.26% of essays expressed optimism in some form (i.e., either *simple optimism* or at least one aspect of a process-oriented perspective, see Fig. S12).

Disadvantaged students were more likely to express simple optimism. In turn, simple optimism predicted worse academic outcomes. Figure 2a shows that 16% of control-condition students expressed *simple optimism*. Students from disadvantaged backgrounds were

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significantly more likely to express *simple optimism* than advantaged students (19% versus 15%; $\chi^2(1) = 29.52$; $p < .001$).

[INSERT FIGURE 2]

Did *simple optimism* predict a lower likelihood that students would maintain full-time enrollment throughout their first year of college and a lower first-year GPA? It did. Students who expressed *simple optimism* were 4.4 percentage points *less* likely to complete the first year full-time enrolled than those who did not (95% CI [-.066, -.022], robust SE = .011, $p < .001$, Figure 2b). They also obtained a first-year GPA that was .13 points lower (equivalent to .18 standard deviations, 95% CI [−.165, −.095], robust SE = .018, $p < .001$, Figure 2c). These associations were stronger yet for students from disadvantaged backgrounds: in this group, simple optimism was associated with a 10.2 percentage-point lower likelihood of full-time completion and a .20-point lower first-year GPA. The disadvantaged–non-disadvantaged difference in slopes was significant for both outcomes (completion interaction: β = −.058 [−.097, −.019], SE = .020, t(10,436) = −2.79, p = .005; GPA interaction: β = −.070 [−.139, −.001], SE = .035, t(10,395) = −1.99, p = .047).

Advantaged students were more likely to express a process-oriented perspective, which in turn predicted better outcomes. About a quarter of control-condition students expressed the idea that potential belonging concerns are common (27%), nearly two-thirds expressed the idea that belonging concerns are temporary (63%), and about one-fifth expressed the two jointly (22%). As Fig. 2 illustrates, advantaged students were significantly more likely to spontaneously express these ways of understanding belonging (for *commonality*: 28% versus 23%; raw values; $\chi^2(1) = 29.07$, $p < .001$; for temporariness: 65% versus 59%; $\chi^2(1) = 39.89$, $p < .001$). Since the vast majority of essays that expressed *commonality* also expressed *temporariness* (82% in control), *commonality* and the joint expression of *commonality* and *temporariness* yield similar results; we report analyses of the joint expression in Fig. S1.

Together these results indicate that, while a process-oriented view of the college transition is available to students even without a targeted intervention, there is inequality in these underlying beliefs.

[INSERT FIGURE 3]

As Fig. 4a illustrates, control-condition students who expressed the idea that belonging concerns are common were 3.5 percentage points more likely to complete the first year of college enrolled full-time than those who did not (95% CI [.017, .053], robust SE = .009, $p < .001$). They also earned first-year GPAs that were .084 points higher (equivalent to .12 standard deviations, 95% CI [.053, .115], robust SE = .016, $p < .001$, Fig. 4b). The interaction between expressing *commonality* and disadvantaged status was not significant for full-time completion (β = -.018, SE = .018 [−.053, .017], $t(10,436) = .99$, $p = .322$). It was for GPA (β = .077 [.016,

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.138], SE = .031, $t(10,395) = 2.53$, $p = .012$): among advantaged students, commonality was associated with a .084-point higher GPA, whereas among disadvantaged students it was associated with a .161-point higher GPA.

[INSERT FIGURE 4]

Similarly, students who wrote about belonging concerns as temporary were 4.4 percentage points more likely to complete the first year of college enrolled full-time than those who did not (95% CI [.028, .060], SE = .008, $p < .011$, Fig. 4c). Their first-year GPAs were also .114 points higher (equivalent to .16 standard deviations, 95% CI [.087, .141], SE=.014, $p < .001$, Fig. 4d). The interaction between discussing *temporariness* and disadvantaged status was not significant for either outcome (full-time completion: $\beta = .021$ [−.010, .052], SE = .016, $t(10,436) = 1.32$, $p = .186$; GPA: $\beta = .005$ [−.048, .058], SE = .027, $t(10,395) = .20$, $p = .842$).

Thus, students who spontaneously expressed a process-oriented perspective absent intervention did better in the first year of college, both in maintaining full-time enrollment and in earning a higher GPA, controlling for gender and incoming academic preparation. The positive relationship between GPA and discussing the *commonality* of concerns was greater for socially disadvantaged students.

