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Unpacking Motivational Culture: Diverging Emphasis on Communality and Agency Across STEM Domains

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The current research examined whether life sciences vs. engineering/physical sciences vary in the visibility and value of communality and agency. Overall, we find an emphasis on agency in engineering/physical sciences and a greater balance between communality and agency in the life sciences. We examine motivational culture as represented in environmental structures (Study 1), in signals sent and received in academic displays (Studies 2A–B), and in individual-level motives and cognitions (Studies 3–4). Study 1 analyzed archival course data to find that courses (*N* = 11,222) in engineering/physical sciences included fewer collaborative assignments than courses in life sciences. Study 2A's content analysis documented that bulletin boards (*N* = 68) in engineering/physical sciences academic buildings conveyed less communal purpose, and Study 2B found that participants (*N* = 44) perceived greater communal purpose when viewing novel bulletin boards experimentally manipulated to include the cues identified in Study 2A. In Studies 3 (*N* = 326) and 4 (*N* = 110), engineering/physical science majors reported a strong agentic focus, compared to life science majors' more balanced focus. Further, the strong agentic focus of engineering/physical science students waned over time. This investigation of motivational cultures highlights the daily practices and institutional contexts that can shape individual-level motives and cognition related to engagement in STEM, both *within* and *across* different STEM pathways.

Keywords: goals, STEM, culture, communality, agency

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Science, technology, engineering, and mathematics fields are commonly perceived as offering opportunities to fulfill agentic more than communal goals (Diekman et al., 2011, 2020; Morgan et al., 2001): Agentic motives focus on promoting the self, and communal motives focus on attending to others. Yet both agency and communality are fundamental motives that contribute to optimal human functioning (Bakan, 1966; Helgeson, 1994). In the current work, we investigate whether local STEM cultures differ in how they structure and signal agentic and communal opportunities, and whether students in different STEM domains report values reflecting the stereotypic pattern (focus on agency) or a balanced pattern (focus on both agency and communality). Agentic and communal goals may be differentially emphasized across areas of STEM, and documenting such *motivational cultures* provides a rich opportunity to understand how different motives are perceived and pursued across different areas of STEM.

Defining Motivational Culture

This investigation adopts a structural perspective on motivation, where an individual's motives and perceived opportunities are embedded within a broader system of social roles. Consistent with a culture cycle lens (Cheryan & Markus, 2020; Markus & Kitayama, 2010), institutional contexts, interactions with others, and individual-level motives, cognitions, and behaviors operate in mutually reinforcing cycles. Motives do not exist solely within the individual: The will of an individual is expressed in particular environments that afford that motivation (Kruglanski et al., 2014). In essence, an agentically focused culture will include structures and signals that emphasize self-promotion or achievement, whereas a communally focused culture will include structures or signals that emphasize connecting to others or serving a broader community.[1] Agentically focused cultures cue opportunities to advance the self, whereas communally focused cultures cue opportunities to connect to or help others.

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[1] Notably, the goal content of *agency* and *communality* is orthogonal to the distinction between *performance* and *mastery* goal pursuit. Performance vs. mastery orientations focus on whether the intent is to display competence (performance) or to develop competence (mastery). Thus, an agentic goal of achievement might be pursued with a performance orientation or a mastery orientation (this is typically how performance or mastery goals are studied). Less frequently studied, but possible, would be to examine whether communal goals are pursued with performance or mastery intent (e.g., is the goal to display capacity to collaborate with others, or is the goal to develop capacity to collaborate with others). The current paper focuses on goal content (agency and communality) rather than on goal pursuit, which could be enacted with mastery or performance orientation.

The structures or signals to agency and communality that vary across local contexts are essential to understand. Goal congruity theory posits that individuals enter into roles that are perceived to fulfill their valued goals—the perceived *affordances* of a role to fulfill communal or agentic goals matters (Diekman et al., 2020). Further, individuals whose values align with those embedded in an organization are more likely to succeed in and advance in an organization (attraction-selection-attrition hypothesis; De Cooman et al., 2009). Consistent with a culture cycle perspective (Cheryan & Markus, 2020), individuals' own values and perceived affordances are expected to align with the patterns of motivational structure and signaling in the environment. Motivational culture—what goals are afforded, signaled, and endorsed in a particular context—provides a key to understanding the landscape in which people navigate educational and occupational pathways.

In particular, these studies apply this theoretical framework to understanding how students navigate their educational roles. How do institutional-level contexts, such as course activities or physical displays in campus buildings, cue agency and communality? How do individual students perceive the goal opportunities of their majors, and what goals do students in different majors particularly value?

Do Motivational Cultures Differ in Life Sciences and Engineering/Physical Sciences?

This initial investigation of variability in motivational cultures compares the structures, signals, and student cognitions and values in the domains of life sciences (e.g., biology, biochemistry, microbiology, and zoology) compared to engineering/physical sciences (e.g., specific forms of engineering, computer science, chemistry, and physics). We chose to explore this distinction for several reasons. First, the topics of study within these disciplines can foster structures and signals that emphasize agency versus balanced agency/communality. Life sciences may be experienced as aligned with communality because of the inquiry into processes involving living beings (Mayr, 1997) and that apply directly to human health (Collins et al., 2003). In contrast, engineering/physical sciences examine processes related to nonliving entities (e.g., algorithms, machines, elementary particles, and molecules; National Research Council, 2010). Consistent with this idea, undergraduate students believed that working in medical and social sciences compared to engineering/physical sciences provided more involvement with other people (Morgan et al., 2001).

The engineering/physical science and life science domains also vary visibly in who engages in these fields. Women represent a larger proportion of undergraduate and doctoral degrees in life sciences than engineering/physical sciences (Cheryan et al., 2017; National Science Board, 2019; NCES, 2016). Who is present and leading the field can shape beliefs about goal opportunities; in hypothetical organizations, female leaders were perceived as leading in contexts that offered more communal opportunity, relative to male leaders (Joshi & Diekman, 2021). Further, engineering and physics are more strongly characterized by competition and dominance culture (i.e., masculinity-contest culture), relative to life science fields such as biology and chemistry (Vial et al., 2022). The greater predominance of men may lead to masculine cultural defaults broadly (Cheryan & Markus, 2020), including in perceptions of what motives are visible and valued. For these reasons, we anticipate that the stereotypic focus on agentic motivational culture will be more pronounced in engineering/physical sciences, whereas motivational culture will be more balanced between agency and communality in life sciences.

Capturing Motivational Culture: Person and Environment

To examine motivational culture, we investigate multiple levels of culture, consistent with frameworks that examine how individuals exist within broader contexts (Cheryan & Markus, 2020; Diekman & Schmader, 2021; Markus & Kitayama, 2010). Here we examine how the cultures of life sciences vs. engineering/physical sciences vary by documenting structures and signals of valued goals in the environment, and perceived affordances and values held by the individual. Across both environmental and individual levels, we anticipated that the stereotypic focus on agency would be more pronounced in engineering/physical sciences than in life sciences.

Environmental Structures and Signals

A key component of a cultural perspective is that norms and expectations are communicated through artifacts or activities present in the environment (Kitayama & Cohen, 2007). Notably, in academic departments, environmental artifacts provide messages both about the nature of the work, as well as how much different groups are represented in that environment (Soylu Yalcinkaya et al., 2021).

