Modeling Peer Selection and Influence in Youth Social Networks: A Case Study for U.S. Marine Corps Recruiting and Training

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Summary. Youth currently entering the job market are part of Generation Z. Research suggests that this generation is different from others in their values and life priorities and will challenge organizations who wish to attract, develop, and retain its members while ensuring the same level of operations. We present a simulation-based approach to understanding how peer selection and peer influence drive the spread of behaviors, values, and beliefs through social networks of youths, and how organizations can use influence pathways in such networks to recruit and develop their personnel. We illustrate our approach on a case study of United States Marine Corps (USMC) recruiting and training. We detail the logic and theoretical underpinnings of our model and describe how it allows to understand the driving forces of generational changes in the young American population and how they might be addressed. We show that while peer influence with respect to relevant Marines' traits is a highly elastic process, peer selection is rooted in deep-seated, slowly changing individual perceptions. We further show that peer influence is confined to intimate networks, making intervention difficult. Finally, we discuss recommendations for Marine Corps training and recruiting approaches as implied by the findings from our model.

1. Introduction

American youth, who are members of Generation Z (those born between 1996 and 2010) are hypothesized to be significantly different from their predecessors in a number of meaningful ways. Scientific and anecdotal evidence points to major shifts in the life priorities, values, aptitude, communication patterns, physical as well as mental health and wellbeing, and behaviors of young Americans in the past decade. Such dramatic changes may pose challenges to recruiting and training members of this generation for service in the U.S. Marine Corps (USMC) and other branches of the United States military, more broadly. Despite this projection, the recruitment and training missions of the Marine Corps—in terms of the quantity and quality of future Marines—must remain the same. The dwindling interest in military service and continuing declines in desirable skills and aptitudes among today's young Americans therefore presents risk to the service

which is consistently in seek of new Marines. Spurred by this realization, the USMC Manpower and Reserve Affairs (M&RA) sponsored a study of American Generation Z youth and how their characteristics will potentially require changes to recruiting and training approaches in order to meet their mission.

As part of this larger study, we took an agent-based modeling approach that allowed us to discover and understand the mechanisms responsible for the spread of personality traits relevant for Marine Corps service throughout youth social networks, and further enabled us to evaluate candidate interventions aimed at mitigating or promoting trends within those networks.

The model that we designed allows us to represent youth as individual actors within a larger network of social interactions involving peers and authority figures. We conceptualize individual youth as boundedly rational agents who employ strategies for peer selection and peer influence under the constraints of incomplete information, in order to satisfy their competing desires for social and cultural conformity, individuality, and influence over their peers. Furthermore, the model can represent both unstructured social environments as well as highly structured environments such as those found in military training environments.

With the model established, we then asked two questions: (1) *“What are the individual-level social strategies responsible for the observed trends in a variety of behavioral and attitudinal traits of American youth?”* and (2) *“How can such trends be mitigated or promoted using targeted interventions aimed at the larger youth population or the recruit population of the Marine Corps?”*

Using this model, we show how the core principles of homophily and the selection of unknown personality traits in social ties (indirectly biased by the presence of specific superficial traits) can explain the diffusion of relevant behaviors, values, and attitudes.

We further show that influencing behaviors and attitudes relevant for USMC recruiting and training will be a hard problem, because most influence on these traits is confined to highly intimate layers of youth social networks. However, we demonstrate multiple ways how undesirable trends can be avoided in the training environment through targeted interventions. The first such intervention is the early identification of recruits with poor potential for acculturation and their one-on-one mentorship throughout the training process, possibly coupled with the pairing of these recruits with peers who have proven leadership qualities. The second intervention is a change in the hierarchy of recruit training that would allow members of different training units on all levels up to the company echelon to train together more frequently, allowing exposure to greater thought diversity.

In the following section we first describe the background of the study. Subsequently, we detail our methodological approach. In the final two section we describe the results of our model experiments in detail and we follow this with a broader discussion of the meaning of these findings and their implications.

2. Background

2.1. Marine Corps Recruiting and Training

In 2019 USMC M&RA leadership recognized that the Marine Corps must adjust its current industrial age approaches to better attract, train, and educate future generations of Marines. Specifically, M&RA acknowledged that current Marine Corps recruitment and indoctrination methods were designed for generations of Americans without social media or portable electronic devices and did not account for the cultural shifts that these technologies brought about. As these technologies have evolved into foundational tools for young Americans' sources of entertainment, information, education, and social interaction, it became increasingly clear that past practices in attracting, acculturating, training and retraining young Marines needed to adjust to ensure that the USMC was adequately manned and trained to fight future wars. Consequently, M&RA requested insight on best practices for the recruitment, education, and training of the young American population; a specific objective of the study was to identify risks and opportunities for future manning of the Marine Corps with the target population. The ensuing reports stemming for this study were intended to inform leadership decisions on potential adjustments to recruiting and developing new Marines.

The requested scope of the study focused on the current American population between 13 and 18 years of age. Specifically, M&RA asked the study team to assess the digital, educational, physical, cognitive, and social characteristics and activities of the target population. The study sponsor also sought insight into the target population's perceptions of military service, the nation's role in the world, life goals, aptitude for service and how the population learns, interacts with each other, interacts with authority, and is motivated. The study was further required to consider athletic participation, muscular and cardiovascular fitness, and physical diseases and maladies.

To conduct the study, and to ultimately derive insights and provide recommendations to M&RA, we devised a four-pronged mixed-methods approach. We performed a qualitative meta-analysis of scientific and market research literature studying the target population to formulate major themes and assess the expert consensus about Generation Z. We also conducted statistical analyses of quantitative data, including public-use data sets such as youth surveys, Marine Corps data reporting on Marine characteristics and performance, and Joint data on youth perceptions of military service, to corroborate the consensus identified from the literature, and to further focus the study on issues related to Marine Corps service. Furthermore, we conducted interviews with current Marine Corps recruiters and instructors which resulted in anecdotal supporting evidence based on their experiences with and perceptions of recent recruit cohorts. Finally, we designed and implemented an agent-based model of youth social dynamics to uncover the mechanisms responsible for the diffusion of relevant behaviors and attitudes throughout youth social networks and to demonstrate how these trends may change in the future and how they might be mitigated or promoted through intervention.

