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Dear Reader,

In just our second year since the establishment of the University of Denver's Undergraduate Research Journal (DUURJ), this issue is proof that we have faced and overcome a slurry of unpredictable challenges to undoubtedly plant our presence in the DU community. The accumulation of an unrelenting pandemic, rampant wildfires, widespread social justice protests, ever-compounding climate change, and economic and political turmoil, has efficiently demonstrated the need, the must, for undergraduate students to become passionate about and engage in research.

This journal, one plank in the bridge designed to close the gap, only thrives when students take it upon themselves to commit their time to the mutual goal of refining and showcasing fellow DU student's compositions. This facet of the issue cannot be understated in a time when Zoom and electronic messaging were the only forms of coalescence pushing each editor to remotely fulfill their duties. Despite the physical disconnect, the engagement of our editing board, scattered around the country at times, was unprecedented and truly, impressive.

The unceasing, additive efforts of the editors, copyeditors, authors, and artists have amassed into an elegant and insightful panorama, depicting the prominent role DU undergraduates hold in research endeavors on DU's campus. With topics spanning a multitude of disciplines, from successful post-incarceration reentry to a model based statistical analysis of NFL coaching decisions, this issue provides a glimpse of the opportunities that undergraduate students discover as members of our undergraduate student body.

To our readers, we wholeheartedly thank you for your interest and support, hoping that this glimpse may encourage the entry of an undergraduate into research and the reinforcement of undergraduate inclusion at DU.

To the authors and artists, we are ever grateful for your amenability to trust our journal with the proper presentation of your work and efforts. We would only be a concept without the high-quality submissions that fuel our mission.

To the editorial board, I cannot thank you enough for your individual contributions that truly build and keep this journal alive. To Ava Johnson and Kari Cobb, your tireless work is invaluable, and this issue would not have come to fruition without your steadfast efforts. Maybe we will officially meet in person someday. To Dr. Katherine Tennis, your dependable support is crucial through each stage of the process. Finally, to the original seven, and specifically Carrie Hicks, we are indebted to you for taking the action to transform an idea into a reality, laying the extensive framework that comprises our foundation

When I inherited this journal in its infancy, the difficulties I would confront were unbeknownst to me, the solutions, even more obscure. Through this journey, I have grown and found a labor of love. To those that were uncertain, I want to assure you, DUURJ is here to stay.

Sincerely,

Thane Gehring
Editor in Chief

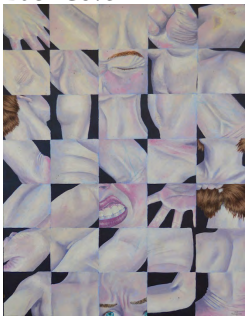
DUURJ

Articles

Front Cover

Scream
by Kari Langford

Back Cover



Deconstruction of Self
by Dora Peregrine

Photograph by Peter Vo

Recidivism: A Case Study of Reentry Resources and their Impact on Successful Reentry Post-Incarceration

Marissa L. Sulmeisters[1], Lisa J. Pasko[2]
[1]Student Contributor, University of Denver
[2]Advisor, Department of Sociology and Criminology, University of Denver

Abstract

This thesis details a case study regarding reentry resources available to returning citizens and their influence on recidivism (returning to prison) likelihood among people released from prison. It explores existing research on recidivism, describes the interviews conducted by the researcher, discusses the implications of this research, and suggests further avenues for research and exploration to better inform policies and future actions regarding reentry resources. Ultimately, this thesis concludes that the most useful resources for returning citizens include resources directed towards meeting basic needs like food, clothing, and transportation, housing resources, support/mentorship groups, family support, and employment organizations. Following further research to strengthen or contradict the results of this paper, future funding and resources should be allocated to these areas which have been listed as most useful for successful reentry.

Keywords: recidivism, reentry, resources, incarceration

1 INTRODUCTION

This thesis studies the conditions which make for a successful reentry process for individuals previously incarcerated. The study originated intending to understand the hardships women face upon reentering society following incarceration. However, based on preliminary research, the study's intention was expanded to understand the hardships all returning citizens face regardless of gender. This eliminated the assumption that recidivism could be a gendered issue and allowed the case study participants to not be restricted by gender. It explores the relationship between resources utilized by previously incarcerated individuals and their successful reentry following incarceration. This research is broken up into a literature review, methods, results, discussion, conclusion, and a future implications section followed by a reference and an appendix section. It culminates in a detailed analysis of reentry resources and recidivism. The goal of this research is to understand which resources have the greatest influence on limiting chances of recidivism for returning citizens, therefore creating the conditions necessary to direct policy guidelines towards decreasing mass incarceration by decreasing recidivism.

Recidivism can best be defined as "to be physically recommitted to the penal system after having been released from a previous period of incarceration"[1]. It "refers to a relapse of criminal behavior, which can include a range of outcomes, including rearrest, reconviction, and reimprisonment"[2]. It is important to understand the relationship between time served and recidivism, the legal and social impediments on successful reentry, the factors which place individuals most at risk of recidivism, the resources which are most beneficial to the reentry process and rehabilitation of inmates, and the impact of reducing recidivism. This will help future researchers and policymakers to know where to focus their attention when it comes to making communities safer, saving taxpayer money, and decreasing the number of people caught in the revolving door of the criminal justice system.

As of 2006, researchers estimated as many as 80% of all offenders relapse into crime[3]. However, research as of 2018 provides a more detailed depiction: "an estimated 68% of released prisoners were arrested within 3 years, 79% within 6 years, and 83% within 9 years"[4]. The United States has the highest percentage of incarcerated individuals in the world; if people who have already been arrested are returning to prison instead of reentering society rehabilitated, the number of people incarcerated will only grow as new people are being convicted of crimes on top of the people already in the system[5]. The crime rate will go up as prison

becomes a temporary relief for individuals until they commence criminogenic behavior. This increasing incarcerated population means taxpayers pay more and more each year to support the criminal justice system. Therefore, decreasing recidivism is of paramount importance, as it will have favorable implications: previously incarcerated individuals will successfully reenter society rather than recidivate, and prison populations will gradually decrease.

2 LITERATURE REVIEW

In preparation for this research project, the literature on preexisting research was gathered utilizing key terms like "recidivism," "reentry," "incarceration," and "risk factors." This section discusses the relationship between time served and recidivism with an emphasis on the goals of prisons, legal and social barriers to reentry, factors impacting recidivism, common reentry resources, and the impact of reducing recidivism. The information gathered during the literature review influenced the primary focus of the interviews conducted by the researcher.

2.1 Time Served and Recidivism

Prisons are intended to deter criminals from recommitting and to deter potential criminals from ever committing a crime, to provide retribution to criminals' victims, to incapacitate inmates by preventing them from committing more crimes in society, and to rehabilitate inmates so they can reenter society successfully and avoid recidivating. In the process of meeting these goals, the conditions of prisons can become barriers to reentry and result in a return to a life of crime.

2.1.1 Prison Deterrence

One of the main functions of prisons is to deter both those incarcerated from recommitting and those at risk of incarceration from committing a crime in the first place. In other words, the negative aspects associated with incarceration must be strong enough to influence people's will to avoid incarceration by abstaining from criminal behavior. Some researchers advocate for the necessity of a cost-benefit deterrent effect. They argue that for people to be able to abstain from crime once they reenter society, the costs of incarceration must outweigh the benefits of committing a crime[6]. Potential costs include loss of liberty, overall time served, loss of social ties, loss of employment/income, and social stigma. Potential benefits of committing crimes include wealth, getting "high," and social prestige. However, this cost-benefit method is not necessarily a thorough assessment of recidivism risks. If social stigma is too great, if lack of employment is too pervasive, if the odds are stacked against rehabilitated individuals, then the benefits of committing crimes become greater than homelessness, poverty, and sometimes death[6]. Therefore, while prison is a deterrent from committing a crime, the detering effect of incarceration is lost if substantial resources are not made available to people reentering society, thereby perpetuating the cycle of incarceration and release.

It is difficult to determine whether time served in prison affects recidivism rates due to the variability of crimes and sentences, the resources available to people when they get out of prison, how old individuals were when they began serving time, the familial and social support system available to them, and other such factors[6]. These factors combine to make each individual's reentry process unique. Despite the lengthy research done regarding incarceration, there are no significant results for or against incarceration as a whole. Some researchers have found that "prison exerts a criminogenic effect" while others suggest that "incarceration effects on recidivism are at best uncertain or minimal"[6].

2.1.2 Prison Retribution

Another function of prisons is to punish individuals for committing crimes. Therefore, incarceration in theory should outweigh the damage done to the victim by punishing the perpetrator. Part of the logic behind longer sentences has been that additional time in prison exacts greater retribution and creates appreciable incapacitation and deterrent effects. However, there is little evidence in support of this. More theorists argue that "the pain and strains of imprisonment, which could contribute to deterrent effects, may be more concentrated in or felt more acutely during the early stages than later stages of incarceration. At the same time, varying durations of incarceration may exert different effects on social bonds, social capital, and labeling processes, and in turn, recidivism"[6]. Longer prison sentences may have more detrimental effects on individuals' reentry possibilities and, as a result, be more costly to taxpayers as more people are being rearrested on top of new arrests made daily. Ultimately, the repetitive cycle of reincarceration both nullifies the attempted reformation of inmates and constitutes an exorbitant cost to taxpayers.

2.1.3 Prison Rehabilitation

Another function of prisons is to rehabilitate individuals so that they can reenter society as fully functioning citizens capable of contributing to the good of society. Involvement in prison programs like those offering formal education to inmates is correlated with lower recidivism rates and greater success re-entering society[3]. It is also possible that since involvement in prison programs is voluntary, involvement in such programs could be one way in which an inmate's dedication to change and to be rehabilitated manifests. Therefore, it is possible prison programs are not correlated with decreased re-

cidivism but that individual determination to change is correlated with decreased recidivism; involvement in prison programs is only a means by which determined individuals gather the tools necessary for success in the outside world. However, there is insufficient research currently regarding the potential of this relationship.

Not all inmates want to stop committing crimes; some become institutionalized in the sense that they cannot imagine functioning outside of prison. Inmates who do not want to change do not participate in programs at all, and they wait until their sentence ends in order to continue committing crimes in the outside world. Institutionalization occurs when inmates lose interest in the outside world and increasingly view prison as their home, only seeking to define themselves within it[3]. Institutionalized inmates may participate in prison programs and even be stellar inmates by prison standards, but they do not want their sentence to end. As a result of institutionalization, inmates do not want to leave prison because it is familiar and comfortable to them while the outside world is foreign and overwhelming. They are uncertain about their capacity to adjust to unfamiliar people, politics, technology, landmarks, social movements, and other developments after living within the shelter of incarceration. Other inmates want to reenter society and participate in the programs but still end up recidivating within a few years of release. This could be due to the phenomenon of "imagined desistance." Barrus defined "imagined desistance" as a type of desistance (ceasing criminal activity) that happens when incarcerated individuals envision their futures and emerging from the system changed without having the tools to change[7]. Therefore, they believe they have changed and will never return to prison because they have been rehabilitated, but they have not been rehabilitated. They can also plan to reenter society successfully but be faced with obstacles they are unprepared to overcome, which ultimately increases their risk of recidivating.

Researchers Gaum, Hoffman, and Venter note that experiences within prison act as moderating factors on the relationship between time served and recidivism by noting that the time spent incarcerated should be used for rehabilitative purposes instead of simply punishment for past crimes. They argue:

> "It is difficult to see how rehabilitation, relying as it does on inmates' abilities to make independent and insightful choices in their lives, and to resolve conflicts in a controlled assertive manner, can ever be successful unless they are encouraged to take responsibility for their work, acquiring skills, participating in hobbies within the prison walls, and learning to know and use their rights effectively inside the prison environment"[3].

To address the rehabilitative needs of inmates while incarcerated, prisons must consider that the needs of inmates are often long-term and orient care towards strengthening the coping skills necessary to help them be successful in society for years to come[8]. While research regarding time served and recidivism is lacking, many studies argue for increased resource availability to inmates while incarcerated so they can build the skills necessary to reenter society post-incarceration as a rehabilitated individual.

Prisons can function in many ways: as punishment for crime, as an opportunity for rehabilitation, or as a networking opportunity for criminals. If the loss is too great for individuals, they adopt the mindset of having "nothing to lose" and continue committing crime post-incarceration. Lengthy prison sentences can mean loss of familial ties, loss of social ties, loss of professional certifications, loss of wealth, a decline of physical and mental health, loss of social skills, and other aspects of a successful life in society. When individuals leave prison with significantly less than they began their sentence, they may feel hopeless and recidivate to the life and the crimes they knew beforehand because it is easier than starting over from scratch. Further, if the treatment or the sentence is unfair (racist, sexist, transphobic, wrongful conviction, etc.) the individual becomes frustrated with the system and comes to mistrust authority and, by extent, disregard the law upon release[6]. Too harsh or unfair punishment overpowers the chances of rehabilitation and leads to recidivism. Incarcerated individuals who do not want to be rehabilitated are also more likely to use prison as a networking opportunity with other criminals rather than utilize resources to help them successfully reenter society. This manifests in prison gang membership as well as criminals picking up new techniques for committing crimes and ultimately escalating the severity of the crimes they commit[9].

2.1.4 Prison Incapacitation

A final function of prisons is to incapacitate individuals, rendering them incapable of harming their victims further or threatening the wellbeing of society while they are incarcerated. In terms of recidivism and its relationship to prison and time served, some theorists suggest that "deterrent effects may be most likely in the initial months of incarceration; at the point, the 'pains of imprisonment' may be felt most acutely and criminogenic experiences that reduce social bonds or increase strain may be nominal"[6]. This would mean lengthy sentences have a curvilinear relationship with recidivism as they counter recidivism to a point before time spent in prison becomes too damaging on an inmate's capacity to be rehabilitated. Ultimately, there are mixed data regarding the impact of prison stays on recidivism as they often contain a balance of criminogenic experiences and rehabilitative experiences which varies by individual, time

served, the prison, social ties, and other such factors[6].

Many prisons are typified by corrupt officials, gang activity, mental health issues, abuse of power, fear, humiliation, and restricted access to food and education, which can traumatize inmates and make it even more difficult for them to reenter society[3]. Such toxic environments make it difficult to transition out of prison into a civilized society where many returning citizens crumble under the pressure of reentry and recidivate. Based on this underlying research, some researchers argue that before reentry programs can be implemented within prisons, further research into the everyday lives of inmates must be completed to understand what resources are most imperative to the success of inmates following their release[9].

2.2 Legal and Social Barriers to Reentry

Judicial and social barriers to successful reentry include tough on crime policy, social stigmas and stereotypes, and requirements of parole. Such obstacles combine to pressure returning citizens into recidivating rather than abandoning criminogenic behavior.

2.2.1 Tough on Crime Policy

The tough on crime movement in the US has caused incarcerated populations to drastically increase since the mid-20th century, making the US the country with the most people incarcerated in the world[8]. This fear of repeat offenders has had an inverse effect on the justice system and increased punitive measures taken against offenders to keep them incarcerated rather than to offer rehabilitative measures focused on deterring recidivism. In other words, "concern over the prevalence of crime and recidivism has in recent years led many people to support a more 'liberal' use of imprisonment and longer prison sentences"[1]. This is often seen in politics as politicians advocate for a "War on Crime," in the media as violent offenders are depicted as pathological criminals, and in memorial policies geared toward decreasing the occurrence of one specific crime based on an especially heinous event. Public fear of victimization "motivates 'get tough' rhetoric and policies that channel money away from prevention and rehabilitation programs," which further contributes to social disintegration and, ultimately, recidivism[10].

A phenomenon has occurred where there is a general decline in funding for educational and vocational programs due to lack of faith in rehabilitation, but these same programs that are losing funding are the programs which facilitate upward mobility through educational, vocational, and professional training[11;9]. Further, studies like those conducted by Nhan, Bowen, and Polzer have found that the removal of support services has led to increased recidivism rates as social disintegration grows un-restricted[10].

Commonly shared sentiments regarding the effectiveness of rehabilitation cause public authorities to not support it and view offenders as lost causes. Therefore, they do not waste legislation on reentry resources, making reentry even more difficult for formerly incarcerated individuals[3]. However, a study following prisoners released in 2005 found that "77% of prisoners were rearrested for a felony or serious misdemeanor, 55% were reconvicted of a new crime, and 28% were sent to prison for a new crime"[6]. Therefore, inmates released following longer sentences and with access to fewer reentry resources saw continued high recidivism rates regardless of increased sentencing and few reentry programs.

2.2.2 Social Stigmas and Stereotypes

Incarcerated individuals and individuals with criminal histories are often referred to as "dangerous classes" and stigmatized as untrustworthy by the public. This contributes to lower employment opportunities for people who employers identify as part of "dangerous classes." It can increase recidivism rates as individuals without jobs or similar support are more likely to resort to previous criminogenic behavior[6]. They choose to make money with familiar practices rather than be broke and homeless while abiding by the law.

Old bills like the "Three strikes and you're out" crime bill in California, which dramatically increased the punishment for persons convicted of a felony who had been convicted of one or more serious felonies in the past, demonstrated strong concern among the public about repeat offenders[1]. Although the bill is no longer active, the sentiments surrounding it remains influential on cultural attitudes towards returning citizens. This combines with general attitudes of fear and mistrust of formerly incarcerated individuals and "NIMBY-ism." This is a phenomenon where people claim to support rehabilitation and reentry for formerly incarcerated individuals but they also have the mindset of "Not In My Back Yard" (or NIMBY) regarding reentry programs. Reentry programs include cottage industries like halfway houses, food and clothing programs, and other organizations geared towards decreasing recidivism rates. Researchers Nhan, Bowen, and Polzer argue that the public's "negative attitudes towards formerly incarcerated individuals perpetuate misguided policies based on incapacitation and retribution that have increased the number of incarcerations while simultaneously dismantling reentry support services"[10]. Such punitive measures and inhospitable climates place increased strain on the reentry process for individuals released from prison.

2.2.3 Requirements of Parole

Smothering restrictions on returning citizens' occupational, housing, and lifestyle pursuits ultimately have

detrimental effects on individuals' ability to reenter society. Former sex-offenders are unable to find housing, former drug addicts can have difficulty affording Urine Analysis tests, and ultimately many formerly incarcerated individuals are unable to cope under the intense pressure of parole. Researchers Gaum, Hoffman, and Venter argue that "if ex-offenders are prevented from gaining lawful employment (e.g., by-laws restricting their employment) they may be prompted or forced to find other ways of supporting themselves which may violate the law"[3]. The immense pressure placed on parolees and formerly incarcerated individuals to stay out of prison while fulfilling the requirements associated with their release ultimately leads to increased "technical violations" like forgetting to call in about their whereabouts, submitting a clean Urine Analysis, having a stable job, etc.[10]. It is also difficult for them to overcome the social impediments to their reentry created by their time in prison, including the following: "adverse effects on ties to family and friends, mental and physical health, employment prospects, and the ability to access public housing"[6]. All of these are useful resources that could make them more successful in fulfilling technical requirements associated with their parole. This helps make them more successful in staying out of prison.

2.3 Factors Impacting Recidivism

Based on preexisting research, the key factors which seem to have the most influence on individuals' likelihood of committing or recommitting crime include race, prison gang membership, gender identity, conviction, family and social environments, mental health and substance abuse issues, and other variables.

2.3.1 Race

Research shows a consistent association of race, gender, age, conviction of property offenses, and arrest history with recidivism. Racial minorities are more likely to recidivate than their white counterparts, men are more likely to recidivate than women (operating on a binary system of measurement), youth are also more likely to recidivate than older previously incarcerated individuals, people convicted of property offenses are more likely to recidivate than those convicted of violent offenses, and those with more extensive arrest histories are more prone to recidivism than those with fewer arrests in their past[4;9;12].

Black males have the highest incarceration rate, being in "state or federal facilities 3.8 to 10.5 times more often than white men and 1.4 to 3.1 times more often than Hispanic men"[12]. This could be due to underlying social factors like racialized politics, racial profiling, racialized sentencing, and socioeconomic status, which combine to impede upward mobility for African American men.

2.3.2 Prison Gang Membership

Prison gang membership is also correlated with a 6% increase in recidivism[9]. People who have a lifetime commitment to crime are drawn to join prison gangs where they network with other inmates committed to a criminal lifestyle. Furthermore, law enforcement officials are more inclined to closely observe known members of prison gangs because they are more likely to participate in deviant activities in and out of prison[9].

2.3.3 Gender Identity

While statistics regarding recidivism rates among women are lower than those among men, there is relatively little research regarding women's experiences during and post-incarceration, as they are a small but growing part of the incarcerated population. As of 2013, women only made up approximately 12% of the incarcerated population, but the growth rate for the population of incarcerated women is significantly higher than for the population of incarcerated men[13]. Other research suggests the number of women in prison increased by 50% between 2000 and 2016, while the number of men in prison only increased 18% during the same period[5]. If recidivism rates are not decreased through improved reentry programs and resources available to women, the number of women behind bars will continue to increase. This will have detrimental effects not only for the women's quality of life but for their families who will lose a primary caregiver and a wage earner[5]. It also has detrimental effects for taxpayers who will see more of their money being used to incarcerate people, and for marginalized communities who will continue to lose members of their community since they represent a disproportionately large portion of the incarcerated population[5].

Most women incarcerated in the US have histories of alcohol and/or drug use as well as have been physically and sexually abused in their lives[8]. Instead of providing them with rehabilitative programs oriented towards helping them overcome trauma and drug use, the justice system fails to respond to trauma. Instead, these individuals are incarcerated in response to the crimes they committed, thus overlooking the factors which influenced such deviant behavior. Other shared themes among incarcerated females' paths to crime include growing up with at least one family member incarcerated, growing up in single-parent homes or without a guardian, high rates of substance abuse, risky sexual behaviors, experiences in violence and abuse, mental and medical health issues, and a significant number of stressful life events relative to their age at arrest[8]. Research following women reentering society found substance use, employment, and housing to be influential factors in successful or unsuccessful reintegration into society. Although women are at a greater risk of experiencing the risk factors which contribute to crim-

inal activity, researchers found that "state-sponsored support to address short-term needs such as housing reduced the odds of recidivism by 83%"[8]. Furthermore, enhanced vocational skills of incarcerated women also helped decrease recidivism as well.

Such research is important for the future of incarcerated women because more women are incarcerated today than there were twenty years ago, which means more women will reenter society in the next few years as their sentences are fulfilled[12]. Resource availability forms a key component of this process because women are more likely than men to experience relationship, housing, health, and other issues post-incarceration which often put them at higher risk of recidivating[13]. Understanding the impact of different reentry resources on recidivism will prove useful in deterring women from participating in the cycle of recidivism which many individuals are caught within. Studies show that the mass incarceration of women decreases the economic and social stability of low income, urban communities, particularly communities of color[5]. Decreased recidivism for women means more stability in families and society as a whole, which will benefit everyone, not just incarcerated, and previously incarcerated populations.

2.3.4 Conviction

The conviction individuals are charged with is also correlated with their likelihood of recidivating. A study conducted by Alper, Durose, and Markman found that in the nine years following their release from prison, people initially arrested for property offenses were most likely to recidivate than those arrested for drug, violent, or public order offenses[4]. In the study, the researchers clarified that "violent offenses include homicide, rape or sexual assault, robbery, assault, and other miscellaneous or unspecified violent offenses;" "property offenses include burglary, fraud or forgery, larceny, motor vehicle theft, and other miscellaneous or unspecified property offenses"[4]. Similarly, "drug offenses include possession, trafficking, and other miscellaneous or unspecified drug offenses"[4]. Lastly "public order offenses include violations of the peace or order of the community or threats to the public health or safety through unacceptable conduct, interference with a governmental authority, or the violation of civil rights or liberties"[4].

2.3.5 Family and Social Environment

Family and social environments have been consistently associated with recidivism among offenders, particularly among juvenile offenders since they do not have the capability of living independently as minors[12]. Offenders over the age of 21 also experience such impediments to reentry from their family and social spheres when those areas of their lives are involved in crime. This includes abusive relationships, substance addiction, gang activity, and other environments where criminal behavior is normalized. As a result, many individuals are barred from seeking help reentering society from their peers and family, which puts them at a further lack of resources and tools compared with previously incarcerated individuals who do not have criminogenic familial and social ties.

2.3.6 Mental Health and Substance Abuse

Other factors which can influence an inmate's chance of recidivating include mental health, history of antisocial behavior (criminal activity), and substance use[12]. Often, reentry programs and prison programs are not concerned with addressing larger issues like psychological distress and psychopathic problems influencing these factors. Furthermore, prisons and jails are often used as an "easy fix" to deviant behavior committed by individuals, thereby creating a criminal record for individuals who need mental health and substance abuse resources rather than incarceration. The comorbidity of mental health issues and substance abuse may prevent previously incarcerated individuals from being able to seek reentry help from services and manage their resources[14]. In such situations, previously incarcerated individuals must receive assistance coping with their mental health before they can feel confident enough to pursue reentry resources upon release.

2.3.7 Other Variables

Influential variables that returning citizens are less capable of controlling include age, antisocial history, race, family criminality, family rearing, and gender, all of which have implications for individuals' chances of recidivating. Variables that are more subject to change regarding returning citizens' likelihood of recidivating include antisocial personality, criminogenic needs, personal distress, social achievement, and substance abuse[12]. Reentry programs can target the latter which can indirectly soften the impact of the less-easily controlled variables on previously incarcerated individuals and help them avoid recidivism. It is important to address such factors because multiple studies show that antisocial behaviors, poor employment, poor mental health, substance abuse, inadequate or inaccessible information about resources, and social environments are just a few of the factors which have been directly tied to chances of recidivism.

2.4 Reentry Resources

Some of the key reentry resources regarding individuals' reentry into society include social networks, substance abuse assistance, education, employment, the fulfillment of basic needs, and awareness and accessibility of resources[11]. The degree to which each of these needs is met influences an individual's likelihood of

recidivating. There are two types of organizations that can assist with reentry: those that help with immediate needs like emergency assistance organizations, transportation help, food vouchers, etc., and those that help with long-term upward mobility like education, employment, and substance abuse rehabilitation[11]. This section is broken up into resource awareness and accessibility, basic needs, social networks, substance abuse, education, and employment.

2.4.1 Resource Awareness and Accessibility

Other factors that influence recidivism are awareness and accessibility. In the US, services such as food assistance, temporary cash assistance, and Medicaid are underutilized due to many people's lack of awareness of their eligibility and lack of awareness of the resource's availability[14]. When it comes to accessing reentry services, many prisoners find the services confusing and intimidating, which makes them more likely to underutilize resources and ultimately recidivate[10]. For example, employment organizations cannot only offer a list of companies hiring. They need to provide a list of companies willing to hire formerly incarcerated individuals, provide references for the formerly incarcerated individuals, help with resume building, and help them prepare for interviews[11]. Similarly, many doctors and health specialists do not accept Medicaid, which leads to patients in need of care not being able to find affordable and accessible care.

Successful reentry requires reentry organizations to improve their coordination of services for formerly incarcerated individuals. However, the current climate of reentry organizations is anything but organized. The resources available to people reentering society is akin to a "hodge-podge assortment of official and unofficial agencies and organizations localized in different regions" which makes it difficult for people to not only be aware of all the resources available to them but to access the resources[10]. Furthermore, applications for such resources often have a 30-day processing period creating a 30-day window where released inmates lack access to food, housing, medical services, and other basic needs[14]. With this in mind, researchers advocate for facilitated access to social service programs as well as access to substance abuse treatment upon release. Such facilitation could be offered through prisons themselves, parole boards, parole officers, and halfway houses. By introducing available reentry resources early, returning citizens have less opportunity to fall back into the old habits which led them to criminal behavior in the first place.

2.4.2 Basic Needs

Aside from education and jobs, previously incarcerated individuals have reported a need for assistance with more basic needs like transportation, access to clothing and food, medical treatment, and housing[14]. In one study, "pre-release inmates...reported that receiving assistance in meeting basic needs was the most important resource in successful integration into the community"[14]. Lack of food, shelter, or medical treatment puts undue stress on individuals to stay alive when their main focus should be staying out of prison. Lack of clothing and transportation make it exponentially more difficult for formerly incarcerated individuals to not only find a job but to get to and from that job daily. Transportation can involve bus passes, light rail passes, bicycles, and ride shares, but such resources are often unavailable, inaccessible, or under accessed due to lack of knowledge about them. Group housing organizations like the Oxford House and other halfway houses and community homes offer not only stability but supportive environments in which returning citizens can thrive. Some organizations help people find clothing for job interviews and other needs as well as non-perishable food donations which alleviate stress and allow people to focus on overcoming the many other obstacles associated with reentering society. By meeting basic needs to survive outside prison, individuals have significantly less stress placed on their day-to-day lives while they work on reentering society successfully.