EQ3: Impact of the Social-Belonging Intervention

The social-belonging intervention increased the expression of a process-oriented perspective and helped distribute the idea of *temporariness* more equitably. Students randomized to the social-belonging treatment were 25 percentage points more likely to express the idea that belonging concerns are common as compared to control-condition students (from 27% to 52%, $\chi^2(1) = 1645.88$, $p < .001$). They were also 8 percentage points more likely to express the idea that belonging concerns are temporary (from 63% to 71%, $\chi^2(1) = 160.48$, $p < .001$). With treatment, advantaged students were still more likely than disadvantaged students to write about the *commonality* of belonging concerns (54% vs. 47%, $\chi^2(1) = 63.51$, $p < .001$; Fig. 5a) and about *temporariness* (71% vs. 69%, $\chi^2(1)=5.99$, $p = .014$; Fig. 5b). However, in the case of *temporariness*, the increase from control to treatment was significantly greater for disadvantaged students (condition × disadvantaged status interaction: $\beta = .045$ [.020, .070], SE= .013, $t(21,647) = 3.54$, $p < .001$), suggesting that the treatment helped distribute this construct

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more equitably. The condition by disadvantaged status interaction was not significant for *commonality* (p = .118).

[INSERT FIGURE 5]

The predictive relationship between each theme and academic outcomes held in the treatment condition, with the magnitude of these relationships similar to that observed in the control condition (Fig. S4).

Discussion

Even as researchers have long pointed to students' beliefs—including about belonging—as important factors in college success[11,53,54,56], there is a lack of scalable, proximal measures of the critical underlying perspectives that can promote students' successful college transition. By applying natural language processing to 25,000 student essays, we provide large-scale evidence that viewing belonging challenges as common and temporary predicts first-year outcomes. Moreover, we develop efficient means of assessing these ideas at scale, an essential step for implementing relevant interventions well.

To do so, we examined essays written by students as they entered broadly representative U.S. four-year colleges and universities, both in response to control materials and an intervention. Because these essays are integral to the saying-is-believing exercise within belonging interventions, they offer a rich and low-burden secondary source of data that informs how students are making sense of the transition. Integrating classic insights on the attributional processes at the heart of social-belonging and related interventions that seek to help students make sense of challenges in college productively[28,52] and modern natural language processing methods, we provide a practical approach to inferring critical underlying perspectives in student writing without additional surveys. The result is a scalable, proximal method appropriate for aggregate/cohort and subgroup monitoring and to inform institutional supports for students.

Our preregistered study yields four key results, each with implications for psychological research and educational interventions. First, we show that we can build scalable language-based measures that face-validly capture the subtle psychological constructs targeted by social-psychological interventions, from essays collected from the intervention exercise themselves and other student writing, control-condition writing. When institutions implement belonging interventions or include other writing tasks for students as they enter college, such language-based measures, when well designed, can provide early and unobtrusive indicators of student beliefs. These indicators, for example, can provide insights into the effectiveness of specific interventions in affecting proximate processes[71,72] and enable nuanced comparison across experimental conditions that incorporate similar writing tasks, informing the fine-tuning of these interventions.

Second, we show that perspectives on belonging vary systematically with the very groups that are advantaged or disadvantaged in general in predominant post-secondary settings. Black, Latinx and Native students and first-generation college students were more likely to express

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simple optimism and less likely to express a process-oriented perspective about belonging as compared to their advantaged peers. While past research has documented intergroup inequality in students' levels of belonging in college[16], we identify systematic differences in the belief systems students bring to college—beliefs that shape how students then interpret and adapt to the college transition. The results imply that inequalities in belonging may arise not only from students' experiences of college but also from the opportunities and experiences students have before and during the transition to college to develop adaptive frameworks for making sense of college experiences. Disadvantage takes a psychological as well as a structural form.

Third, we find that expressing simple optimism predicted worse academic outcomes over the first year of college, in some cases especially for socially disadvantaged students. These findings align with the existing literature on unrealistic optimism[38,39,41,42] and are consistent with the finding that in general students are optimistic about college as they begin college[33,34]. Past research finding the benefit of optimism[35,36] may be best understood as the benefit of optimistic *versus* pessimistic ways of thinking. By contrast, in the present context, while many students articulated optimism about their upcoming college transition,[33,34] few expressed pessimism. Thus, we only compare optimism to the lack of expression of optimism. In this context, and in a context in which many students will inevitably encounter challenges and setbacks, the nature of the optimism students express may matter most. In particular, we find that the process-oriented perspective, understanding belonging worries as common and as temporary, predicted better academic outcomes for all students. While prior work has shown that *offering* process-oriented ways of thinking can promote persistence and achievement, especially among socially disadvantaged students[32,52,55], our results advance theory by showing that naturally holding and *expressing* these perspectives predicts greater persistence and achievement. At a broader level, this finding supports a process-based model of belonging: successful college adjustment depends not on simple positive expectations, but on interpretive frameworks that normalize adversity as common and temporary. This framework links attribution theory with the psychology of belonging, positioning belonging not merely as a feeling but as a dynamic process of meaning-making about one's fit in a context.[45,48]