Goal opportunities in an environment might be afforded through both literal and figurative structures. For example, the placement of furniture in classrooms provides or precludes opportunities for collaboration (Cheryan et al., 2014), and STEM courses that included group work were perceived higher in communal goal affordances (Montoya et al., 2020). Prior experimental work has found that students use such information to discern their likely goal opportunities: For example, an engineering course description that included service learning led to greater expectations of communal opportunities in the course, relative to a control description (Belanger et al., 2017). The question to be addressed in the current research is whether different STEM domains vary in the environmental structures and signals emphasizing communal or agentic goals.

Student Values and Perceived Affordances

Next, we investigated whether individual-level cognitions and values align with the environmental structures and signals. We examined student standpoints through investigating the perceived opportunities to fulfill goals in their STEM majors, and by examining their own agentic and communal values.

Generally speaking, both STEM majors and non-STEM majors consider STEM as affording more agentic goals than communal goals (Diekman et al., 2011, 2020). For example, a study of first-year undecided majors documented greater agentic focus within engineering/physical science fields, whereas they perceived greater communal focus within biological sciences (Stout et al., 2016). Yet specific microcultures in classrooms or research laboratories can provide collaborative and prosocial experiences, and students in these settings report more communal beliefs about

STEM and better performance (Dasgupta et al., 2022; Steinberg & Diekman, 2017; Thoman et al., 2017).

Further, we investigate whether students' own values align with the motivational structures and signals of their majors. Such alignment is predicted from multiple perspectives (e.g., Diekman et al., 2020; Markus & Kitayama, 2010), but this investigation is the first to provide empirical documentation. The perspective that individuals adapt to their culture leads to the hypothesis that engineering/physical science environments will include structures and signals of agentic focus, and engineering/physical science students will both perceive agentic focus in their majors and value agency over communality in their own goal endorsements. A similar pattern of alignment between the environment and students' cognitions and motives would occur within life sciences (reflecting greater balance between agency and communality). Yet, it also possible that communal values will continue to be strongly held, regardless of environmental emphasis, because both agency and communality are fundamental motives that contribute to optimal functioning (Helgeson, 1994). Whether student values align with their perceptions of opportunity and with environmental structural and signals is important to document because incongruity can be an obstacle to persistence.

Current Research

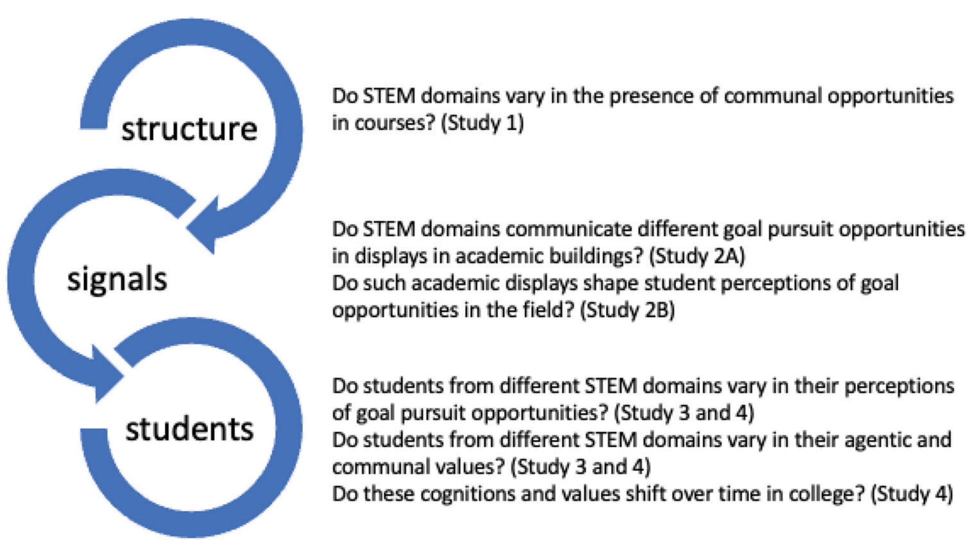
The current research examined whether life sciences vs. engineering/physical sciences vary in the visibility and value of communality and agency. Do motivational cultures vary across these STEM domains? We examine motivational culture as represented in environmental structures (Study 1), in signals sent and received in academic displays (Studies 2A–B), and then individual-level motives and cognitions (Studies 3–4). First, we examine whether activities and artifacts across STEM fields differentially emphasize communality and agency (Study 1 examines collaborative course activities; Study 2 A-B examines physical displays in academic buildings). Study 2B employs an experimental design to test whether environmental signals of motivational culture influence person-level beliefs. Finally, Studies 3 and 4 compare life science vs. engineering/physical sciences students' self-reported goals and affordance beliefs (with Study 4 examining motives and cognitions over time). Overall, these studies aim to investigate how local environments structure and signal what goals are afforded, and how students in these majors perceive their opportunities (see Figure 1).

Across multiple data sets employing different methods, we investigate variation in motivational culture. We anticipate that local STEM cultures will provide a relatively agentic focus: Opportunities for agentic goals will be more visible than opportunities for communal goals. This agentic focus may be especially present in engineering/physical sciences, compared to life sciences. Further, we examine how students perceive goal opportunities: Do students' beliefs reflect an agentic focus, or a balanced focus between agentic and communal goals?

Study 1: Collaborative Structures in Life Science and Engineering/Physical Science Courses

We first examine whether structural features of courses differ across STEM: Do courses in engineering/physical sciences vs. life sciences differ in collaborative assignments? These collaborative assignments can shape students' opportunities to connect to other students and to work together. Courses vary in the number of assignments that include peer-to-peer interaction. For instance, some courses assign more group projects while others emphasize independent study. The communal quality of science and math education relates to students' beliefs about whether STEM fields generally afford communal goals (Steinberg & Diekman, 2017). Study 1 tested whether life sciences courses include greater structural opportunities for collaboration, compared to engineering/physical science courses.

Figure 1
Conceptual Model of Current Studies



Note. See the online article for the color version of this figure.

Method

All procedures were reviewed by Institutional Review Boards under the approved protocols #00204 (Study 2A and 3), #1809393191 (Study 1 and 4), and #10813 (Study 2B). Data and analysis code can be found on Open Science Framework at https://osf.io/w3mx6/ (Joshi, 2021).

Procedure

An external group extracted data from the learning management system (Canvas) employed at a large Midwestern university containing 8 campuses (Diekman et al., 2021). The course data ranged from Fall 2014 to Spring 2021 with a total of 11,222 Canvas course sites (N_{life} = 4388; $N_{eng/phys}$ = 6834; see Table 1). We examined Canvas sites of in-person, 100- or 200-level courses in life sciences and engineering/physical sciences. Because these data were extracted from Canvas at the course level across multiple semesters, demographic information about students or instructors was not available.

Measures

The dataset contained count variables of collaborative assignment types. For each course, data included the number of discussion topics, the number of group assignments, and the number of peer assessment assignments. Analyses controlled for (a) the total number of graded assignments with a point value and due date and (b) course enrollments.