2.4.3 Social Networks

Social networks are significant factors regarding previously incarcerated individuals' successful reentry. Social networks involve familial ties, friends, coworkers, support groups, and other resources which can either ease the reentry process or push formerly incarcerated individuals towards recidivism[10]. Reentry is already a difficult process for many individuals because they are disadvantaged by poor education, poor job prospects, substance use histories, and criminal backgrounds, which limit housing options and can alienate families[11]. Reentry can become more difficult when their desires to not recidivate alienate them from their former friends, family, and associates[11]. When individuals' previous social connections prior to their conviction encourage deviant behavior, "establishment of new social connections that discourage criminality is key for long-term desistance"[7]. Research shows that prison programs which focus on the development of social bonds, social capital, and prosocial strategies for managing strain assist with reentry because many ex-convicts entering society lack the social capital to create favorable social ties[6,11].

2.4.4 Substance Abuse

Along with social networks, substance abuse is a key factor correlated with recidivism[10]. Substance abuse is a debilitating addiction for many people, which often goes untreated while incarcerated. As a result, many

people struggle to stay clean when they have new freedoms not afforded to them in prison. Recovery support groups like Alcoholics Anonymous, Narcotics Anonymous, and other support programs can offer advice, feedback, and inspiration to people struggling with addiction. Studies show that as many as "fifty percent of federal inmates and 16% of state prisoners were convicted drug offenders. In comparison, 53% of state prisoners and 7% of federal prisoners were serving time for violent offenses"[12]. Considering that such a significant number of people are incarcerated for drug use, an effective strategy for decreasing prison populations would be to offer drug treatment programs to previously incarcerated individuals while incarcerated as well as when they reenter society. Research shows a positive correlation between the number of drug and alcohol-related offenses and the total number of times individuals have been imprisoned[3]. If individuals can overcome addictive behavior around substances, they have a better chance of avoiding addictive behavior around catching new charges.

2.4.5 Education

Education plays an important role in the reentry process for previously incarcerated individuals because it helps increase their qualifications for jobs when they are released from prison. Previously incarcerated individuals that earned a GED while incarcerated were significantly less likely to return to prison within three years than those who did not earn a GED while incarcerated. This was particularly impactful among young offenders[15]. In one study regarding the effect of education on recidivism, researchers reported that post-release, "77% of those persons who had completed formal educational offerings [while incarcerated] were employed as reported by a supervising parole officer"[1]. Online and in-person classes and tutoring help equip returning citizens with more resources to help them achieve successful reentry.

2.4.6 Employment

Employment can be one of the most difficult resources for formerly incarcerated individuals to obtain upon release, making it extremely difficult for them to earn money to pay for necessities. Unemployment is one of the strongest predictors of an individual's likelihood of recidivating[16]. Therefore, "educational intervention for inmates results in positive post-release functioning, including higher employment rates, the type and wages of employment found, and a person's success on community supervision"[1]. Losses in education programs and organizations impact the employment of exprisoners which can then influence recidivism[11]. Without a steady income, people struggle to meet even the most basic needs for day to day survival. Employment agencies can help returning citizens not only find jobs, but format resumes and create goals for themselves to pursue.

It is also important to note that recent legislation regarding the Ban the Box initiative has positive implications on future employment opportunities for returning citizens. In previous years, job applications included a box for individuals to "check" concerning if they had been previously incarcerated. The Ban the Box initiative removed this criminal history check box from job applications[16]. Although background checks continue to be a common component of interview and hiring processes, by allowing individuals to interview before the background check is conducted, they have the opportunity to discuss their past convictions openly and honestly. This demonstrates their complete rehabilitation post-incarceration and improves their chances of being hired by the company. Another policy directed towards assisting returning citizens in employment is the Work Opportunity Tax Credit, or WOTC, which allows private employers to apply for federal tax credits for hiring individuals from certain groups, like people released from prison in the last year[16]. However, the WOTC and Ban the Box policies do not do enough to assist with employment for returning citizens. Employers must be more incentivized to hire previously incarcerated individuals, making the Ban the Box initiative less necessary than the WOTC policy if utilized correctly.

2.5 Impact of Reducing Recidivism

Beyond keeping prison beds empty and lowering costs of incarceration, successful reentry is important because it means fewer people behind bars and more people contributing to society as a whole. In 2002, the Bureau of Justice Statistics reported 68% of those released from prison were rearrested for a felony or serious misdemeanor and 63% were recommitted to prison within three years of their release. This is an increase from 63 percent and 41 percent recorded in a study conducted in 1989[9]. More recently, a study that followed released inmates from 2005 to 2014 reported 82% of prisoners rearrested during the 9-year period following their release were arrested within the first three years[4]. Within the first three years out of prison, the first year is the most critical. Dooley, Seals, and Skarbek reported that two-thirds of rearrests occur within the first year following release and dub the first nine months out of prison as the "critical period," because after this period, the re-arrest rate declines for previously incarcerated individuals[9].

The United States has the highest incarceration rate, but it is unclear if the country has the highest recidivism rate as well, as most countries do not list recidivism rates[2]. State prison populations have increased by 700% since the 1970s, as well as average time served, which increased by nine months between 1990 and 2009[6;12].

As of 2014, 2.8% of adults were under some form of correctional supervision[12].

The employability rate of previously incarcerated individuals "represents employment with a stable employer, the payment of state and federal taxes, and the receipt of credits for quarters of employment through social security administration"[1]. Decreasing recidivism can improve the health and social well-being of the public by increasing public safety, helping to control institutional overcrowding, and ultimately reducing financial burdens on taxpayers[8;14]. As of 2011, associated costs of incarceration were more than $52 million[12]. This does not include indirect costs like social services, child welfare, or education. It demonstrates the potential for dissemination of unused funds if fewer people are incarcerated.

The relationship between recidivism and reentry organizations impacts the neighborhoods and their residents beyond just the previously incarcerated individuals. The effects of mass incarceration will be felt for years to come, which means the dependence of exprisoners on reentry organizations is unlikely to end and may even increase[11]. This makes it even more important to understand the relationship between recidivism and reentry programs so that taxpayers can save money, crime rates can go down, and more people can contribute to society.

Based on the supporting literature, it was determined that the best way to understand which resources are most useful to reentry was to conduct interviews with previously incarcerated individuals who have since successfully reentered society. The purpose of this research was to understand which reentry resources were deemed most useful by individuals who have experienced successful reentry. Their responses would then be utilized to inform future research and policy recommendations regarding reentry resources.

3 METHODS

The initial goal of this research was to learn more about the hardships that women face upon reentering society following incarceration and what resources are available to help them through the difficult changes which accompany reentry. This goal was chosen due to preliminary research that women are more likely than men to experience relationship, housing, health, and other issues post-incarceration, which often put them at higher risk of recidivating by committing new crimes to send them back to prison[13]. However, upon gathering research through literature and interviews, it became clear that this statement was not supported across studies, that recidivism is not a gendered issue, and that the pandemic must be addressed for both men and women reentering society to decrease prison populations as a whole. The goal of the research became to understand how resource availability influences people's likelihood of recidivating so that policy and procedure recommendations can be made regarding reentry programs and resources.

A series of seven detailed, qualitative interviews were undertaken, with an orientation around reentry processes including resources and obstacles which returned citizens experienced during their reentry process. The anonymous interviews were conducted with each individual either in person or over the phone depending on accessibility, and they lasted between thirty and ninety minutes in length. The participant demographic includes people who have personal experience reentering society post-incarceration and are no longer on parole, some of whom have experience providing reentry services to previously incarcerated individuals–a professionalization based on personal experiences which makes them some of the most valuable resources returning citizens could utilize.

The interviews were based on the template listed in the appendix. They were conducted in an open-ended manner and allowed each participant to guide the interview with their narrative. Participants were asked to discuss their experiences reentering society post-incarceration, specifically to elaborate on factors that assisted or impeded their process of reentry, such as what obstacles they faced, what resources they had available to them, and what resources they wished had been available to them.

Based on the conflicting research regarding the conditions leading to incarceration, the identities which influence experiences with incarceration, and the usefulness of resources in the reentry process, a case study regarding the reentry process of seven individuals who were previously incarcerated was conducted. Each of the individuals was a current resident of Colorado, had previously been incarcerated within the Criminal Justice System, and had been on parole but was no longer on parole. The researcher identified potential interview participants based on social networks they had built through previous work with a non-profit reentry organization in the Denver area. The seven interview participants were chosen based on a snowball and networking method. Through the non-profit, the researcher was able to connect with five people to interview and then network with those individuals for two more interview participants. The organization did give explicit consent to the researcher, allowing her to work with them and obtain contacts from them for her research.

The information gleaned from the interviews was then compared with that from analyzing pre-existing literature to theorize potential reentry programs and resources to provide returning citizens. This was the most useful method to conduct the research because it embodied a non-invasive way to address predominant personal issues faced by a marginalized and often

Table 1 Study Demographics

Participant	1 (JA)	2 (TJ)	3 (BT)	4 (JM)	5 (LM)	6 (JC)	7 (TS)
Age	41	48	49	60	36	51	47
Race	Hispanic	African American, Caucasian, Native American	White	White	Native American and Caucasian	White	African American
Gender	Man	Man	Woman	Man	Man	Man	Man
Employment Status	Full Time	Full Time	Full Time	Full Time	Full Time	Full Time	Full Time
Socio-economic Status	Working Class	Working Class	Middle Class	Middle Class	Working Class	Working Class	Working Class
Relationship	Yes	No	Yes	Yes	Yes	No	Yes
Offense	Gang-related 2nd degree murder	Drug distribution, theft	Meth distrbution and manu-facturing	Racketeering	2nd degree assault	Sexual offense	Gang-related homicide
Time Served	32 years	4 years	6 months	5 years	3 years	20 years	22 years

misunderstood population of people. The interviews were then coded for similar responses where reentry resources were concerned, specifically regarding which resources each individual found most useful to their reentry process, which resources were not provided but they wished had been provided, which resources were more difficult for them to utilize, and which resources were easier for them to utilize. The demographics of the participants in the study are summarized in Table 1.

The participants ranged in ages between 36 and 60 years old. Six of the seven participants were men and one was a woman. Three of the participants were white, one was African American, one was Hispanic, one was Native American and Caucasian, and one was African American, Caucasian, and Native American. All of the interview participants were employed full time. Two of the participants identified as middle class and five of the participants identified as working class. All but two of the participants reported being in a steady relationship with a significant other. Their offenses included gang related second degree murder, drug distribution and manufacturing, theft, racketeering, second degree assault, sexual offense, and gang related homicide. Four of the participants served five years or less and three participants served twenty years or more.

4 RESULTS

Based on the interviews, the following information was gleaned from the participants and categorized into seven classifications of resources and stressors. The results included implications for resources like program participation while incarcerated, obstacles faced upon reentry, basic needs, employment, familial relations, desired resources, and emergent themes.

4.1 Program Participation While Incarcerated

Prisons provide various classes and activities in which inmates can participate, some of which can help prepare them to reenter society successfully. All of the seven interview participants in the case study reported utilizing various prison resources, including faith-based programs, resume-building classes, meeting with a substance abuse-recovery group, taking academic classes, or tutoring other inmates while incarcerated. Most participants reported that the classes on substance use and resume building were not useful to them as they did not cater to their substance abuse-recovery needs and their reentry needs. They remarked that they wished the programs had involved more mentorship and advice aspects. They also reminisced that the usefulness of the programs provided to them was determined by the mindset and determination of the inmate.

> "There are programs, but you have to want to get better. You have to want to rehabilitate yourself. I'm telling you, there's not a lot of guys in there that do." –JM

The participants who participated in academic programs did so because they were dedicated to making the most of their time while incarcerated and to reentering society with more tools to help them succeed. The interview participants who reported participating in faith-based programs reported they felt more at peace with their circumstances than before they began tak-

Table 2 Reentry Barriers

Participant	1 (JA)	2 (TJ)	3 (BT)	4 (JM)	5 (LM)	6 (JC)	7 (TS)
Unemployment	X	X	X	X	X	X	X
Housing/Shelter	X	X			X		X
Mental Health		X			X		X
Substance Use Recovery		X	X		X	X	
Food/Clothing	X	X		X	X	X	X
Transportation	X	X			X	X	X

ing the class–remarking increased feelings of empathy, increased devotion to religious faith, increased sense of belonging to a favorable community, and increased hope for their future post-incarceration.

> "And some people are like 'when did you start doing reentry?' and I'm like 'when I was inside.' And that's where the work really starts. People come and see you, like church folks. And people come in and talk, motivational speakers, and then you have movie time, and all that stuff. I engulfed myself in everything that was outside...So I got all kinds of knowledge about where I wanted to go, and I developed some confidence about what I could do." –TJ

4.2 Obstacles Faced Upon Reentry

Different stressors individuals face during their reentry process can influence their likelihood of recidivating. Each of the interview participants experienced specific obstacles to their successful reentry, however, there were also trends in types of barriers to reentry each participant faced. These barriers were broken into five categories including unemployment, housing/shelter basic needs, mental health, substance use recovery, food/clothing basic needs, and transportation basic needs. All seven participants experienced unemployment for some period of time, four of the seven participants experienced difficulties finding housing, three of the seven participants experienced mental health issues, four of the seven participants utilized substance abuse or similar support programs, six of the seven participants experienced difficulties procuring food and clothing, and five of the seven participants experienced difficulties with transportation. Ultimately, each participant described the process of re-entering society as a difficult process due to both obstacles and massive changes in lifestyle following incarceration.

> "I had to uh learn how to drive. I had to find a job. I had to find a place to live, housing." –TJ

The type of offense a person served time for also influences their reentry process and specific reentry obstacles they may face. Different social stigmas and legal precautions accompany each offense with which individuals are charged, and such offenses include sexual offenses, violent offenses, and drug offenses, to name a few.

> "One of the difficulties that a person with a sexual offense has is that that kind of ends the conversation for a lot of people. So if you're looking for a job or if you're looking for whatever, umm, as soon as they find that out, that's the end of the conversation. So it's very difficult in that circumstance." –JC

Common barriers to reentry discussed by the interview participants were most easily summarized in Table 2.

4.3 Basic Needs

For this research, basic needs include food, clothing, transportation, and housing. All of these resources are crucial to human survival since they enable individuals to partake in other resources beyond their basic needs. Six of the seven interview participants reported utilizing reentry services for basic needs like food and clothing. Five of the seven interview participants reported utilizing transportation services in their reentry process. Other resources addressing basic needs include food stamps, emergency support centers like food and clothing banks, bike rentals, and passes for public transportation.

4.3.1 Housing

Although housing is a seemingly obvious resource returning citizens need, it is still considered a basic need by many standards. Without shelter, individuals are homeless and therefore unable to fully participate in society since they lack an address that is utilized for mail, identification, and even job offers. Four of the seven interview participants reported utilizing housing resources during their reentry process. Those that had strong familial support throughout their reentry process were less likely to report housing as a significant obstacle or stressor since they had outside assistance.

The main obstacles associated with obtaining housing post-incarceration involve affordability and accessibility. Returning citizens must find housing within their price range, close to public transportation so they can get to and from work, and they often must fulfill other requirements associated with community homes. Such requirements include urine analyses, curfews, cleanliness, chores, and other contributions to the community.

> "A severe lack of affordable housing made reentry very difficult and it continues to make reentry difficult today." –TS

Housing was not only important for shelter, but it offered community support for individuals who did not have much support. It created a sense of community and a support system for those who rented rooms in halfway houses with people in similar situations as themselves.

> "I can't stress enough how much of a difference it made living in an Oxford House, or any sort of community environment. There's not a whole lot of opportunity for people to be around somebody that's been through it and done well if you're going to do it on your own." –LM

4.4 Employment

Employment is an important aspect of reentry since it provides an income for individuals to begin saving money, builds their resumes, and provides beneficial networking opportunities with other citizens. All of the participants listed employment as a priority upon reentering society. Employment is a condition of parole as well as a condition of housing in many halfway houses. Therefore, it is a major concern for returning citizens.

> "Everything that I had to do at the Oxford house was just reassuring that I could make everything happen for parole that they were asking. You know, maintain employment, maintain sobriety, hold yourself accountable to meetings that you have to be at, get your license before driving your car, you know." –LM

Five of the seven participants found employment through social networking with family and friends while the remaining interview participants found employment through employment agencies. Four of those who found employment through social networks have experienced more consistent employment and upward mobility in their careers. They are also currently working with reentry organizations as resources they either found useful or wished they had had access to in their own reentry process. The two remaining participants who found employment through employment resources are employed in careers with less upward mobility. This could be related to their conviction record or their method of procuring employment without networking opportunities.

> "He was like 'you're coming to work for me because I need you to work with the youth offenders.' And I was like 'okay.' So then I worked there for almost a year because it was only the summer program. And then I moved into being a medical case manager...Umm, yup… And I started here as a vocational specialist and I worked my way up to manager and then director." –BT

4.5 Familial Resources

Family connections can be predictors of successful reentry because they can mean extra assistance and support for returning citizens. Six out of the seven interview participants listed their family as a prominent resource they utilized in their reentry process. Most utilized family for housing, money, clothing, food, transportation, and general morale-boosting. The participant who did not utilize their family as a resource noted significantly more difficulty meeting basic needs like food, clothing, transportation, and even housing.

> "Family is huge. So my family, they kicked in with some assistance that I really needed...It always helps to have good strong family support along with good strong community support." –TS

Many of the interview participants also remarked on some factors which inhibit the ability of returning citizens to receive help from family upon reentering society. Family members can be prevented from assisting their returning relatives if they are receiving government assistance as well as if they too have a history of criminal activity and are on parole or still committing crimes (for instance gang activity).

> "I couldn't live with any of my relatives that were out here because all of them were on government subsidized housing and if you are a recipient of government subsidized housing, you cannot have people who are on parole living with you." –TS

4.6 Desired Resources

As the interview participants have all successfully reentered society and have direct experience utilizing an array of reentry resources, their reflections regarding what resources they would have desired in their reentry process hold significant weight. Among the participants,

when asked about what types of resources they wish had been more readily available to them, they remarked that assistance with basic needs (food stamps, transportation assistance, clothing, etc.), information about what resources were available to them, mentorship programs, and mental health services would have been most helpful to them. Four of the seven participants reflected on difficulties having enough food, having appropriate clothing for work, and traveling between their place of residence and their place of employment as well as to and from urine analysis tests. Further, four of the seven participants remarked that they would have liked to know more about what resources they had access to at the time. They were sure to note that there are more resources available to previously incarcerated individuals today than there were a few years ago when they began their reentry process. They mentioned the need for an up-to-date database with information regarding the types of resources available to returning citizens.

> "I guess [I would want] just more information. Because there is a lot of places out there, but if they could just make it more systematic. As far as the places to go for trying to find a job as a felon, trying to buy an apartment as a felon. Or what kind of credit is available to you. Or how to set up a bank account and stuff like that. You know, stuff that helps you actually function… You know, just having people explain that a little better." –JA

Four of the seven interview participants remarked on the lack of mentorship resources available to returning citizens and discussed potential assistance a mentor could give with navigating resources.

> "I think reentry programs are important. I think it should be thought through what reentry programs people should be going to, and what's a good fit. And back then, they didn't have peer mentors, or peer navigators or those things. And I think now we do have those things, and it's more helpful. I didn't have much. No. Umm, my probation officer gave me some directives, but it was more 'Get a job. Follow the rules. Do your UAs,' and kind of that stuff." –BT

One out of the seven participants remarked that they would have liked to have more access to mental health services upon reentry. They remarked that the reentry process is a very difficult time for many previously incarcerated individuals, particularly those who have little resources to assist them.

> "I just wish there was more mental health resources when I came home. Because there was a lot of things that I was dealing with concerning PTSD and some trauma from prison. And if I could have gotten over some of those things that I was going through, I probably wouldn't have done some of the self-medication that I did with alcohol or gone through some of the depression that I was going through when I was released." –TS

4.7 Emergent Themes

A common theme that emerged from the research unexpectedly was advice regarding embracing change and the value of a positive mindset. In terms of the reentry process, the interview participants discussed the mentality which helped them reenter society successfully. They talked about stressors like parole obligations, lost social connections, taxes, expenses like rent, food, clothing, transportation, and other basic needs which make people uncomfortable in society.

> "When you're faced with all those responsibilities and everything that you have to do in society in order to be efficient and productive, it's easy to get discouraged or give up. And they'll use crime again as a vehicle to go back to prison where they're taken care of. Where they don't have responsibilities." –LM

The interview participants also talked about mindset changes in terms of addressing ways of thinking which got them in trouble with the law in the past. They talked about the value of changing their attitude and mindset to lead a more sustainable, productive, and successful life outside of prison.

> "You just kind of have to accept in a lot of ways that it's a new life. Nothing's the same. You can't go back to your old life because that's not what you want to do anyway." –JA

> "I knew that there was a huge possibility that if I didn't change the way I thought about my relationship to society, my relationship to authority, my relationship to myself, then I had a really big chance of doing what I saw most of the people I saw in there doing and coming back for their second or third term in prison." –LM

The interview participants also shared insights about recidivism and the mindsets they utilized to avoid such patterns. They discussed the value of recognizing malignant behavior patterns as abnormal and unnecessary as well as their potential to have severe consequences on their future.

> "Men who get into prison, come out. Get into prison, come out. Get into prison, come out. It becomes a normal part of life. It's just something that happens. And they just sort of see themselves as either a victim of that or that it's unavoidable or inevitable, or whatever. And so, I mean, it's like when somebody gets a cold and people just say well people just get colds from time to time. Well these guys just go to prison from time to time... You just can't think that way." –JC

5 DISCUSSION

5.1 Professionalization

Based on the responses to the interviews regarding resources utilized and obstacles faced, a theme has emerged regarding the most useful reentry resources. The majority of the interview participants have pursued careers in reentry resources for people returning from incarceration. Therefore, their responses when asked about the most useful resources for reentering society were thoughtful and well-informed. These individuals "do not 'put it all behind them' in exchange for conventional lifestyles, values, beliefs, and identities. Rather, they use vestiges of their deviant biography as an explicit occupational strategy"[17]. This professionalization of their past has made them invaluable resources to individuals returning from incarceration as well as to researchers looking to understand more about the reentry process. They each faced unique reentry obstacles and became passionate about utilizing their own experience to help steer other people on the right path to successful reentry. By becoming the mentors and providers of resources that many of them wished they had during their own reentry process, they have helped to improve the chances of individuals reentering society successfully. They drew upon not only their personal experience but the experiences of the people they have helped in their jobs. They discussed significant stressors they faced like meeting their own basic needs including food, clothing, transportation, and housing as well as the value of support groups or mentorships, family support, and employment.

5.2 Basic Needs

As noted by Costopoulos, Plewinski, Monaghan, and Edkins, assistance with basic needs is one of the most influential factors in successful reentry[14]. Unreliable or unaccounted for transportation, food, shelter, clothing, and medical treatment create additional stressors for returning citizens who also must find a job, fulfill parole requirements, and ultimately reintegrate themselves into society. Returning citizens need access to organizations which offer assistance with transportation–like bike donations and public transportation, which offer food donations–like food stamps and nonperishable food donations, and which offer access to clothing donations. They also need access to halfway houses and medical treatment–each of which are difficult to locate and apply for following incarceration and depending on their crime.

5.3 Employment

As English noted, unemployment is one of the strongest predictors of recidivism[16]. Since all of the interview participants identified unemployment as an obstacle they faced, it is not only a significant issue for its impact on prison populations, but its widespread influence on previously incarcerated individuals. Therefore, employment agencies need to offer more information to returning citizens to help them find, qualify for, interview for, and keep jobs.

5.4 Support

Mentors, familial support, and support groups can form positive social networks encouraged by Nhan, Bowen, and Polzer to ease the reentry process for returning citizens[10]. It was also recommended by Barrus for individuals to establish positive social networks following incarceration to help deter them from recidivating and encourage them to avoid deviant activities[7]. Such support groups can also have positive influences on returning citizens' mental health and by extension their reentry because they offer them advice, help, and even people with whom to talk. This is supported by Costopoulos, Plewinski, Monaghan, and Edkins, who argued that mental health and substance abuse can combine to create even greater barriers to successful reentry by preventing individuals from seeking reentry help[14]. Therefore, it is important to offer resources like support groups and positive social networks so returning citizens can overcome mental health issues and substance use, allowing them to successfully reenter society. Receiving assistance with substance use recovery was also connected with successful reentry by Gaum, Hoffman, and Venter[3], who identified a correlation between drug and alcohol-related offenses and the total number of times individuals had been sentenced. Therefore, substance abuse recovery assistance like support groups could decrease individuals' likelihood of recidivating for drug-related offenses which would decrease the number of people incarcerated.

> "When I stopped using, that's when I leaned on my family... Umm, where a lot of people don't have family with resources that can do that. So, if it was just me, and I was out there

> alone, I absolutely would have needed housing assistance, umm employment assistance, transportation assistance. Umm, and just general, like peer support." –BT

The interview participants often discussed the impact such stressors can have on individuals' successful reentry prospects and the value of mentors and support groups as well. Role models, the opportunity to learn from others' experiences, and empowering social spheres help equip returning citizens with the necessary mental and emotional tools to be resilient in the face of adversity and impediments to their reentry. They were forthcoming when comparing personal experiences to those they heard about from returning citizens whom they had helped.

> "It's easy for people to say, 'this is too much, I don't want to do this', and they want to go back. I think that plays a significant factor in people [recidivating], and it maybe has to do with the fact that there's not a whole lot of mentors out there saying 'you got this.'" –LM

They also discussed the value of support groups and similar networking with individuals who have successfully reentered society. They placed great value on the inspirational value individuals can have to people who would otherwise feel alone and weak when faced with a task as daunting as reentering society successfully.

> "If you can see someone succeed from where you had the worst time of your life, and you can see someone succeed from that vantage point, then maybe you can as well." –TS

6 CONCLUSION/RECOMMENDED NEXT STEPS

It is important to recognize that no resource was clearly identified as the most useful resource between the seven interview participants. This implies that returning citizens are in unique situations which require different combinations of resources for them to be successful. Therefore, funding and support should be allocated to the resources which are most commonly identified as useful resources, even though they may not be every individual's champion resource. Based on this research, the most useful resources for reentry include resources directed towards meeting basic needs like food, clothing, transportation, and housing resources, support/mentorship groups, family support, and employment organizations. Considering that this is a broad spectrum of relatively common reentry resources, the greater overarching problem may be a lack of accessibility and the knowledge that such resources exist. Therefore, policies and funding should be directed towards supporting such organizations so they can better assist returning citizens and alleviate high recidivism rates which would contribute to society as a whole.

6.1 Recommended Next Steps/Insights and Implications

6.1.1 Policy Implications

Based on the research, future policy recommendations should be directed at providing increased funding and accessibility for reentry resources. The specific reentry resources which should be targeted by such policies include meeting basic needs like food, clothing, transportation, and housing resources, support/mentorship groups, family support, and employment centers.

Policies directed at funding basic needs would include long-term commitments made by returning citizens to the organizations in return for their services. This is to ensure that returning individuals take as much assistance from reentry organizations as they can without jumping from organization to organization. By committing to organizations that provide basic needs, the organizations can monitor returning citizens more closely to ensure their successful reentry. For example, housing should be offered in conjunction with access to food stamps, transportation, and clothing for those who express a need for them.

Policies directed at support and mentorship programs would include funding for support groups structured similarly to Alcoholics Anonymous or Narcotics Anonymous, which provide not only a support network but an accountability mentor. This would also require the involvement of parole officers who would need to help coordinate meetings and hold parolees accountable for attending those meetings. Similar programs already exist but are not enforced widely, therefore, widespread enforcement of such mentorship and support programs will help more people successfully reenter society.

Although it would be difficult for funding to be provided for familial resources, exceptions could be made for families who pose no other red flags for housing parolees besides being on welfare, food stamps, or Medicaid.

Policies directed at supporting employment centers would involve funding for up-to-date resource management, initial meetings mandated and scheduled by parole officers and more incentives for employers to hire previously incarcerated individuals. By funding employment centers, they can stay up to date on employment opportunities for returning citizens as well as provide quality assistance to them in their job search. By mandating a meeting with an employment organization, more returning citizens can start their reentry process by at least learning about employment oppor-

tunities, if not finding a job right away. Lastly, while there are already tax incentives for employers to hire people with criminal records, the incentives are not enough. Increasing the incentives directed at employing previously incarcerated individuals combined with the previously implemented Ban the Box political movement can create more jobs and decrease stigma against people with criminal records.