Fourth, we find that the belonging treatment increased the likelihood that students expressed a process-oriented perspective, reducing observed gaps, though some inequality remained. This finding provides proximal evidence that the intervention changed the underlying psychological mechanisms targeted by the belonging exercise[28]. Furthermore, the methods provide a way of quantifying the effectiveness of the treatment, including in reducing group differences on its central psychological target, immediately after intervention delivery from the content of both control- and intervention responses themselves.

Overall, our work serves as a case study within a growing body of work[73–79] leveraging computational methods to capture subtle yet powerful psychological constructs. In domains like law enforcement[80,81] and (mental) health care[82–84], institutions are collecting large amounts of language data and that can be systematically analyzed to drive institutional improvement. In education, this approach can yield immediately available process measures to inform institutional

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leaders of prominent beliefs in a student body and help leaders address these beliefs, including both to implement social-belonging and related interventions effectively (e.g., to fine-tune materials, or to offer real-time feedback or further guidance to participants during or after writing tasks) as well as to inform other institutional communications.

Limitations & Future Work

Internal validity. Human coding may introduce biases and measurement error, which we sought to mitigate with demographically conscious rater recruitment, calibration and double-coding, robustness checks (see Supplementary Note 3 and Fig. S5), as well as lexical and convergent validity.

Why is there inequality in simple optimism and process-oriented beliefs? Understanding the source of this psychological inequality is an important direction for future research. There are several possibilities. First, perhaps students from disadvantaged groups have less access to social networks (parents and other family members, friends) that share process-oriented perspective ("My first semester was hard too…"). Second, disadvantaged students may be less apt to assume that their experiences, particularly worries, are normative on campus—after all, they are often underrepresented in post-secondary settings and face other forms of marginalization; advantaged students, by contrast, may readily assume that whatever worries they have are likely normal. Third, disadvantaged students may be disproportionately exposed to well-intentioned but simplistic encouragement ("You belong here!")—perhaps even in efforts to bolster their belonging. Indeed, research finds that adults are most apt to provide inflated praise to children in whom they perceive low self-esteem—praise that ironically undermines self-esteem[43]. Fourth, students who face identity-based threats to belonging may be loath to engage in considering the possibility of challenges, as such challenges may seem to confirm their lack of belonging. Simple optimism may thus seem to serve a protective function.

Generalizability. As noted, a strength of this study is that our data rely on essays written by students entering institutions that are broadly representative of 749 4-year colleges and universities in the United States.

Although simple optimism and a process-oriented perspective are relevant to constructs beyond social-belonging[52], we do not know whether our computational measures would transfer directly to saying-is-believing essays implemented in other social-psychological interventions or to other sources of text (e.g., other pre-college writing tasks, daily diaries, social media posts). Future work should evaluate the generalizability of our measures and adapt them as needed, which may require collecting new annotations. Such adaptation is also required for measuring related but distinct psychological constructs, such as a growth mindset about intelligence.

Student identity groups and institutional contexts. The binary categorization we used to distinguish students who are advantaged in college from students who are disadvantaged follows prior work[30,56]. It is helpful for quantitative analyses but oversimplifies the complexity in student identities as well as how those identities interact with diverse institutional contexts with their own histories and affordances for belonging[55,85]. Due to space limitations and data sparsity, we

did not disaggregate by race, first-generation, or gender nor estimate intersections. Similarly, we estimate the cross-institution average association, and we do not disaggregate by institution type. Examining heterogeneity across student subgroups, institutions and cohorts is a key direction for future research, for instance to assess whether process-oriented thinking is most predictive of first-year outcomes in school contexts that afford student identity groups greater opportunities for belonging.