Results

Each dependent variable was analyzed with separate Poisson loglinear models to examine the effect of STEM domain on course activities. We dummy-coded each Canvas course site as life science (1) or engineering/physical science (0) using major classification from prior research (Stout et al., 2016).

As shown in Table 2, STEM domain type significantly predicted the inclusion of discussion topics, group assignments, and peer assessment assignments, controlling for number of students enrolled and number of assignments (see online supplemental materials for means). Specifically, engineering/physical science Canvas course sites included significantly fewer discussion topics, group assignments, and peer assessment assignments than life science course sites.

Discussion

Data across multiple campuses and several years show that STEM courses in life sciences vs. engineering/physical sciences provide different structural opportunities to work with others. In these early-curriculum classes, students in engineering/physical sciences have fewer opportunities to engage with their peers through discussion topics, group assignments, and peer review assessments. Yet the presence of communal opportunities early on (or lack thereof) may be important in shaping students' motivation to persist in their STEM major.

Study 2A: Academic Displays as Signals of Motivational Culture

Studies 2A-B examine the presence and consequences of the physical artifacts of bulletin boards in campus buildings. In Study 2A, we provide an in-depth examination of a particular campus environment by collecting and analyzing the images displayed in core STEM academic buildings. Based on the cues to motivational culture identified in Study 2A, we then experimentally manipulate these in Study 2B.

Method

Procedure

Two research assistants captured digital images from 3 buildings (biology, engineering, physics) at a midsized Midwestern campus. Images were captured within a two-day span during Spring 2018. Research assistants were instructed to photograph all bulletin boards on the first floor of each building and to avoid taking photographs of people. Research assistants captured images during less populated times. A total of 68 images were collected, with 29 images from the biology building, and the remaining 39 from the engineering (N = 26) and physics buildings (N = 13).

Table 1
Life and Engineering/Physical Science Courses

Life Science courses			Engineering/Physical Science courses		
Major	Frequency	Percentage	Major	Frequency	Percentage
Biology	2,560	58.3%	Math	2,968	43.4%
Geology	613	14.0%	Chemistry	2,236	32.7%
Physiology	524	11.9%	Computer Science	703	10.3%
Anatomy	185	4.2%	Physics	640	9.4%
Radiology	182	4.1%	Astronomy	187	2.7%
Microbiology	168	3.8%	Engineering	56	0.8%
Earth Sciences	64	1.5%	Aerospace Studies	24	0.4%
Medical Sciences	43	1.0%	Statistics	20	0.3%
Human Biology	23	0.5%			
Plant Science	14	0.3%			
Animal Behavior	8	0.2%			
Zoology	4	0.1%			
Total	4,388	100%	Total	6,834	100%

Table 2
Life Sciences Offer More Collaborative Course Assignments

	Frequency of collaborative course activity								
	Discussion topics			Group assignments			Peer assessment assignments		
Predictors	*b*	*Exp*(β)	*p*	*b*	*Exp*(β)	*p*	*b*	*Exp*(β)	*p*
STEM domain	0.66	1.94	.001	1.64	5.15	.001	4.48	88.56	.001
Total students enrolled	−0.002	0.99	.007	0.004	1.00	.001	0.01	0.99	.001
Total assignments	0.04	1.04	.001	0.04	1.04	.001	0.05	1.05	.001

Note. Positive β indicates more of the activity for life sciences than engineering/physical sciences, and negative β indicates more of the activity for engineering/physical sciences than life sciences. Unstandardized betas, *b*, and odds ratios, *Exp*(β), presented.

Each image was edited to be the same width dimensions and to obscure any identifying information (i.e., student images and institutional information). Photo-editing procedures involved steps to minimize potential confounds in the coding process. We removed identifying information about the departments to minimize the influence of coders' expectations about these fields. In addition, coders did not attend and were not familiar with the university where images were collected (materials are available from authors). Three sets of paired research assistants aided in the three stages of this Study: 1) capturing bulletin board images, 2) coding goal content, and 3) coding text content and representation.

Sensitivity analyses showed sufficient power (.80; α = .05; N = 68) to detect small to medium sized effects. A mixed model ANOVA with 2 groups and 2 repeated-measures could detect within-between interactions with an effect size of f = .14 or larger.

Measures

All minor discrepancies in coding goal content or goal cues were resolved through discussion and reported values represent the agreed-upon count or rating.

Goal Content. The coding scheme for agentic and communal purpose was based on existing measures of communal and agentic goals (Diekman et al., 2011). Communal purpose was defined as orientation to others, such as aspects related to community outreach programs, mentoring, collaborating, and altruistic opportunities (see Figure 2 for examples). Agentic purpose was defined as orientation to promoting the self, such as internship opportunities, graduate or career opportunities, independent work, and professional development opportunities.

Prior to coding, two coders were trained to identify communal and agentic goal content. For each board, goal content was measured through a holistic assessment of goals based on both pictures and images on each board. Ratings provide overall goal content perceptions of communal and agentic cues. Coders independently rated how much each bulletin board signaled communal purpose (k = .82) or agentic purpose (k = .72). Ratings were agreed upon by coders. Because certain board items can be both highly communal and agentic, coders provided a rating for each goal on a scale of 1 to 7, with increasing scores reflecting greater goal purpose. Coders were instructed to code boards that cued collaboration or opportunities to help others in either images or text as highly communal. Coders were also instructed to code boards that cued independence and self-development in either images or text as highly agentic. Boards that lacked cues related to helping others, working with others, and conducting research that benefits others were rated lower on communal goal content. Boards that lacked cues related to achievement, gaining skills, and learning new material were rated lower on agentic goal content. Boards that contained both types of content were rated highly on both goal indices.

Gender and Group Representation. Coders counted the numbers of individuals visually identifiable as men or women on each bulletin board. When visible gender was unrecognizable due to low image quality, coders did not count the individual. Coders then assessed whether each bulletin board contained groups of people (0 = not present, 1 = present).