Policy recommendations from this research clearly show the varying influence of individual factors on different people and that re-entry organizations should recognize this. However, while housing and employment are important for some returning citizens, family counseling, drug treatment, life skills training, and other resources may be more important initially. This helps lend insight into future research so the reentry process can be better understood and therefore better supported to decrease recidivism.

6.1.2 Future Research

To ensure thorough data collection and accurate policy recommendations, further research must be done. This study focused on reentry resources using a case study and an analysis of literature. Considering the small population of the case study, more research must be done with a larger, more diverse sample size to ensure accurate and thorough data collection. This would solidify the conclusion regarding the relationship between reentry resources and recidivism.

To build off of this study, further research must be done on the influence race has on recidivism, the influence gang-related activity has on recidivism, and the influence trauma has on recidivism. It is also important to widen the span of research to include more successfully returned citizens to ensure more accurate and representative data.

Furthermore, if this research had been given more time, it could have been useful to create comparison groups between successfully returned citizens and those who recidivated and to interview more people. Interviewing more people would increase the diversity of the sample group which would make the data more inclusive of people from different backgrounds and with divergent identities. Comparing successfully and unsuccessfully returned citizens would provide more insight on not only what made people successful but what made them unsuccessful, which would allow for more causal analysis instead of correlation analysis of reentry resources and obstacles.

It is also important to note that the professionalization of some of the interview participants could have been a contributing factor to their successful reentry. Therefore, further research on the benefits of using one's past to shape a successful career and future should be studied as well as more interview participants should be selected who have not professionalized their past experiences. This would contribute to further understanding of what resources returning citizens have found most useful to them in their reentry process and what resources they wished had been provided to them. This would solidify, if not narrow down, the data supporting future policy implications regarding steps taken to reduce recidivism.

7 APPENDIX

7.1 Reentry Interview Guide

Date:
Interview Code:
Pseudonym:

First, I will ask you a few questions about your life, in order to gather some context to your story and your reentry into society post-incarceration. As a reminder, anything you feel uncomfortable answering, you can just say "pass," and we will quickly move on to the next question. All the information you provide will remain confidential.

General Information
Age:
Ethnicity:
Gender:
Socioeconomic Status:
Employment status:
Marital/Relationship Status

1. One of the goals of this study is to learn about how the justice system and society can offer better resources and programs to help people reenter society and decrease recidivism rates. This requires us to know about your pathway through life, both before and after your incarceration. Can you please tell me about yourself? With events you feel comfortable sharing, can you please tell me about your life history, including any activities, relationships, or other things you feel are relevant to your story? (early family life, parental/sibling/friend/significant other/work relationships, significant childhood events, school experiences, work history, romantic attachments, housing situations, etc.) What of these factors do you feel have had the most influence on your life?
    (a) Can you tell me about your life story? Before and after incarceration?
2. How many years were you incarcerated for?
3. How long have you been out of prison?
4. Can you please describe what reentering society was like for you?

   (a) Difficult, family connections, job search, housing, substance use help, acceptance, stereotypes, internal struggles?
5. Can you tell me about the decision-making processes and difficulties around terms of parole and/or catching new charges?
6. Did you participate in a reentry-type program while you were incarcerated, prior to your release from prison?
   (a) What sort of things did you learn in this program and do you think it was helpful to you?
7. What sort of resources did you have access to for help reentering society when you were released from prison?
   (a) Which of these resources did you find most useful to you in reentering society post-incarceration and avoiding recidivating?
8. What resources do you wish had been provided to you when you were released from prison but weren't provided to you?
   (a) Why do you think they would have been helpful?
9. What are some things which made you successful in reentering society?
   (a) Relationships, reentry resources, job, responsibilities, reentry program?
10. What are some things that made reentry more difficult for you?
   (a) Stressors, challenges, pushes/pulls towards recommitting crimes?
11. What are some tools and resources you struggled to find, and what are some tools/resources that you found easier to get?
12. If you could give one piece of advice to someone reentering society post-incarceration, what would you tell them?

8 EDITOR'S NOTES

This article was peer reviewed.

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Comparison of Forensic Interview Techniques

Avery Stackle[1], Naomi Wright[2], Anne DePrince[2]
[1]Student Contributor, University of Denver
[2]Advisor, Department of Psychology, University of Denver

Abstract

Experts question whether the techniques used to interview crime victims and witnesses during investigations are optimized to gather the most accurate information while minimizing the potential for negative experiences for the interviewee. In response, this study used a randomized-control design to compare a novel trauma-informed interview created for this study against an established interview, the Enhanced Cognitive Interview (ECI). Participants (N = 45) were recruited from a university human subjects pool. Participants watched a video depicting a robbery, responded to surveys during a 30-minute delay, and were randomized to answer questions about the video in the trauma-informed (n = 21) or ECI condition (n = 24). Participants were compared based on the accuracy and inaccuracy of their memory and their experience during the interview. The two techniques did not significantly differ on any outcome, suggesting the trauma-informed approach added little to the ECI, but also did not detract from the ECI, in a laboratory setting. Findings are discussed with respect to implications for the efficacy and uptake of evidence-based interview techniques in applied legal settings.

Keywords: trauma, witness interviewing, law enforcement, Enhanced Cognitive Interview, recall, accuracy

1 INTRODUCTION

Traumatic events can constitute a crime, and when that is the case, the criminal justice system often interviews the person who experienced or witnessed the crime. Eyewitness statements can contribute to trial evidence and tend to be more convincing at trial than other evidence[1;2;3]. Yet, standard forensic interview techniques can introduce inaccuracies into testimonies by inadvertently leading interviewees to incorporate suggested information into their memory of the event[4]. The primary evidence-based approach to forensic interviewing is also the best researched, known as the Enhanced Cognitive Interview (ECI). While the ECI has documented efficacy in producing accurate testimonies in naturalistic and lab settings, forensic professionals have suggested the ECI may not account for the cognitive differences in the encoding and recall of memories for traumatic events and may also fail to minimize the potentially negative experience of being interviewed in a forensic setting[5]. Yet, to date, a trauma-informed approach to forensic interviewing has not been studied in a laboratory or applied setting. Thus, there is need for empirical evaluation of a trauma-informed version of the ECI. The current study aims to assess whether a trauma-informed forensic interview is superior to the ECI for: (1) the facilitation of accurate memory recall; and (2) the subjective experience of interviewees.

1.1 History of Forensic Interviewing

Before the establishment of evidence-based forensic interviews, law enforcement professionals used many and varied approaches to interviewing. Typically, forensic interviews asked participants to freely recall the event in chronological order, with follow-up questions using who, what, when, where, why, and how prompts[6]. However, these types of questions can provide unintended scaffolding that leads interviewees to recall inaccurate information[4]. Traditional interview techniques also tended to comprise close-ended questions, which can limit the amount of recall compared to open-ended questions[7].

1.2 Cognitive Interview and Enhanced Cognitive Interview

Given the problems traditional forensic interview techniques can cause, the Cognitive Interview (CI[7]) was developed to elicit information using principles from memory research. The CI was developed based on findings that memories are encoded in a network across

multiple neural structures[8], meaning that retrieval techniques that use multiple strategies should be more effective than focusing on recall using only one strategy[9]. Thus, the CI relies on multiple retrieval cues to elicit recall of an event from these overlapping neural areas[10]. The retrieval cues include: context reinstatement, encouragement to report everything without guessing, recall with perspective-taking, and recall with varied temporal order. The CI was later revised into the Enhanced Cognitive Interview (ECI), which comprises the four mnemonic techniques from the original CI, with clearer guides for how interviewers should communicate and build rapport with interviewees[11].

The ECI's rapport-building section was added because personal communication was shown to build trust with interviewees and increase interviewees' comfort when sharing personal information[11]. The main components of ECI rapport building involve the interviewer personalizing information at the beginning of the interview (i.e., using the interviewee's name or inquiring about biographical information) and communicating empathy by showing concern for and understanding of the interviewee. The interviewer also asks the interviewee general personal questions, such as their interests.

The first retrieval cue in the ECI, *context reinstatement*, is based on the context maintenance and retrieval (CMR) model of memory[12]. The CMR model suggests that experiences are encoded in memory as a mental representation that includes contextual elements like sounds or sights. CMR posits that by activating components of the original representation in the neural network during recall, the overall recall of related information will be enhanced. Context reinstatement is implemented in the interview by instructing participants to "reinstate in your mind the context surrounding the incident[7]."

The second retrieval cue, *report everything without guessing*, is based on findings that victims and witnesses of crime tend to recall peripheral details, such as the color of a water bottle, rather than characteristics of a perpetrator[13;14]. Asking the interviewee to recall everything they can is intended to encourage reporting of potentially vital peripheral details that may otherwise have been considered unimportant[7]. The report everything without guessing cue is implemented by instructing participants to "report everything that [they] can about [the event]" and describe "all the details [they] can without leaving anything out." The interviewer then gives the participant as much time as they need to recount all of the details they can remember about the event.

The third retrieval cue, *recall with perspective-taking*, is based on findings that a shift in perspective when recalling an event increases the amount of information a participant recalls, fostering recall of new details not identified in the first recall attempt[15]. The recall with perspective-taking cue is implemented by asking participants to close their eyes and imagine the scene of the event from the perspective of another person who was present (e.g., the witness, victim, offender) and describe the event from that individual's perspective.

The fourth retrieval cue, *recall with varied temporal order*, is based on associative-chain theory[16], which suggests that recalling information prompts the recall of other information encoded around the same time. Reversing the order of recall has also been shown to allow investigators to better distinguish truthtellers from liars because such reversals require greater consumption of cognitive resources, which would otherwise be devoted to self-presentation of "honesty[17]." The recall with varied temporal order cue is implemented by asking interviewees to describe the event in reverse order, starting with the end of the event and progressing backward to the beginning.

In numerous empirical studies, the ECI has demonstrated superiority over traditional interview techniques in eliciting more accurate and less inaccurate information in both naturalistic and lab settings[18]. Most frequently, the ECI has been studied in analogue laboratory settings[18], which typically involves exposing participants to an analogue crime victimization experience, either through a pre-recorded video[19] or live experiences facilitated by researcher confederates[20], and a delay generally ranging between a few minutes to 24 or 48 hours. Finally, participants engage in an interview using the ECI protocol or a Standard Interview condition (SI). The SI interview typically includes prompts to describe the event in chronological detail, consisting primarily of close-ended questions which can limit the amount of recall[7]. The ECI has also been evaluated in naturalistic settings, such as having police officers trained to use the ECI, with the visual stimuli being the real crimes the victim or witnesses were a part of[21].

1.3 Trauma-Informed Cognitive Interview

Independent of the ECI literature, experts in applied forensic interviewing have made calls to refine traditional interviewing techniques to account for cognitive differences in memory of traumatic events and minimize potential retraumatizing effects of being interviewed[6]. The trauma psychology and criminology literatures suggest that the experience of engaging with the legal system and participating in a forensic interview can be a secondary traumatic experience for victims[22]. In response to these findings and the on-the-ground experience of legal professionals, interview protocols that incorporate trauma-informed principles, such as the Forensic Experiential Trauma Interview[6], have begun to emerge. Compared with the ECI, which has decades of efficacy research, there have been no formal evaluations

of interview techniques that were specifically designed to be trauma-informed. Thus, it is unclear whether a trauma-informed forensic interview could reduce interviewee stress during the interview or even be a positive source of support during a challenging experience for interviewees. Advocates of such an approach have suggested trauma-informed interviews should build on a free-recall framework by adding six components.

First, it has been argued that trauma-informed forensic interviews should acknowledge the potential emotional and cognitive consequences of traumatic experiences. For example, an interviewer might state, "Experiencing [or witnessing] a crime or remembering it can be difficult for some people. I'm sorry you had to experience [or witness] that. I also know it can be difficult to talk to a stranger. I really appreciate you being willing to talk about it." Acknowledging the effects of trauma is intended to assist in establishing rapport and help the interviewer demonstrate empathy to promote the interviewee's feelings of safety and trust. Second, proponents suggest trauma-informed interviews should use the language "what are you able to remember?" to destigmatize the common experience of traumagenic amnesia and reduce pressure to confabulate details. Third, advocates suggest asking about interviewees' thought processes during the event. This technique is intended to reduce the likelihood of interviewers asking "why" questions (e.g., "Why didn't you fight back?") that can inadvertently convey blame to victims or witnesses of crime.

A fourth trauma-informed interview strategy is asking about memories of sensory detail from the event (e.g., what the victim or witness remembers hearing or smelling). Questions regarding the victim's or witness's tactile memories are drawn from the idea that tactile memories are what the more primitive part of the brain remembers, which more efficiently stores trauma memories than other parts of the brain. We speculate that this is referring to the up regulation of the amygdala response during a trauma which results in the remembrance of more specific sensory details[23]. Anecdotally, Strand[6] described that eliciting memories from this portion of the brain has yielded useful information for the investigation and increased recall of memories brought up from recalling the tactile experience. Fifth, trauma-informed interview advocates suggest asking interviewees about their emotional and physical reactions during the event. These questions are useful because it can provide the interviewer with a deeper understanding about the context or severity of the event. Understanding the context and severity of the traumatic event will give the investigator evidence about the impact of the crime. Finally, advocates suggest asking during a trauma-informed interview what was the most difficult or unforgettable part of the event, which can cue key details about the event that the interviewee may have omitted if it did not seem relevant to the investigation[6].

Proponents suggest that trauma-informed forensic interview techniques can produce increased quantity and accuracy of recalled information and create a more supportive interviewing experience for interviewees. However, there are no publicly available trauma-informed forensic interview protocols and no such protocol has been empirically tested in a lab or applied setting[6]. Thus, there is need to evaluate the effectiveness of a trauma-informed version of the ECI.

1.4 Current Study

The current study employed a randomized control design to investigate two types of forensic interview techniques: the ECI and a novel Trauma-Informed Cognitive Interview (TICI) created for this study. The techniques were compared based on the accuracy and quantity of interviewees' free recall of narrative details from an analogue crime film, as well as interviewees' satisfaction with the interview experience. We hypothesized that, relative to participants randomized to the ECI condition, participants in the TICI condition would report (1) a larger quantity of accurately recalled information; (2) a lower quantity of inaccurately-recalled information; and (3) greater satisfaction with the interview experience. Given the exploratory nature of this project, and to check the efficacy of the randomization to an experimental group, measures of participant individual difference and characteristics of the interview were assessed. Assuming the efficacy of randomization, it was hypothesized that there would be no significant differences between the experimental groups.

2 METHODS

A University Institutional Review Board reviewed the protocol and approved the study.

2.1 Participants and Setting

Participants were 45 adult (18 years or older) undergraduate students from a private liberal arts university in the Midwest United States. Participants were recruited through the university's human subject pool website. Participants were compensated with course credit. The sample was predominantly female (33 women, 73.3%; 12 men, 26.7%). Most participants were first- or third-year students (53% first-year (n = 24); 13% second-year (n = 6); 29% third-year (n = 13); 4% fourth-year (n = 2)). Participants' racial/ethnic backgrounds were representative of the student population from which this sample was drawn, with most participants identifying as White (38 White or Caucasian, 1 Black or African American, 5 Asian or Pacific Islander, and 1 other race/ethnicity). On average, participants

self-identified as holding a mid-level social status (M = 5.89, SD = 1.61) within their communities. A majority of participants reported being full-time students (n = 40; 88.9%), but 19 had additional employment (44.2%). In terms of sexual orientation, most of the sample identified as heterosexual/straight (n = 40; 88.9%), with the remaining 11.1% (n = 5) identifying as lesbian, gay, bisexual, asexual, or another sexual orientation. Additionally, 43 participants were from the United States and 2 participants were from a different country of origin. Finally, in terms of exposure to crime, 15 participants indicated that they had been a victim of a crime, and eight participants indicated they had committed a crime. A total of 11 participants indicated that they had reported a crime to legal authorities, and 13 had been interviewed by police before participating in this study. This study was conducted in two research office rooms located on a university campus. The study began in the first room, which was furnished with a table, laptop computer, and chairs for the participant and researcher. The second room was organized like a police interview room, with a single table flanked by a chair on either side.

2.2 Materials

2.2.1 Analogue crime video

A video depicting an attempted armed robbery was used as the encoding stimulus. The video was recorded from a camera mounted on a helmet worn by the point-of-view (POV) character, so the video appears from the perspective of the crime victim. The POV character (victim) is on a bike ride when approached by a man on a motorcycle with a firearm who demands the POV character's bicycle and wallet (Figure 1). The POV character avoids the offender and runs away. The video is about 2.5 minutes long and was sourced from YouTube using the search terms "Go-Pro" and "crime"[24]. The sound from the video was removed because the people depicted spoke a language other than English which would introduce variability among a sample with varied language proficiencies.

Figure 1. Screenshot of the analogue crime video that participants viewed

2.2.2 Independent variable: two interview techniques

The Enhanced Cognitive Interview (ECI) is an interview technique developed from cognitive theories of memory and comprises four techniques[11]. These four techniques include context reinstatement, encouragement to report everything without guessing, recall with perspective-taking, and recall with varied temporal order. The ECI also relies on basic guides to effective communication and rapport building.

The Trauma-Informed Cognitive Interview (TICI) was developed for this study based on the ECI and publicly available descriptions of trauma-informed interview techniques. The TICI relies on similar techniques as the ECI but also uses an understanding of encoding and retrieval of trauma-specific memories. In the TICI, the interviewer acknowledges the trauma the participant may have experienced while trying to minimize additional harm of the interview experience, such as not asking questions that could place fault on the participant.

2.2.3 Dependent variables

Interviewee recall: accuracy and inaccuracy

All interviews were transcribed and then all participant dialogue was partitioned so that every word the participant said was in its own paragraph. For example, if a participant said 200 words in their interview, the transcribed interview would be broken into 200 paragraphs. Each participant's recorded words were then grouped together into "fact" statements which could either be a single word (e.g., "white") or phrases (e.g., "there was a gunman"). These fact groupings were then coded as either accurate, inaccurate, repetition, opinion/unknown, or filler. All of the interviews were coded by a single primary coder; and as is standard for qualitative double-coding to ensure coding reliability, 20% of the interviews (n = 9) were double-coded. Cohen's Kappas (i.e., a measure of inter-rater reliability) were acceptable (>.6). Statements were coded as "accurate" if they were correct based on the video stimulus. Statements were coded as "inaccurate" if they were incorrect based on the video stimulus. Statements were coded as "repetition" if the participant had already referred to the given fact earlier in their interview. Statements were coded as "opinion/unknown" if they were opinionated in nature (e.g., "He seemed like maybe he was having a bad day") or the coder could not verify the veracity. Statements were coded as "filler" if they did not fit into one of these categories (e.g., "no" or "I don't know" statements). The totals for each of these categories were then summed, and the participants' total number of accurate (M = 53.73; SD = 20.23) and inaccurate statements (M = 6.82; SD = 4.40) was used for our accuracy and inaccuracy outcomes.

Subjective interview experience

The Response to Forensic Interview Participation Questionnaire (RFIPQ) is a 22-item measure adapted for this study from Newman and colleagues' Response to Research Participation Questionnaire[25]. The RFIPQ assesses participants' perceptions of the interview procedure and was analyzed as an outcome in the current study. Participants were asked to rate on a scale of 1 (strongly disagree/no) to 5 (strongly agree/yes) how strongly they agreed with statements regarding their participation in the forensic interview. Example items include, "I gained something positive from participating in the interview" and, "The interview took too long." The participants' ratings on the survey questions were then summed (M = 87.78; SD = 8.14). For the current study, Cronbach's α = .80 (Cronbach's α is a statistical indicator of internal reliability, meaning a statistical indicator of whether the items within the measure were all assessing the same construct).

2.2.4 Potential Covariates

Measures of individual difference, including gender, age, trauma history, substance abuse, duration of the interview, attention to the video, and interviewer identity had the potential to contribute to differences in the dependent variable. Differences in these variables between participants in the two randomized experimental groups (ECI vs. TICI) were assessed to determine whether it was necessary to include these variables as covariates in the hypothesis testing analyses. The measures used to assess these variables are described below.

Demographic attributes

Participants responded to 20 demographic questions assessing their race/ethnicity, age, gender, sexual orientation, crime victimization and perpetration, and previous history with forensic interviews. Age and gender were assessed as potential moderators of the relationship between interview condition and outcomes; the other demographic information was used to characterize the sample.

Mental health and substance use

Depression, post-traumatic stress symptoms, and substance use were measured as potential moderators of the relationship between interview condition and outcomes.

Depression

The Patient Health Questionnaire (PHQ-9[26]) is a depression screening tool often used in healthcare settings[27]. The measure includes 10 questions. The first nine questions probe how often the participant has experienced problems (e.g., "Little interest or pleasure in doing things;" "Poor appetite or overeating") in the last two weeks, rated on a 0 (not at all) to 3 (nearly every day) scale. The tenth question asks participants to rate how difficult their life has been made by the endorsed problems (not difficult at all to extremely difficult). The PHQ-9 has been shown to have excellent internal reliability (Cronbach's α = .89[27]) and to predict depression diagnoses based on a clinical interview[28] and other standardized measures of depression symptoms (e.g., Beck Depression Inventory[29]). For the current study, internal reliability was excellent (Cronbach's α = .88).

Post-traumatic stress symptoms

The Trauma-Symptoms Checklist - 40 (TSC-40[30]) is a 40-item self-report measure of symptomatic distress in adults arising from traumatic experiences. Participants are asked how often they experienced 40 items (e.g., "insomnia;" "sexual problems;" "feelings of guilt") in the last 2 months. Each question is associated with 6 different trauma symptom subscales (disassociation, anxiety, depression, sexual abuse trauma index, sleep disturbance, and sexual problems). The participant's answers to the relevant items were summed for each subscale. The total score (McDonald's coefficient Ω = .93) has been found to be internally reliable and have convergent validity with participant-reported cumulative exposure to traumatic events[31]. For the current study, Cronbach's α = .85.

Substance use

The Alcohol, Smoking, and Substance Involvement Screening Test (ASSIST)[32] is a substance use screening measure focused on frequency of use of 9 substances in the past 3 months, measured on a scale from 0 (never) to 4 (daily or almost daily). Answers are summed and the scores on the higher end of the spectrum are determined to be in need of intervention. Queried substances include alcohol, cocaine, tobacco products, cannabis, amphetamine type stimulants, inhalants, sedatives or sleeping pills, hallucinogens, and opioids. This section of the ASSIST showed a good internal consistency (α = .68–.88), good concurrent validity with the CRAFFT Substance Use Screening Tool (r = .41–.76; $p < .001$[33]). For the current study, Cronbach's α = .67.

Recognition of video stimulus details

An attention check quiz was used to confirm participants were paying attention to and encoded the broad contents of the video stimulus. Attention was evaluated as a potential covariate. The quiz comprised five multiple choice questions such as, "What color was the van that went by at the beginning of the video?" with potential responses including "black," "white," "red," and "blue." These questions were created for the current study based on the video stimulus.

Trauma history
The Brief Betrayal Trauma Survey[34] includes 11 behaviorally-defined trauma items (e.g., "You were deliberately attacked that severely by someone with whom you were very close") to screen for lifetime trauma exposure, which was evaluated as a potential covariate. Given that trauma history can relate to memory and attention differences, the BBTS was used to evaluate differences in trauma history between experimental groups. This measure has demonstrated good test-retest reliability[34], and convergent validity with trauma symptoms[35].

Awareness of deception
At the end of the study session, participants were asked questions about the true purpose of the study (e.g., "If you had to guess, what do you think the study is about?"). No participants in the study were found to be aware of the study's purpose.

Measures of ethical adherence
Participants' emotional reaction to the video and their reaction to the procedures were evaluated to ensure adverse participant experiences were identified and addressed.

Emotional reaction to video
A short questionnaire, developed for a previous study of forensic interviewing[36], was used to assess participants' emotional reaction to the video stimulus. Participants were asked to "Think about how the video you have just watched made you feel," rating six emotions (e.g., *happy*, *excited*, *okay*, *calm*, *sad*, and *angry*) on a 7-point Likert scale (1 = "not at all;" 7 = "very much"). Additionally, the survey asked participants to indicate which of the six emotions best describes how the video made them feel and write a short free-response explanation. Emotional reactions to the video stimulus were assessed to identify potential adverse reactions to the video and assess differences between experimental groups.

Perception of research participation
The Response to Research Participation Questionnaire (RRPQ[25]) includes items that assess participants' perceptions of the research procedures, including the relative benefits, costs, and emotional reactions. The RRPQ was used to monitor ongoing participant perceptions of costs and benefits to adjust protocols as needed to maximize benefits and minimize costs to participants. First, participants were asked to rank their top three reasons for participating in the research study from a list including nine choices (e.g., "I was curious;" "for the compensation"). Next, participants rated 23 items (e.g., "Knowing what I know now, I would participate in this study if given the opportunity") tapping their reaction to participating in the study from 1 (strongly disagree/no) to 5 (strongly agree/yes). Participants' responses were summed, with negatively worded items reverse scored, so that higher scores indicated a more positive experience participating. The scale has demonstrated excellent internal reliability in adults (Cronbach's α = .83[25]) and had excellent internal reliability in the current study (Cronbach's α = .82).

2.3 Interviewer Training and Fidelity

Each research assistant (RA) was trained to facilitate the first half of the study session, as well as to administer the protocols for both interview conditions. Interviewers were trained to strictly adhere to the interview script. To receive training approval, RAs were required to review the materials individually and with either the Principal Investigator (PI) or the Graduate Research Assistant (GRA) supervisor, and conduct a full mock interview that was audio recorded and assessed by the PI and/or GRA supervisor for fidelity to interview script. All RAs received feedback on deviations from script; interviewers who made more than 5 minor (e.g., wording slightly differs) or 2 major (e.g., asking a prompt out of order, using unscripted wording) deviations from the interview script received feedback on discrepancies and were required to complete a second audio-recorded mock interview. All RAs achieved fidelity to the script by the second practice administration. Study interviews were audio recorded and transcribed. Ongoing checks of fidelity to the script were also conducted. All RAs maintained adequate adherence to the interview scripts.

2.4 Procedure

The study procedure was completed during one visit lasting approximately 90 minutes. Each session was facilitated by two RAs. One RA facilitated all of the procedures leading up to the experimental interview, including consent and the consent quiz, administering the video stimulus, and the pre-interview surveys. The second RA conducted the experimental interview, post-interview surveys, and debriefing procedures. At the start of the session, participants received consent information in writing and verbally. After discussing consent information, the research assistant administered a consent quiz to check understanding of the consent information[37]. Following the consent procedures, participants viewed the video stimulus on a computer screen approximately 12 inches from their face at eye-level. Immediately following presentation of the video stimulus, participants were asked to complete self-response measures in Qualtrics during a 30-minute delay period to simulate the gap between a crime and when a victim is interviewed by police.

The series of surveys and questionnaires were pre-

sented in the following order: Emotional reaction to video stimulus survey, demographic questionnaire, MacArthur Scale of Subjective Social Status, Patient Health Questionnaire, Trauma-Symptoms Questionnaire, Alcohol, Smoking and Substance Involvement Screening Test (ASSIST), and the Brief Betrayal Trauma Survey. If the participant completed all of these surveys and questionnaires before the 30-minute delay period ended, participants worked on a word search puzzle.

After the delay period, participants were escorted to another room with the second RA. Participants were interviewed using one of two interview types, the Enhanced Cognitive Interview (ECI) or the Trauma-Informed Cognitive Interview (TICI). The interview condition (the ECI or the TICI) was randomly assigned to the participant. The interview was audio recorded and later transcribed and coded for recall of the film stimulus.

After the interview, participants responded to post-interview questionnaires, including: the Recognition of Video Stimulus Details, the RFIPQ, and the RRPQ. After the second block of questionnaires, participants' awareness of the study deception was assessed. Then the participant was debriefed and given the opportunity to re-consent after learning about the deception. Finally, participants were offered a list of potential support services and then thanked for their time. After the study, participants were compensated through the human subject pool system.

2.5 Data Analysis

Data was analyzed using SPSS (Version 25.0). To assess whether potential covariates should be included in hypothesis testing analyses, separate independent-samples t-tests evaluated whether the two randomized interview conditions differed based on demographic or interview characteristics. To compare the effects of the interview condition (ECI vs. TICI) on average recall accuracy, average recall inaccuracy, and overall interview experience, a one-way between-subjects ANOVA was conducted.