Tables

Essay Construct	Definition	Illustrative Student Response Demonstrating the Construct	Words And Phrases Most Associated with the Construct
Simple **optimism**	The writer conveys optimism that they will come to belong at school, WITHOUT a mention of belonging challenges being common.	I'm nervous to start college because you know, IT IS COLLEGE! But I am also very excited. I have only been to two schools, my elementary school went up to the 8th grade and it was right across the street. Then high school about 15 minutes away now college is going to be about an hour away and I will be dorming! I have been to [College Name] a couple of times and the people there are so friendly. **I know I'm going to love it.**	
Belonging concerns are **common**	The writer communicates that it is normal to have concerns about belonging in college and/or that many students have these worries.	I feel as though **every student that is transitioning from high school worries about "fitting" in to the college life**. This feeling is similar to kids moving from middle school to high school which allows me to understand that it really isn't about "fitting" in, but rather finding who I am. **Everybody is on the same boat** coming into college and I worry that I just want to find people similar to me. I also worry about being homesick which I believe **every student that is away from home** for the first time will feel. It'll be tough, but having less worries about fitting in and just working through trying to find friends that are common with you which will be there will make the transition easier and faster.	

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Belonging concerns are **temporary**	The writer communicates an understanding that challenges to belonging are not permanent.	One of my worries going into college is getting along with my roommates. I have plenty of close friends going to [College Name] so i have no worries about meeting people. Most people worry about their roommates because they will be the ones you spend the most time with. **I believe people grow more comfortable over time because they adjust to the setting and how people are.** Students can meet more people to feel more at home.	

Table 1. Definition, example, and correlational word cloud for the three perspectives on belonging. The constructs were automatically annotated using classifiers fine-tuned on manually labeled essays (Methods). Resulting annotations were binary for each construct (0=absent, 1=present). Differential word clouds show the words and phrases most associated with each construct, with word size representing the association strength (beta coefficient) controlling for student gender and high school standardized test score as covariates, following prior work[55], and word color representing their relative frequency (from gray [rare] to blue to red [most frequent]), following prior work[65]. All words and phrases shown are significantly associated with the constructs controlling for multiple comparisons (Supplementary Note 4). The word clouds illustrate but do not define each construct, as they cannot convey contextual meaning or the absence of terms (see Table 2 for complementary evidence). Analyses are based on n = 21,189 essays.

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	Dictionary	Simple optimism beta [95% CI]	p	Commonality beta [95% CI]	p	Temporariness beta [95% CI]	p
	Social processes	-.13 [-.14, -.11]	0.000	.27 [.26, .28]	0.000	.19 [.18, .20]	0.000
	Time orientations	-.03 [-.04, -.01]	0.000	-.06 [-.07, -.04]	0.000	.19 [.17, .20]	0.000
Cognitions	Cognitive process.	-.15 [-.16, -.13]	0.000	.15 [.13, .16]	0.000	.16 [.14, .17]	0.000
Cognitions	Insight	-.14 [-.15, -.12]	0.000	.10 [.08, .11]	0.000	.21 [.20, .22]	0.000
Cognitions	Comparisons	-.14 [-.15, -.13]	0.000	.09 [.08, .11]	0.000	.14 [.12, .15]	0.000
Pronouns	I	.28 [.27, .29]	0.000	-.18 [-.19, -.17]	0.000	-.19 [-.20, -.18]	0.000
Pronouns	WE	-.11 [-.13, -.10]	0.000	.15 [.13, .16]	0.000	.11 [.10, .12]	0.000
Pronouns	YOU	-.11 [-.12, -.10]	0.000	.01 [.00, .02]	0.188	.12 [.10, .13]	0.000
Pronouns	THEY	-.19 [-.20, -.18]	0.000	.15 [.13, .16]	0.000	.13 [.11, .14]	0.000
Emotions	Positive emotion	.26 [.25, .27]	0.000	-.07 [-.09, -.06]	0.000	-.14 [-.15, -.13]	0.000
Emotions	Negative emotion	-.01 [-.02, .01]	0.285	.14 [.13, .15]	0.000	-.02 [-.04,-.01]	0.000
Emotions	Feel	-.02 [-.03, -.01]	0.005	.16 [.15, .17]	0.000	.12 [.10, .13]	0.000
Emotions	Anxiety	.01 [.00, .03]	0.082	.15 [.14, .16]	0.000	-.02 [-.03, .00]	0.023

Table 2. The Linguistic Inquiry and Word Count (LIWC 2015) dictionaries, which most distinguish the three ideas. Pronouns represent multiple forms of the pronoun, hence the capitalization. Color scale corresponds to strength of correlation, from red [strong negative, -1] to dark green [strong positive, 1]. All associations (betas) control for student gender and high school standardized test score. *P*-values are conservatively adjusted for multiple comparisons across all LIWC dictionaries, not just those shown in the table. Moderate effect sizes are typical for language correlations in between-person analyses[66]. See https://osf.io/adbg8/ for all LIWC dictionary results. Analyses are based on n = 21,189 essays.