We believe that such a mixed-methods approach to answer personnel questions in the domain of military service is novel, especially owing to the use of agent-based modeling to support the study and complement the other three methods of inquiry. We are not aware of other similar studies that employed this multi-pronged methodological approach to a future manning or personnel issue.

While the ultimate set of recommendations delivered to M&RA rested on findings accumulated through all four methods of inquiry, in this document, we focus on what we believe to be the most innovative aspect of our approach, the agent-based model and related analysis.

2.2. *Agent-based modeling of trait diffusion*

Agent-based models (ABMs) simulate decision-making of individual agents who interact with each other and with their environment. Historically, ABMs have been useful in elucidating how macro trends emerge from the uncoordinated behavior of boundedly rational actors acting on incomplete information. ABM researchers have also contributed towards explanations of diffusion of behaviors, norms, and culture. Axelrod (1997) observed local cultural convergence, but global polarization when probability of interaction between agents located in a rectangular grid depended on their cultural closeness and attempted to coordinate their cultural traits. Agent-based modelers have since revised and extended Axelrod's original model. Klemm et al. (2003) added small random perturbations to the agents' cultural genome and found that such "cultural noise" actually leads to less diversity in the long run. Parisi et al. (2003) replaced the homophily mechanism with a social influence mechanism, where agents set their cultural traits based on the average trait in their neighborhood. Centola et al. (2007) extended the homophily mechanism towards evolving networks. In their model, agents whose similarity falls below a threshold value sever their link and instead select another neighbor randomly. This led to the discovery of distinct intervals of the threshold value which resulted either in complete individuality, multiple cultural clusters, or global monocultures. Finally, Flache and Macy (2011) tested a version including both social influence and network homophily. This resulted in highly robust and persistent cultural diversity.

Other agent-based models of cultural diffusion assumed incomplete knowledge of agents. Bednar and Page (2007) and Bednar et al. (2010) created and analyzed models in which agents play several games with different payoff matrices. Each game represents a different cultural feature. Agents possess limited cognitive capacities and their rule sets for both games are forced to overlap to a certain degree. The authors found that this leads to the spreading of cultural memes through the transfer of dominant strategies from one cultural feature to another. A different approach to represent agents' indirect inference of others' cultural traits is the use of observable "tags" (e.g., physical features, markings, clothes, etc.). Hales (2000) developed a model in which agents played one-shot prisoner dilemma games only with agents possessing the same tag. Each agent was either an absolute cooperator or defector. Over the course of many generations this led to homogenization of the tag-groups into clusters consisting solely of either cooperators or defectors. Hammond and Axelrod (2006) also made use of tags in their agent-based model of ethnocentrism. The simulation results implied that the emergence of cooperation was contingent upon the evolution of in-group favoritism.

Some agent-based modeling studies have also considered the effect of network structure on the diffusion of cultural practices such as cooperation. Santos et al. (2006) investigate the nature of cultural diffusion when agents have the option to update both their game-playing strategies as well as their neighborhoods. Chiang (2013) also studied the relationship between dynamics of cooperation on networks and nodal attributes and

found that cooperative strategies are robust when conditional upon node centrality.

3. Literature Review

As a new generation of Americans begins to take shape and move toward adulthood, there is mounting interest in their attitudes, behaviors, and lifestyle choices. Dimock (2019) define anyone born in or after 1997 and prior to 2010 as a member of Generation Z. From a demographic perspective, Gen Z in the United States is already the most racially and ethnically diverse generation, as a bare majority of 6- to 21-year-olds (52 percent) are non-Hispanic whites; one-in-four are Hispanic (Fry and Parker, 2018). This diversity translated into their desire to create an equitable environment for everyone (Seemiller and Grace, 2016), and their passion for making their world a better place (Loveland, 2017).

Generation Z youth tend to grow up more slowly and are the most protected and safest generation ever: they engage in sex at a later age, hold off longer on obtaining a driver's license, engage in alcohol consumption less, delay moving out of their parents' house and achieve financial independence later than their Millennial predecessors (Twenge, 2017). Research has also found that Gen Z adolescents are less likely to engage in social activities such as dating, going out without their parents, and going to the movies (Twenge et al., 2019b). Paradoxically, in large part because of the influence of social media (i.e., cyber-bullying, constant image curation, social comparison pressures, etc.), these youth have gotten accustomed to stress and pressure from a remarkably young age; in fact, they have grown up so fast in some ways that they seem to behave like "mini-adults" rather than kids (Bergh and Behrer, 2016).

In terms of influences, one study showed that educators and parents have the greatest impact on learning and personal development, while friends and peers as a group were ranked third (Caraballo, 2018). Other research indicates that Generation Z students value input from their peers more than parents or other role models, especially when compared with previous generations. For example, Generation Z relies on the opinions of their peers more than admission or school counselors when it comes to selecting a college (Loveland, 2017).

Media consumption is another aspect of life where Generation Z behavior has dramatically changed compared to previous generations. Adolescents in the 2010s spent significantly less time on print media, television, or movies compared with adolescents in previous decades; while the average 12th grader in 2016 spent more than twice as much time online compared to the average 12th grader in 2006 (Twenge et al., 2019a). In 2017, 87 percent of U.S. adolescents reported having access to a smartphone with Internet access; 74 percent had access to a desktop or laptop with Internet access; 41 percent had access to a tablet with Internet; 29 percent had a Smart television or gaming console; 11 percent had a cell phone without Internet access; and three percent had none of these (Villanti et al., 2017). Research further identified that adolescents spend less time (compared to previous generations) on in-person social interaction with peers, getting together, socializing with friends, going to parties, going out, dating, going to movies, riding cars for fun; these decreases occurred while digital interaction and social media use rose (Twenge et al., 2019b).

Research identifies two important functions served by social media for Generation Z users: (1) the ability socially connect with others and the ability to manage the impression individuals make on others (reputation building, impression management, and online self-presentation) (Meshi et al., 2015). As a result, experts in marketing to Gen Z say that a one-size-fits-all approach will not work, instead recommending approaching this generation with an understanding that they want to be seen as unique individuals and as “engineers” working to piece together who they are and what they want to become (Fromm and Read, 2018).