3 RESULTS

A total of 47 participants were recruited and completed study activities. Of the 47 participants, 2 participants were excluded from analyses for deviations from protocol (i.e., materials out of order; audio recorder malfunction). Of the 45 participants who were included, 24 were randomly assigned to the ECI condition and 21 were randomly assigned to the TICI condition. All variables of interest were assessed for skew, kurtosis, and normality using the Shapiro-Wilk Test, given its superiority over the Kolmogorov-Smirnov Test for smaller sample sizes[38]. All variables had acceptable distribution, with the exception of the accuracy and inaccuracy variables, which had acceptable skewness and kurtosis, but did not have normal distribution. Given that transforming the accuracy and inaccuracy variables would have affected the ease of interpretation and that there were mixed indications of normality, the variables were left untransformed.

3.1 Emotional Response to Video

Participants' ratings for six emotions (*happy*, *excited*, *okay*, *calm*, *sad*, and *angry*) were evaluated to determine emotional reactions to the video. For the positive emotions, participants reported feeling "not at all" *happy* (M = 1.16, SD = .37) and a "low" level of *excitement* (M = 1.80, SD = 1.30). For the neutral emotions, participants reported feeling a "low" level of *okay* (M = 1.98, SD = 1.51) and a "low" level of *calm* (M = 1.61, SD = .87). For the negative emotions, participants reported feeling "slightly" *sad* (M = 3.40, SD = 1.63) and "slightly" *angry* (M = 3.39, SD = 1.67).

3.2 Covariates

Separate independent-samples t-tests evaluated whether participants in the two randomized interview conditions differed based on demographic or interview characteristics (Table 1). The t-tests indicated participants in the two conditions did not differ by participant characteristics, including attention check results (scored out of 100; lower scores indicate fewer questions correct), age (in years), gender (1 = woman; 2 = man), trauma symptoms (TSC-40 scored from 0-120; lower scores indicate less severe trauma symptoms), substance abuse (lower scores indicate less substance use), or interview characteristics, including interview duration (how long the interview was, in minutes), and interviewer (which researcher conducted the interviewer). The t-tests indicated no differences between experimental conditions based on participant characteristics. As such, subsequent analyses did not include covariates.

3.3 Outcomes

We hypothesized that the TICI interview condition would perform better than the ECI interview condition across three outcomes. One-way between-subjects ANOVAs evaluated the effect of interview condition (ECI vs. TICI) on accuracy (i.e., participants' number of accurate statements), inaccuracy (i.e., participants' number of inaccurate statements), and subjective rating of interview experience. No significant main effects were found for any of the examined outcomes, including accuracy (ECI M = 53.38, SD = 20.75; TICI M = 54.14,

Measure	ECI		TICI			
	M	*SD*	*M*	*SD*	*df*	*t*
Gender	1.29	.46	1.24	.44	43	.40
Age	19.46	1.18	19.71	2.26	43	-.49
Trauma Symptoms	78.54	25.38	92.43	26.96	43	.39
Substance Abuse	13.38	3.51	12.52	3.31	43	.83
Duration	10.78	3.43	12.77	4.23	43	-1.75
Attention Check	.88	.34	.86	.36	43	.17
Interviewer	5.67	2.12	5.38	2.22	43	.44

*$p < .05$

Table 1 Analyses comparing participants in the two experimental groups based on individual characteristics revealed there were no significant differences between the two groups, indicating the experimental randomization was effective

SD = 20.12; *F*[1, 44] = .02, *p* = .90, η_p^2 = .88), inaccuracy (ECI *M* = 5.92, *SD* = 3.35; TICI *M* = 7.86, *SD* = 5.25; *F*[1, 44] = 2.24, *p* = .14, η_p^2 = .05) or subjective interview experience (ECI *M* = 89.04, *SD* = 7.04; TICI *M* = 86.33, *SD* = 9.20; *F*[1, 44] = 1.25, *p* =.27, η_p^2 = .03).

4 DISCUSSION

The present study evaluated whether a novel trauma-informed approach to forensic interviewing designed for this study (i.e., Trauma-informed Cognitive Forensic Interview; TICI) addressed concerns raised by law enforcement[6] that existing interview approaches fail to elicit accurate information and can be perceived negatively by interviewees. Specifically, this study empirically tested the efficacy of the TICI against the current gold-standard forensic interview protocol (i.e., Enhanced Cognitive Interview; ECI) for eliciting participant memories of an analogue crime event and perceived experience during the interview. Based on a review of the research literature regarding memory[23;39;40] and trauma-informed practices[41;42;43], it was hypothesized that the TICI would elicit more accurate recall, less inaccurate recall, and be evaluated as better for overall experience by participants. The results showed that the ECI and TICI did not significantly differ in accuracy and inaccuracy of information elicited during the interview, or participant perception of their interview experience. Both interviews elicited a greater number of accurate than inaccurate statements, and both interview types were perceived relatively positively by participants. These results did not align with our hypotheses that the TICI would produce superior outcomes to the ECI. Though the current study used a relatively small sample from a population with limited generalizability, these results provide initial support that a TICI can achieve parity with the gold standard ECI. That is, adding trauma-informed strategies to the ECI does not appear to diminish the ECI's efficacy.

The following section will consider three potential explanations for why the TICI did not surpass the ECI with respect to interviewee recall accuracy, inaccuracy, and subjective interview response. The first explanation for the current study findings is that methodological limitations precluded detection of differences in the performance of the two interviews. The small sample size may have limited power to detect effects. The time delay of 30 minutes may not have been sufficient to permit forgetting for a complex narrative memory. The video stimulus likely did not produce the type of peri- and post-traumatic cognitive responses that the TICI was designed to address.

The video stimulus limitation warrants further discussion, given that it is central to this manipulation and should be considered carefully by future researchers. From a cognitive perspective, highly stressful events like crime victimization can produce up-regulation of amygdala activity and down-regulation of hippocampal activity[23]. As a result of these cognitive changes, memories of stressful events like crime victimization tend to include strong encoding of specific details (e.g., a water bottle), but include weaker encoding of associations between detailed elements, such as the temporal or spatial context[13;14]. Though some participants in the study were able to take the perspective of the first-person victim in the video, most viewed the crime as having happened to someone else or believed the incident to have been acting. Further, participants' neutral affective rating of the video suggests that the video did not elicit a strong arousal response. This finding confirms that the steps taken to protect participants from unnecessary distress was effective. Many studies have successfully evaluated the ECI technique using analogue crime videos[7;10;19]. However, because the TICI addresses trauma-related cognitive and emotional responses, performance differences may be undetectable when the recalled stimulus was perceived as an everyday event. Alternatively, the use of a novel video stimulus may not have been as efficacious an analogue crime experience as the stimuli used in ECI studies. Because the differences between the ECI and TCI are designed to account for cognitive effects of acute stress on memory, the use of a low-affect video may have contributed to the similarities in performance between the ECI and TICI. Future research could examine whether a more stressful stimulus (e.g., confederate theft of an object[20]) or paired arousal condition at encoding (e.g., electrical stimulation) might result in clearer differences in memory performance between the ECI and TICI. In tandem, the ECI and TICI could be piloted in an applied

context, after an individual has experienced a crime. While applied settings present their own methodological limitations, primarily that veracity of recall often cannot be confirmed, research with crime victims could be a useful avenue for future research on these forensic interviewing techniques.

The second explanation of the current results is that the ECI may be effective in supporting the cognitive and emotional needs of crime victims, despite not being designed to be trauma-informed. Indeed, the core content of both the TICI and ECI techniques are similar and rooted in best practices for eliciting memories. Thus, the focus of the ECI on facilitating accurate recall—regardless of the traumatic nature of a to-be-recalled memory— may have resulted in strategies that support the cognitive and emotional needs of someone who has recently experienced a potentially traumatic event.

The third explanation of our findings is that the TICI technique used in the study may not have incorporated enough trauma-informed elements to be significantly different from the ECI in eliciting accuracy, inaccuracy, and subjective interviewee experience. The differences between the two interview techniques' scripts were minimal, with additional language such as acknowledging the potential trauma of the interviewee's crime experience in the rapport phase; the interviewer asking "What are you able to remember about what happened?" in the "total recall" phase, and additional trauma meaning questions at the end. The relatively minimal differences between the interviews was intentional, to focus on the inclusion of specific interview changes proposed by advocates for trauma-informed interviewing in the literature[5].

5 FUTURE DIRECTIONS

The current study is one of the first to test a trauma-informed forensic interview. As such, there are numerous possible directions for future research in this area. One direction would be testing the TICI in an applied setting, as interviewees would be experiencing true cognitive effects of the stress of crime victimization. Further developing the TICI is a second avenue for future research to consider. For example, the TICI could incorporate elements from Trauma-Focused Cognitive Behavioral Therapy (TF-CBT), which is the standard treatment for individuals experiencing distress following a traumatic event. Given concerns for potential traumatization during a standard interview, using TF-CBT interventions, such as relaxation, may be supportive. Relaxation techniques could support interviewees physically and emotionally, which may support their recall ability[44]. Implementing such techniques as part of the TICI could be evaluated in future research.

Given the ECI's documented success in eliciting more accurate recall and less inaccurate recall than the standard police interview, it may be appropriate to focus on implementation of the ECI into the law enforcement setting. In studies that have tested the ECI with law enforcement, the technique was well-received by the officers and training was efficiently implemented[21]. Despite the substantial evidence that the ECI is efficacious and accepted in the field, there appears to be limited uptake of the ECI in practice[45]. The limited implementation of the ECI in practice suggests that forensic interviewing research may benefit from shifting focus to identifying and addressing barriers to the uptake of the existing well-validated approaches to interviewing victims and witnesses, such as the ECI, into practice in the field.

Despite the lack of support for the current study's hypotheses, we believe continuing to develop the TICI and studying an updated TICI technique against the existing validated interview techniques in an applied context are important next steps for researchers in this domain. In addition, focusing on implementing the already well-studied ECI into law enforcement training and practices should be considered. It is crucial that research continue contributing to the development of forensic interviewing techniques so that the experience of forensic interviewees can be improved while also supporting collection of accurate forensic evidence.

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7 EDITOR'S NOTES

This article was peer reviewed.

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Making the Violin Fashionable: Gender and Virtuosity in the Life of Camilla Urso

Maeve Nagel-Frazel[1], Meyer Frazier[2], Antonia Banducci[2]
[1]Student Contributor, University of Denver
[2]Advisor, Lamont School of Music, University of Denver

Abstract

In the late nineteenth century, the violinist Camilla Urso (1840-1902) was widely recognized as the pre-eminent female violinist in the United States. As a nationally famous celebrity, Urso became a pedagogue and role model to subsequent generations of female violinists. Both the wide-ranging geographic spread of Urso's career and her direct advocacy for women violinists played a pivotal role in changing cultural ideals of violin performance from a militant and masculine bravura tradition into a fashionable pursuit for young women. A classmate of Henryk Wieniawski (1835-1880) and a concert rival of the Norwegian virtuoso Ole Bull (1810-1880), Urso's career rested on the shoulders of the nineteenth century bravura tradition. In her own playing, Urso merged virtuosic works with a feminine sensitivity creating a celebrity persona of the "The Queen of the Violin," while also redefining gender norms of violin performance for women. First, this paper will examine Urso's celebrity through two contrasting concerts, one in 1852 and the other in 1885, that illustrate the development of her repertoire and shed light on the world on the nineteenth century concert artist. Secondly, this paper will explore Urso's role as a pedagogue through her professorship at the National Conservatory of Music, her connection to the New York Women's String Orchestra, and her own published writings. Through her performance and teaching, Urso profoundly changed the possibilities for women violinists at the turn of the twentieth century.

1 INTRODUCTION

Urso was born in Nantes, France in 1840 to Salvator and Emilie Urso*. Both of Urso's parents were musicians; her father was a flutist in the theater orchestra and an organist in the local church while her mother was a well-respected singer. Thus, Urso was a part of what Nancy Reich has called the "Musician-Artist Class": a nineteenth century European social class composed of professional musical families[2]. Both Urso's professional musical career and choice of the violin as an instrument would have been unthinkable in practically any other social circumstance. After becoming one of the first women to graduate from the Paris Conservatoire, in 1852, Urso came to the United States for a concert tour and subsequently remained in the United States for fifty years. During her fifty-year career, Urso performed in forty-five states, and at least eight countries. Some highlights of her career include: a five-day musical festival in benefit of the San Francisco Mercantile Library Association in 1870; the American premiere of the Joseph Joachim and Edward Lassen violin concertos in 1891 and 1893, respectively; as well as the creation of her own touring concert company that ran from 1873 to 1897. Urso's repertoire contained over a hundred pieces, including some of the most difficult virtuoso works ever written for the violin.

In the nineteenth century, the violin was a male dominated instrument, supported by a robust tradition of virile virtuosity. Male critics consistently objected to the physicality of female violin performance; as the scholar Tatiana Goldberg notes, the "twisted upper torso, 'strange' head position, the clamping down of the chin, unattractive rapid arm movements and the standing position of the performer, facing the public, were all considered inherently unfeminine"[3]. Objections to women's physical performance were grounded in gendered ideals of the violin; the violin itself was considered feminine, therefore, male performers were considered a complimentary mate to the female violin. This tradition of viewing the violin itself as feminine both encouraged a virtuoso tradition of masculine and militant performances while enforcing the discordance between binary gender norms and women who attempted to play the violin. In other words, it was heterosexually acceptable for men to play a female-gendered instrument

*Many nineteenth century sources, as well as earlier scholarship, give Urso's year of birth as 1842. However, Johanna Selleck discovered Urso's birth certificate which lists her year of birth as 1840. For further discussion see "Camilla Urso: A Visiting Virtuoso Brings Music to the People," by Johanna Selleck[1].

but was considered inappropriately sexual for women to do so[4].

By the middle of the nineteenth century, a small number of women had become successful professional violinists; however, generally they gained notoriety as child prodigies and were fetishized as a singular exception to the norm. Furthermore, after gaining acclaim as a *wunderkind*, their careers often ended upon their marriage. At the start of Urso's career in the 1840s, she only had three female violinist contemporaries: the sister violinists, Teresa and Maria Milanollo (b. 1827, and 1830) and Wilma Norman Neruda (b. 1838), all three of whom rose to international acclaim in Europe as child prodigies[†].

2 URSO AND HER REPERTOIRE: EARLY YEARS

Initially Camilla Urso's career followed a similar trajectory to that of the girl *wunderkind*, however, the longevity of Urso's career and the complexity of her repertoire was unheard of for a mid-nineteenth century female violinist. Solo recitals were rare in the nineteenth century, instead programs consisted of a variety of songs, opera arias, and instrumental showpieces. For example, when Urso debuted at New York's Metropolitan Hall on September 30, 1852, she only performed three selections: Violin Concerto No. 24 in B minor by Viotti, *Souvenirs de Bellini* by Alexandre Artot, and Air Varie No. 6 by Charles August de Beriot. The other pieces on the program included Beethoven's *Egmont Overture*, Rossini's *Overture to Othello*, as well as the song "Love's Dream" by Rosner, and "The Nymph's Echo melody with Oboe" sung by Madame Oscar Comettant. This concert format is similar to almost all mid-nineteenth century American classical music concerts, and exemplative of the majority of Urso's performances.

Urso's early repertoire primarily consisted of virtuoso theme and variation works meant to showcase the technical prowess of the performer. One such example, exemplative of Urso's repertoire from this period, is *Souvenir de Bellini* by Alexander Artot. Composed in 1841, *Souvenir de Bellini* is a theme and variation set based off the operatic compositions of Vincenzo Bellini (1801-1850). Beginning with a virtuosic introduction consisting of three large runs, *Souvenir de Bellini* is dramatic, operatic, and incredibly virtuosic throughout. Artot's *Souvenir de Bellini* uses a variety of advanced violin techniques including fast arpeggios, up-bow staccato, frequent octaves, thirds, and sixths, as well as fast spiccato double-stops. The theme and variation format clearly delineates sections for the listener and allows the performer a chance to show off their facility with a specific technique in each section.

From her arrival in New York City in September 1852 to Urso's marriage three and half years later in June of 1856, Urso's repertoire remained primarily confined to virtuosic showpieces. As the only string player in her traveling concert troupe, Urso did not play chamber music, and with very few exceptions did not have the opportunity to play large concertos with an orchestra because most American orchestral institutions were either nonexistent or in their infancy prior to the Civil War. Urso did perform the *Fantasie on Themes from Lucrezia Borgio* by Philippe Sainton with the New York Philharmonic conducted by Theodore Eisfelt on January 20, 1855; however, such appearances were the exception rather than the rule for Urso.

3 URSO AND HER REPERTOIRE: LATER YEARS

Over the course of her career, Urso's repertoire widened in scope. In her later career, Urso included more sophisticated concert transcriptions, violin concertos, and sonata excerpts in addition to her standard virtuosic showpieces. While on tour with the Camilla Urso Concert Company, Urso developed a standard a program model that included two programmed works, and a slurry of her standard encores. Urso's programmed works tended to be larger virtuoso pieces such as *The Carnival of Venice* by Paganini, while her encores tended to be arrangements of popular songs such as "The Last Rose of Summer" or piano works such as Schuman's *Träumerei*. Occasionally she included other concert pieces such as the Capriccio by Niels Gade, or sonata excerpts such as the Solo Violin Sonata by Friedrich Wilhelm Rust. Touring with a concert company had a practical benefit of reducing the amount of pieces Urso had to learn for each season.

Throughout her career, Urso gave less than five recitals that come close to the modern definition of a solo recital. Urso's solo recital programs are indicative of both the development and breadth of her repertoire. On September 7, 1885, Urso gave a recital with the pianist August Sauret at the Westminster Presbyterian Church in Minneapolis, Minnesota. Urso's program included the second and third movements of the Mendelssohn Violin Concerto, two Chopin transcriptions by Urso herself, *The Devil's Trill Sonata* by Tartini, *The Carnival of Venice* by Ernst, *Capriccio-Valse* by Wieniawski, selections from Bach's Partita No. 3 in E Major, a transcription of Schuman's *Traumerei*, as well as excerpts from Violin Sonata No. 2, Op. 78 by Joachim

[†]After the two sisters became concert sensations in France, Maria Milanollo died at age sixteen in 1848 of whooping cough. Her elder sister, Teresa Milanollo lived until 1904 and continued to perform after her sister's death, even composing several pieces for violin in her later years[5]. Wilma Norman Neruda, otherwise known as Lady Halle, was an Austrian violinist who rose to prominence in Europe. Affectionately referred to as "the violin fairy," Neruda was admired by many prominent violin virtuosos including both Vieuxtemps and Joachim[6].

Raff, and finally *The Witches Dance* by Paganini. Also on the program were three unspecified piano solos performed by Auguste Sauret. Urso's program from 1885 is both large and difficult; in it, she blends difficult virtuoso works by Paganini and Ernst with excerpts from a standard violin concerto, and a variety of short concert transcriptions, providing a unique picture of the breadth and power of Urso at the height of her career.

Urso's two virtuoso works, the *Carnival of Venice* by Ernst, and *Paganini's Witches Dance*, were staples Urso used to impress audience members with virtuosic spectacle. Both are also exceedingly difficult and make use of a large variety of advanced violin techniques within a theme and variation format. Ernst's *Carnival of Venice* includes fast arpeggios, up-bow staccati, and whole passages in octaves; it also includes more difficult techniques such as left-hand pizzicato, and artificial harmonic double-stops. In one passage, as illustrated in figure 1, the performer is required to play the theme in the upper voice while simultaneously plucking an accompaniment with the left hand on the G string.

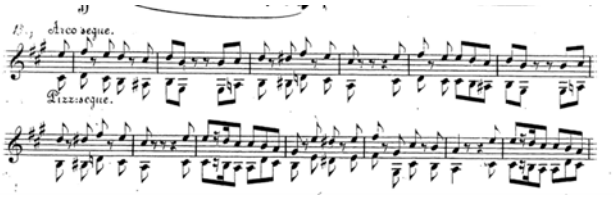

Figure 1. Ernst, Carnival of Venice. The bottom line is played pizzicato with the left-hand at the same time as the top line.

In a review of her performance, *The Star Tribune* commented, Urso's "fingers seemed to be playing tricks with the double harmonics but her grave face with its closed eyes denied the imputation. She seemed to be doing it in her sleep"[6]. The prevalence of difficult virtuoso works on Urso's recitals emphasizes her skill on the violin. Many modern violinists shy away from these types of compositions due to their sheer difficulty, yet Urso "seemed to be doing it in her sleep."

In addition to her virtuosic works, Urso also included the last two movements of the Mendelssohn violin concerto in her recital. In contrast with modern violinists who frequently perform concertos, Urso rarely performed concertos; but when she did, the Mendelssohn violin concerto appeared often on her programs though often in an abbreviated form. With the exception of the Beethoven violin concerto, the Mendelssohn concerto is the only concerto Urso performed more than two or three times. Though flashy, the Mendelssohn concerto is equally melodic and much easier than the later repertoire on this program. Clearly, Urso impressed her audience with her performance. One reviewer commented, "These brilliant and difficult passages are such as to test the highest skill and Madame Urso made good her claim by the perfect fluency with which they were rendered with no note slighted and with apparently no effort to herself"[6]. Indeed, Urso's performance probably took minimal effort considering how frequently she had performed this work.

The third main category on Urso's 1885 Minneapolis recital was concert transcriptions and encores. Urso performed around fifteen of her own concert transcriptions as encores throughout her career. Most of Urso's transcriptions are arrangements of classical piano works by Chopin and Schuman or arrangements of popular songs by composers such as Louis Gottschalk, and Stephen Foster. On this particular recital Urso performed her own arrangements of Schuman's *Traumerei*, and Chopin, Nocturne in D flat Major, Op. 27, as well as one of the Op. 64 Waltzes by Chopin. The practice of concert transcriptions was commonplace among nineteenth century performers, however Urso herself minimized her role as an arranger in a letter to Lydia Avery Coonley Ward in 1893, writing, "Aside a few soli of no importance. I have only arrangements or more properly transcriptions from works of Schubert, Chopin, Mendelssohn"[7]. All in all, this is a hefty program that many modern violinists would be reluctant to undertake. Even though Urso performed on the lyceum and vaudeville circuit, her artistic merit should not be underestimated.

4 THE GIRL VIRTUOSO: CAMILLA URSO'S EARLY AMERICAN CAREER

When Urso arrived in New York in early September of 1852, at the age of twelve, with her father and Aunt Caroline, she was following a popular tradition of European virtuosos embarking on American concert tours. Only two years earlier, the Swedish soprano, Jenny Lind, had entranced American audiences as she toured under the management of P.T. Barnum, while the violinists Henri Vieuxtemps, Ole Bull, and Charles August de Beriot all made concert tours of the United States in the mid nineteenth-century. Urso's nineteenth-century biographer, Charles Barnard, claims an unidentified American concert promoter sought out Urso and offered her a three-year touring contract accompanied with the promise of riches: "He would pay Mademoiselle Urso the sum of thirty thousand francs the first year, sixty thousand francs the second year and one hundred thousand francs the third year. Traveling and hotel expenses for three people were to be paid and altogether it was a flattering offer"[8]. Urso's talent served as a source of income for her family, and such a lucrative offer, especially for a girl violinist with relatively limited prospects, was difficult to pass up.

Newspapers began advertising Urso's first appearance almost a month before the concert. *The New York Times* heralded the arrival of the "juvenile violinist, aged 11 years, of the Musical Conservatory of Paris," as early as September 10[9]. In addition to Urso, her promoter

also engaged the pianist Oscar Comettant, his wife Mrs. Comettant, a singer, and Mr. Feitlinger, a tenor for her debut concert[10]. The concert was conducted by Theodore Eisfeldt and accompanied by a "grand orchestra." The members and size of the orchestra are not known, though it probably numbered no more than two dozen musicians.

Very few, if any, other female violinists had performed in America before 1852; therefore, Urso was an unusual sight. With equal parts captivation and wonder, *Dwight's Journal of Music*, the pre-eminent classical music journal of the time in America, recorded that, on account of Urso's small size, "during her performance she stands on a small moveable platform three or four foot square"[11]. Newspaper reviews were fascinated with the paradox between Urso's perceived delicate femininity and intense virtuosity. *Dwight's Journal of Music* again commented: "The little maiden is plain, with strong arms and hands enlarged by practice of her instrument; yet her appearance is most interesting; a face full of intellectual and sedate expression, a large forehead wearing a pale cast of thought"[12]. At the same time the journal labeled her New York debut "one of the most beautiful and touching experiences of our whole musical life," praising "the firm and graceful bowing, the rich pure refined tone, the light and shade, the easy control of the arpeggio, staccato, and double-stops" in Urso's performance of Artot's *Souvenir de Bellini*[12]. Early captivation with Urso from the musical critics, and concert-going public laid a foundation for her later successes; however, Urso's early career was defined by her identity as a child prodigy and both her repertoire and concert reach remained relatively limited.

5 URSO ON THE LYCEUM CIRCUIT: THE MATURE ARTIST GIVES A SOLO RECITAL

The majority of Urso's career was spent on the lyceum concert circuit, and it was this institution that was crucial to the development of her celebrity. After the spending the Civil War in Nashville, Urso busily re-established her place on the musical scene in Boston and New York with a renewed fervor in the 1860s and 1870s. Beginning with the formation of the Camilla Urso Concert Company, a division of the Redpath Lyceum Bureau, in 1873 Urso embarked on yearly tours that took her everywhere from California to Vermont to Australia.

Though the members of her company changed each season, the instrumental makeup of her company remained relatively stable. Besides Urso, her husband, and manager, Frederic Luere, the Camilla Urso Concert Company consisted of a male pianist, several singers, and occasionally a dramatic reader or elocutionist. The members of her company changed over time from the soprano Clara Kathleen Rogers in 1874 to the elocutionist Helen Hall in 1901 among scores of other artists. The lyceum concert circuit was a vast network of individual lyceum courses located across the east and middle-west of the United States. Originally designed as a vehicle for public lecturers, the introduction of musical acts in the 1870s, as Sara Lampert explains in the book *Cosmopolitan Lyceum: Lecture Culture and the Globe in Nineteenth Century America*, "expanded the market for foreign artists in America while creating new avenues for American musicians to develop regional and national touring careers"[13].

In the summer and fall of 1885, Urso gave several recitals with the pianist Auguste Sauret throughout the Midwest. Urso's concert on September 7, 1885, in Minneapolis, is an excellent example of Urso in performance at the height of her celebrity. A concert review in the *Minneapolis Star Tribune*, from Urso's September 7, 1885 recital, begins with a sense of awe at the prospect of an Urso concert, "though the night was dark and rainy, the lecture room of Westminster church was filled by an audience mostly composed of music lovers who were not to be drawn away from this treat"[14]. Likely traveling all day, the artist did not appear on the stage until 8:30pm. Reviews in both the *Star Tribune* and the *Minneapolis Daily Tribune* paint a vivid picture of Urso in performance:

> Madame Urso stands about five feet high in her little white slippers and if she were standing on a pair of scales would probably tip them at 175 or 180 pounds. She wore a roseleaf pink trained robe, last evening, and an expression of profound gravity. The robe was low necked and sleeveless and lighted up with iridescent beads but nothing lightened up the facial expressions for one fleeting moment. Madame Urso made a slight formal bow, moved the diamond pendant on her necklace under her left ear placed her violin under her fair, pretty chin and deliberately closed her eyes against the audience[14].

The "expression of profound gravity" on Urso's face described by this reviewer positions Urso as a stoic and statuesque performer. Despite her virtuosic repertoire, Urso was not a flashy or fiery player. In fact, Urso's acceptance as a female violinist was most likely tied to her grave style of performance that did not overtly challenge expected gender norms.

In recital, the height of Urso's power and acclaim are evident. In 1885, Urso was at the highpoint of her career. At forty-two years of age, Urso had significant experience as a performer while still being well received by concert audiences and not yet plagued by a later injury to her right wrist that would hamper her playing. The *Minneapolis Daily Tribune* commented on the "varied

and remarkable powers of the artist," while also recognizing the unique format of the solo recital: "A program giving the star so large a space is undoubtedly to the popular taste and is certainly more satisfactory than a two-thirds dilution in second or third class support"[15]. Very few musicians in the late nineteenth century were famous enough to sell out a solo recital. In this regard Urso was a notable exception. The only other American female violinist able to carry a solo recital during this period was Maud Powell (1867-1920), Urso's significantly younger contemporary.

Figure 2. Camilla Urso in 1881. Courtesy of the Camilla Urso Collection, University of South Carolina Special Collections and Archives.