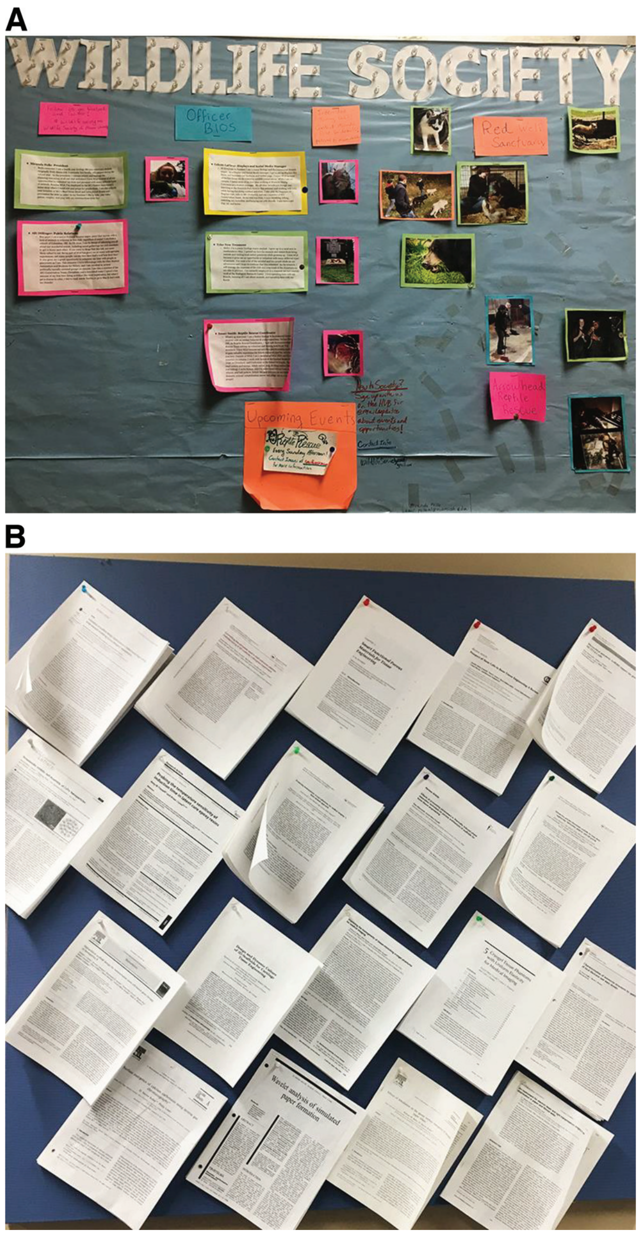
Text Content. Coders recorded whether the bulletin boards contained text related to (a) *helping others or being altruistic,* (b) *collaboration or working with others,* (c) *knowledge development/learning*, and (d) *succeeding/gaining recognition* (for each, 1 = present; 0 = not present). An example of *helpful* text was "Physics Education research . . . working to help more people succeed in physics," whereas an example of *collaborative* text was "With physics, you can communicate with people from different fields." An example of *knowledge development/learning* was "Students are exposed to new research methods and topics," and an example of *succeeding/gaining recognition* text was "The physics faculty seeks to recognize high achievement through awarding departmental honors."

Results

Goal Content

To examine whether the purpose presented on bulletin boards varied by STEM domain, we conducted a 2 (STEM Domain) × 2 (Goal Type) mixed ANOVA with STEM domain as a between-subjects factor. As shown in Figure 3, the STEM Domain × Goal interaction, $F(1, 66) = 5.49$, $p = .022$, $\eta_p^2 = .08$, reflected different patterns of portrayed agentic and communal goal content. Engineering/physical science bulletin boards conveyed a strong agentic focus: Agentic purpose ($M = 4.21$, $SD = 2.24$) in engineering/physical science bulletin boards was significantly higher than communal purpose ($M = 2.26$, $SD = 1.41$), $F(1, 66) = 16.11$, $p < .001$, d = .99. In contrast, life science bulletin boards conveyed balanced agentic and communal purpose: These displays did not differ in the presence of communal purpose ($M = 3.00$, $SD = 1.81$) and agentic purpose ($M = 3.21$, $SD = 1.57$), $F(1, 66) = .14$, $p = .714$, $d = .09$. Moreover, engineering/physical science boards, compared

Figure 2
Examples of Bulletin Boards Rated Highly on Communal Goal Content (A) and Agentic Goal Content (B)



Note. See the online article for the color version of this figure.

to life sciences boards, contained greater agentic content, $F(1, 66) = 4.22$, $p = .044$, $d = .51$, and nonsignificantly less communal content, $F(1, 66) = 3.63$, $p = .061$, $d = .47$.

What Specific Cues Inform Perceptions of Purpose?

Using bulletin board as the unit of analysis, we conducted regressions to determine whether specific visual or text cues predicted coders' perceptions of conveyed purpose, above and beyond STEM domain. The multilinear regression model revealed that the presence of fewer men, more women, and more groups positively cued communal purpose (see Table 3). In contrast, the presence of groups negatively cued agentic purpose.

Specific forms of text also informed perceptions of purpose. Not surprisingly, the largest text effect was that the presence of helping text predicted communal purpose. More surprising is that the presence of collaborative and learning text predicted agentic purpose; yet this finding is consistent with prior evidence that communal practices can be seen as supportive of agentic goals of self-development in education (e.g., Fuesting et al., 2019). The inclusion of specific predictors statistically accounts for the STEM domain difference in communal but not agentic purpose: Engineering/physical sciences were perceived as cuing more agentic purpose than life sciences, even when accounting for these specific forms of information.

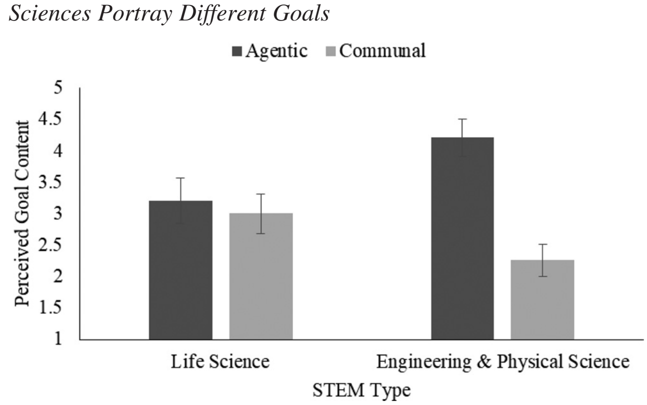
Discussion

Study 2A documented that the departmental displays naturalistically located in STEM environments differed in their goal-relevant content. Specifically, the bulletin boards in engineering/physical science buildings signaled an agentic focus (i.e., greater agentic than communal purpose), whereas bulletin boards in life sciences signaled a balanced agentic and communal focus. Further, specific elements of the displays accounted for differences in the perceived communal purpose of engineering/physical sciences compared to life sciences. In Study 2B, we experimentally manipulated these features (helping text and depiction of people) to assess effects on student perceptions of goal opportunities in the local culture.

Study 2B: Consequences of Environmental Markers on Student Perceptions

In Study 2B, we randomly assigned participants to view bulletin boards that varied in their content. To minimize confounds, we created images of bulletin boards ostensibly in buildings of novel STEM domains. Using novel STEM fields removes the potential influence of existing stereotypes. This study thus provides an experimental test of whether environmental-level indicators of motivational culture influence individual-level beliefs.

Figure 3
Bulletin Boards in Life Sciences and Engineering/Physical Sciences Portray Different Goals



Note. Error bars reflect ± 1 standard error. Coders rated portrayed purpose on scales from 1 to 7, with higher values indicating greater presence of purpose.

Table 3
Bulletin Board Content as Cues to Motivational Culture

Predictors	Goal content					
	Agentic			Communal		
STEM domain	*b*	β	*p*	*b*	β	*p*
Life Sciences (1) vs. Engineering/ Physical Sciences (0)	−1.074	−0.265	.019	0.51	0.157	.152
Representation						
# of men present	−0.03	−0.04	.800	−0.18	−0.36	.028
# of women present	−0.08	−0.10	.495	0.22	0.34	.020
Group presence	−1.59	−0.39	.003	1.41	0.43	.001
Text						
Helping	−0.92	−0.18	.103	1.30	0.32	.004
Collaborative	0.96	0.23	.038	0.20	0.06	.584
Knowledge development	1.09	0.23	.036	−0.60	−0.16	.140
Success and recognition	1.21	0.21	.077	−0.17	−0.04	.758

Note. Unstandardized and standardized betas presented. Positive β indicates more goal content for life than engineering/physical sciences, and negative β indicates more goal content for engineering/physical sciences than life sciences. All text categories and groups were coded as 1 present or 0 not present.