Digital media have a growing role in education as well. In a sample of Generation Z youth, YouTube was ranked second only to teachers as a preferred learning tool and ranked well ahead of lectures, in-person activities with classmates, learning applications, and books (Caraballo, 2018). While proof of the efficacy of using digital tools for learning is not yet solid, some studies show the use of YouTube and other applications as a teaching vehicle has a positive impact on students’ learning outcomes and satisfaction (Orús et al., 2016). Other studies examined how the widespread use of smartphones serves as both a distraction in the form of multitasking during class (McCoy, 2020) and an opportunity to enhance lectures via the recording of video segments, real-time class polling, or note-taking (Keengwe et al., 2014).

We were further interested how the social networks (offline and online) of Generation Z youth are structured and how they factor into influencing individual’s values and behaviors. The evidence suggests that sensitivities to peer opinions are possibly larger in adolescents than in older age groups (Crone and Konijn, 2018). Peer influence effects have been well-demonstrated in adolescent decision-making research, showing that adolescents take more risks in the presence of peers and when peers stimulate risk-taking. These findings have been interpreted to suggest that adolescents have a strong need to follow norms of their peer group and show in-group adherence (Braams et al., 2019; Ciranka and van den Bos, 2019). Evidence shows that adolescent friendship networks play a strong role in shaping problem behaviors like delinquency, alcohol use or smoking, but problem behaviors also inform friendship choices (Osgood et al., 2015). Paluck et al. (2016) showed that peer influence can also lead to positive outcomes. The researchers implemented an intervention program for a random subset of public middle schools. Seed groups of randomly selected students from intervention schools were assigned to an intervention program that encouraged them to take a public stance against conflict at school. Results show that school-wide levels of conflict decreased at intervention schools. Moreover, levels of conflict decreased more at intervention schools where seed group students contained more “social referents” (i.e., higher status, more popular students who others take to be models for behavior and norms).

The relationship between peer influence and peer selection seems to be complex: adolescents selected friends based on whether they drank alcohol, but not based on whether they engaged in physical activity. On the other hand, the results showed that youths tended to assimilate their physical activity patterns with those of their friends; however, evidence for assimilation of drinking behaviors among friends was mixed (Long et al., 2017).

The position of individuals in the larger social network also seems to matter. Gentina et al. (2016) showed that adolescents with more close first-degree relationships (direct

friends) within a specific peer group and/or a high need for uniqueness engage in more risky behavior, while adolescents central to the entire network (more indirect relationships, i.e., friends of friends and friends-of-friends-of-friends, etc.) score higher on ethical predispositions.

Another concern for Generation Z are declining levels of mental health. Generation Z youth are more likely to be diagnosed with anxiety and depression, and these conditions in turn affect their ability to learn (American Psychological Association, 2018). Additional research implies that Generation Z requires more dedicated emotional support systems in environments like college than any other generation historically (Seemiller and Grace, 2016). Furthermore Barry et al. (2017) find a moderate correlation between adolescents' social media use and symptoms of anxiety, depression, and attention deficit/hyperactivity disorder (ADHD).

Concerns about this generation's physical health are also widespread. Today's youth are less likely to be physically active and more sedentary than previous generations (Katzmarzyk et al., 2017). This is coupled with a significant increasing trend in obesity in youth—about one in five adolescents today is likely to be obese (Hales et al., 2017).

A significant amount of research has also focused on the question of leading, motivating and teaming of Generation Z. For instance, research illustrates that academic motivation and persistence can be profoundly affected by relationships with thoughtful adults who honor adolescents' desire for status and respect (Elliot et al., 2018). Today's adolescents have also been found to have a desire to experience positive emotions relevant to status or respect from peers or admired adults, and such emotion have been shown to increase their attention, motivation, and learning (Telzer, 2016).

Surveys suggest that Generation Z adolescents are ready to work for leaders who develop strong personal relationships with them (Dabke, 2018). Additional research shows that today's youth are most responsive to transformational leadership styles (Bass and Riggio, 2006). Transformational leaders behave in ways that make them admired, respected and trusted by their followers, and as a result, followers identify with and want to emulate them. While these leaders are willing to take risks and think "outside the box", they can be counted on to do the right thing because they regularly demonstrate high standards of ethical conduct.

In terms of motivation, this generation ranks personal achievement and success as more important than previous generations (Swartz et al., 2017). They also believe the ideal learning environment is "me and the Internet" and prefer independent learning as opposed to group assignments (Seemiller and Grace, 2016).

Finally we were interested youth's propensity for military service. Surveys show that today's young Americans are significantly less patriotic than previous generations (Funk and Hefferon, 2019). Yastrzemsky (2016) further identifies factors that correlate with youth propensity for service: it is negatively associated with U.S. war casualties, higher educational attainment, higher socio-economic status, and living in an urban or suburban area, while being positively correlated with public support for war, rises in unemployment, conservative ideology, and traditional attitudes toward gender roles. Propensity for service also varies by region, being significantly higher in the U.S. South compared to other regions (Maley and Hawkins, 2017).

4. Methods

To explore the trends in relevant youth behaviors, values, and attitudes, and to determine which mechanisms contribute to the spread of such trends, we designed and implemented an agent-based model. The purpose of the ABM is to track and predict the spread of behaviors, attitudes, and values in American youth populations from a known baseline.

The following subsections outline the logic of the model from a high-level perspective. For a detailed description of model logic, see the Online Supplemental Information [†]

4.1. Design Concepts

We designed the model to be able to represent traits, behaviors, and environments relevant to Marine Corps recruiting and training efforts. We represent two types of contexts in our model: A purely social environment of middle school and high school-aged youth centered around friendship networks and focused exclusively on peer relationships, and a highly structured environment representing entry-level Marine Corps training which tracks both peer (recruit-to-recruit) interactions as well as recruit-instructor interactions. In terms of individual characteristics, we represent a whole suite of behaviors, such as rates of physical exercise, digital media use, or drug use, and personality traits such as selflessness, independence, or propensity for military service. We also represent demographic characteristics such as sex, age, and race, among others. However, the model is entirely agnostic with respect to which traits are being represented: Any trait is ultimately represented as an instance of an abstract trait object parameterized by a small set of constraints.