Figure Captions (Repeated)

Fig. 1. Overview of our analytic approach. After annotating a subset of essays capturing students' beliefs about their college transition, we used natural language processing to predict those belief annotations for all essays and related these beliefs to first-year academic outcomes.

Fig. 2. The presence of *simple optimism* in student essays and its association with outcomes. Panel (**a**) shows the proportion of students expressing simple optimism. Error bars represent 95% confidence intervals. Asterisks represent the statistical significance of the difference, as measured by a chi-square test (***: $p < .001$). Panels (**b**) and (**c**) show the beta coefficients between expressing *simple optimism* and full-time completion and GPA, respectively, overall and by disadvantaged status. Dots represent the coefficients and lines represent robust standard errors. Each dot represents a different regression. Models include the following covariates: essay word count, gender, and high school standardized test score (Methods). These

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analyses used control-condition data only (n = 12,632 essays for Panel (a); n = 10,604 for Panel (b), n = 10,561 for Panel (c)). However, treatment-condition data yield similar results, see Fig. S2.

Fig. 3. The presence of a process-oriented perspective in student essays. Panel (a) shows the proportion of students expressing the *commonality* of belonging concerns, while Panel (b) shows the proportion of students expressing the *temporariness* of belonging concerns, both split by disadvantaged status. These analyses used control condition data only (n=12,632 essays). Error bars represent 95% confidence intervals. Asterisks represent the statistical significance of the difference, as measured by a chi-square test (***: $p < .001$).

Fig. 4. The association between a process-oriented perspective and academic outcomes. Beta coefficients between essay construct (*commonality* in Panels a) and b) and *temporariness* in Panels c) and d); independent variable) and academic outcomes (full-time completion in Panels a) and c), GPA in Panels b) and d); dependent variables) overall and by disadvantaged status. Dots represent the coefficients and lines represent robust standard errors. Each dot represents a different regression. Models include the following covariates: essay word count, student gender and high school standardized test score. The figure uses control-condition data only (n = 10,604 for Panels (a) and (b), n = 10,561 for Panels (c) and (d)). However, treatment-condition data yield similar results, see Fig. S2.

Fig. 5. The impact of a brief exercise on students' perspectives. The social-belonging intervention increased the likelihood that students expressed a process-oriented perspective, especially the idea that belonging concerns are common. Panel a) shows *commonality* and Panel b) shows *temporariness.* Error bars represent 95% confidence intervals. The bars are not stacked; transparent, lined bars (representing treatment) are behind colored ones. The treatment group bars are based on n = 12,368 essays, the control group bars are based on n = 12,632 essays. Asterisks represent whether the difference by disadvantaged status, as measured by a chi-square test, is statistically significant in the treatment condition (*: $p < .05$, ***: $p < .001$).

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Data Availability

While the essays cannot be released to protect student privacy, our analytic sample, including language-based predictions for themes, can be found at https://osf.io/rpg9j/.

Code Availability

All code, used for developing RoBERTa models as well as the regression scripts can be found at https://osf.io/rpg9j/.