Method

Participants

Study 2B recruited 46 STEM majors to participate and compensated $.50 for their time. Of these students, 10 were life science majors and 39 engineering/physical science majors. An additional 2 participants were excluded due to failed attention checks. The sample was mostly male (69.6%) and White (57.8%; 42.2% Black/African American) with an average age of 33 ($SD = 9.98$).

Sensitivity analyses showed sufficient power (.80; $\alpha = .05$; $N = 46$) to detect small to medium sized effects. A repeated-measures ANOVA was powered to detect a 2 × 2 interaction with an effect size of $f = .17$ or larger.

Procedure

Participants sequentially viewed four bulletin boards, each from a novel STEM domain (*ecopsychology, cliodynamics, nutrigenomics*, and *synthetic biology*). We manipulated goal focus in displays using the group and gender cues identified in Study 2A (see online supplemental materials). Participants viewed two boards that presented communal affordances, such as groups of people working together (i.e., communal-cue condition), and two boards that presented agentic affordances, such as individuals working alone (i.e., agentic-cue condition). Drawing from Study 2A, the communal-cue vs. agentic-cue boards also included depictions of more women and groups. The 4 STEM domains were counterbalanced so that participants saw only the communal or agentic version of each specific STEM domain. Analyses were conducted across the two blocks with a total of eight bulletin boards.

Measure

After viewing each bulletin board, participants were instructed to imagine themselves in each department and to rate how likely they were to experience communal and agentic opportunities in that particular department. Communal affordance items were *work with or collaborate with others*, *conduct research that benefits others, form connections with others,* and *increase your affiliation with others* (αs > .93). Agentic affordance items were *gain competence, gain new skills, gain a deeper understanding of course or research materials,* and *gain success* (αs = .95). Items were measured on scales from 1 (*Not at all*) to 7 (*Extremely*).

Results

To examine if environmental cues influenced perceived goal affordances, we submitted the data to a 2 (Goal Cue) × 2 (Affordance Type) repeated-measures ANOVA with participant gender as a covariate.[2] Only the main effect of Goal cue emerged, $F(1, 44) = 5.02$, $p = .030$, $\eta_p^2 = .10$: Communal-cue bulletin boards were perceived higher in communal and agentic affordances than agentic-cue bulletin boards (see Figure 4).

Discussion

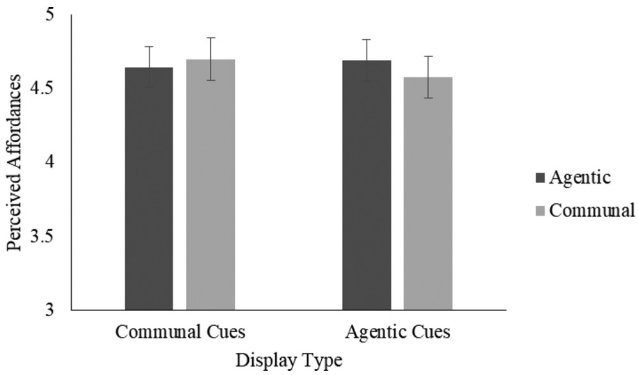
Study 2B examined the causal implications of displays that explicitly cue communality. Here, the experimental manipulation of displays to include depictions of collaborative activity and more women led to differential perceptions of communality across hypothetical departments. These studies provide evidence that the motivational signals in environments can influence individuals' perceptions of goal opportunities.

Study 3: What Goals Are Emphasized by Life Sciences and Engineering/Physical Sciences Students?

Studies 1 and 2 documented that that the structures engineering/physical sciences afford less collaboration than those in life sciences, and the visual displays in engineering/physical sciences emphasize agency, whereas those in life sciences emphasize a balance of communality and agency. We now turn to documenting the psychology of *students* in these majors. In Studies 3 and 4, we examine whether life science students and engineering/physical science students differ in the motivational opportunities they perceive and in the goals they

[2] Including participant age and reported SES did not change the pattern or significance of these effects.

Figure 4
Bulletin Boards Portray Different Goal Opportunities



Note. Error bars reflect ± 1 standard error. Participants rated affordances on scales from 1 (not at all) to 7 (extremely).

personally value. Does the agentic focus conveyed in STEM structures and signals manifest in student cognitions and values?

Method

Participants

326 STEM majors were recruited from the introductory psychology participant pool at a large Midwestern university as part of a mass survey data collection across two semesters. Participants were each compensated with partial course credit. The sample included 140 men and 180 women. The sample was majority White (73.1%), in their 1st or 2nd year of undergraduate education (69.3%), and 89.9% were between the ages of 18–20. As shown in Table 4, of these students, 229 were life science majors (64 men; 160 women) and 96 engineering/physical science majors (76 men; 20 women; majors were classified as in prior research; Stout et al., 2016). For a mixed 2 (STEM domain: life science, engineering/physical science) × 2 (Goal type: agentic, communal) × 2 (Gender: men, women) interaction with STEM domain and gender as between-subjects variables (power = .80; α = .05, $N = 326$), sensitivity analyses indicated a detectable small to moderate effect size of $f = .09$.

Procedure

Participants completed the measures described below and reported their major and demographics.

Measures

Major Affordances. Participants rated how much their major fulfilled communal and agentic goals on scales ranging from 1 (*Not at all*) to 7 (*Extremely*). Students rated how much their *major* provided opportunities to fulfill 9 communal goals (*help others, serve humanity, serve the community, work with people, connect with others, attend to others, be intimate, gain spiritual reward*; α = .90) and 13 agentic goals (*gain power, gain recognition, achieve, gain mastery, self-promote, be independent, gain status, focus on the self, succeed, gain financial reward, gain self-direction, be competitive*; α = .93). An example communal affordance item is “As a student in the courses for your major, are you able to serve the community?”

Personal Goal Endorsement. Participants rated several goals according to “how important each of the following kinds of goals is to you personally” (Diekman et al., 2010). The 10 communal goal items included *helping others, serving humanity, serving the community, working with people, connecting with others, attending to others, caring for others, intimacy, spiritual reward,* and *serving as a role model in society* (α = .90). The 14 agentic goal items included *power, recognition, achievement, mastery, self-promotion, independence, individualism, status, focus on the self, success, financial reward, self-direction, demonstrating skill or competence,* and *competition* (α = .91). Ratings were made on scales ranging from 1 (*Not at all important*) to 7 (*Extremely important*).

Results

Goal affordances and endorsement were submitted to 2 STEM Domain (life science, engineering/physical science) × 2 Goal type (communal, agentic) × 2 Gender (men, women) mixed analyses of covariance (ANCOVAs) with goal type as the within-subjects factor and gender as the covariate.[3]

What Goal Opportunities Do Students See?