The model is based on theories of cultural evolution, notably employing ideas and mechanisms from dual inheritance theory (Boyd and Richerson, 1985), while also representing a set of concepts widely recognized as drivers of social influence within the field of social network analysis. In its simplest terms, the model aims to predict an individual's set of traits and their social ties in the future, as a function of their present set of traits and social ties (and sets of traits of those ties), while doing this for every individual in the larger social network at a point in time. While we recognize there are certainly many additional factors that play into how personality traits and social networks of youth change over time, such as the influence of parents, educators, and other authority figures, as well as individual psychology, and genetics, we do not take these factors into account in this model and represent the trait and network dynamics as a pure function of peer influence and the individuals' positions in the larger peer network. The two main forces that drive the model forward are peer selection and peer influence. Peer selection refers to how individuals determine who becomes or ceases to be part of their personal social networks, and how likely they are to interact with each member of that network. Peer influence then refers to how individuals adapt their traits based on the traits that they perceive in the members of their personal networks.

For this model we use the mechanism of indirect bias (Boyd and Richerson, 1988) as a means for peer selection. This mechanism assumes that the relevant personality traits are not directly knowable by others (we call such traits "hidden") and that individuals thus use sets of observable characteristics (such as outward behaviors, demographics, or

[†]Available at <https://...>

appearance) instead to estimate the personality traits of others. While the accuracy of these individual estimates may differ greatly, individuals will update them periodically to reflect more recent data (i.e., their cumulative experiences with others). While other notable mechanisms of peer selection certainly exist, the mechanism of indirect bias has been previously shown to lead to valid results in other models of diffusion of cultural traits (Revay, 2017). We then apply the principle of homophily to our mechanism for peer influence: We assume that individuals are naturally conformist in that they periodically adjust their behaviors, attitudes, and values to match more closely those of their social ties. The choices of mechanism for peer selection and peer influence are not driven by any assumptions about the psychology or natural dispositions of the actors that we aim to represent in our model. Instead, we take the choice of social ties and the adjustment of one's own traits to be a boundedly rational decision driven by the nature of social cooperation in the context of cultural practices, where returns are maximized for all parties involved when those practices are shared among the actors. Thus, we conceptualize social interaction as a pure coordination game, where actors receive positive payoffs when their hidden traits, shaped by their culture, closely align, while receiving negative payoffs when their hidden traits diverge. To demonstrate this idea, we take the example of sharing the road with other drivers: It does not matter which side of the road we decide to drive on, if everyone coordinates their behaviors, and if everyone has high confidence in others' behavior. This logic can be extended to various categories of cultural practices such as language, etiquette, social norms, or even behaviors such as smoking, exercise, or media use (where in the latter two cases, the costs incurred through the lack of coordination may be predominantly associated with feelings of exclusion and emotional discomfort).

Apart from the main forces outlined above, the model also allows the user to inject external forces into the simulated youth network, by defining parameterized strategies for recruiting subsets of the population based on their characteristics and their position in the network, and simulating interventions carried out on the recruited populations by selectively adjusting their traits. Additional forces are present in the training environment on the model. The first is a constraint on which individuals can interact (and how frequently), representing the hierarchical structure of Marine Corps training. The second factor is the presence of instructor agents. The traits of these agents are not subject to the forces of peer influence and their interactions with recruit agents are forced at predetermined intervals and thus not subject to the forces of peer selection.

4.2. Model Processes

As stated above, the model can represent an unstructured, purely social environment, as well as a structured training environment. These two environments may be run separately and independently, or in sequence as two phases of the same simulation. In that case a subset of the social environment population is sampled to seed the training environment population. The next two sections outline the processes and scheduling relevant to the two environments.

4.2.1. Initialization

To initialize the model, we first create the agent population. We do this by taking a random stratified population sample from the American Community Survey and using it to seed the observable traits of the agents. In the model experiments conducted for this study, the observable traits were limited to age, race, and sex. To seed the hidden traits of agents, we use survey response data from the Monitoring the Future Survey (Miech et al., 2019). Notably, hidden traits are operationalized as specific survey questions (or possibly composite indices formed from a set of questions), and their variants as responses to these questions. The model then calculates the probability density function of responses to each referenced survey question independently for every stratum present in the random stratified sample. Subsequently, the model will sample a response to each referenced survey question for every record in the random stratified sample from the distribution associated with its stratum. Appendix A describes how the hidden traits used for this study were operationalized using specific sets of survey questions and responses.

Once the characteristics of the agent population are defined this way, the model proceeds to generate a social network in which the agents will become embedded. The network is generated using an exponential random graph model (ERGM) estimated from data on high school friendship networks (McFarland et al., 2014). The ERGM creates a social network that considers multiple structural factors as constraints on the probabilities of existence of ties between an arbitrary pair of nodes (representing agents). For example, the model assigns a higher probability of mutual ties, ties between individuals that have common friends, and ties between individuals that share the same race, gender, or age. In contrast to the original ERGM, our model uses only a subset of factors, due to the lack of data for certain factors (e.g., club ties among individuals and their GPA).

4.2.2. Social Environment

The main flow of the simulation consists of three types of events. First, agents are randomly activated in turn and they decide whether to delete any existing social ties and whether to create any new ones. Agents are more likely to delete ties to agents whose observable traits are perceived to be associated with hidden traits that the agent perceived as undesirable. This perceived association is based on the agent’s history of interactions and measured by the agent’s base-level activations for individual observable traits

Next, agents are randomly activated, and they interact with their ties. Once again, the likelihood of an agent’s interaction with each of its ties is determined by their perceived preference for their observable traits as determined by the agent’s prior experience. The interaction itself then proceeds by comparing variants of a randomly selected hidden trait between the two agents. The agents will then evaluate the interaction as either successful, with increasing likelihood if their variants are similar to each other, or unsuccessful, with increasing likelihood if their trait variants are significantly different.

At each time step, agents will also be given an opportunity to update their own hidden traits. The probability with which agents adjust their traits is controlled by a model

parameter. The agents will adjust their hidden traits to more closely match the variants that they perceive to be dominant in their social ties. We implement two alternative mechanisms for this process. One is based on the base-level activation concept and takes into account past states as well (we call this the “slow” influence process). The other one only takes into account the hidden traits of ties in the present moment (we call this the “fast” influence process). We call these fast and slow, because “fast” propagates influence among the agents much quicker than “slow.”

Finally, after a predetermined number of activation rounds, which constitute a simulation year, part of the agent population “ages out” and exits the simulation and a subset of newly created agents (of minimum age, as defined by the user) enters the simulation. These processes are repeated for a predetermined number of simulation years.