6 THE DEVELOPMENT OF CELEBRITY

Although Urso is not a household name today, during her lifetime she was a celebrity. Nineteenth-century publications and newspapers frequently used Urso as a comparative standard in performance reviews, especially towards younger female violinists*. Testaments to Urso's celebrity include her appearance in serialized novels such as *His Fleeting Ideal* published in 1892, and the issuing of a commemorative "Camilla Urso Mantel Clock" by the E.M. Welch company in the early twentieth century. In addition "the Camilla Urso Stakes" an annual horse race, still occurring to this day, in San Francisco was named after her[16]. To nineteenth-century music critics as well as young female violinists, Urso became the token female violinist in America, and, if not the only, certainly the most prominent model of a highly competent professional female violinist at the turn of the Twentieth-century. The prominence of Urso's reputation and high stature within the cultural world was part and parcel to Urso's later efforts to advocate for female violinists. Without an established reputation, Urso's longstanding pedagogical reach would have been impossible.

7 ADVOCATION FOR FEMALE VIOLINISTS

As a result of her celebrity status, Urso became one of the leading violin pedagogues in America at the turn of the century. Without the existence of Urso's personal papers and more extensive correspondence, it is difficult to ascertain the specificities of Urso's pedagogical methods†. However, some notable pedagogical examples exist. In 1893, Urso gave a speech at the World Columbian Exposition in Chicago during the Women's Musical Congress which ran from July 4-6, 1893. In Urso's speech "Women and the Violin" she advocates for economic and professional equality for women orchestral musicians‡. In her speech, Urso argues for the acceptance of women violinists. Urso argued that the feminine nature of the violin actually enhances the femininity of women who choose to play it: "a pretty woman, handsomely attired… is more picturesque and possesses more attraction than the male performer"[7]. Urso's endorsement of female violin performance is an rejection of the traditional male performance tradition.

As a violinist who had personal experience with institutional discrimination, she used her speech to advocate for women violinists while also speaking out against institutional barriers for women violinists. Not only did contemporary gender ideals discourage women from seeking careers outside the home, until 1904 women were barred from orchestral unions and thus were unable to secure a steady paying orchestral job§. In her

*For example, the *Brooklyn Daily Eagle* reported on June 28, 1869: "Miss Toedt's playing, while it lacks perhaps firmness and precision of Camilla Urso, who is older by many years, has all her feeling and expression, if not more."

†Urso's great granddaughter, Emily Rotsch, told me that most of Urso's papers were likely given to her early biographer Charles Barnard and the existence of her other papers is unknown at this time. Of Urso's five children, only her three daughters, Emily Taylor (1857-1941), Caroline Taylor (1860-1908), and Camille Luere Roe (later Dewey) (1864-1956), were still alive at the time of her death in 1902[17].

‡The manuscript of Urso's speech was originally discovered by Susan Kagan, who published a full copy of the text in her article "Camilla Urso: A 19th Century Violinist's View" published in the Spring 1977 issue of Signs. Kagan informed to me through email that she sold the manuscript to the music auction firm J J Lubrano in 2012. The current location of the manuscript is unknown[18]. The full text appears in "Camilla Urso: a 19th Century Violinist's View," by Susan Kagan[19]. The same speech also appears in "Women in Music: An Anthology of Primary Source Readings," by Carol Neuls Bates[20]. Interestingly, a letter to Lydia Avery Coonley Ward suggests Urso was originally solicited to submit one of her own compositions for performance, but most likely decided to speak instead due to a cycling accident in September 1892 which severely hampered her playing[7].

§Many professional women violinists emerged in the latter half

speech, Urso acknowledged the struggles women violinists face, stating "few can become virtuosi and many really good players must stay at home"[3]. In spite of institutional discrimination, Urso firmly believed in the capabilities of female violinists and stressed that in her speech. In her speech she asserted: "women as a rule play better in tune than men" and "they play with greater expression, certainly, than the average orchestral musician"[19]. When Urso employed women violinists to reinforce her orchestra, "they were quick to understand, prompt at rehearsals, obedient and attentive to the conductors remarks and not inclined to sneak away under a pretext…if the rehearsal was a trifle long"[19].

8 URSO'S PROFESSORSHIP AT THE NATIONAL CONSERVATORY OF MUSIC

Urso's 1893 speech was the fruit of her own checkered career as a pedagogue which began with her association with the National Conservatory of Music. After extensive concertizing around the world, Urso made a more permanent relocation to New York City in 1890 beginning the most intensive focus on pedagogy in her life thus far. Paramount to her residence in New York from 1890-1893 was Urso's professorship at the National Conservatory of Music in New York City. Due to very limited surviving records, Urso's affiliation with the National Conservatory has never been explored in published material. A notice in the *Brooklyn Eagle* from November 23rd, 1890 announced "Camilla Urso has joined the staff of the National Conservatory of Music in New York as professor of violin playing"[22;23]. Urso's fame and status as a foreign artist created a compelling advertisement for the newly established National Conservatory and this announcement was reprinted widely in newspapers and music periodicals throughout the U.S. Based on newspaper records, it seems likely that Urso only taught at the National Conservatory during the academic years of 1890-91, 1891-92, and 1892-93; Urso left for an extended tour of Australia in 1893 and did not return to New York until the fall of 1895, at which point she was no longer associated with the school.

Originally founded as the School of American Opera in 1885 by Jeannette Thurber, the National Conservatory primarily provided vocal instruction, therefore the amount of violin students enrolled was comparatively small. The head of the string department, and long-standing violin professor, Leopold Lichtenburg (1861-1935) does not appear in the National Conservatory account books until 1888 implying the National Conservatory did not hire any orchestral faculty until several years after the school's founding[‡]. To further emphasize the disparity in enrollment between instrumental and vocal departments, of the fifty-three pupils from Brooklyn mentioned in the *Brooklyn Daily Eagle* in 1892, only three are violinists[25]. Therefore, it seems likely that Urso only taught a handful of students at the National Conservatory.

Urso's professorship at the National Conservatory was unusual because, while there were female voice professors, Urso was the only female professor among the orchestral faculty, emphasizing the institutional barriers women faced in professional pedagogical environments. Even though amateur music teaching was dominated by women in the late nineteenth-century, teaching at a professional conservatory, even one as new and progressive as the National Conservatory, presented obstacles for women[††].

While teaching at the National Conservatory, Urso felt that American students were not at an appropriate technical level. In a somewhat satirical article published on May 26, 1892, the *Brooklyn Daily Eagle* reported that "during the daytime Camilla Urso, Leopld Lichtenberg, Victor Herbert, Otto Oesterle, and their associates disposed of about forty ambitious youth of both sexes who want to play orchestral instruments of one sort and another"[26]. This same sentiment is also echoed in an article written by Urso herself entitled "On the Study of the Violin: Pertinent Advice From the Pen of One Well Qualified to Give it" published in the *Musical Record* in 1898. Despite the increasing prevalence of American violin students, Urso writes that most of her violin students at the National Conservatory were ill prepared and had received an insufficient musical education:

> When I belonged to the faculty of the national Conservatory of Music of America, at one of the yearly examinations…out of the fifty-four pupils who competed for a mission to enter these classes only two were accepted. The applicants had all studied for several years and came from all parts of the United States. The two admitted were the only ones who filled satisfactorily the requirements exacted, simple enough as the requirements were. All that was asked of them was to play acceptably the elementary exercises[27].

In another article discussing student violinists, Urso reveals, with veiled contempt, how none of the applicants to the National Conservatory had good quality

of the nineteenth century yet most of them made careers as orchestral soloists, recitalists, and private teachers. Despite legal permission, in practice many women were barred from orchestral careers until well into the twentieth century[21;3].

[‡]The account book chronicles the school's finances from December of 1885 to January of 1891 and does not mention Urso[24].

[††]Outside of the National Conservatory, Urso also taught a number of private students during her 1890-93 residence in New York. It is possible to trace some of Urso's pupils in New York through newspaper records including Bertie Webb, Cecilia Bradford, and Eleanor Hooper (later Coryell).

instruments[§]. Urso's bitter attitude may suggest Urso left the National Conservatory out of dissatisfaction, however, other factors, including her significant wrist injury in September 1892, also influenced her break with the institution after only three years[¶].

9 URSO AND NEW YORK WOMEN'S STRING ORCHESTRA

Despite leaving the National Conservatory, Urso remained involved in the pedagogical world, including becoming the honorary president of the New York Women's String Orchestra. Carl Lachmund founded the New York Women's String Orchestra in 1896, making it one of the earliest "lady orchestras" in the United States[30]. Urso became involved with the orchestra during its inaugural season and appeared as a soloist with the orchestra on at least one occasion before her death in 1902[||]. In a letter to the orchestra's director, Carl Lachmund, dated January 24, 1896 Urso accepted Lachmund's offer to be the honorary president of the orchestra, stating "I shall be much pleased to see such an excellent thing established in New York and be prosperous. Indeed, there is so much excellent talent among women of the kind required that need but an opportunity to be heard, that I have no doubt—of the society's success. I accept with pleasure your offer"[32]. Of course, the position of "honorary president" was nominal in nature; Urso was not involved in the running of the orchestra, and her "honorary presidency" was mostly used to garner publicity for concerts. In fact, business documents from the Carl Lachmund collection at the New York Public Library show Urso was not listed on any official orchestra documents and was not in attendance at any concerts during their first season[32].

The New York Women's String Orchestra was comprised of professional musicians, but did not give public concerts; instead, their annual season of four concerts was available to members who paid a yearly fee of $10. Outside of their subscription concerts, the orchestra also frequently gave charity concerts[33]. An article in the *Musical Courier* noted the orchestra had three-hundred annual subscribers[31].

Nonetheless, Urso used the New York Women's String Orchestra as a way to champion the successes and capabilities of female orchestral musicians. In a letter written by Urso, reprinted in the *Musical Courier* dated February 25, 1898, Urso stated, "The excellent shading and time, skillful technic, perfect intonation and graceful style of this organization goes far to confirm my demands of years ago for women's admission as violinists to theatrical and other orchestras as a means of livelihood. . . Let my sisters agitate this question and assert their rights"[34]. To those who doubted women's capabilities as orchestral musicians, Urso brandished the Women's String Orchestra as an example of a venue in which women were already successful orchestral musicians.

Letters between Urso and Lachmund also suggest Urso received pupils from the orchestra. In one letter she states, "It might be possible that some of the girls would like coaching for solo work and I promised to let them know if I had every time for such - and will call it a kindness if you will tell them of my presence here"[34]. In yet another letter she writes "you will announce to the orchestra that I am receiving pupils"[34]. Urso's role within Lachmund's orchestra provided Urso with a means to acquire pupils and extend her influence as a pedagogue.

10 URSO AND HER OWN VALUABLE IDEAS FOR PUPILS

Despite her advocacy, Urso's own writings about female violinists are firmly grounded in cynicism. Urso concluded her article "Valuable Ideas for Pupils" published in the January 1892 issue of Etude Magazine with a blunt piece of advice: "You see that my life is made up of hard work, and under the circumstances I should say to young girls who are thinking of becoming professional violinists, 'Don't.' Solo playing and teaching are all that are open to women violinists now-a-days"[35]. This advice contrasts sharply with Urso's efforts to champion women violinists, readily acknowledging that, despite her success and fame, female violinists faced discrimination and less reliable sources of income, a fact Urso knew well, since from 1898-1901, despite her successful career, Urso appeared in vaudeville shows for monetary reasons.

11 CONCLUSION

Given the available evidence, did Camilla Urso really do, as Edith Lynwood Win proclaimed in 1908, "more in America to cause girls to enter the field of violin playing than anyone else has done"[36]? It is unlikely that Urso was the single defining factor in changing societal

[§] "It is remarkable how many who have not even the plea of poverty buy instruments of the cheapest kind. These thoughts passed through my mind when I listened a few weeks ago to fifty-four applicants for the violin classes of the National Conservatory of Music. Hardly one had an instrument that could be called passable. This is a serious mistake"[28].

[¶] Urso was knocked down by a bicyclist in September 1892, badly injuring her right arm. According to some accounts, Urso's performing was never the same again after this injury. One article from 1895 claimed this accident "resulted in the crippling of her hand for all other purposes save for handling her bow" and mentioned that three years after the accident "she is unable to sew with it, and prefers, at present, her left hand in shaking hands"[29].

[||] A notice in the Musical Courier from April 20, 1898 reported "The third concert of the Women's String Orchestra Society of which Carl V. Lachmund is conductor, will take place April 21 in Mendelssohn Hall. The soloists will be Mme. Camilla Urso, violinist, and honorary president of the society"[31].

attitudes towards women violinists. However, many accounts of women violinists at the turn of the century named Urso as their primary inspiration. The violinist, Lucille Eldridge-Shafer fondly recalled her first meeting with Urso, stating "she was the first lady violinist worthy of name that I heard and how her playing did enrapture me"[37]. An admirer recalled in *Demorset's Family Magazine* "I think my first impressions of Camilla Urso as played ten years ago with the old Philharmonic Orchestra in the Boston Theatre are shared by many of the girl violinists of today whose first aspirations were aroused by her exquisite renderings of the Mendelssohn concerto"[38].

Surely, we can see Urso as a figure of change. When Urso arrived in New York in 1852, a female violinist was a rare spectacle, yet by 1900 women violinists had become a more commonplace occurrence, if not a fashionable pursuit for young women. In 1901, attitudes toward women violinists had changed to such an extent that the music critic George Lehman proclaimed "society's attitude toward the woman violinist is so completely metamorphosed that a young girl, possessed of neither wealth nor great physical or mental charms, but capable of playing the violin tolerably well, is strongly fortified for social and even material success"[39]. The many American violinists who rose to prominence in the 1880s and beyond including Maud Powell, Marion Osgood, Geraldine Morgan, Nettie Carpenter, Arma Senkra (Harkness), Teresina Tua, Olive Mead, Lillian Shattuck, and Marie Soldat Roeger all rest on the shoulders of Camilla Urso. In her widespread concerts and private teaching, Urso demonstrated that women were very capable of playing the violin and subsequently inspired a generation of female musicians.

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13 EDITOR'S NOTES

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Examining Climate Change Effects on Flowering in Moss Campion

Mykaela Tanino-Springsteen[1], Olivia Dewitt[1], Anna Sher[2]
[1]Student Contributor, University of Denver
[2]Advisor, Department of Biological Sciences, University of Denver

Abstract

Examining the variation in the collection date of herbarium specimens is a common method for studying the phenological effects of climate change on a flowering plant species. We used herbarium data to examine how warming temperatures have affected flowering time in *Silene acaulis* in the state of Colorado. *Silene acaulis*, commonly known as moss campion and cushion pink, is an alpine tundra plant. Using ordinal date of collection as a proxy for flowering date and year collected as a proxy for increasing average temperature, a linear regression test found that there was no significant relationship between increasing temperatures and flowering time. Further examination of the herbarium data revealed a pattern of summertime specimen collection for *Silene acaulis*. As a species that flowers in response to snow melt, the collection pattern indicates that herbarium data is insufficient for assessing the phenological effects of climate change on *Silene acaulis*. More intensive research on the relationship between snow melt and flowering time is needed to understand the impacts of climate change on *Silene acaulis*.

Keywords:
Phenology – the study of the timing of recurring biological events
Abiotic – non-living aspects and components of an ecosystem
Biotic – living components of an ecosystem
Silene acaulis – an alpine tundra plant commonly known as moss campion and cushion pink
Ecosystem – a system of abiotic and biotic community interactions
Herbarium – a collection of plant specimens and their associated data

1 INTRODUCTION

The study of conservation biology aims to understand and mitigate factors that threaten biodiversity. As rising global temperatures impose dramatic changes throughout the world, studying the impacts of climate change on individual species and ecosystems is vital for designing and implementing conservation strategies. One method for studying climate change and its impacts on flowering plants and their surrounding ecosystems is by examining changes in phenology of flowering time.

Phenology refers to the timing of recurring biological events; it can be influenced by abiotic and biotic factors. The annual flowering of plants is an important phenological phenomenon that is primarily influenced by temperature and precipitation. As global temperatures rise due to climate change, precipitation and temperature patterns have changed for many ecosystems. In response to these shifts, many plants have begun to flower earlier in the year[1,2].

Silene acaulis, commonly known as moss campion and cushion pink, is a cushion plant that grows in alpine tundra ecosystems and can be found at higher elevations throughout most of the Western United States. It has been observed that the primary factor influencing phenology in *S. acaulis* is snow melt[3]. As a plant growing in mountainous areas, *S. acaulis* is expected to show a significant trend of earlier flowering time because climate change is found to have disproportional effects on high latitude and high elevation ecosystems. Some studies of *S. acaulis* have indeed documented earlier flowering and changing pollinator interactions in *S. acaulis* due to warming temperatures[3,4].

Herbarium data can be used to provide long term trends in phenology. Herbarium specimens are often collected when flowering or fruiting, making collection date a good proxy for flowering date. Because climate change records show increased temperature with time, looking at the collection date of specimens over time can indicate whether flowering time is occurring earlier

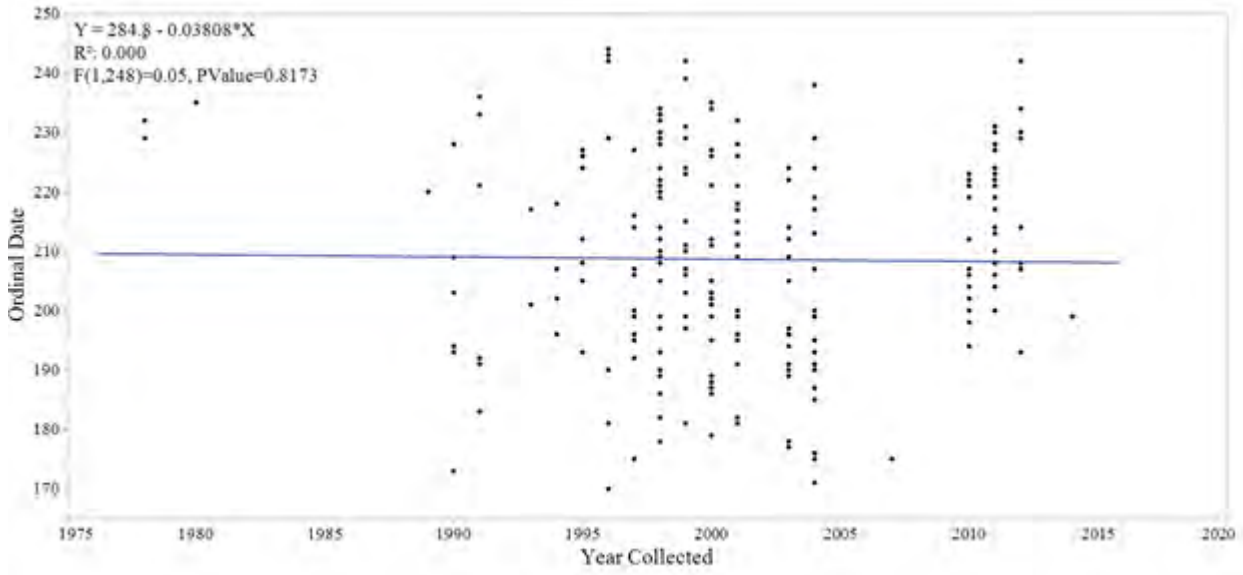

Figure 1. The graph shows the linear regression line for the relationship between the year collected and ordinal date (measurement for flowering time) of the species *Silene acaulis*. The equation of the line is $Y = 284.8 - 0.038X$, with $R^2 = 0.00$, and $p = 0.8173$.

in relation to warmer winters and springs. Herbarium data can be particularly useful for a plant species such as *S. acaulis* which lives in areas that are more difficult to access or monitor.

In this study, the long-term effect of rising temperature on *S. acaulis* flower phenology was tested using linear regression to determine how ordinal date, an approximation for flowering date, changed over time in the state of Colorado. It was expected that ordinal date would decrease as collection date increased, showing a trend of earlier flowering times in *S. acaulis* as a result of climate change.

2 METHODS

S. acaulis data for the state of Colorado was collected from the Rocky Mountain Herbarium Specimen Database website[5]. Within the database website, "Silene acaulis" was entered as the search term in the scientific name search field, "Colorado" was used as the search term in the location search field, and "Rocky Mountain Herbarium" was selected in the herbarium search field. No other search filters were used. The resulting data set was then downloaded and processed to exclude non-flowering specimens and specimens that were missing the day, month, or year from their time of collection.

The Excel equation, =ABS(TEXT(X-DATE(YEAR(X), 1,0), "000")), was used to calculate ordinal date, where X is the date (Year, Month, Day) of specimen collection. Ordinal date gives an approximation of the day of the year that each sample was flowering. To test for a relationship between *S. acaulis* phenology and rising temperatures, linear regression was used to determine whether there was a relationship between the year collected and the ordinal date. Ordinal date was the dependent variable and year collected was the independent variable.

3 RESULTS

The graph of the data shows a small negative slope in the regression line. It also shows acceptable distributions of data as well as a clearer picture of the data and how it may have changed over time. In the raw data, ordinal date for collection of samples shows that specimens were collected between the months of June and August. The slope of the regression line is -0.038 and the equation is $Y = 284.8 - 0.038X$, with $R^2 = 0.00$, and $p = 0.8173$. The slope of the regression line is not significant, and the p-value is much higher than the 0.05 accepted alpha value parameter. The graph shows a slight general trend in the data of earlier flowering over time, but this is not significant enough to show a true trend in the data.

4 DISCUSSION

The results do not support the hypothesis that *S. acaulis* has been flowering earlier over time in response to warming temperatures. The linear regression shows that there is no significant relationship between ordinal date and collection date ($R^2 = 0.00$, $p = 0.8173$); thus the null hypothesis fails to be rejected. Because the linear regression does not indicate a significant relationship,

it suggests that *S. acaulis* phenology has not changed over time in response to rising temperatures. Although the data analysis for this study does not show a relationship between ordinal date and year collected, it does not mean that climate change has no effect on flowering time. In fact, many other studies of *S. acaulis*, including specifically in Colorado, have shown that the species has experienced flowering times earlier in response to climate change[3]. Because other studies have found that *S. acaulis* has had earlier flowering patterns with increased global temperatures, and because there was a slightly negative slope, the results from this linear regression suggest that a Type II error occurred. In other words, there is evidence of a relationship between climate change and flowering time, but there is not sufficient data for this relationship to be seen in this statistical analysis.

The lack of a causal relationship between the collection date and ordinal date is likely due to specimen collection habits of *S. acaulis*. *S. acaulis* typically blooms in the summer months of June, July, and August. This is reflected in the herbarium data set, as all specimens were collected during this expected time frame. Earlier collection dates during the spring would be needed to determine if there is earlier flowering occurring as a result of climate change. Many herbarium specimens are collected with flowers, making collection date a possible estimate for flowering date. However, because there were no specimens collected during the spring, it is likely that the collection date does not accurately reflect the approximate time of initial flowering. Thus, herbarium collection date may be not the best indicator for earlier flowering time of *S. acaulis* in relation to climate change.

Because the herbarium data results are inconsistent with previous recorded trends of earlier flowering times in *S. acaulis*, specimen collection habits should be altered, and other study approaches should be utilized to research the effects of climate change on S. acaulis phenology. To provide more accurate data about changes in *S. acaulis* phenology, a more intensive approach of monitoring *S. acaulis* flowering in relationship to snowfall and snow melt should be utilized. Studies that have monitored for flowering after snow melt have been successful in determining earlier flowering[3]. Furthermore, herbarium specimen collectors should consider looking for and harvesting specimens of *S. acaulis* at an earlier date to provide more comprehensive data for when *S. acaulis* begins flowering. This may be applicable to other species as well.

The study of *S. acaulis* is important because it can provide information on climate change effects in alpine tundra ecosystems. Phenological studies are particularly important for possible conservation efforts as they can provide valuable information on the reproductive success and dispersal of *S. acaulis* as the species faces the threat of climate change. This information will also be important to understand how plants and animals that rely on *S. acaulis* as a nurse plant or food source may be impacted. However, as studies of *S. acaulis* continue, more intensive snow and flower monitoring research is needed as herbarium samples may not provide the most accurate method for examining climate change effects on flowering time.

5 EDITOR'S NOTES

This article was peer reviewed.

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Drivers and Barriers of Diversity and Inclusion in Business: Interviews with Nine Field Experts

Alana Aragon[1], Sung Soo Kim[2]
[1]Student Contributor, University of Denver
[2]Advisor, Daniels College of Business, University of Denver

Abstract

In an ever-diversifying world, Diversity and Inclusion (D&I) strategies must exist in organizations to achieve the potential of positive business and employee outcomes. Businesses must understand how to get diversity and inclusivity in their organization, and how to mitigate the barriers they will face in doing so. Inclusion, "the degree to which individuals feel a part of the critical organizational processes"[1] is crucial for employees and organizations to receive the benefits of diversity. In a climate where inclusion is valued, employees show better affective states (e.g. engagement and belonging) and higher organizational commitment[2] leading to improved business outcomes. To address a gap in the D&I field, a literature review and interviews with nine field experts were conducted to identify actual drivers and barriers of D&I in business. These responses suggest that inclusion must be looked at through multi-level organizational scrutiny and requires a continual process of analysis. This research contributes business thoughts, strategies, and barriers to fostering inclusion in organizations to the D&I field. These findings are not only compelling for the case for inclusion, but in addition, provide supported D&I practices for businesses that foster inclusion.

1 INTRODUCTION

Society is becoming more diverse and systemic barriers in organizations are being broken down to allow for the workforce to follow in this trend. Organizations have long endorsed the benefits of diversity, but the current research all points to the fact that diversity alone is not sufficient to realize the potential benefits. To achieve the full potential of diversity, a climate of inclusion must be felt by employees, and some experts say that diversity management must occur to create this climate. This thesis reports an in-depth analysis of the drivers and barriers for diversity and inclusion (D&I) in business today. More specifically, it examined the following questions: why is D&I important in business, how do businesses drive D&I, and what barriers exist? To answer these questions, this work presents a literature review on the previous research on D&I management and data gathered from in-depth interviews with nine field experts.

By conducting a literature review, this investigation seeks to understand the history and effects of both inclusion and diversity management. It begins by distinguishing between the terms diversity and inclusion by using definitions created by Mor Barak, a D&I expert. Studies done by other D&I experts such as Shore and Findler examine the shortcomings of solely focusing on diversity. Equally important, the literature review looks at studies that identified positive employee and business outcomes–such as ones completed by Ferdman[3] and Wheeler[4]. This research also explores models created by Jackson and Holvino[5] to understand how we can measure diversity and inclusion in organizations. By combining expert studies on inclusion and diversity, this research presents the "business case" for D&I as well as exploring its critiques.

To gather in-depth observations and opinions about the state of D&I in businesses, eight interviews were conducted with nine field experts. These interviews focused on D&I initiatives the company has already implemented or are working to implement. One objective for this research was to find out what the actual drivers and barriers for D&I are in businesses. To understand how the literature on D&I work compares to the on-the-ground situation, this study also investigated the experts' understanding of the terms inclusion and diversity management.

Ultimately, this investigation led to the key conclusion that D&I is integral to create successful employees and businesses. The work of D&I practitioners is never done and must constantly be revaluated within business. Doing so, allows businesses to identify the drivers and barriers for D&I. Through the initiatives that are used by real practitioners' barriers that create exclusive

environments are mitigated. The practitioners' insights differed in some ways from the literature which will be considered in the following section.

2 LITERATURE REVIEW: DIVERSITY, DIVERSITY MANAGEMENT AND INCLUSION

Diversity and inclusion are terms that are often used together and while interrelated, are perceived distinctly and lead to distinct outcomes. This section will attempt to define each individually, but it should be noted that there is often overlap and correlation.

2.1 Diversity and Diversity Management

Globally, the population is becoming increasingly diverse and this includes demographic changes in the workforce. Diversity is the representation of multiple identity groups and their cultures[3]. Mor Barak, a leading researcher, has defined workforce diversity as, "the division of the workforce into distinction categories that (a) have a perceived commonality within a given cultural or national context and that (b) impact potentially harmful or beneficial employment outcomes such as job opportunities, treatment in the workplace, and promotion prospects—irrespective of job-related skills and qualifications"[6]. This definition will help to understand the significance of diversity management and inclusion in the following sections. Workforce diversity can lead to positive outcomes, but the studies show that diversity alone is not enough. It was found that being part of the minority group in a diverse organization has significant negative effects on the affective experiences of employees[2]. It can also lead to negative results in the organization—such as, increased conflict and turnover, lower cohesion, and poorer performance[6]. Growing diversity in the world and more diverse workforces make evident the importance of addressing and mitigating these negative outcomes. These studies show that when diversity of employees is not managed well, it hinders business and hurts employees.