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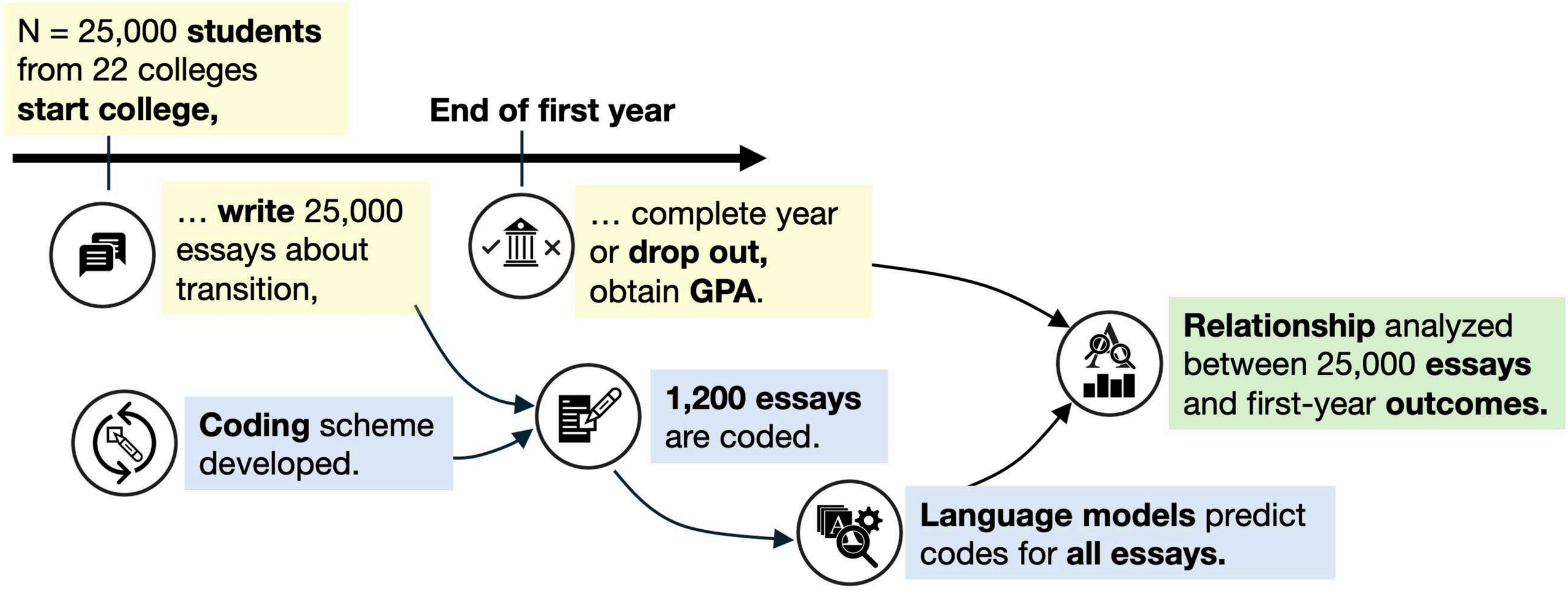
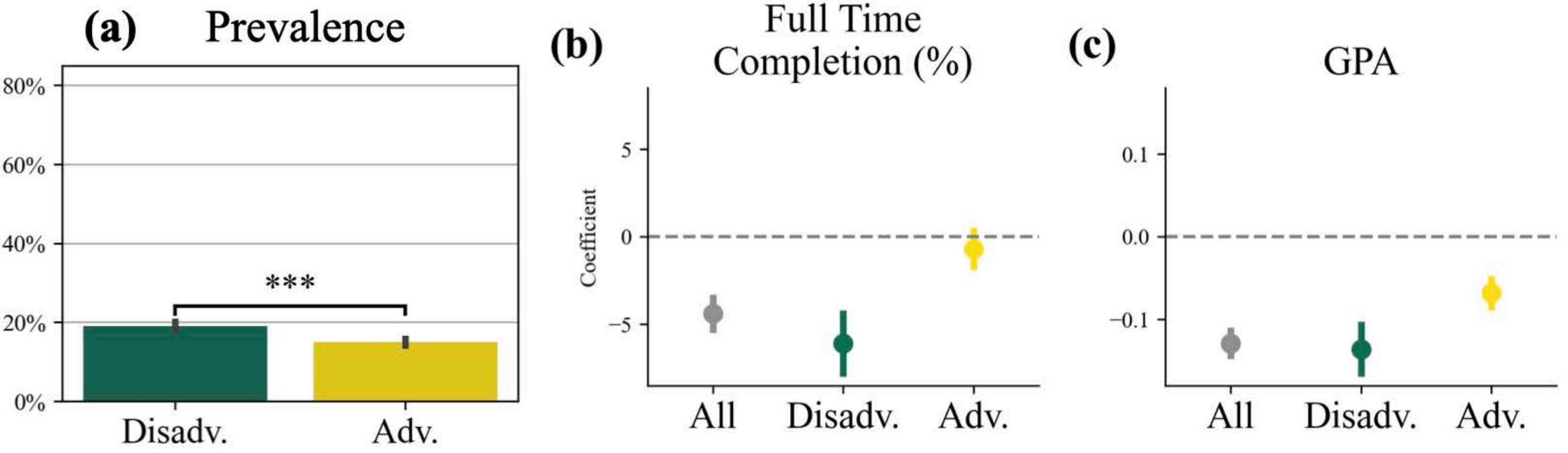