Consistent with previously documented stereotypes, students perceived greater agentic opportunity ($M = 4.94$, $SD = 1.24$) than communal opportunity ($M = 4.38$, $SD = 1.42$), $F(1, 322) = 13.18$, $p < .001$, $\eta_p^2 = .04$, in their STEM majors. This pattern was more pronounced among engineering/physical science majors, as reflected in the STEM Domain × Goal interaction, $F(1, 322) = 16.29$, $p < .001$, $\eta_p^2 = .05$. As shown in Figure 5, engineering/physical science students perceived greater agentic opportunities ($M = 4.92$, $SD = 1.31$) than communal opportunities ($M = 4.13$, $SD = 1.42$), $F(1, 322) = 70.18$, $p < .001$, $d = .93$; this agentic focus was attenuated in life sciences ($M_{communal} = 4.64$, $SD = 1.40$; $M_{agentic} = 4.96$, $SD = 1.21$), $F(1, 322) = 29.82$, $p < .001$, $d = .61$. In addition, life science majors perceived greater communal affordances than did engineering/physical science students, $F(1, 322) = 14.89$, $p = .006$, $d = .31$. The STEM domains did not differ in perceptions of agentic affordances, $F(1, 322) = .07$, $p = .789$, $d < .01$. Students majoring in engineering/physical science perceived a strong agentic focus in their opportunities, whereas students majoring in life sciences perceived more balance of agentic and communal opportunities.

What Goals Do Students Value?

The goals personally endorsed by students differed from the opportunities they saw in their majors. Here, the STEM Domain × Goal interaction, $F(1, 321) = 21.98$, $p < .001$, $\eta_p^2 = .06$, revealed that life science majors valued communal goals ($M = 5.62$, $SD = .93$) more highly than agentic goals ($M = 5.21$, $SD = .95$), $F(1, 321) = 36.88$, $p < .001$, $d = .68$. In contrast, engineering/physical science majors' valued goals were balanced ($M_{communal} = 4.99$, $SD = 1.25$; $M_{agentic} = 5.22$, $SD = 1.10$), $F(1, 321) = 3.55$, $p = .06$, $d = .21$.

[3] Including participant SES did not change the pattern or significance of these effects.

Table 4
Participant Representation Across STEM Domains

Life Science majors	%	Engineering and Physical Science majors	%
Biology	47.6	Informatics	39.2
Human Biology	27.5	Computer Science	23.7
Animal Behavior	10.9	Chemistry	16.5
Biochemistry	10.0	Information Systems	4.1
Microbiology	1.7	Game Design	3.1
Environmental Science	0.9	Biotechnology	2.1
Molecular Life Sciences	0.9	Computer Science and Math	2.1
Optometry	0.4	Data Science	2.1
		Intelligent Systems Engineering	2.1
		Astrophysics	1.0
		Audio Engineering	1.0
		Biomedical Engineering	1.0
		Chemistry and Math	1.0
		Mathematics	1.0

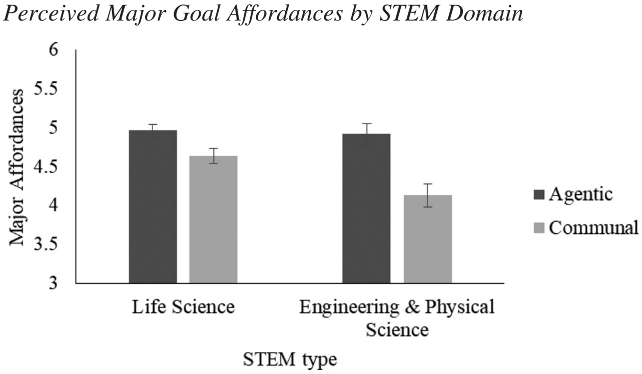
Discussion

These data document that life sciences vs. engineering/physical sciences students perceive their STEM majors to afford different goal configurations, consistent with the environmental structures and signals documented in Studies 1 and 2. The stereotypic pattern of greater agentic than communal focus was heightened among engineering/physical sciences relative to life sciences. Both STEM domains were seen as offering opportunities to achieve or develop mastery, but opportunities to connect with or help others were seen as more available in life sciences. The perceived predominance of agentic opportunities in engineering/physical sciences may lead to experiences of lack of fit for some students, particularly given that engineering/physical science students valued both agentic and communal goals. To determine whether these cognitions and values are stable or shift over time, we turned to longitudinal methods in Study 4.

Study 4: Student Motivational Foci Over Time

In this study, we examined student cognitions and values across a year of their college experience. The majority of Study 3 participants were early in college, and thus it is unclear whether the perceptions and values documented there persist as students advance in their majors. In particular, it is important to see whether engineering/physical science students' affordances remain agentically focused, and whether their values shift away from balanced agency/communality to an agentic focus. If engineering/physical science students perceive few communal opportunities, even in more advanced activities in their major, but retain high levels of communal values, they may experience detrimental effects of lack of fit. On the other hand, the affordances of engineering/physical sciences might shift as they advance through course work and engage differently with peers and instructors. Specifically, the agentic focus perceived by engineering/physical science students may attenuate over time if achievement or mastery in these fields is increasingly pursued in light of collaboration or projects with societal application (e.g., capstone projects). Indeed, advanced chemistry students reported high levels of both communal and agentic affordances (Riegle-Crumb et al., 2019).

Figure 5
Perceived Major Goal Affordances by STEM Domain



Note. Participant responses could range from 1 (*not at all*) to 7 (*extremely*). Error bars reflect ± 1 standard error.

Method

Participants

Participants were recruited from introductory STEM courses or the psychology participant pool at a midsize Midwestern university. The e-mail recruitment message called for STEM majors to participate in a longitudinal study of perceptions about whether different roles fulfill valued goals.

In time 1, 168 STEM students were each compensated with a $10.00 gift card or partial course credit. The time 1 sample included 77 men, 79 women, and 12 participants who did not disclose their gender. The sample was majority European American (82%), and age ranged from 17 to 30. Of these students, 93 were life science majors (32 men; 55 women; 6 did not specify) and 75 engineering/physical science majors [45 men; 24 women; 6 did not specify; majors were classified as in prior research (Stout et al., 2016; see Table 5).

Approximately one year later (time 2), 110 students from time 1 (57 women, 53 men) were compensated with a $15 gift card. These students constituted the core sample for analyses. Among the men, 24 were life science majors and 29 were engineering/physical science

Table 5
Participant Representation Across STEM Majors

STEM domain			
Life Science majors	%	Engineering and Physical Science majors	%
Biology	39.8	Computer Science	28.0
Zoology	26.9	Chemical Engineering	13.3
Biochemistry	19.4	Mechanical Engineering	13.3
Microbiology	9.7	Chemistry	12.0
Environmental Earth Science	2.2	Bioengineering	5.3
Biological Physics	1.1	Electrical Engineering	5.3
Geology and Botany	1.1	Physics	5.3
		Software Engineering	5.3
		Computer Science & Software Engineering	2.7
		Mathematics	2.7
		Mathematics and Physics	2.7
		Computer Engineering	1.3
		Engineering Management	1.3

majors.[4] Among the women, 38 were life science majors and 19 were engineering/physical science majors. The attrition from time 1 to time 2 was 58 participants, or 34.5% of time 1 participants (varying from 20.8% of time 1 female engineering/physical science majors to 35.6% of time 1 male engineering/physical science majors). For a mixed 2 × 2 × 2 × 2 interaction with two between-subjects variables (power = .80; α = .05, N = 110), sensitivity analyses indicated ability to detect a small to moderate effect size of f = .14.