Notably, diversity management was a term that started being used in the 1990s as a result of the increased diversity in the workforce. Simply put, diversity management is how organizations manage diversity. In an investigation by David Pitts[7], he historicizes the concept, explains the different understandings of the definition of diversity management, and tests the outcomes of diversity management. Diversity management practices vary between organizations and investigations. There are primarily three views on diversity management: traditional with a focus on recruitment, representation, and numbers; management-orientated with a focus on the employee and their experience; and a combination of both in a more comprehensive approach[7]. Pitts' investigation in 2009 was the first large-N study using public sector data that linked diversity management with work related outcomes. Their main findings were that diversity management matters and it matters particularly for employees of color[7]. Particularly, it was found that (1) people of color do not report good performance or job satisfaction as often as their white counterparts and (2) that with strong diversity management, people of color have more positive perceptions of their organization and higher job satisfaction[7]. Through this study, it indicates that diversity management does have positive outcomes on employees and organizations.

Increased diversity and businesses' focus on these diverse employees means that diversity management causes a shift in the organization's climate. In an empirical test of diversity climate by Buttner, Lowe, and Bilings-Harris, they examined two dimensions of diversity climate, the perceived fairness in employment decisions with respect to the ethnicity of employees and fulfillment of diversity promises to employees of color as they related to employee outcomes (organizational commitment and turnover intentions)[8]. This research suggests that it is most important to focus on perceptions of diversity climate and human resource decisions that directly affect employees of color[8]. Human resource decisions are often management decisions such as hiring, promotion, feedback and performance evaluations. This leads to the importance of diversity management as a tool to create a positively perceived diversity climate.

Although diversity management has sometimes been critiqued for not doing enough, it shows potential when used to create a climate of inclusion. In a meta-analysis by Mor Barak & co., they found that diversity management efforts that promote inclusion lead to increased positive outcomes and negate negative consequences. The implications for diversity management were: management actively recruiting and retaining a diverse workforce, fostering a sense of belonging in the organization, constantly assessing the climate to provide a diagnosis, and analyzing inclusion at all levels in the organization[1]. Therefore, diversity management is a key aspect in creating perceived inclusion which is critical for realizing the beneficial outcomes of diversity in the workforce.

Conversely, diversity management has seen push back from organizations and received other critiques. In one article, John Wrench argues that diversity management can be harmful by raising up critical opinions of the practice. Critics believe that it is a "soft option" by taking the focus away from racism and ignoring that some groups have more systemic marginalization[9]. He also argues that it replaces the moral argument behind diversity with a business argument, and takes away from equality measures and anti-discrimination strategies[9]. While it does use examples of the TUC Black

Workers Conference voting against diversity management, it lacks empirical evidence on the negative effects of diversity management. The lack of critiques in the D&I field may suggest that there are still holes in the current pool of analysis on inclusion and diversity management.

2.2 Inclusion

More and more, the research points to the importance of inclusion over and above diversity to achieve beneficial results. Mor Barak's[1] definition of inclusion was used to guide this research which states, "the degree to which individuals feel a part of the critical organizational processes, such as access to information, connectedness to co-workers and ability to participate in and influence the decision-making processes." Ferdman's book[3] explains that inclusion is what organizations must do to receive the benefits of diversity, and states, "inclusion involves how well organizations and their members fully connect with, engage, and utilize people across all types of differences"[3]. This book and the other studies in the literature review conducted show that inclusion can increase positive effects on employees and organizations. Inclusion can enhance performance by leading to greater engagement, stronger teams, and more creativity[4].

However, without this climate of inclusion, the opposite occurs and there are significant negative effects on employees and organizations. Findler et al investigated diversity in Israel and found that the experience of exclusion, due to belonging to a minority group in an organization, affects employee outcomes and leads to negative affective experiences[2]. In an analysis of existing research it maintains that an employee's perception of inclusion affects the employee's wellbeing, satisfaction, and organization commitment[2]. The Findler et al. study found that management practices directly impact perceived inclusion and exclusion, organizational structure must be constructed to view inclusion at all levels, and that organizational norms must be assessed and changed to promote an inclusive culture.

One method proposed for analyzing inclusion in organizations is the Multicultural Organization Development Model developed by Jackson and Holvino as an assessment and developmental tool. This is a change model that supports the movement of an organization from monocultural (an exclusionary organization) to multicultural (an inclusive, diverse, and equitable organization)[5]. With this model, organizations can identify where they are on the spectrum and utilize the key organizational dimensions given to direct goals[5]. Once an organization reaches multicultural, this signifies that it shows, acts, and changes so that it actively includes and integrates people and perspectives from diverse identities into the organization[5]. This tool contributes to analyzing inclusion throughout organizations and is one of the first of its kind to be developed. While originally created to analyze inclusion in higher education, it has the potential to translate well into the business world where there is currently no standardized model for analyzing inclusion.

While inclusion can be analyzed at various levels, much of the current existing research focuses on how leaders affect inclusion. Perceived inclusion is felt by the individual, but is largely affected by the leadership and climate of the organization. In another study by Cottrill et al, they found that authentic leadership can promote inclusion which leads to employee benefits—such as, organization-based self-esteem and organizational citizenship behavior[10]. Authentic leadership theory believes that these types of leaders foster open communication and encourage follower's ability to be their self. In this study, it showed the importance of authentic leadership as it fosters inclusion by making employees feel important, valued, and trusted which leads to positive employee outcomes[10]. In addition to exemplifying the positive impacts of certain leadership types, this study also demonstrates the importance of organizational leaders in affecting inclusion.

With the rise in Diversity and Inclusion initiatives, it begs the question of what barriers exist that halt progress in organizations. Michael Wheeler, a corporate diversity leader, presents some of these key barriers: complexity, competing issues, lack of history and credentialing for D&I, untapped resources, lack of inclusion, programmatic and simplistic approaches rather than strategic and systemic ones, lack of clarity on "it"[4]. D&I is a complex issue that is only beginning to be understood and valued by organizations and employees. Due to this, there are many ideas about inclusion, but not as much empirical evidence for methods on how to ensure inclusion[6]. These challenges also present opportunities for more research.

2.3 Summary of Literature Review

The literature review found that there is extensive research on the benefits of managing diversity to create an inclusive climate for employees and the business. The literature not only introduced the positive benefits of inclusion on employees and business, but also established that negative effects exist when inclusion is not felt by employees. It explored studies conducted national and internationally, and throughout, a clear business case was presented for inclusion. One model (the Multicultural Organization Development Model) is also introduced as a potential tool for analyzing Diversity and Inclusion. However, there is a current gap in knowledge on how organizations are creating inclusive environments and what barriers are inhibiting it. This presented an opportunity for this research to add

to the D&I literature and provided the framework for interview questions. For primary research, eight interviews were conducted with nine field experts to explore whether the literature is applied and valued in business. While it was found that there are similar perceptions around the importance and impacts of D&I, there is also some disagreement among priorities and terms.

3 INTERVIEW METHODOLOGY

For field expert interviews, a mix of organization types were chosen in order to present an analysis of D&I that has a larger scope. To work with human subjects, the proposed study went through an ethical review and was approved in the IRB process (IRB#1536601-1). Using the DU network, recruitment emails were sent to field experts that were either alumni or professionals who were referred to the study by faculty in the Daniels College of Business. All interviewees gave consent to record the interviews and use their name in this thesis.

To start, one of these eight interviews was conducted with a joint pair working with D&I in the same organization which brought my number of interviewees up to nine. Of this number, six worked in human resources in various businesses, one worked in the University of Denver Cultural Center, one owned her own consulting firm for D&I for businesses and organizations, and the last one worked as an engagement specialist for a P.R. firm that works with progressive, nonprofit organizations. Eight of the nine interviewees work in Colorado and one worked in New York. Eight are currently still working and one is retired after more than 20 years in the field. Eight were female and one was male. My subjects worked in a wide variety of organization sizes, from being part of a small team of 4 full-time staff serving the local area to the Vice President of HR for a global company and everything in between. Some of them had very established D&I initiatives while others were in the grassroots stages. This variety allowed for a wide range of perspectives and experiences.

Overall, interviews typically lasted from thirty-minutes to an hour with eight questions. From the interview transcripts, two tables were created to analyze the data. The first allowed for side-by-side comparison of responses for each individual question and person. After examining this data, a second table was created that divided the questions into six categories: Experience and Importance, Inclusivity, Diversity Management, Diversity Management and Inclusivity, Barriers and Challenges, and Overarching Themes. For each category, keywords, similarities in responses, and differences in responses were examined. For ease of presentation in this thesis, five categories are used to organize and report interview findings in the following section. Each section starts with a word cloud visualization of the keywords (exact words or synonyms) found repeated throughout various interviews. The size of the words correlates to the amount of interviewees who mentioned it during that section. For example, the larger words were mentioned by more people which suggests a higher importance. Following keywords, responses are presented using a chart to compare similarities and differences in responses. In the discussion section, key takeaways and their impact on the D&I business field are considered.

4 INTERVIEW FINDINGS

4.1 Experience and Importance of D&I

Interviewees shared their own experiences with D&I, and the importance they attached to the subject.

Figure 1. Experience and Importance of D&I Word Cloud

Topics (Questions)	Keywords (#/9)	Similarities in Responses (#/9)	Differences in Response (Subject Initial)
Experience and Importance (1,4)	Human Resources (6) Personal Experience (6) Business (5) Community (4) Priority/Important(4) Perspectives (4)	Work Role (9) Want places where people done look alike or are a representative mix (7) Academics (5) Business case, good business, money standpoint (5) Better employees (ex. innovation, connection with customers, engagement, retention, less conflict, better decisions and performance, perspectives) (5) Candidates want to work in a diverse environment (3) Requires work (3) Legal case (2)	All work in different areas of business. Pay equity, emotional intelligence (MH) Leveling the playing field, structural inequity, colonization (J) Moral case (KN) Creating space (M) Process to raise issues on diversity and inclusion (S) Different factors of diversity (G)

Table 1 Experience and Importance of D&I Response Chart

Notably, all of the subjects have experiences through their job related to D&I. Many of them also mentioned personal experiences in relation to D&I and five of them mentioned encountering D&I through academics or in the academic field. A lot of the interviewees cited the importance of D&I as it related to better employees, better businesses, and maintaining a representative mix of people and opinions.

While most of the responses were quite similar, there were some unique examples mentioned that are important to highlight. The importance of D&I was brought

up in relation to the failings of Western civilization, lasting impacts of colonization, and structural inequalities. The moral case for D&I was also brought up in addition to the importance of having many types of diversity.

4.2 Inclusion

This section looked at what inclusion meant for each interviewee and how their organization created an inclusive environment.

Figure 2. Inclusion Word Cloud

Topics (Questions)	Keywords (#/9)	Similarities in Responses (#/9)	Differences in Response (Subject Initial)
Inclusivity (2,5) +Extra Comment (M)	Differences Valued (6) Participation or Voices (5) Bias (5) Everyone or Everybody (5) Active, Intentional, Aggressive (5) Included or welcomed (3) Skills/Qualified (3) Opinions/thoughts (3) Pronouns (2) Training (2) Contributions (2)	Allusion to a spectrum of not ever done learning to be more inclusive (8) Diversity gets to impact (6) Empowered to be authentic or express diversity (5) Operating against inequitable landscape in American Business (5) Values (5) Educational Programming (5) Celebrations (4) Expand sourcing to hire diverse candidates (4) Providing equal opportunity (4) Employee resource, affinity groups (4) Physical accessibility, visual cues (3) Representative of community (3) Non-visual diversity factors (3) D&I group (3) Buy-in, importance in top/leadership level (3) Intentional decisions to fill leadership with divers candidates on early career side, searching for diverse candidates (top and bottom idea) (3) Accessible language (2) Performance management system (2)	Well-being, ability to be a decent human being, swift to act (A) Affermative action, curriculum, context, or history (J) Diversity in leadership fades away (MH) Fully informed (KN) Bias Interrupters (KN) Active learning (M) Accommodation (G) Affirmative Action (J) Non-mandatory training (K)

Table 2 Inclusion Response Chart

Right away, there are some common themes among the key words related to describing inclusion. Inclusion was often related to the idea of having differences valued, all people welcomed, and platforms to participate and share opinions. In terms of strategies implemented, many of them mentioned active and intentional decision making, permeation of D&I as a value throughout the organization, and policies and structures to support diversity.

As for drivers of D&I, many of the interviewees agreed upon similar themes. All of them reported that the organization must recognize the value of diversity. All of them said the organization had to provide structural support through policies and procedures. Some specific initiatives mentioned were pay equity and identity-based groups. There were some differences in responses that did not correlate with the common themes mentioned above.

4.3 Diversity and Diversity Management

These questions related to the interviewees understanding of diversity management and ways their organization uses it.

Figure 3. Diversity and Diversity Management Word Cloud

Topics (Questions)	Keywords (#/9)	Similarities in Responses (#/9)	Differences in Response (Subject Initial)	Other Comments
Diversity Management (3,6) + EC S	Active, intentional (6) Policy/process/procedure (4) Metrics/Data (4) Recruitment (4) Open/honest/transparent (3) Qualified (3) Community (2) Impact (2)	Unfamiliar with the term diversity management (4) Don't like the term (3) Unsure (1) Supportive or a diverse community (5) Talk about senior levels (5) Proactively recruit (5) Representation in team (3) Succession/Promotion (3) Homogeneous in leadership (3) Structural support (2) Don't specifically pursue anything, organic recruiting process, intentional decisions at the top (2) D&I council (2) Termination (2) Better employees (2) Talk/communication (2)	Affirmative action and misconceptions, level the playing field, chief diversity officer (J) Need Inclusion for diversity to be sustainable, diversity is getting people in the door (KN) Performance management rely on trust and confidence of the employee (A&B) Pay analysis (K) Policy is like a bandaid, reverse discrimination (MH) D&I stuctute and strategy tied to performance bonuses, affinity groups, anonymous process where employees could bring issues up in the organization (S) Location posting(G)	Disconnect among academia and practice (MH) Quotas (J)

Table 3 Diversity and Diversity Management Response Chart

Interestingly, there was more unfamiliarity and negative conations around the term diversity management. Many mentioned that they shy away from creating specific policies dealing with diversity. For those who did mention policies, a lot of them were in relation to the recruitment process and internal data analysis. When Affirmative Action was mentioned, it was often alluded

to as the earlier stages of D&I strategy and the large misconceptions around it.

Four people were unfamiliar with the term diversity management. Two of them did not like or criticized the term. One was unsure if they understood the term correctly. The two who did not mention something along the lines of this came from the same organization in which I conducted the joint interview. Despite the unfamiliarity with the term, all still tried to answer the questions to the best of their abilities.

4.4 Diversity Management and Inclusivity

This question looked at whether diversity management is used as a tool for inclusivity.

Topics (Questions)	Keywords (#/9)	Similarities in Responses (#/9)	Differences in Response (Subject Initial)	Other Comments
Diversity Management + Inclusivity (6.b)	Yes (6)	Can't do one without the other (2)	Diversity sustainable only with inclusion (KN) Inclusion not a conversation yet; employee engagement surveys, innovation, recognition of new ideas, budget, trainings, affinity groups, holidays, newsletters (A&B) Challenge ourselves (G) Structures make progress for more inclusive environment (J) Evaluated on diversity of team, used as coaching tool, bias-awareness training	Employee engagement (A&B)

Table 4 Diversity Management and Inclusivity Response Chart

From the keywords, I can conclude that the majority of people believed diversity management is used for inclusivity. There were many more differences in the responses for this question. It was emphasized that diversity is only sustainable with inclusion.

4.5 Barriers and Challenges

These questions dealt with barriers and challenges the interviewees thought existed or had witnessed for D&I in business.

Figure 4. Barriers and Challenges Word Cloud

There were some barriers and challenges identified

Topics (Questions)	Keywords (#/9)	Similarities in Responses (#/9)	Differences in Response (Subject Initial)	Other Comments
Barriers/ Challenges (7,8) +EC G +EC MH +EC M +EC S	Bias (7) Communication (5) Resistance (4) Takes work (4) Survey (3) Perspective (3) Context (2) Threat (2)	Resources (time, budget) (4) Common goals/values (4) Bring awareness (4) Hiring well-qualified people (4) People who are promoted/punished for doing well/bad in D&I (3) Different elements of diversity (3) Transparency (3) Serious about need for D&I (2) Organizationally challenged in how it is structured (2) Can do things within sphere of influence (2) Broadening lens/perspective (2) No flexibility (2)	Mental health and well-being (A&B) Gender diversity, options, challenge getting diversity into organizations; pushback from customers, coach employees (G) Not prioritized by leadership, no space; Ability to be authentic, not having context or understanding realities student of color live (J) Mindsets, positive intelligence, D&I needs to step back and do education and mitigation for employees to be more inclusive; Expect resistance, use inclusion nudges and other strategies to get around it (KN) Equivalencies/ skills/cultural (M) Obsession on quotas; diversity of though (MH) Visibility, addressing gaps (S) Learn from mistakes, better to individually follow up because of biases and threats, just ask to be allies (K)	Make better employees (MH)

Table 5 Barriers and Challenges Response Chart

various times by interviewees. As shown in the keywords, bias came up throughout almost all of the interviews. Many of them also mentioned resistance, lack of resources, and inflexibility within their organization structure as barriers. While there was a lot of diversity within the specific barriers mentioned, all of the interviewees' answers included solutions to mitigate these different barriers.

5 DISCUSSION

Figure 5. Themes Throughout Word Cloud

Throughout the interviews, each person brought their own perspectives and experiences working in D&I to the table. Nevertheless, all of them recognized the importance and value in having a diverse, inclusive organization. Except for one person, all alluded to the idea of a spectrum for D&I work in an organization. This is further demonstrated by the diverse stages of D&I strategies all the subjects' organizations were in. This point is easily related to the Multicultural Organization

Topics (Questions)	Keywords (#/9)	Similarities in Responses (#/9)
Throughout Interviews	Talk/Communication (8) Spectrum/Still Learning/ Improving (8) Recruitment/Retainment (5) Affirmative Action (4) Bias-Awareness Training (3) Engaged/Engagement Survey (3)	Structural support through policies/procedures (9) Recognizing the value of diversity in org (9) Diverse perspectives/opinions (8) Drivers of Inclusion and Diversity: Intentional recruitment (7) Reflected in leadership/Buy-in from leadership (7) Diversity gets to impact (7) Education/trainings(7) Open and honest communication (6) Work enviornment (6)

Table 6 Themes Throughout Response Chart

Development[5] model that analyzes organizations on a spectrum from exclusionary to multicultural. None of them use this specific model, but the observation of D&I as a spectrum (as in D&I work never being finished) within an organization was touched on in-depth by various practitioners. Some of them had very established D&I strategies while others were in the grassroots stage. Interestingly, while interviewees reported varying degrees of D&I in their organizations, they identified similar sets of drivers to move their organizations to a more inclusive, diverse organization.

In all but one interview, the importance of having diverse perspectives and opinions in the organization was mentioned. The interviewees talked about the value this brings to the organization including employee engagement, innovation, and better solutions. This correlates to the research on inclusivity done by Wheeler[4] and Findler, et al[2] that found inclusion can lead to greater engagement and more creativity. Five of the interviewees mentioned that there is a huge business case for D&I and that it makes better employees. This is impressive because it shows the importance of D&I permeating throughout the organization. For an organization to be successful in today's world, it must value diversity and actively pursue inclusion.

Interestingly, the term diversity management is found to be a relatively unused and uncommon word in the D&I field in business. There were only two people who did not have a reaction to the term, while the rest either had not heard it, did not like it, or were unsure about it. This difference in the terminology between the literature and interviewees may illustrate a large disconnect between academia and actual business practices. Pitts' investigation[7] also explained that diversity management has changed connotations throughout the years which could have impacted the subjects' feelings and knowledge about the term. Despite unfamiliarity with the term, interviewees were encouraged to answer the question to the best of their abilities. As a result, many of them did mention strategies that would fall under diversity management (e.g. recruitment, promotion, policies) even without completely understanding the term.

Many of interviewees identified communication in their organization as a key driver for D&I. For inclusivity to happen, they believed open and honest communication on why D&I is valued and essential in business must permeate throughout the organization. Therefore, many of them correlate D&I into the values their organization has established. Interviewees also identified the importance of leadership buy-in. This is consistent with the studies mentioned previously by Cottril et al[10] in which they identified the leader and authentic leadership as key components for fostering open communication that creates a more inclusive environment.

Additionally, a majority of interviewees attribute the progress in D&I to the structural support they have in place through policies and procedures. Included in these policies and procedures: intentional recruiting for diverse and qualified candidates, affinity groups, specific budgets, D&I councils, and education or training around unconscious biases. Most of the comments around recruitment, promotion, feedback, and performance evaluation are all part of diversity management and contribute to a positively perceived diversity climate[8].

Many of the interviewees mentioned that the work environment has a critical impact in building an inclusive organization. Stating that it is not enough to have diversity, but that organizations must create channels for diverse people to impact operations or voice their opinions. The interviewees also cited internal analyses as a way to identify gaps and exclusive behavior. By communicating these findings, they can be used as coaching tools. Many believed that termination and corrective action can play a large role in portraying that the organization values diversity. The research Findler et al,[2] did coincide with this finding and found that an organization needs to constantly strive to assess and change its norms to promote an inclusive culture.

Even though interviewees recognized numerous drivers of D&I, all of them also identified many challenges for creating a diverse and inclusive organization. All of them mentioned either resistance, bias, or feeling threatened as a barrier. This coincides with Wheeler's[4] reports that lack of inclusion, people not wanting to be inclusive, is a barrier. Interviewees offered more specific reasons for why that happens and how it presents a challenge. Many of them also mentioned that the organization itself can act as a barrier due to how it is structured, lack of flexible options or working in an inequitable landscape and lack of resources like time and budget. While they all shared challenges, they also all mentioned ways to mitigate these barriers using the tools mentioned above as drivers of inclusivity.

Overall, this research took an in-depth look at the real field of D&I in business as it relates to the literature. While there was overlap between real practices and challenges, there was also some disagreement. The method-

ology and integrity of the research was sound. By creating two tables, it allowed direct comparison. Since the second table used short-hand, each interview transcript was examined to verify keywords. This study looked at a broad-scope of business to further contribute to general D&I knowledge. These findings suggest real-world strategies to impact D&I within business. Notwithstanding, there is still a lack of research on real business initiatives and challenges in D&I. There is also further research to be done that looks at D&I strategies among the same industry or even in the same business which was not done here. This research looked at a wide scope of business with some having a global reach—the D&I field would additionally benefit by focusing new research on international companies. While this research contextualizes and looks at D&I strategies mentioned in literature with real-life practices, there is still a lack of research on empirical evidence of D&I methods and strategies. More research is necessary in this field for businesses to continue along the spectrum of attaining a truly diverse and inclusive organization.

6 CONCLUSION

This study is one of the first of its kind in the D&I field to study the demonstrated drivers and barriers of D&I, and suggests discrepancies between the literature and real-world practices. It also provides key takeaways for business practitioners as D&I was identified as crucial to the success of employees and business in both the literature review and interview study. In particular, practitioners emphasized the importance of D&I being clearly communicated as crucial and valued in the organization. Furthermore, the interviewees alluded to the idea of D&I as a spectrum and emphasized the importance of continued learning—suggesting the use of internal processes and surveys to evaluate gaps in where their organization is failing at D&I. The majority of discrepancies were found in the terminology used by practitioners and encountered barriers in the D&I field.

The in-depth interview study conducted in this research allowed for comparison between the D&I methods and models used in literature and those implemented in real business practices. Many of the findings in interviews correlate with the literature. According to the field experts interviewed, the principal drivers of D&I include: structural policies and procedures, intentional recruiting, affinity groups, D&I councils, education and training, and promotion consideration. D&I in their organizations is often looked at through retention, promotion, and at the employee level. Leadership and communication has been found to be one of the key approaches for fostering a climate of inclusion in organizations. Still, common sets of barriers for building inclusive organizations persists in many organization such as bias, resistance, lack of resources, and structural problems. These barriers can be overcome by a commitment to D&I through the mentioned processes and procedures.

An organization's commitment to D&I creates better work environments and makes a particular difference for people from marginalized communities. Prior research suggests that positive effects of D&I practices increase in magnitude when looking at employees of color[7]. This thesis outlines common strategies used in business, and the barriers these field experts have encountered when attempting to create a diverse and inclusive environment. By using this research as a guide, businesses at any stage of a D&I plan can draw from the experiences of experts. It implies that organizations are largely responsible for their employee's perception of inclusion while providing practices that foster the positive benefits of diversity.

7 EDITOR'S NOTES

This article was peer reviewed.

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Fourth Down Decision Making: Challenging the Conservative Nature of NFL Coaches

Will Palmquist[1], Ryan Elmore[2], Benjamin Williams[2]
[1]Student Contributor, University of Denver
[2]Advisor, Department of Business Information and Analytics, University of Denver

Abstract

This thesis analyzes the hypothesis that coaches in the National Football League are often too conservative in their decision making on fourth downs. I used R Studio and NFL play-by-play data to simulate actual football plays and drives according to different fourth down strategies. By measuring expected points per drive over thousands of simulated drives, we are able to evaluate the effectiveness of different fourth down strategies. This research points to a number of conclusions regarding the nature of NFL coaches on fourth downs as well as the complexity of modeling and simulating decision making in a complex sport such as professional football. While we are able to demonstrate areas where a more aggressive fourth down strategy could be utilized to a team's advantage, this research demonstrates that fourth down decision is not a simple binary choice and that making this critical decision must be taken in context. In other words, further research should be done that takes into account additional variables and their impact on a team's decision to "go for it" or not on fourth down.

Keywords: sports analytics, data analytics, statistics, simulations, football, fourth downs

1 INTRODUCTION

The 2009 season marked a major turning point in the use of analytics in the National Football League[1]. For the first time, a large pool of data was available to teams and statistical modeling gained popularity in front offices and on the field. One particular game during that season is credited with bringing analytics into the spotlight. Coach Bill Belichick's New England Patriot's led the Indianapolis Colts by six points and faced a fourth-and-2 on their own 28-yard line. In these situations, teams have three choices: punting the ball, giving possession to the other team but leaving them further from a scoring opportunity; attempt a field goal for 3 points (if within range); or go for it with the intention of earning a first down but run the risk of a turnover. In this case, the Patriots were out of field goal range and going for it could result in giving the Colts a very strong field position. To the typical coach, a punt would seem like the obvious choice. Instead, Coach Belichick chose to go for it: they turned the ball over, the Colts gained possession deep into the Patriots' territory, and ultimately scored the game-winning touchdown on the ensuing drive. Though Belichick's decision proved costly, analytics proved that the decision gave the Patriots the greatest probability of victory[2]. This particular play, dubbed the "Belichick fourth-and-2", ultimately marked one of the first times modern analytics gained widespread coverage in the NFL.

A few years prior, the decision-making tendencies of NFL coaches began to attract analytical scrutiny. For example, using play-by-play data and dynamic programming, Romer[3] asserted that NFL teams' behaviors on fourth downs often fail to maximize their overall chances of winning the football game. It was suggested that coaches are too passive on fourth downs and elect to punt or kick a field goal too often. One drawback of this research was that it only covered fourth down scenarios with one yard to go for the first down. Though limited in scope, Romer's research began to show that coaches and teams were lacking in their ability to select plays, especially on fourth downs.