4.2.3. Training Environment

The dynamics present in the social environment are all in effect in the training environment with three notable modifications. Unlike the social environment, which is initialized with a fully formed social network, the training environment begins with an empty network (no ties are present). This represents the reality of Marine Corps training, especially recruit training, where individuals have almost no preexisting social connections, with minimal exceptions. Also, in contrast to the social environment in which agents are able to interact with any of their ties at any moment (ignoring preferences based on base-level activation for the moment), the ability to interact with others in the training environment is constrained on the basis of unit assignment. This reflects the structured nature of Marine Corps training where certain training activities are strictly limited to members of the same unit. Each level k of unit hierarchy in the training environment is then assigned a probability of interaction. These probabilities are free parameters of the model. Each round, for every agent independently, the model samples a hierarchy level based on their relative probabilities. The agent then may only interact with others who share the agent’s unit on the given level of hierarchy (but need not necessarily be assigned to the same unit on lower levels of hierarchy).

Finally, the training environment is marked by the presence of instructor agents. An instructor agent may be assigned to each unit at each level of the training hierarchy (this may be customized by the user to some extent). Every recruit agent in that unit then has a tie to the instructor unit, which cannot be deleted at any time. Furthermore, instructor agent will force interactions with all the agents in its unit once every f_t rounds. The quantity f_t , also referred to as the training frequency, is a free model parameter and represents the frequency at which formal training activities occur in the simulated training environment. Additionally, the hidden traits of instructor agents are fixed throughout the simulation, unlike those of recruit agents.

5. Results

5.1. Model Calibration and Validation

We first attempted to ascertain the validity of the model, that is to determine whether it accurately measures the quantities that it is purported to measure. We did this by

Table 1. Fixed model parameters

<i>Parameter</i>	<i>Value</i>
Population size	1000
Sampled region	Entire U.S.
Rounds	500
Rounds per year	100
Warm-up rounds	20
Minimum age	13
Maximum age	18

Table 2. Varied model parameters

<i>Parameter</i>	<i>Range/cases</i>	<i>Increment</i>
Network density	[0.01, 0.1]	0.01
Influence process	slow/fast	N/A
Tie creation rate	[0.01, 1]	0.01
Tie deletion rate	[0.01, 1]	0.01
Trait adjustment probability	[0.1, 1]	0.1
Mutation rate	[0.01, 0.1]	0.01

executing a series of large batches of model runs with different parameter configurations, initialized with data from 2012, and comparing the outcomes of model simulations run for five simulation years with subsequent data from the years 2013-2017. While we varied a subset of model parameters throughout this process, we kept the remainder of the model parameters fixed, as we do not believe that they would significantly change the dynamics of the model, or they were constrained by the research questions. The parameters that were fixed are listed in Table 1 along with their values. The parameters that were varied are then listed in Table 2, along with their corresponding ranges of values. For the validation experiments we tracked a set of seven traits that were deemed relevant to recruiting and training for the Marine Corps. These traits were *propensity for military service*, *healthy lifestyle*, *digital media use*, *substance use*, *delinquency*, *emotional wellbeing* and *sociality*. To learn how we operationalized these traits see the the Online Supplemental Information.

The tie creation/deletion and trait momentum parameters were varied to determine the degree of “elasticity” in the peer selection and peer influence processes of youth actors. The mutation rate was varied to allow for fine-tuning the degree to which subsequent cohorts of youth differ from one another. Also considered were two different hypothesized mechanisms for determining peer influence. Furthermore, runs with different combinations of traits present were run to ascertain the possible unknown dependencies between traits as perceived by youth (consciously or not). Finally, the density of the social network (greater density means a larger number of ties between the agents) was varied to allow for representing social networks at varying levels of intimacy, i.e., networks with a lower number of ties between agents means the agents have a smaller number of more intimate connections.

Table 3 shows the set of parameter values that resulted in the best fit with empirical data. Figure 1 illustrates the goodness-of-fit in graphical form. To see more detailed goodness-of-fit reporting see the Online Supplemental Information.

Table 3. Calibrated model parameters

<i>Parameter</i>	<i>Value</i>
Network density	0.02
Influence process	varies by trait
Tie creation rate	1
Tie deletion rate	0.01
Trait adjustment probability	0.5
Mutation rate	0.05

We observe that the final parameter configuration shows moderate to good fit across the six indices shown in Figure 1. We have observed a poor fit for the delinquency index (not shown) across all tested parameter settings. This observation could be potentially ascribed to the presence of environmental factors (in addition to social factors) that strongly affect youth delinquency (Grucza et al., 2018).

The calibrated set of model parameters raises some interesting implications about the nature of peer influence and peer selection in youth networks with respect to the measured traits.

5.2. Projecting future trends in relevant traits of American youth

Upon validating the agent-based model and calibrating important model parameters, we ran simulation batches to project trends in the same set of six relevant behavioral and attitudinal traits of American youth. To study the trajectory of each trait, we initialized agent populations based on the 2019 ACS and MtF data sets and ran the model for five simulation years. We ran 100 such simulations, resampling the agent population along with all the agent attributes each time. This allowed us to project the distribution of variants of the tracked traits out to the year 2024.

Figure 2 shows the results of the projection simulations. We note that propensity for military service is projected to decline. Projections over the next 3 years show that the share of the 12th grade population that will be at least somewhat likely to join military service will decrease and likely range between 4 and 8 percent. Based on the simulations, we project that on average 5 percent of 12th graders will be at least somewhat likely to join the military in 2024. We further project that the share of 12th graders who use digital media more than 20 hours per week will continue increasing and will likely fall somewhere in the range of 60 to 65 percent in 2024, compared to less than 50 percent in 2019.

We also predict likely further declines in the rates of in-person social engagements, engagement in health habits, self-reported emotional wellbeing, and legal substance use among the 12th graders by the year 2024. The model projections show on average 60 percent of the high school senior population engaging in in-person social activities (other than school) at least once week in 2024, compared to 72 percent in 2019, although a minority of simulations show no drop off. The fraction of seniors who engage in a wide range of health-promoting habits “on most days” is also set to decline to 50 percent, down from 63 percent in 2019. Additionally, almost 60 percent of 12th graders reported that they are “mostly well” from an emotional point of view in 2019. We predict that this number will drop to below 50 percent in 2024. Finally, the fraction of seniors who use

Fig. 1. Range of average trait values simulated from 2012 data compared to empirical 2012-2017 data.