N = 25,000 **students** from 22 colleges **start college,**
End of first year
… **write** 25,000 essays about transition,
… complete year or **drop out,** obtain **GPA**.
Coding scheme developed.
1,200 essays are coded.
Language models predict codes for **all essays.**
Relationship analyzed between 25,000 **essays** and first-year **outcomes.**

Simple Optimism

Association with…



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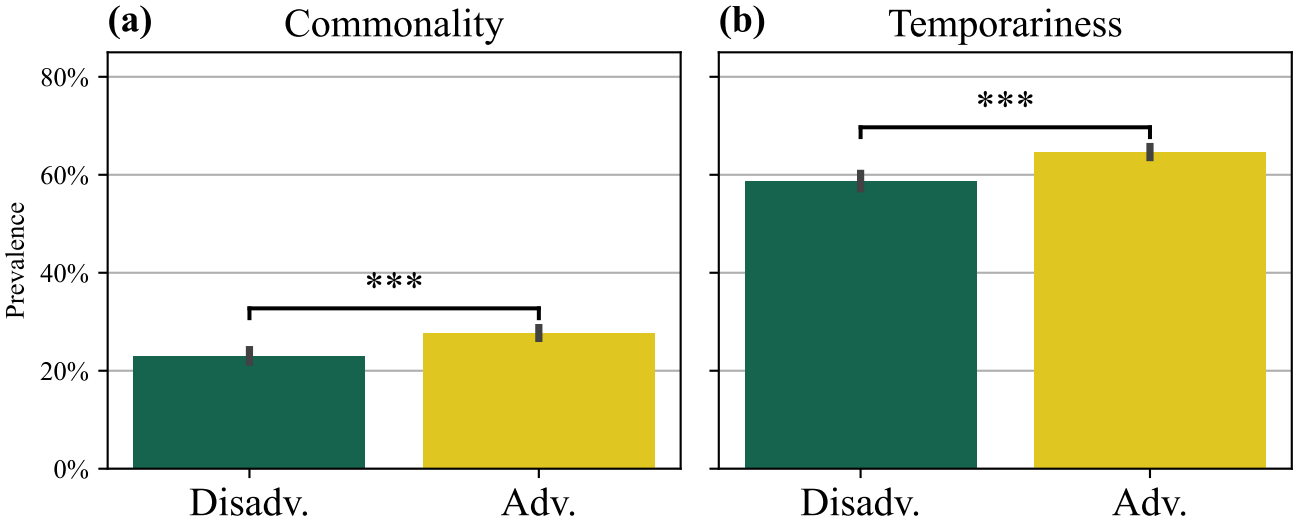
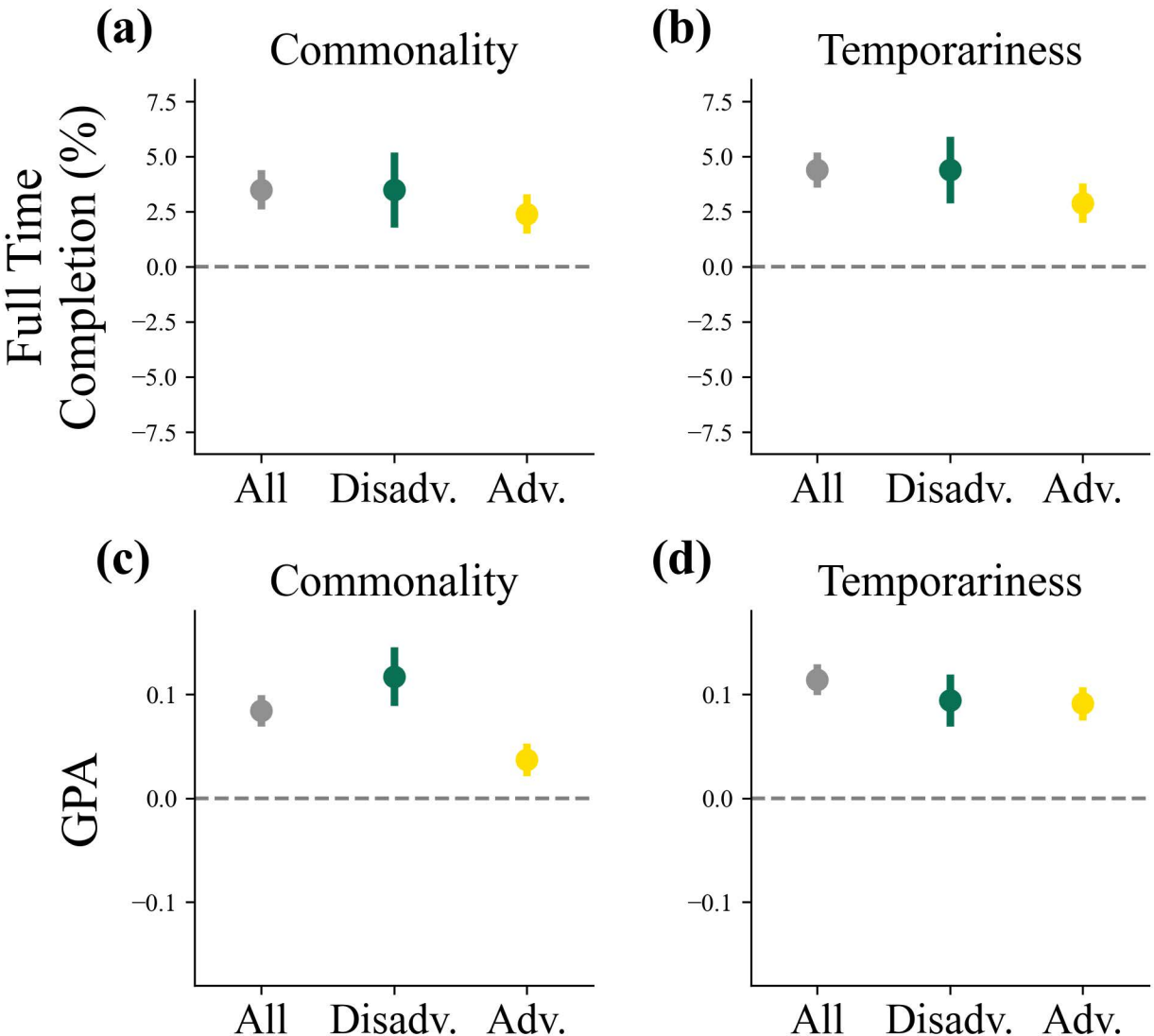
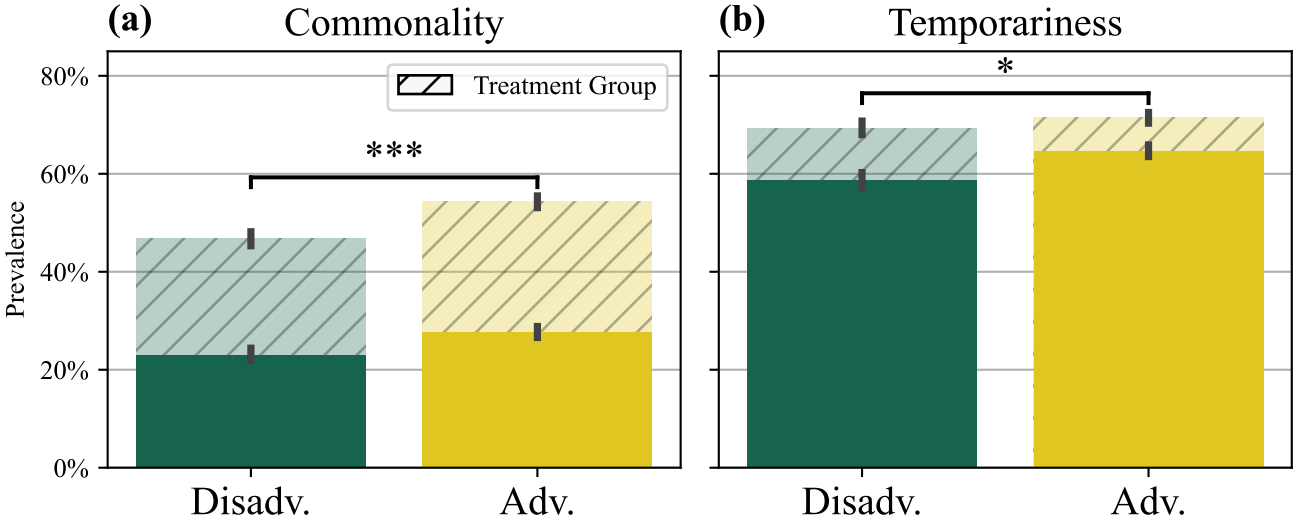



(a)
Commonality
(b)
Temporariness
Full Time Completion (%)
7.5
5.0
2.5
0.0
−2.5
−5.0
−7.5
All
Disadv.
Adv.
(c)
Commonality
(d)
Temporariness
GPA
0.1
0.0
−0.1
All
Disadv.
Adv.

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