Building on Romer's research, Causey, Katz, and Quealy[4] developed what has since been termed the "New York Times 4th Down Bot". This expands on Romer's research to include optimal decision making at every yard line and every yards-to-go distance on the field (see Figure 1). Their research sought to provide an impartial strategy for approaching fourth downs and yielded results that would be considered very aggressive when compared to the typical coach's decision making. For example, their model suggests a team should

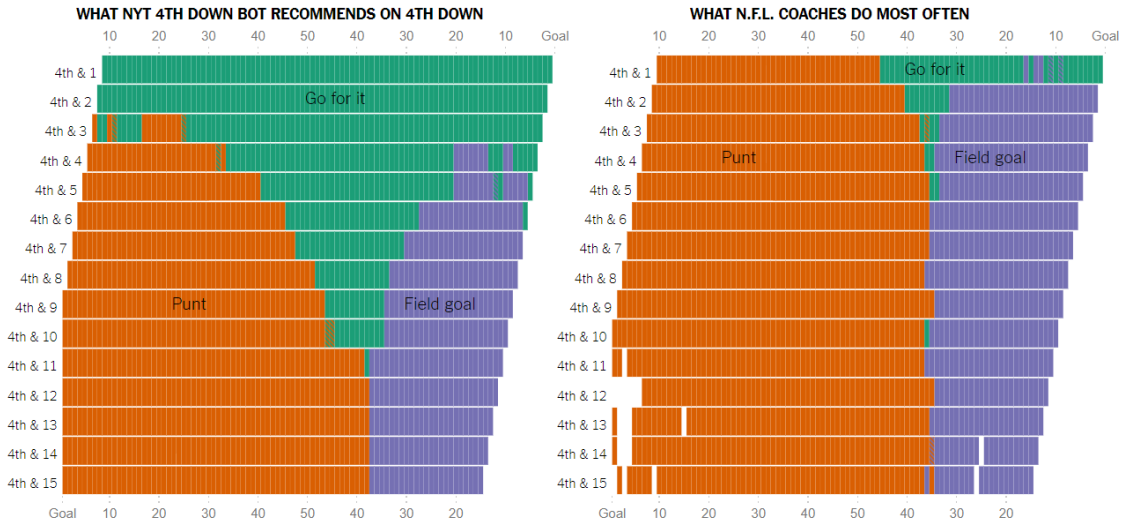

Figure 1. NYT 4th Down Bot

go for it on fourth-and-2 anywhere beyond their own 28-yard line, an idea that would seem extreme to the vast majority of coaches. This is exactly the strategy that was employed by Coach Belichick in the game versus the Colts described earlier. Their research supports, in summary, the idea that coaches are far too conservative on fourth downs.

More recently, Yam and Lopez[5] found that teams miss out on an extra 0.4 wins per year by not implementing a more effective fourth-down strategy. In their research, Yam and Lopez account for additional factors like time remaining, point differential, and the relative offensive and defensive strengths of each team. They draw a similar conclusion to past research: NFL coaches are too conservative.

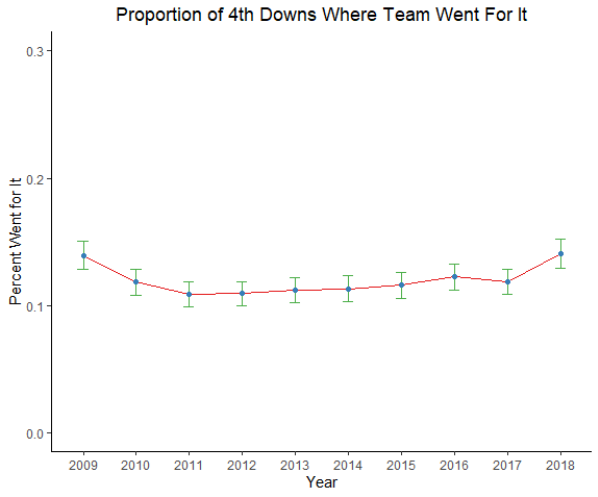

Figure 2. Proportion of fourth downs where the team went for it from 2009 to 2018. In other words, the proportion of run or pass plays on fourth down.

Despite convincing research, the conservative nature of the NFL on fourth downs has not changed in any meaningful way in recent years. Figure 2 demonstrates the relatively steady trend of fourth down decision making, with coaches electing to go for it between 11% and 14% of the time over the past 10 seasons. Despite an uptick in 2018, the data shows little to no changes in decision making on fourth downs. This begs the question: why is it that teams and coaches make decisions, particularly on fourth downs, that decrease their chances of winning? The answer may lie more in behavioral psychology than statistical analysis. A paper by Urschel and Zhuang[6] points to risk and loss aversion as the culprits of poor decision making, specifically on kickoff decisions. Their prospect theory-based model suggested that coaches tend to be overly cautious due to a greater sensitivity to losses relative to wins. This potentially comes from external factors like the ridicule faced when an aggressive play fails. In other words, the conservative choice, though suboptimal, will yield far less criticism. This idea of risk aversion could be one of the many factors influencing the strategic decision making of NFL coaches on fourth downs.

The purpose of this thesis is to test differences in a team's expected points by utilizing a very aggressive fourth down strategy. Past research has shown a tendency of NFL coaches to act conservatively on fourth downs. Despite a plethora of statistically significant findings, coaches have continued to execute suboptimal decision making in these situations. The 4th Down Bot points out that more than half of all plays result in a gain of 4 or more yards[7] so one would think that going for it on fourth down would be more common, especially when a team is within a couple of yards of a first down. However, coaches have largely stuck to their traditional

strategies and the use of an optimal decision-making strategy, supported by analytical theory, to choose plays is not widely adopted. One of the primary goals of this paper is to further demonstrate the need for coaches in the National Football League to approach fourth downs in a less conservative manner. With the nflsimulator package[8], we are able to simulate drives according to different strategies with the purpose of evaluating the effectiveness of a rather extreme fourth down strategy. The strategy is simple – regardless of field position, a team will choose to go for it on fourth down. Along different starting field positions, we aim to evaluate the difference in expected points per drive in comparison to a traditional fourth down strategy.

2 RESEARCH BODY

2.1 Data

In order to address this problem, we use NFL play-by-play data from the National Football League's (NFL) publicly available Application Programming Interface (API). In particular, this API is accessed via the well-known R statistical software[9] package called nflscrapR[10]. This package allows users to analyze an extensive library of NFL data on the single play, game, and season level. The functions within this package not only parse and clean the data from NFL.com but provide detailed metrics to enhance data analysis. In addition, Elmore and Williams[8] developed an R package called nflsimulator that is used to simulate plays and drives using the data in nflscrapR. Note that a drive is defined as a series of plays when the offensive team has possession of the ball. A drive ends when the team's possession of the ball ends, either through a score, punt, turnover, or the clock expiring.

The dataset used for simulating drives in this project includes almost fifty thousand plays from the 256 games in the 2018 NFL season. For each recorded play, nflscrapR provides over 250 individual variables ranging from simple items like the current yard line to more complex data like the expected points added from air yards on a pass play ("air_epa"). The level of granularity of the data allows for the nflsimulator functions to capture necessary data to simulate drives.

2.2 Methodology

2.2.1 Stimulating Drives

When we began the project, we wanted to simulate different fourth down strategies on a single drive basis and estimate the average expected points for each. Using the nflsimulator R package and the sample drive function in particular we are able to simulate individual drives according to different strategies. The function itself takes the starting yard line (measured as yards from the team's own goal), the data set used (in this case 2018 play-by-play data), and the scenario or strategy being tested. Figure 3 shows an example play used in the simulations.

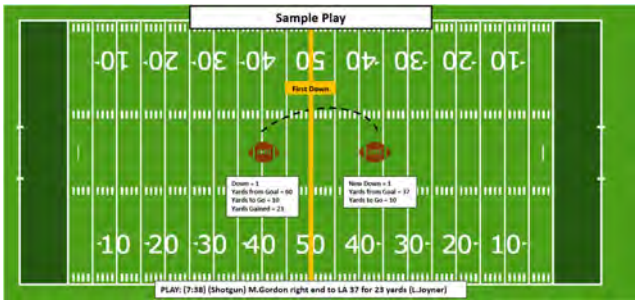

Figure 3. A sample play from the NFL's API, accessed by the nflscrapR package[10]. Shows a random run play starting 60 yards from goal on first down. Melvin Gordon ran for a gain of 23 yards to the opponent's 37-yard line.

Acting on the notion that NFL coaches are historically too conservative, we wanted to test a very aggressive fourth down strategy in comparison to what NFL coaches typically decide on fourth downs. The aggressive strategy in this case involves a team electing to go for it on fourth down regardless of the usual decision-making variables such as down, field position, and yards to go. It is important to note that the two strategies differ in the way they sample from the play-by-play data being used. The normal strategy will sample from the collection of actual plays as one would expect, matching variables like down, yards to go, yard line, etc for each new play in the drive. However, the "going for it" strategy samples from first and second down plays on second down, second and third down plays on third, and third and fourth down plays on fourth. In doing so, we eliminate some of the psychological effects of choosing to go for it on fourth down (as there is no alternative in this strategy) while allowing for a larger sample of plays.

A summary of the results comparing the two strategies is given in Figure 4. The results are based on running 1000 drive simulations for every five-yard increment between 5 and 95 under each respective strategy. We are able to compare the two strategies directly with regard to expected points per drive. A drive that ended without a score (turnover or punt) results in zero points, a touchdown is 7, a field goal is 3, and safety is 2. The final expected points value for each yard line is the average points per drive over all the simulations.

The results show that for the aggressive strategy (G), the expected points per drive is higher from the 5-yard line all the way to about the 40-yard line. At that point, the normal NFL strategy (N) yields a higher expected points value for all yard lines until the 95 (95 yards from the team's own goal). These results make sense in context as the data represents singular drives, so a

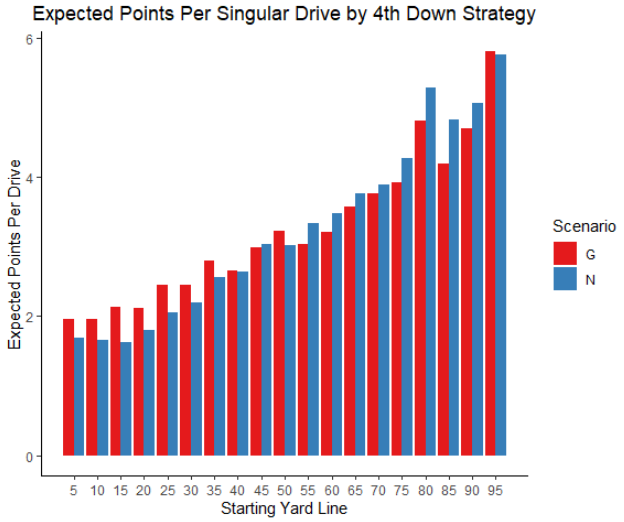

Figure 4. Graph is based on 1000 simulations of singular drives at every five-yard increment on the field for two different fourth down strategies. G represents the home team's strategy of going for it on fourth down no matter what, while N represents a team acting in accordance with normal fourth down decision making. Expected points per drive is the average points per drive of the simulation data.

simulation ends with either a turnover, a punt, or a score. From the 5- to 40-yard line, going for it would yield a higher amount of points, yet this does not factor in the opposing team's field position in the event of a turnover. This is important to consider since turning the ball over on a team's own 10-yard line would almost certainly lead to a score for the other team. However, comparing the two at the 95-yard line is worthy of discussion. After trailing the N strategy for a majority of the starting yard lines, the G strategy takes over again at the 95. In other words, when a team starts a drive 5 yards from goal, going for it on fourth down would yield greater expected points than acting in accordance with the typical NFL coach.

2.2.2 *Stimulating Until Score*

After analyzing the two strategies on a singular drive basis, we thought it was important to account for the opposing team's chances of scoring on the ensuing drive. For example, the opposing team's expected points after turning the ball over on your own 10 should be factored into the drive simulation. In order to account for this more realistic scenario, we utilized the sample drive until score function from the nflsimulator package. This function simulates drives until a team scores. The function takes into account factors such as field position in the event of a turnover, punt distance when a team elects to punt, and allows for the testing of the two strategies against each other. By taking a home team strategy and an away team strategy, we can assess how a strategy stacks up against the other. With regard to calculating and storing expected points, the only change comes from the fact that a score for the opposing team (strategy 2) results in a negative points value for the home team (strategy 1). The results of the simulations are shown in Figure 5. Note that these simulations are based on 1000 drives at each yard line from 5 to 95 in increments of five yards.

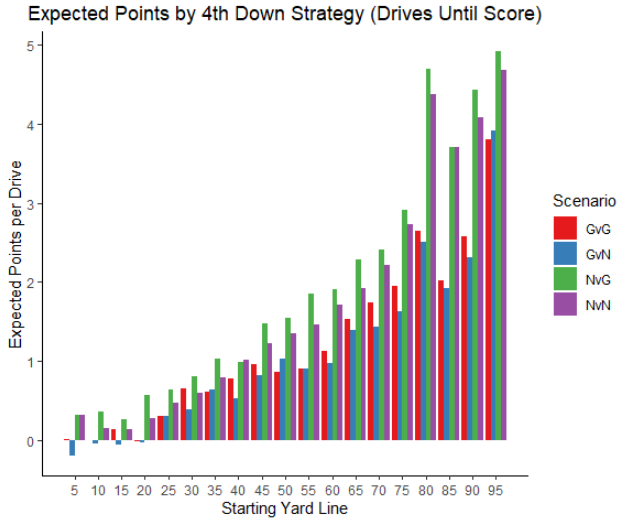

Figure 5. Using the drive until score function, we were able to run 1000 simulations at each five-yard increment on the field and for all four possible combinations of two fourth down strategies. The G in GvN represents the home team's strategy of going for it on fourth down no matter what, while N represents a team acting in accordance with normal fourth down decision making. On the y-axis is expected points which is the average expected points per simulation.

Figure 5 shows it is important to account for the opposing team when testing a fourth down strategy. In particular, the figure shows that a normal strategy for fourth downs is optimal at the vast majority of yard lines on the field when tested against the aggressive strategy. The aggressive strategy is indeed overly aggressive and lacks nuance in its decision making. In other words, home teams have higher expected points at almost all yard lines when using a normal strategy against a team that is using this very aggressive strategy. This makes sense when considering the fact that going for it on fourth down every time, regardless of field position or time of game, is not a realistic strategy. Not only can it give good field position to the opposing team, but it also could result in going for it in situations that are difficult to convert such as fourth down and 25 yards to go. Overall, it became clear that simply going for it on fourth down no matter what would likely lose out to the average NFL coach's fourth down play calling.

2.2.3 *Drives Per Score*

Next, we looked at an aspect of the simulation data other than expected points, namely, the number of possessions before a score takes place (drives per score).

Figure 6 shows the distribution of drives per score for each strategy at 10-yard increments on the field. These yard increments are the starting yard line of the simulation. The overall distributions are as one would expect. We see that the closer the starting yard line is to the goal line, the fewer number of drives typically take place before a score. Looking closer at the comparison between strategies shows the two scenarios that start with the normal strategy (NvG and NvN) have a higher count of drives with only one possession before a score. This is likely due to the ability to kick a field goal, resulting in teams having to travel a shorter distance before recording a score. Another aspect of the charts worth noting is the spike in the dark blue line (GvN) at the 10-, 20-, and 30-yard lines. For all 3, the GvN scenario has its highest frequency at a value of 2 drives per score. This suggests again that going for it close to your own goal line will often lead to the opposing team scoring on the following drive.

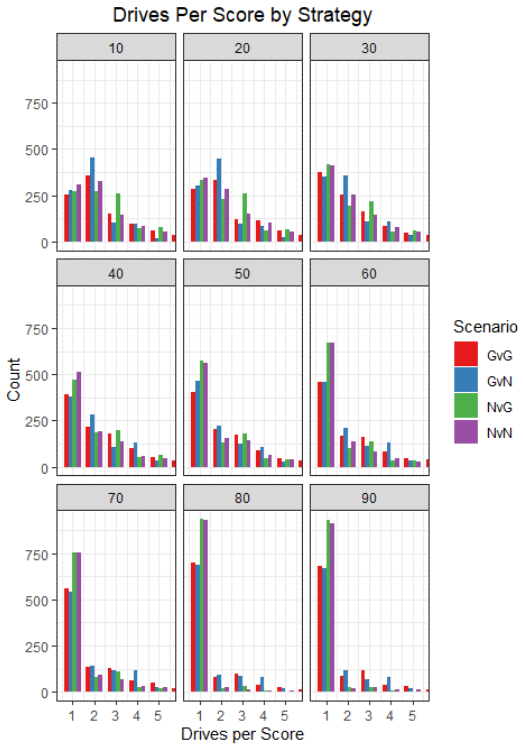

Figure 6. Shows the frequency of drives per score at 10-yard increments for all four possible combinations of two fourth down strategies. The G in GvN represents the home team's strategy of going for it on fourth down no matter what, while N represents a team acting in accordance with normal fourth down decision making.

2.2.4 Testing a New Strategy

After testing the rather extreme strategy of going for it on fourth down no matter the circumstance, we wanted to test another slightly different approach. The simulation data clearly pointed to the fact that a more effective fourth down strategy would need to take into account additional factors. This would include things like time of game, opposing team's skillsets and tendencies, or the yards to go to the first down. Because a fourth and 15 and a fourth and 1 are very different scenarios in the NFL, we chose to modify the existing fourth down strategy to a cutoff point of 5 yards to go. For example, a fourth down and under 5 yards to go results in going for it, while a fourth down of 5 yards or over results in the typical coach's decision (usually a punt or field goal). Figure 7 reflects this minor change in strategy on the singular drive level.

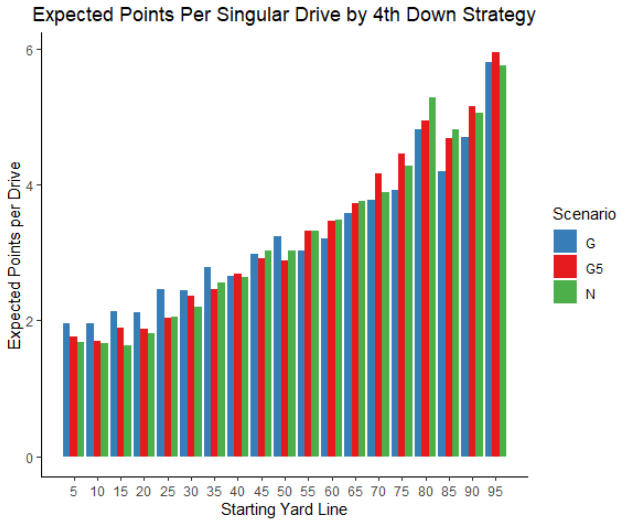

Figure 7. Graph is based on 1000 simulations of singular drives at every five-yard increment on the field for three different fourth down strategies. G represents the home team's strategy of going for it on fourth down no matter what, G5 represents a strategy of going for it no matter what when there is less than five yards to go, and N represents a team acting in accordance with normal fourth down decision making. Expected points per drive is the average points per drive for the simulations.

The figure shows that the new strategy (G5) yields a higher expected points per drive than the original aggressive strategy (G) at every yard line after 50. Not only does it outperform our more aggressive fourth down strategy, it has higher average expected points than the normal NFL coach's decision (N) at the 90- and 95-yard lines. As we mentioned earlier, the earlier yard lines (5-50) are harder to analyze without taking into account the opposing team's ensuing drive, so the underperformance of the strategy at those yard lines is not important to our results.

Figure 8 also shows an improvement over the original going for it strategy when reevaluating the drive until score simulations.

By comparing all three strategies when they are facing the typical decision making of an NFL coach, N, we can compare the three on a level scale. Besides a couple of interesting outliers at the 30- and 70-yard lines, the normal strategy still performs the best when put against

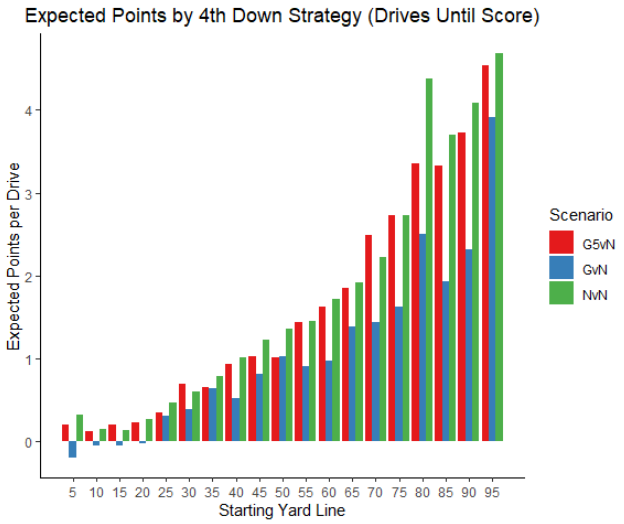

Figure 8. Uses the drive until score function to run 1000 simulations at each five-yard increment on the field and for combinations of opposing fourth down strategies. The G in GvN represents the home team's strategy of going for it on fourth down no matter what, the G5 in G5vN represents going for it only when there is less than five yards to go to a first down, and N represents a team acting in accordance with normal fourth down decision making. On the y-axis is expected points which is the average expected points per simulation.

an opponent with a normal strategy. However, the G5 strategy performs significantly better than the G strategy. This would suggest that the addition of this "under 5 yards to go" criteria to our going for it strategy leads to a noticeable improvement in fourth down decision making.

3 CONCLUSIONS AND FUTURE DIRECTIONS

Overall, this project revealed interesting conclusions as well as possible avenues for future research. By simulating NFL drives according to different fourth down strategies, we were able to show that coaches are likely too conservative on fourth downs in certain situations. Starting with a simple approach of simulating single drives, this research suggests that it is more beneficial to always go for it when starting at the 95-yard line. Furthermore, when simulating until a team scores, we can see that going for it every time on fourth down does not account for certain important aspects of the game. We found that a fourth down decision must be taken in the context of additional factors like the distance to the next first down or score. By adding a single criterion to the strategy where a team will go for it when it is fourth down and less than 5 yards to go, we saw a large improvement in expected points per drive. This suggests a possible idea for future research in which other factors are tested to create a better fourth down strategy. We could test other "yards to go" cutoffs or variables, like time remaining and opposing team defensive ability, to create a more realistic fourth down strategy.

Additionally, the project demonstrated a common trend regardless of the strategy or functions being used for simulation. In all data sets and for all strategies, there is a noticeable drop off in expected points from the 80- to the 85-yard line. This drop off is then followed by a return to the normal trend at the 90-yard line (see Figures 3, 4, 6, and 7). This could suggest a tendency towards coaches acting more conservatively when 15 yards from goal then when they are 20 or 10 yards from goal respectively. This odd finding is certainly something to look into in future research.

In conclusion, simulating fourth down strategies in the NFL has been the subject of extensive research often suggesting that coaches are too conservative in their decision making. The research in this paper supports some aspects of this argument and reveals very promising paths for future research. The strategies employed in our simulations demonstrate that a more aggressive strategy is warranted at certain yard lines and that fourth down decisions should not be made with one simple strategy, but with one that accounts for the unique context of each and every play.

4 LESSONS LEARNED

While conducting research for this thesis, I learned a lot of valuable lessons outside of fourth down decision making in the NFL. First and foremost, I was able to greatly improve my knowledge and skill in the R programming language. My knowledge of gathering data, manipulating data, constructing complex loops, and creating informative data visualizations were just some of the many aspects of the language that I was able to add to my repertoire. I learned about the time-consuming nature of running thousands of simulations on a computer for hours on end, as well as ways to utilize additional computing power through the Parallel package[11]. My advisors taught me the convenience of using Git in order to directly link to an online repository, share code with colleagues, and, in general, control a project under a revision control system. Last and certainly not least, I learned the importance of debugging as I assisted my advisors (Dr. Elmore and Dr. Williams) with the early stages of the nflsimulator package. In doing so, I acted as a test user to find and help correct errors in a package made to handle complex problems and large amounts of data. Overall, the experience provided me an invaluable learning experience and exposure to the application of analytics in the sports industry.

5 ACKNOWLEDGEMENTS

I would like to thank my advisors Dr. Ryan Elmore and Dr. Ben Williams for their time and assistance in conducting this research. The two of them helped me at every turn from de-

bugging code to brainstorming fourth down strategies and everything in between. I am especially grateful that I took Dr. Elmore's sports analytics class which opened up my eyes to the industry. In working with these two, I found an area that combines two of my biggest interests.

6 EDITOR'S NOTES

This article was peer reviewed.

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The Business of Education: The New Role of Education in the Globalized Knowledge Economy

Tatiana Follett[1], Libbi Levine Segev[2]
[1]Student Contributor, University of Denver
[2]Advisor, Department of Business Ethics and Legal Studies, University of Denver

Abstract

The globalized knowledge economy has altered the nature of work such that employees in almost all fields and positions must have strong STEM, global competency, and critical thinking skills. A lag in the American education system has created a skills deficit for companies. Many employers report an inability to find workers with the skillset required for knowledge-economy positions. This skills deficit is detrimental to both American workers and corporations, ultimately negatively affecting the American economy. This paper uses the Programme for International Student Assessment (PISA) exam and other subject-specific data to analyze American high school students' performance in the areas of STEM, reading, global competency, and critical thinking. The data show American high schoolers perform behind their international peers and do not possess the basic skills needed for successful participation in the knowledge economy, particularly in the areas of STEM, global competency, and critical thinking. Potential solutions include Project-Based Learning (PBL) and school-business partnerships, continuing education and wage increases for STEM educators, and multidisciplinary learning. To ensure the continued success of American business, the education system will need to improve to cater to the changing workforce of the globalized knowledge economy. Failure to do so will harm students, employees, businesses, and the American economy.

1 INTRODUCTION AND REVIEW OF LITERATURE

1.1 The Knowledge-Based Economy

1.1.1 Definition and Meaning

Rapid technological development and increased trade have created a global economy and shifted industry in the United States and around the world. Technology and globalization have done more than change commerce in industry, they have also altered the way wealth and potential are valued in post-industrial economies[1]. The 'Knowledge Revolution' is ushering a "transformation from a world largely dominated by physical resources to a world dominated by knowledge"[1]. The knowledge-based economy is a trend found in advanced economies toward "greater dependence on knowledge, information and high level skills..."[2]. Thus, economic activity in post-industrialized nations, such as the United States, is changing from one that values physical, tangible assets to one that values intangible assets such as intellect, critical thinking, and knowledgebase.

1.1.2 Effects on Business and the Economy

Already as of 2006, the globalized knowledge economy was beginning to affect businesses in the United States. Companies are increasingly expanding internationally and consequentially facing a growing need for talent that can "work effectively with foreign employees and business partners" (Committee for Economic Development, 2006). According to the Committee for Economic Development's 2006 report, 58% of growth in earnings in U.S. businesses was from overseas[2]. The international growth of American earnings is an important indication that U.S. companies are becoming more global in nature. This translates to a growing need for American employees who have the skills and competencies to understand, work with, and serve a variety of cultures and populations.

Dr. Lutz, education scholar and founder of the education consulting firm LutzGLOBE, feels that the American education system is educating students based on the 20th century economy, and that American business and economy is already suffering[3]. Lutz also believes that lack of strong leadership in education and business, as well as a lack of connection between business and the education system, does not provide the connections needed for employees and employers to be successful

in the knowledge economy[3].

In a study conducted by the RAND Institute on Education and Training, business leaders expressed their ideas about the projected skills needed for current and future employees, as well as the preparedness of their employees to fill these skills.[4]. Although old, the report provides insight on how the knowledge economy was shaping, and continues to shape, the 21st century globalized knowledge economy. When 175 business leaders from 16 U.S. corporations were interviewed about the preparedness of college grads for work, many remarked that, although college grads were not prepared to handle post-graduation work, the problem stemmed from poor education in primary and secondary school[4]. Many also worried that too few students were choosing to study STEM majors, in part because their high school coursework did not prepare them for college-level STEM classes. As a whole, corporate leaders were "uncertain about whether they will be able to meet their standards for domain knowledge in entry-level employees in the future"[4].

Business leaders also felt that entry level employees did not have the critical thinking skills necessary, especially in terms of decision-making skills. Furthermore, they felt entry-level employees were ill-prepared to complete the on-the-job training required in a continuously evolving workplace[4].

1.1.3 Effects on the Job Market

Manufacturing jobs and many other blue-collar positions are moving offshore, leaving in their wake knowledge-based jobs which require a completely new skillset[5]. Historically, a high school education needed only to prepare graduates for repetitive positions, such as manufacturing, which demand a basic knowledge of science, technology, engineering, and mathematics (STEM) and minimal critical thinking skills. However, "The crucial resources...have changed from being of physical and material character...to so-called knowledge capital or intellectual capital..."[6]. Today, workers in the knowledge-economy are expected to think analytically, have a global mindset, and use STEM, especially technology, in almost all fields.

As Figure 1 illustrates, Americans believe that outsourcing is the biggest threat to American workers in the global economy. 80% of American workers found outsourcing to be harmful, more than those who find the increasing number of immigrant-workers to be harmful.

As Figure 2 shows, employment growth in the 35 years between 1980 and 2015 was 50% overall. However, 77% of employment growth was in occupations requiring analytical skills, compared to just 18% in occupations requiring physical skills. PEW defines jobs with high levels of analytical skill as those requiring "critical thinking and computer use"[?].