Procedure

After granting informed consent, participants completed a battery of measures. Only those relevant to current hypotheses are reported here; other measures and results are available from the authors. All hypotheses and analyses presented here are new; analyses testing different hypotheses that employed measures and/or subsamples have been previously (Belanger et al., 2020; Benson-Greenwald & Diekman, 2021; Diekman et al., 2020). Participants reported their goal endorsements and items relevant to their current STEM major. After completing the study, participants were debriefed and compensated.

Measures

Measures were collected at both time points.

Major Affordances. Participants rated the goal opportunities of their major on shortened versions of the Study 3 measures. Ratings were made on scales ranging from 1 (*Not at all*) to 7 (*Extremely*). Participants first rated how much their *major* provided opportunities to fulfill 3 communal goals (*serve the community, work with others,* and *help others*; α_{T1} = .70; α_{T2} = .71) and 3 agentic goals (*gain power, achievement,* and *independence*; α_{T1} = .54; α_{T2} = .69).[5]

Personal Goal Endorsement. Participants rated the personal importance of each communal goal (α_{T1} = .89; α_{T2} = .88) and agentic goal (α_{T1} = .85; α_{T2} = .87) on the same items as Study 3. Ratings were made on scales ranging from 1 (*Not at all important*) to 7 (*Extremely important*).

Results

We examined variation in goal affordances and endorsement in 2 STEM Domain (life science, engineering/physical science) × 2 Goal type (communal, agentic) × 2 Time × 2 Gender (men, women) mixed ANCOVAs, with STEM domain as a between-subjects factor and gender as the covariate. We report all significant effects ($p < .05$).[6]

What Goal Opportunities Do Students See?

Consistent with Study 3, the Goal × STEM Domain interaction showed that the effect of goal type was more pronounced among engineering/physical sciences, $F(1, 107) = 4.35$, $p = .039$, $\eta_p^2 =$ .04. Yet these patterns varied across time, as reflected in the Goal × STEM Domain × time interaction, $F(1, 107) = 6.43$, $p = .013$, $\eta_p^2 = .06$. As shown in Figure 6, engineering/physical science students' perceptions of greater agentic than communal opportunities attenuated over time. Engineering/physical science majors perceived greater agentic opportunity (M = 5.51, SD = .92) than communal opportunity (M = 4.64, SD = 1.12) at time 1, $F(1, 107) =$ 30.39, $p < .001$, $d = -1.07$, but to a smaller extent at time 2 ($M_{agenticT2}$ = 5.18, SD = 1.12; $M_{commnalT2}$ = 4.80, SD = 1.30), $F(1, 107) = 5.22$, $p = .024$, $d = .44$. In contrast, the balanced opportunities perceived by life sciences majors showed stability: Life sciences majors' perceived agentic affordances (M = 5.04, SD = .92) and communal affordances (M = 4.85, SD = 1.13) did not differ at time 1, $F(1, 106) = 2.07$, $p = .154$, $d = .28$, or time 2 ($M_{agenticT2}$ = 5.10, SD = 1.13; $M_{commnalT2}$ = 4.82, SD = 1.30), $F(1, 107) = 3.62$, $p = .060$, $d = .37$.

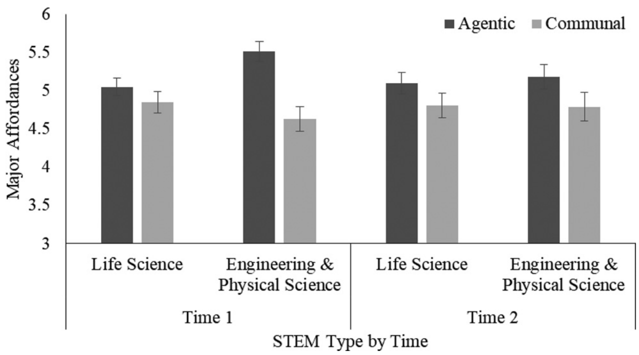
Another way to describe this pattern is that engineering/physical science students' cognitions become more similar to life science students with college experience. At time 1, the agentic affordances perceived by engineering/physical science students were higher than life science students, $F(1, 107) = 7.11$, $p = .009$, $d =$ .52, but did not differ at time 2, $F(1, 107) = .15$, $p = .701$, $d = .06$.

[4] One participant reported changing major from life sciences to engineering/physical sciences after Time 1; in analyses the participant was categorized as a life science major.

[5] Although the alphas for major agentic affordances are low at Time 1, we retained the scale average in order to compare results across time points.

[6] Including participant age did not change the pattern or significance of these effects.

Figure 6
Perceived Affordances in Majors Vary by STEM Domain and Time



Note. Error bars reflect ± 1 standard error. Participants rated affordances on scales ranging from 1 (not at all) to 7 (extremely).

The communal affordances did not differ between life science students and engineering/physical science students at either time point [time 1, $F(1, 107) = .90$, $p = .345$, $d = .18$, or time 2, $F(1, 107) = .01$, $p = .916$, $d < .01$]. In sum, the agentic focus of perceived opportunities in engineering/physical sciences appears to attenuate over time.[7]

What Goals Do Students Value?

Again, students' reports of their personal values diverged from their perceived opportunities. Similar to Study 3, the Goal × STEM Domain interaction, $F(1, 105) = 7.90$, $p = .006$, $\eta_p^2 = .07$, revealed that life science majors reported a greater communal focus ($M = 5.18$, $SD = 1.24$) than agentic focus ($M = 4.63$, $SD = .99$), $F(1, 105) = 20.27$, $p < .001$, $d = .88$, whereas engineering/physical science students reported balanced agentic and communal endorsement ($M_{communal} = 4.88$, $SD = 1.40$; $M_{agentic} = 4.86$, $SD = 1.12$), $F(1, 105) = .03$, $p = .867$, $d < .01$. Effects of time or gender did not reach significance, $ps > .14$.

Discussion

The striking finding of Study 4 is that although life sciences and engineering/physical sciences report different goal opportunities early in college, these perceptions become more similar over time. With greater college experience, both engineering/physical science and life science students perceive opportunities to fulfill agentic and communal goals in their majors. The agentic focus of engineering/physical science students present early in college shifts to greater balance just a year later. This pattern provides reason for optimism, because perceiving one's major as supporting the fulfillment of a wide range of goals can benefit student motivation and persistence. This variation in affordances across time is consistent with prior research showing that motivational effects fluctuate over time in college (Allen et al., 2018).

These findings also provide a clear message that early in college, highly communal students may experience a lack of fit in their engineering/physical sciences environments. Similar to Study 3, early-college engineering/physical science students perceived a stronger agentic than communal focus in their major. This early-college differential agentic focus also aligns with the structures and signals of the environments documented in Studies 1 and 2. For students who are highly communally motivated, they may perceive agentically focused environments as places where they cannot be their authentic selves (Schmader & Sedikides, 2018). Both engineering/physical science students and life science students reported high levels of communal values, and thus local cultures who seek to retain a wide range of students may benefit from adapting structures and signals to include communality.