Fig. 2. Model projections from 2019 data.

legal addictive substances such as nicotine or alcohol is projected to decrease slightly in all likelihood by 2024, although a minority of simulations suggest a rebound in substance use by the last year of the projection period.

5.3. *Interventions and their effects in different types of networks*

We also investigated whether interventions that target a small sample of the simulated agent populations could potentially have any effect beyond those directly affected. Our hypothesis was that if intervention participants were strategically chosen such that they would represent a subset of agents that wield a significant degree of influence among their social ties, the effects on the recruited individuals could diffuse throughout their personal social networks. We studied how such dynamics played out in high intimacy networks (about 2 social ties on average), since such networks were identified as the most important conduits of influence in the context of the studied set of traits. We also compared how these dynamics change when considering medium-to-high intimacy (about 5 social ties on average) and medium intimacy (about 17 social ties on average) networks. To demonstrate the effect of interventions, we chose the health-promoting habits trait. We then ran simulations tracking the distribution of variants of this trait within the agent population. At onset of each simulation a small subset of agents was selected to participate in an intervention. The size of the subset was varied between 1 and 5 percent of the entire agent population with increments of 1 percentage point. We ran 30 simulations per intervention size. We also ran 30 simulations with the same configuration, but without conducting an intervention, as a baseline to control for trait dynamics unrelated to the intervention. The group to undergo the intervention was chosen by selecting the top n percent of agents in terms of their in-degree (i.e., the number of others who have ties to a given agent). We chose this approach because the in-degree represents the popularity or centrality of an agent. Recruiting some of the most popular agents within the network was hypothesized to help in spreading the effects of the intervention throughout the remainder of the social network. The intervention itself consisted in changing the selected agents' variants in the health-promoting habits trait to the maximum possible value. Thus, it was assumed that the success rate of the intervention with respect to its direct participants was 100 percent. We opted for this approach because we were not interested in the effects of the intervention on its direct participants but rather on its effects throughout the entire social network.

Figure 3 shows the average effects of interventions over the course of 5 years after conducting the interventions on the group of direct participants. Figure 4 then shows the average increase in the frequency of the desired trait variant 3 years after the intervention as a function of intervention population size.

Our simulations demonstrate that there is very little diffusion of intervention effects beyond its direct participants in high intimacy social networks when the intervention population size is below 5 percent of the total population size. Moreover, effects of such interventions fade within five years even within the intervention population. Significant diffusion effects in high intimacy networks are only observable when the size of the intervention population size is 5 percent of the total population. In this case we observe an average difference of 13 percentage points in the frequency of the desired trait variant 5 years after the intervention compared to a baseline simulation without an intervention.

In contrast to high intimacy networks, the other two types of networks show significant diffusion of intervention effects when intervention population size is larger than 1 percent of the total population size. Moreover, as seen in Figure 4, the rates of diffusion increase monotonically with intervention population size. The relationship for high-to-medium intimacy networks is highly linear with about 6 individuals reached per every intervention participant. The simulated data does not indicate that the relationship is linear for medium intimacy network, instead suggesting diminishing returns with increasing intervention sizes. Despite this, anywhere between 4 and 12 individuals are reached per every intervention participant. Interventions in high intimacy network do not show any relationship between intervention size and the rate of diffusion, with anywhere between 0 and 4 individuals reached per intervention participant after 3 years.

5.4. Training Environment Dynamics and Factors of Successful Acculturation

Next, we focused our attention to the training environment and the changes in recruits' traits as a result of both top-down and peer influence. We track the distribution of multiple traits that are deemed important in recruits' development into successful Marines (U.S. Marine Corps, 2020). We ran 100 simulations of with 50 recruit agents and a single instructor agent, representing recruit platoons with an assigned Platoon Sergeant. We immediately notice a significant bifurcation effect between sets of simulations with identical parameter settings that occurs early into the training simulation. Figure 5 shows the average value of the growth mindset trait over the course of the training phase of the simulation for two sets of populations[‡]. For the purposes of this analysis, a successfully developed unit is one whose average trait value exceeds 4 (out of 5). We therefore further investigate which conditions (arising from sources of model stochasticity) factor into successful development of units.

Notably, the ratio between the average trait value across the entire unit and the average trait value of influencing agents is the same for both successful and unsuccessful units (see Figure 6). This suggests that in both scenarios, agents from the entire trait spectrum exert a level of peer influence. What matters is the not just who does the influencing, but rather who influences whom.

Figure 6 shows the factors that were deemed to significantly affect trait dynamics within the training populations later in the simulations. We notice that when units fail to successfully acculturate throughout training, the total pull of bottom performers (those whose trait value is 2 or less on a 1-5 scale) is significantly larger (in absolute terms) in the initial phases of training compared to successful units. Here total pull is defined as the sum of trait adjustments made by other agents when a bottom performer was a contributing influence for that adjustment (see section 2.1 of the Online Supplemental Information for an explanation on how influence is determined in the social network)]. In other words, bottom performers in failed units were more likely to negatively influence those who performed above their level, rather than positively influencing someone who performed below their level. Another related factor contributing to units failing to acculturate is the average difference between the trait values of influencers

[‡]see section 3.2 of the Online Supplemental Information to learn how we operationalized growth mindset

Fig. 3. Diffusion of target trait variant as a result of interventions in different types of networks.

Fig. 4. Increase in target trait variant frequency 3 years after intervention in different networks.

Fig. 5. Bifurcating paths of unit development with respect to the growth mindset trait.

and those being influenced. Units that failed in their acculturation process showed a smaller difference, meaning that overall instances of peer-to-peer influence were less positive compared to successful units. Additionally, in failed units, bottom performers were more likely to influence peers with a higher average number of social ties within the unit social network, as suggested by the difference in the total weighted influence exerted by bottom performers. Here weighted influence is influence weighted by the in-degree of the influenced agent.

5.5. Probability of Successful Acculturation as Function of Unit Structure

Just like in the case of the social environment, we may use the model to explore how different interventions in the training environment affect outcomes. We do this to specifically investigate how different structures of the training unit hierarchy, and associated rates of interaction between recruits from different units (at various levels of the hierarchy), affect the spread of desirable traits. For our experiment we run simulations with 200 agents, representing a training company, divided into four platoons of 50 agents, each further divided into four squads of roughly 12-13 agents. We then run 15 different configurations marked by varying probabilities of interaction between recruit agents

Fig. 6. Notable differences in failed and successful units

Table 4. Unit interaction probabilities

<i>Case</i>	<i>Probability of interaction within own:</i>		
	<i>Squad</i>	<i>Platoon</i>	<i>Company</i>
1	1.0	0	0
2	0.9	0.1	0
3	0.8	0.2	0
4	0.8	0.1	0.1
5	0.7	0.3	0
6	0.7	0.2	0.1
7	0.6	0.4	0
8	0.6	0.3	0.1
9	0.6	0.2	0.2
10	0.5	0.5	0
11	0.5	0.4	0.1
12	0.5	0.3	0.2
13	0.4	0.4	0.2
14	0.4	0.3	0.3
15	0.34	0.33	0.33

based on whether or not they belong to the same unit at each level of the hierarchy. Table 4 lists the probabilities in detail. This represents the level of permeability in the structure of training, or in other words, the frequency of training activities that include members of different units at different levels.

Figure 7a shows boxplots for average unit scores in the growth mindset trait at the conclusion of the training simulation as a function of training structure. Figure 7b then shows boxplots for the average number of time steps needed until successful acculturation (defined as the average unit score exceeding 4.5). We see that while in all instances the acculturation is successful and takes about the same time, the final average value of the growth mindset trait grows with increasing permeability of the training hierarchy. It should be noted that the growth mindset trait is already fairly well developed in the recruit population at the onset of training. To contrast our findings with a trait that is significantly less developed among the target population, we also analyze simulations that track the obedience trait[§]. As in the case of growth mindset, the average obedience score at the conclusion of training grows with increasing unit permeability, as shown in Figure 8a. Apart from this, the time needed for acculturation, and the actual probability of successful acculturation also increases (see Figures 8b,c).

6. Discussion

6.1. Peer influence as a “fast” process

Four of the six measured traits show a better fit with the data when using the “fast” influence process. This suggests that youth tend to adapt their behaviors and attitudes in these domains based on the variants that are dominant in their social circles in the current moment, without regard to past states, however recent. This is in line with

[§]see section 3.2 of the Online Supplemental Information to learn how we operationalized obedience

Fig. 7. Growth mindset development as a function of training unit hierarchy.

anecdotal observations of youth always reacting to the latest fads and trends that come and go quickly.

6.2. Peer selection as an inelastic process

On the other hand, the parameters that drive the mechanisms of peer selection, namely tie creation and deletion rates, along with the interaction candidate selection mechanism, suggest that this process is the result of slowly evolving sentiments that are not subject to rash decisions. The base-level learning approach to identifying candidates for social ties and interaction indicates that experiences from the past may become ingrained over time to the extent that changes in the present moment might not be enough to sway an individual's decision. Furthermore, the slow rate at which agents change their personal social networks demonstrates that individuals may be wary of quickly abandoning ties even if perceptions of them may have shifted negatively.

6.3. Importance of high-intimacy networks

The model shows the best fit with empirical data when only the core layer of the most intimate social ties is represented. This indicates that the traits that we have measured are largely influenced by some of the most intimate peer relationships of youth, namely their inner core of a few closest friends; at the same time, the influence of other friends and acquaintances on the relevant traits is relatively negligible. Here, we emphasize that these observations refer solely to the relative role of different types of peer relationships. Arguably, parents, educators, and other authority figures may also significantly influence youth in these qualities, however, we did not represent this type of influence in the model.

The dominance of high-intimacy networks in the process of influencing relevant youth traits will pose an additional challenge to military recruiting. Unlike in lower intimacy networks where the centrality of agents in the network structure is more evenly distributed, high intimacy networks are marked by the presence of a few highly central, and therefore presumably highly influential agents when compared to the rest of the

Fig. 8. Obedience development as a function of unit hierarchy.

Fig. 9. Distributions of node centrality in simulated networks representing different layers of intimacy.

network. Figures 9 show the distribution of relevant measures in the different social networks. This suggests that identifying the “right” candidates for intervention that can spread its effects beyond their immediate circle of intimate ties is a process associated with much higher stakes, compared to lower intimacy networks. Furthermore, our analysis of intervention effects shows that the size of the intervention that will be necessary to effectively drive the spread of desirable traits throughout the social network is larger when compared to lower-intimacy networks, and this will undeniably drive up the costs associated with such intervention efforts.

6.4. Propensity for military service as inelastic trait

Propensity for military service was one of the two traits (along with sociality) that showed a better fit with the empirical data when using the “slow” peer influence process that relied on the base-level learning mechanism which takes into account the entire history of experience with variants of the trait. This signals that unlike some of the

other traits, propensity for service may be slower and harder to influence. This in turn implies that military services will be significantly challenged to intervene in the youth population and attempt to shore up propensity on the cohort level.

6.5. Preventing Negative Peer Influence in Training

Our analysis of the simulated training environment suggests that the main factor in failed unit acculturations is the negative influence of less acculturated recruits exerted on their better acculturated peers. Furthermore, the “fork” that puts units on different paths leading to either successful or incomplete acculturation comes very early into the training period. This suggest that the Marine Corps and other services will be pressed to develop ways to quickly identify recruits with low acculturation potential, closely monitor their activity to prevent their influence on fellow recruits and provide them with one-on-one focus to increase the likelihood of their own successful acculturation. Another way to prevent incomplete or unsuccessful acculturation of recruits on the individual or unit level is to identify peer leaders early and assign them to fire teams or squads that include recruits with low potential recruits.

Fig. 10. Example simulated networks using a siloed training hierarchy (left) and a permeable hierarchy (right).

6.6. Allowing for a Less Siloed Structure of Training

When we simulated different gradations of training unit permeability, we observed that less siloed structures tend to improve outcomes on the aggregate level for a variety of desirable traits. We believe that a training structure which allows recruits to interact with

their peers from outside of their own units more frequently (on all levels—squad, platoon, and company), is better suited for the spread of positive peer influence. Specifically, we hypothesize that in siloed structures, pockets of potential negative peer influence can become more easily entrenched. The variety of individuals and therefore attitudes and behaviors that recruits are exposed in a permeable training structure then decreases the likelihood of becoming trapped in an unhealthy environment, as is showcased in Figure 10.