General Discussion

These studies investigate the existence and consequences of varying motivational cultures across the STEM domains of life sciences versus engineering/physical sciences. Across both environmental aspects (course activities and physical displays) and individual aspects (perceived goal opportunities and personal values), we find evidence that the motivational culture in engineering/physical sciences emphasizes agency. Courses in engineering/physical sciences included fewer collaboratively structured assignments than those in life sciences, and bulletin boards in engineering/physical sciences academic buildings conveyed less communal purpose. Students' own cognitions and values aligned with these environmental structures and signals: Engineering/physical sciences students reported greater agentic focus, whereas life sciences students reported either an attenuated agentic focus or a balance of goal opportunities.

Theoretical Contributions

This research builds on goal congruity theory (Diekman et al., 2017, 2020) by highlighting the institutional structures and practices that can shape individual-level motives and cognition related to engagement in STEM pathways. Examining motivation through a cultural lens expands understanding of how students navigate their STEM pathways because these structural and environmental practices can constrain or amplify individual motivation. Consistent with Kruglanski et al. (2014), "will" is a psychological property expressed within conducive environments; motivation thus is usefully construed not just as a property of a person, but also of a place.

The documentation of motivational culture, as reflected in students' perspectives and in environmental aspects such as course activities or academic displays, provides a new lens to understand student motivation as fundamentally embedded in local contexts. This theoretical emphasis aligns with calls in the literature to understand self-control as not solely emanating from the self, but also as emanating from situations (Fujita, 2011). For example, self-regulation is frequently conceptualized as an individual-level phenomenon: How can an individual student build self-control or avoid temptations? The current works carries forward the idea that environments constrain or facilitate the motives of an individual (Kruglanski et al., 2014). Here, we shift the focus from individual motivation (e.g., goal endorsement) to also include motivational

[7] Analyses examining perceived major affordances found that engineering/physical science students who left compared to those who stayed after Time 1 did not differ on perceived agentic affordances, $F(1, 153) = 0.12$, $p = .732$, $d < .01$. The attenuated gap at Time 2 does not appear to be due to attrition from Time 1 (see online supplemental materials for means).

opportunities present in the local culture that surrounds that individual. Situating individual motivation within cultures provides a view of motivation that includes structural and contextual processes, rather than solely intrapersonal or interpersonal processes.

Practical Implications

These studies provide novel information about the potential for local environments to shape the goal opportunities present and perceived by students. Overall, STEM pathways that offer communal opportunities yield increased interest, especially for women (Diekman et al., 2011) or for underrepresented minority students (Estrada et al., 2018; Thoman et al., 2017). Due to a perceived lack of communal affordances in the engineering/physical sciences, efforts to broaden representation in STEM might focus on embedding communal affordances in engineering/physical science environments. The current work suggests that structural and signaling practices may be a point of intervention: For instance, institutions can include greater depictions of collaborative science activity and provide assignments that allow greater collaboration and connection with peers. Embedding communal opportunities within structures and practices may be a route to increasing women's sense of belonging in their STEM majors (Belanger et al., 2020), fairness in STEM environments (Joshi & Diekman, 2021), and commitment to STEM (Thoman et al., 2015).

Limitations and Future Directions

The documentation of different motivational cultures in two domains of STEM offers an advance over considering STEM as a monolith, but this binary division continues to oversimplify the complexity of these fields. Yet, the existing framework can provide a foundation for further exploration. Certainly, an important path for future research is to understand how local environments differ not only between STEM fields but also within STEM fields and across institutions. The current research demonstrates that there can be considerable difference in the motivational culture of STEM fields, even within one university. Future work documenting markers of motivational cultures should consider examining cues within a wider range of contexts, including institutions that serve primarily Black, Hispanic, or Native students. Understanding variability over time also provides new directions for research: The finding that student perceptions of affordances converged over time leads to questions about underlying mechanisms. One hypothesis is that the course structures and topics shift from early college to late college, and in so doing shift in their provision of communal and agentic opportunities. Prior research has found that students who report greater communal experience in their science and math courses perceived STEM fields to afford more communal goals (Brown et al., 2018; Steinberg & Diekman, 2017). Further understanding variability across institutions, regions, nations, or time is a valuable direction for advancing knowledge about the existence and consequences of motivational culture.

A limitation of the current research is that these data cannot yet speak to student characteristics, such as socioeconomic status, age, or past STEM performance, that might intersect with their experience of STEM culture. For example, these studies did not examine student socioeconomic status or first-generation status. Higher education signals an independent culture that can be a cultural mismatch to the interdependence of first-generation students (e.g., Stephens et al., 2012). Understanding how student SES or first-generation status affects their experience in local cultures that differentially emphasize agency or communality is a fruitful avenue for future work.

A cultural perspective also highlights the importance of studying individuals who shape culture: In this instance, instructors hold and convey messages about the values central to their disciplines. Indeed, instructors create and communicate goal opportunities by how they structure their courses: Is collaborative work part of the course? Are students graded on a curve (and thus competing with each other)? These activities and messages matter for student experience; growth-oriented instructors are perceived as offering both communal and agentic opportunities in their courses, and these perceived affordances relate to students' self-reported engagement and helping behavior in class (Fuesting et al., 2019). Yet, how much faculty can influence classroom practices can be constrained by various factors, including broader institutional and departmental support. Individual faculty efforts to shift motivational culture will be more successful if the local culture is embedded in broader contexts that support such cultural change.

Finally, this initial investigation of motivational culture focused on agentic or communal content of goals. Yet, there are other meaningful aspects of goal pursuit that might vary with local culture, including goal pursuit processes (Fishbach & Ferguson, 2007), how individuals regulate their own motivation (Scholer et al., 2018), or the structure of goals (Scholer et al., 2018). Specific local cultures can bolster or inhibit motivational benefits by influencing these aspects of goal pursuit, above and beyond effects of goal content. In addition, it is also important to examine the impact of motivational cultures on performance within these pathways. For instance, what are the costs or benefits of emphasizing both agentic and communal goals on student experience and performance? Unpacking motivational culture thus provides a rich domain for future exploration.

Conclusion

This research documents that local STEM cultures vary in their emphasis on communal and agentic goals. Considering motivational culture can provide new insights in understanding motivation as embedded and expressed in both individuals and environments, and in illuminating how students navigate their educational and occupational pathways.

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In the article "Measuring Avoidance-Related Trait Anger: American and Polish Versions of the Avoidance Motivated Response to Anger Scale (AMRAS)," by Kinga Szymaniak, Sylvia K. Harmon-Jones, and Eddie Harmon-Jones (*Motivation Science*, advance online publication, February 28, 2022, http://doi.org/10.1037/mot0000263), the acknowledgment of support in the title page author note was incomplete. The full acknowledgment is as follows: "This work was supported by the National Science Center under the Preludium 2018/31/N/HS6/00201 grant and the Etiuda 2019/32/T/HS6/00082 scholarship awarded to Kinga Szymaniak and by the Australian Research Council under Discovery Project DP180102504 awarded to Eddie Harmon-Jones. Sylvia K. Harmon-Jones was supported by an Australian Government Research Training Program scholarship." All versions of this article have been corrected.

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