6.7. *Connections to Other Methods*

As noted in the introduction, the agent-based model and the associated analyses were a part of a larger mixed methods study that sought to investigate the current generation of young Americans and associated implications for Marine Corps recruiting, training, and education. Throughout the study, the agent-based model functioned as a tool that supported findings obtained through other methods (such as the qualitative meta-analysis or the interviews with Marine Corps recruiters and instructors), as well as a driving force that led to the extending or refocusing of the scope of inquiry for the study as a whole.

For example, our training model experiments showed the importance of providing recruits individual focus and one-on-one mentorship to prevent spread of negative traits. This is supported by our interviews with Marine Corps drill instructors who saw significant benefits in recruit development when such methods were employed. Furthermore, our qualitative meta-analysis of literature related to Generation Z priorities reflected a desire on the part of today's youth to be treated as genuine individuals and a penchant for a tailor-made career experience that is suited to their own skills and preferences. Similarly, both the interviews that we have conducted as well as our meta-analysis provided support for the notion that Generation Z youth prefer less overtly hierarchical and authoritarian structures in lieu of approaches that are more *laissez-faire* and put equality and diversity (from both a cultural and thought perspective) at the forefront.

At the same time, some of our findings stemming from experimentation with the agent-based model are at odds with insights derived using other methods of inquiry. Notably, our model suggests that intentionally pairing well-acclulturated recruits possessing strong leadership qualities with peers showing lower levels of potential can increase overall performance and likelihood of success. However, our qualitative meta-analysis as well as our interviews indicate that the Marine Corps will be hard pressed to identify and develop enough recruits with sufficient leadership skills from among Generation Z youth. In the context of physical preparedness, our model projects further deterioration of health and fitness among the current generation in the coming years, suggesting a cause for heightened concern. This is in contrast with what we have heard in interviews with Marine Corps recruiters: The observation that recent recruits arrive to recruit training more physically prepared than ever (a phenomenon largely ascribed to training apps and the wealth of online resources) was a strong and recurring theme.

6.8. *Implications*

We believe that in light of the insights derived from our modeling effort, the Marine Corps and possibly other military services will be significantly challenged to attract and develop quality recruits in the coming years. The Marine Corps will be faced with a target population that will be less healthy, with decreasing levels of wellbeing, while at the same time increasingly focused on digital interaction through social media at the expense of in-person social experiences. Additionally, we show that correcting the course in relevant youth traits will prove difficult, because of the intimate nature of social ties that most likely influence young Americans decisions in these areas, coupled with the slow-changing nature of attitudes towards serving in the military.

Furthermore, we identify possible reasons for breakdowns in the training process. The Marine Corps will have to respond to the possibility of poorly performing recruits “poisoning the well” early on during training. A significantly siloed training process, one in which most group training activity is limited to members of the same unit, will also pose additional risks related to pockets of negative peer influence adversely affecting the acculturation of unit members.

We therefore recommend that the Marine Corps explore engaging candidates’ intimate ties such as their closest friends in the recruiting process to spur propensity for service. We furthermore suggest that the Marine Corps make attempts to connect with this generation’s digital upbringing by incorporating digital learning and digital methods into the training process. Finally, we recommend that the Marine Corps expand an effort to connect with generational values, while adjusting training processes to align with both the values and needs of Generation Z recruits. This can be done by expanding focus on one-on-one mentorship, making a push towards a less siloed training hierarchy, and increasing emphasis on the development of soft skills such as leadership qualities and teamwork.

6.9. *Conclusion*

We have developed an agent-based model of youth social dynamics to support a study of potential adjustments to Marine Corps recruiting, training and education efforts as a response to significant generational shifts in youth attitudes, behaviors, values, and life priorities. The model represents youth as individual boundedly rational agents embedded in complex social networks affected by forces of peer selection and peer influence. The purpose of the model was to understand the specific mechanisms which cause behavioral and attitudinal trends to emerge and shift, afford insights into how such shifts might be mitigated or promoted through simulating interventions, and to project future trends. We have used various empirical data sets to calibrate and to validate the model. Thanks to this validation, we were able to demonstrate a level of fit with empirical data that instilled confidence in the simulated outcomes. This in turn allowed us to proceed with simulating projections and interventions in the simulated status quo. Furthermore, the model validation effort has indicated that the chosen set of behavioral mechanisms that we have implemented have realistic counterparts in actual youth social dynamics. That is, we believe that youth do in fact use observable traits to estimate the presence of unknown behaviors, values, and attitudes in order to build personal social networks of culturally similar peers, and that they are conformist in how they adapt to the perceived

dominant behaviors and attitudes in their intimate social circles.

The model has demonstrated its value as a central piece in the study of Generation Z proclivities and its effects on Marine Corps recruiting and training. It has allowed us to investigate concepts uncovered by our qualitative meta-analysis or our statistical analysis of empirical quantitative data, by translating them into model terms and simulating ensuing social dynamics. The outcomes of these simulations then uncovered additional insights that ultimately led to recommendations corroborated by multiple approaches and to further refining the scope and focus of our efforts in an iterative fashion.

However, some limitations remain. Our model is only as good as the data used to calibrate it. Specifically, we had no primary data on youth social networks available to us. Instead, we had to rely on a previous model of social network structure based on data that was collected more than a decade ago. Furthermore, we were able to recreate the model only partially because our data on youth attributes did not include the entire set of variables needed for the full social network model. We believe that the performance and fidelity of the model would be significantly improved if we had the resources to conduct our own data collection effort on youth social networks and subsequently estimate our own model of social network structure. A related shortcoming is the difficulty of translating some concepts found in the literature into model terms. Building indices measuring concepts such as delinquency, wellbeing, or physical fitness often proved difficult because we were forced to rely on the limited secondary data that we had at our disposal.

Despite these limitations we have been able to generate significant insight beyond what we would have derived solely employing methods traditionally applied in these types of reviews, such as meta-analyses of literature or statistical models of quantitative data. Our modeling approach combined these other methods and eventually resulted in a richer set of recommendations for the Marine Corps recruiting and training efforts.

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