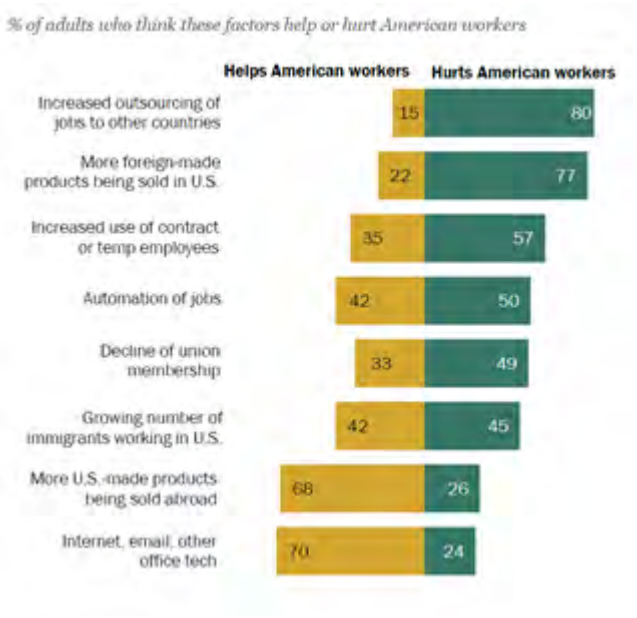

Figure 1. Global Economy Factors and Perceived Effect on Workers[?]

Furthermore, the manufacturing and other low-skill jobs that remain in the United States are changing due to technology improvements. Some U.S.-based companies have found that, although they would like to keep manufacturing in the United States, high school graduates are unable to handle the work. This forces companies to move their operations to countries with a more comprehensive STEM education, such as Poland: "There is a growing research suggesting that some of the new jobs...are fundamentally different from the ones that have been lost"[7]. According to global audit, financial, and consulting firm, Deloitte, the American manufacturing industry could face a skills gap of 3.5 million jobs in the next decade. The company claims that there are not enough workers "literate" in STEM to fill the requirements of employment in modern advanced manufacturing[8].

It is clear to both experts and American workers alike that the nature of work in America is changing. The skillset required of the 21st century worker is becoming fundamentally different from that required one or two generations ago. While the job market has rapidly evolved over the last decades, the education system in the United States has lagged, exposing a gap between the outdated skillset of American high-school graduates and the skillset required in a knowledge-based economy. The result of this gap is detrimental to both American workers and corporations. Unqualified American workers experience job loss and unemployment while American corporations are left with positions that they are unable to fill. To remain globally competitive, the United State education system must seek innovative reform solutions, especially in the realms of critical

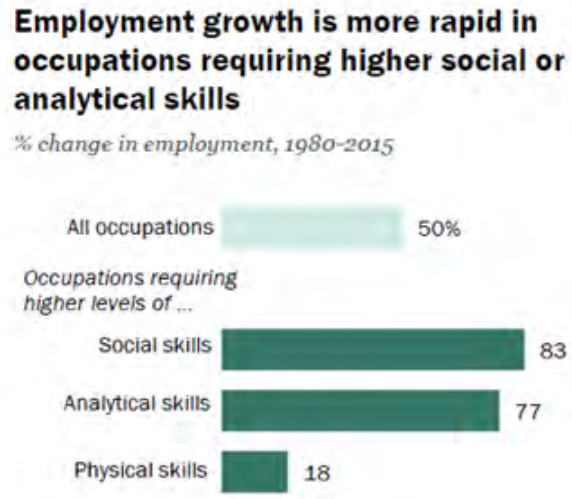

Figure 2. Employment Growth in Various Skillsets[7]

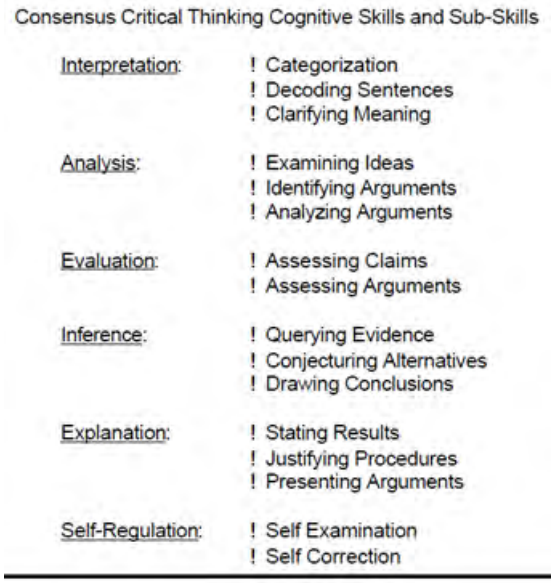

Figure 3. Five main elements of critical thinking[9]

thinking, STEM, and global competency.

2 FINDINGS

2.1 Required Skills

Technological development and globalization have played crucial roles in the development of the knowledge economy, particularly in post-industrial economies. As the nature of the economy changes, so too does the sought-after skills in the new, knowledge-based economy. While physical and tangible skills were appreciated in previous economies, the skills necessary for success in the knowledge economy are critical thinking, STEM (science, technology, engineering, and math,) information analysis, foreign language, and cultural awareness.

2.1.1 Critical Thinking

As knowledge and intellect become firms' largest assets, the need to constantly update these assets, as one would update old manufacturing equipment, becomes greater[1]. A study by the Pew Research Center in 2016 found that 45% of employed adults have taken a class or received extra training in the previous year to learn various skills necessary for their current job or for advancement in their career[?]. Critical thinking and lifelong learning are comprised of a series of skills that enable the worker to continuously improve his or her most valuable asset: knowledge. In previous eras, students in public school were taught basic skills, while those destined for more prestigious careers learned how to think in university classes: "The masses were thus taught while the future owners and managers...acquired...critical thought"[1]. This system of thinking is an outdated remnant of the industrial economy that will need to be replaced by curricula that focuses on teaching critical thinking skills at all levels of education.

As Figure 3 shows, the six main categories of critical thinking are: interpretation, analysis, evaluation, inference, explanation, and self-regulation. While this graphic was developed as a rubric for nurses in a clinical setting, it has since been frequently cited as a critical thinking evaluation framework in several fields, including education[10].

Thus, the foundational skill for workers in the knowledge economy will be the ability to continuously learn[11]. This is supported by the results of the 2018 PISA exam, which provides data on students' problem-solving skills. In particular, the 2018 PISA assessed students ability to work on problems in a group[12]. Across OECD member countries, 28% of students can only solve straightforward problem-solving skills. However, in some countries, notably China, Japan, and Singapore, 83.33% of students are skilled in collaborative problem-solving[13]. While it is important that the American education system provides basic reading, writing, and mathematics skills, it is pertinent that the system also provide the tools to enable graduates to learn and develop knowledge after compulsory school years.

2.1.2 STEM

The development of the knowledge economy and the increasing prevalence of technology in the workplace demands a working knowledge of computers and other technology. According to the Pew Research center, 85% of adults claim that competency in computer technology is important for a worker to be successful in the economy today[?]. A basic understanding of STEM, and

Skill	% Description
Basic operations and concepts	Foundational ability to use technology%
Technology productivity tools	Use of technology to aid in learning and productivity%
Technology communication tools	Use of technology to interact with peers, experts, and audiences%
Technology research tools	Use of technology to find and analyze information as well as to collect and report data%
Technology problem-solving and decision-making tools	Use of technology to develop problem-solving strategies%

Table 1 Technology skills for knowledge economy curricula[14]

Course	% of Teachers Confident in Teaching the Course
Web Design/Creation	17%
Robotics	12%
Data Analytics	11%
Graphic Design	11%
Computer Programming	8%
Engineering Design/ CAD	7%
App Design/Creation	5%

Table 2 Teacher Confidence in Teaching Technology Courses[17]

Course	% of Schools Offering the Course
Computer Fundamentals	76%
Graphic Design	66%
Enginerring Design/CAD	63%
Web Design/Creation	59%
Robotics	58%
Computer Programming	54%
App Design/Creation	35%
Data Analytics	20%

Table 3 Technology Courses offered in High Schools[17]

especially in technology, uses the ability to think critically. A solid foundation in STEM "removes traditional barriers" and allows for "innovation and the applied process of designing solutions to complex contextual problems using... technologies"[15]. In essence, it is necessary to equip all future workers, regardless of their desired career path, with the technology skills to enable them to tackle the complex, intellectual issues required of the modern knowledge worker.

While different professions will require specific technology skills, there is a set of basic skills that should be integrated into compulsory public education in the United States[14;16]. See Table 1 for a list of the basic technology skills that should be included in public school curricula.

A 2018 study conducted by PricewaterhouseCoopers (PwC) in cooperation with the Business-Higher Education Forum indicates that students do not have access to technology and/or technology courses, and teachers are not prepared to teach these courses[17]. Table 2 shows the percentage of teachers who are confident in teaching course in various technology subjects, and Table 3 illustrates technology-related classes offered at high schools.

The use and prevalence of technology in our society is increasing. Thus, the above skills, especially the use of technology to conduct research and solve problems, accompany critical thinking skills and pertain directly to employability in the knowledge economy.

2.1.3 Global Knowledge and Competency

Finally, because the knowledge economy is partially a result of decreased trade barriers and globalization, knowledge workers need cultural awareness and foreign language skills[5]. The development of global trade and the post- industrial economy have both occurred within the last 80 years, practically in tandem[18;19]. Thus, as knowledge workers have become prominent members of the American workforce, companies have become more international in nature. There are multiple education and workforce experts who cite the growing importance of foreign language and cultural awareness skills in the knowledge economy. William Kirwan, former president of the University of Maryland system, remarks that the K-12 system needs to prepare students with a "foundation in foreign languages and an appreciation of other cultures"[5]. Sandra Kerka, author of several education books, notes that "intercultural

communication" is key and "foreign language skills are becoming essential career skills"[11]. The global nature of business in the 21st century means that students need to be "learning how to think about global issues" by being able to analyze other cultures, draw "parallels" in their own communities, and learn how to communicate with groups of people who have different viewpoints[3]. In recent decades, the term cultural intelligence has come to prominence as it embodies the idea of effective assimilation and communication with other cultures. A worker with cultural intelligence can interpret or even imitate the behaviors of an individual from another culture[20]. Cultural intelligence embodies everything from knowledge of another culture to minute details such as body language (Lutz, 2019). As intercultural communication becomes easier with the aid of technology and transportation, foreign language skills enable knowledge workers to communicate with employees from other countries and cultures. Learning a foreign language also increases cultural awareness and knowledge. Recent updates in language teaching curricula have included an increased focus on the "inseparability of language and culture..."[21]. Thus, foreign language education is not only important for the development of the analytical skill but also to increase cultural awareness and intelligence.

2.2 Comparison of U.S and Competitor Country Skillsets

2.2.1 2015 Programme for International Student Assessment (PISA) Results

The following is a collection of charts and graphs illustrating American students' performance in the three main subjects tested by the PISA exam. As stated above, the PISA exam is formulated to test not only students' knowledge of each subject, but also their ability to make inferences, draw conclusions, and analyze information, which are main indicators of critical thinking ability. Therefore, the higher students score on the exam, the more they are drawing conclusions and making inferences from the data. Thus, the higher the score, the more competency students have in the subject and the better their critical thinking skills.

Science

Table 4 shows selected results of the 2015 PISA exam for science.

The United States scored a 496, around the OECD average of 493 and well below nations such as Singapore, Japan, and China. An analysis of PISA 2012 data from the National Science Foundation indicates that the United States places below 15 other OECD member countries[23].

Figure 4 illustrates the number of students that scored below a level two on the science exam from the United States and various similar and high-performing competitor countries. For reference, scoring a level two on the science section of the PISA exam requires only "low-level inferences" and "basic or everyday knowledge"[2].

Country	Mean Score
OECD Average	493
Singapore	556
Japan	538
China	529
Germany	509
United States	496

Table 4 2015 PISA Science Results[22]

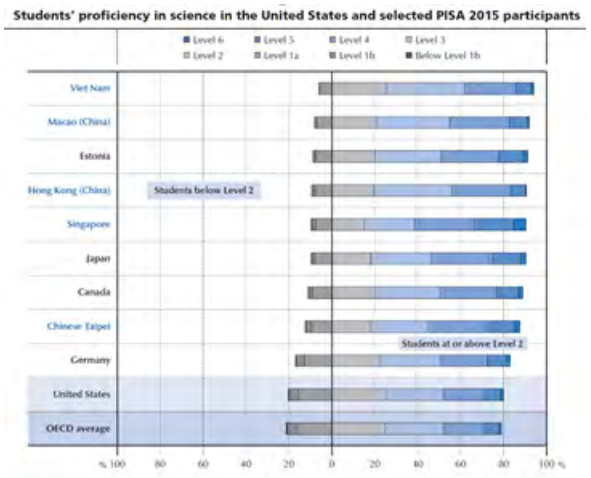

Figure 4. 2015 PISA Science Results - Selected Countries' Level 1-6 Performance[22]

Reading

Table 5 provides data for PISA reading performance.

The United States scored a 497 out of a possible 698, statistically insignificant from the OECD average of 493. For comparison Singapore, the top scoring country, earned a 535.

Country	Mean Score	95% Confidence Interval
OECD Average	493	
Singapore	535	532-538
Canada	527	522-531
Japan	516	510-522
Germany	509	503-525
China	509	506-511
United States	497	490-504

Table 5 PISA 2015 Reading Results[22]

Country	Mathematics
OECD Average	490
Singapore	564
China	544
Japan	532
Canada	516
Germany	506
Russia	494
United States	470

Table 6 2015 PISA Mathematics Scores[22]

Figure 5 shows the average three-year change among selected OECD and non-OECD countries that took the 2009/2012 and the 2015 PISA exam.

Mathematics

Table 6 provides information about selected countries' mathematics scores from the 2015 PISA exam.

As seen in Table 6, the United States score of 470 is below the OECD average of 490 and well below the scores of competitor countries such as China, Japan, Germany, and Russia. Also of statistical significance is the comparison of 2012 results with 2015 results.

The United States scores changed significantly between 2012 and 2015. American students scored over 10 points worse, on average, than in 2012. For comparison, Russia had a statistically significant increase of over 10 points between 2012 and 2015.

PISA 2018 Exam: Global Competency

In 2018, the PISA exam included testing on global competency for the first time. PISA noted that, since the Cold-War, "ethno-cultural conflicts have become the most common source of political violence in the world"[12]. In light of this, the PISA 2018 exam included a global competency section to provide data for the development of evidence-based curricula to help prepare students to tackle these global political issues. In particular, PISA felt that education systems can help students become "global citizens" by teaching how to critically evaluate information and social media platforms and encouraging an appreciation for different cultures and languages[12].

PISA tested students on global competency through two sections: a cognitive assessment and a global questionnaire[12]. PISA identified four main aspects of global competency that are important to assess: knowledge, cognitive skills, social skills and attitude, and values. Both the cognitive test and the student questionnaire tested students' knowledge and cognitive skills. The student questionnaire tested social skills and attitudes. "Values" was not assessed on the 2018 exam.

Foreign Language Instruction

In the United States, just 20% of students in primary or secondary school take a foreign language, compared to 92% of primary or secondary school students in Europe[24]. In China as of 2006, 67.4% of those with junior secondary education had studied one or more foreign languages. This equates to 32.86% of the total population[25]. Of those who had studied a foreign language, 93.8% studied English, with 21% reporting that they are able to sustain a conversation in English[25]. In contrast, only 0.67% of students taking a foreign language in the United States in the 2007/08 school year studied Chinese[26]. Furthermore, of the language classes taught in U.S. schools, 78% are introductory-level courses lacking in-depth topics requiring critical thinking[26].

The lack of foreign language proficiency in schools is already presenting itself in the business sector. In the United States, business executives speak an average of just 1.5 languages, compared to their peers in the Netherlands, who speak an average of 3.5[26].

3 ANALYSIS

3.1 2018 PISA Test Results

3.1.1 Science

As Table 4 indicates, the United States' science score of 496 is statistically insignificant from the OECD average score of 493[13]. Not only was American students' performance unremarkable, but it also fell well below the performance of a number of other nations, many of whom are direct competitors to U.S. businesses and economy. Japan, China, and Germany's scores are all higher than the United States' score. Table 4 delves further into the achievement disparity between the United States and competitor countries. The table shows the percentage of students scoring each of the proficiency levels on the science portion of the exam.. In this respect, too, the United States is similar to the OECD average and behind the performance of competitor countries.

The scores point to two main issues that will negatively affect American business and economy in the globalized knowledge economy. Secondly, as noted by the RAND Global Preparedness and Human Resources study, a weak STEM education in high school means that many college students do not have the foundation necessary to be successful in a STEM major. This is supported by the data from the National Center for Education Statistics, which finds that between 22.2% and 23.9% of STEM majors require remedial coursework[27]. When analyzed together, the PISA scores, RAND business leader study, and need for remedial STEM education in college point to a severe deficit in STEM education in the United States. This deficit is detrimen-

Figure 5. 2015 PISA Reading Results: Average three-year trend [22]

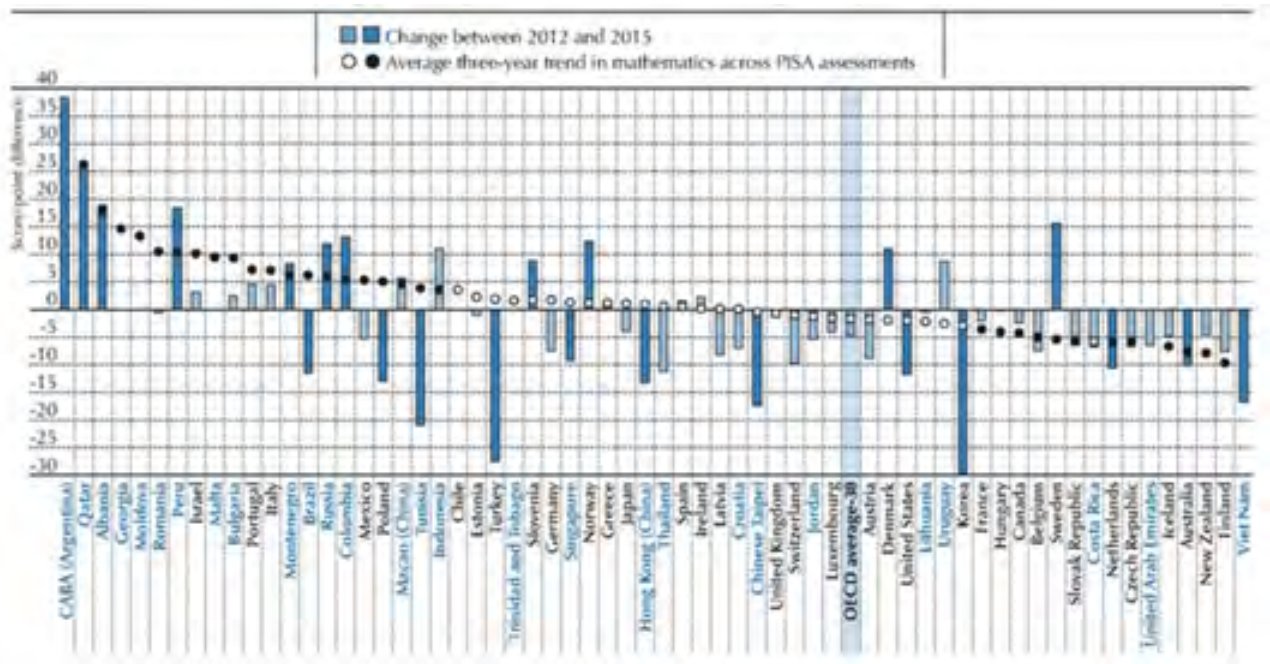

Figure 6. 2015 PISA Mathematics Scores [22]

tal to any economy, but especially so in a developing knowledge economy in which the most valued assets are knowledge and thinking skills.

3.1.2 Reading

Although reading is not often explicitly referenced as a crucial skill in the knowledge economy, and does not pertain directly to STEM education, it is a compulsory skill that enables lifelong learning. Reading functions as the foundation for learning a variety of other subjects, including STEM and foreign languages.

Figure 4 shows U.S. reading scores as compared to the OECD average and competitor country scores. Once again, American students' performance is unremarkable. In an industrialized society in which almost every career requires reading and comprehending texts, this skill is crucial. However, with the onset of the post-industrial knowledge economy, American students' lackluster performance is likely to negatively impact employability even more.

Table 5 shows the score difference, in points, between the 2012 and 2015 scores. The United States had a minor decrease in scores of around 2 points. When analyzed alone, this information is not remarkable. However, China and Russia, both developing economies and members of the widely known BRICS countries, a group of emerging economies, showed comparatively significant improvement of around 12 and 17 points, respectively (the BRIC Counties definition and synonyms, n.d.). Germany, a developed nation with a rich history of innovation and discovery, improved it's reading score by six points. Reading is a crucial aspect of learning, and constant learning is becoming crucial for employability. Thus, in order to stay competitive, the United States needs to provide a better foundation for preparing students for lifelong learning as required in the knowledge economy.

3.1.3 Mathematics

As illustrated in Figure 5, the United States' average PISA Mathematics score of 470 lies twenty points, or 4% below the OECD average of 490.

Table 6 shows the score-point difference between 2012 and 2015 scores for several OECD countries. The United States' mathematical scores showed an alarming 12-point decrease between 2012 and 2015. Other countries displayed marked improvement during the same time, indicating that the United States is starting from behind and falling even further behind in the global race to build knowledge capital. Russia showed a promising 12-point increase in scores. The mathematics data shows that American students are not learning the thinking skills necessary for work in the knowledge economy, especially when compared with students in other developed and developing nations.

3.1.4 Technology

Given the meteoric rise in technology and internet use in recent decades, it is unsurprising that the American school system is lagging in implementing both the resources and the talent to teach students the necessary skills for the knowledge economy.

As with critical thinking skills, inadequacy in technology education stems from teachers who are not prepared to teach skills needed in the knowledge economy. Students do not have access to valuable technology courses because there is insufficient talent to teach courses in these emerging industries. Figure 6 shows just how few teachers can teach technology skills. No more than 17% of teachers feel comfortable teaching a technology course, and as few as five percent feel comfortable teaching an App-Design course. In terms of technology education, American students are not just underperforming, they are not being given the opportunity to perform at all. The severe lack of teachers with technology skills indicates that teacher-education systems are outdated, and the U.S. schools are not including the necessary courses to prepare teachers for educating knowledge workers.

Unsurprisingly, American students have little access to technology courses in high school. As with science and mathematics courses, in college, it is difficult to master a subject to which the student has had no prior exposure. While a strong majority, 76%, of schools offer courses in basic computer skills, only 63% offer Engineering Design/ CAD courses, 54% offer computer programming courses, and only 20% offer courses in Data Analytics. Since 2013, demand for data scientists has risen by 344%[28]. Furthermore, data shows that the demand for data scientists exceeds the supply[28]. Students need exposure to current technology courses in high school, both to guide them to relevant post-graduate career and academic paths and to give them the necessary skill base to later master these subjects. The American education system cannot afford to stall the implementation of comprehensive, required, and relevant technology courses.

3.1.5 Critical Thinking

While limited, the data presented by the PISA exam and other sources is similar to the data for the other subjects. American students' performance is in no way remarkable and fell below the exceptional performance of main competitor countries such as China, Japan, and Singapore.

Teaching critical thinking is difficult, and often requires individualized feedback[29]. Critical thinking requires educators to teach students a methodology for thinking. Although it is possible to teach critical thinking through the instruction of other compulsory subjects, it requires educators to teach beyond rote memorization of facts and force students to contemplate

larger problems through the aid of guiding questions. However, if educators are the product of a system that does not teach a critical thinking framework, then educators will not be equipped to teach these frameworks in their own classrooms. The data show that one of the main barriers to teaching critical thinking is teachers' lack of critical thinking skillset[29]. Thus, just as future educators are trained to teach addition and spelling, they must also be trained to teach thinking.

As a whole, on their own, these scores are concerning for the United States, a country that currently leads the free economic world and is at the forefront of innovation. However, in comparison to competitor countries' performances such as China, Japan, and Germany, these scores indicate that the United States is at risk of falling behind the global race to educate workers in the knowledge economy. Failure to reform the education system will negatively impact American business and potentially jeopardize the United States' place as a global economic powerhouse.

3.2 Global Knowledge and Competency

3.2.1 International Instruction

Students well-equipped to fill the needs of American businesses in the knowledge economy need a working knowledge of the cultures and countries of the world. However, two thirds of American schools do not have the resources necessary for international education, an indication that American education system, as compared to competitor nations, is failing to prepare students for 21st century work. Test scores further support this claim. In the United States, social studies courses are dedicated to providing information about U.S. and world history, culture, and politics[30]. As the data about students' geography and social studies show, American students are severely lacking in global knowledge. According to National Geographic, locating nations on a map is a basic skill designed to be accomplished by American students in grades two through four, and one which many students have not mastered (National Geographic, n.d.). Given business leaders are looking for extensive global competency, American students shocking dismal global knowledge base is concerning[4].

3.2.2 Foreign Language

American students' nearly absent foreign language skills do nothing but reinforce the stereotype that Americans are completely inept at language. Just one in five American students take a foreign language, compared to over nine of ten European students and 67.4% of Chinese students. Beyond this, most Americans do not go beyond basic instruction, as evidenced by the facts that 78% of language courses are introductory level. Mandarin Chinese is one of the most spoken languages in the world, yet less than one percent of American students learn the language[31]. Many argue that as English has become a global language which is often used in international business and government transactions, there is no longer a need for widespread foreign language proficiency. This theory is only partially true. While English is a global language, and business and governmental transactions are overwhelmingly conducted in English, day-to-day interactions in international teams are still hampered by difference in language. American business people conducting work with an international team from Germany, for example, will still require accommodation for daily communication[32]. However, this methodology has repeatedly caused trouble, especially in foreign policy crises. During the Cold War, the American government ramped up Russian learning programs out of necessity. However, soon after the collapse of the USSR in 1991, these programs were dissolved. During the tense moments of the Russian annexation of Crimea in 2014, the American government was left scrambling for Russian speakers to aid in international relations initiatives.[32]. It is crucial for the American education system to prioritize language learning on a wider scale and to a deeper degree to ensure maximum preparedness for globalized political and economic transactions.

4 DISCUSSION

4.1 Potential Solutions

4.1.1 School-Business Partnerships

Several education scholars have promoted the idea of stronger relationships between schools and the businesses for which the graduates will work[1;3;11;33]. Unlike the industrial economy in which workers were merely the means by which the true assets, machinery, could produce goods, employees are now the assets. Similarly, just as employers used to have exact specifications for the machinery used in their production lines, employers in the knowledge economy are specific about the skills they look for in potential employees. The best way to ensure our school system is catering to these specific needs, both to prepare students and to provide a feasible talent pipeline for American businesses, is to foster a closer relationship between schools and businesses.

Project-Based and Multidisciplinary Learning

One way to do this is to introduce more "project-based learning" (PBL) into school curricula[3;12]. By presenting students with real-world projects based on collaboration with businesses, students hone a relevant skillset through "multidisciplinary" learning, wherein students confront multiple subjects and concepts in one learning environment[11]. This method also exposes students to potential, relevant careers and promotes

early connections between students and employers. Admittedly, partnerships of this kind can be difficult to foster, especially in rural communities[3]. However, the possibility of virtual relationships between schools and businesses is a viable option[3]. The other problem with this idea is that it requires individual relationships between schools and businesses, making it difficult to implement on a national scale. However, the potential for digital learning makes mass implementation more feasible. The American school system could look at the possibility of a digital course-pack containing a host of projects developed by American businesses which pertain to a variety of subjects. Although this does little to foster personal connections between students and businesses, it makes valuable headway in tailoring the students' education to the needs of the knowledge economy. Such project-based learning will also benefit students by encouraging critical thinking, particularly problem solving, and developing valuable soft skills such as interpersonal relations and time-management.

One small-scale trial of a school-wide project-based-learning program provides evidence that PBL, when combined with intensive classroom education, can enrich students' STEM knowledge, expose students to possible STEM pathways, and improve overall interest and participation in STEM[23]. It should be known that this case did not follow the students as they continued into college and post-college careers. Hence, the case has multiple limitations and should be reviewed with acknowledgement of the limited scope of the study. Nonetheless, the case shows promising results. With the help of the B-PASS grant, the STEM curriculum at José Marti MAST 6-12 Academy (JM-MAST) in Miami-Dade was reformed to include: the development of a teacher development program and real-world experiences with local business partners. Just prior to winning the B-PASS grant, JM-MAST was converted from a traditional public school to a STEM focused school. Before and after the transition, the school served neighborhood students. Facing a shortage of STEM teachers with real-world experience and insufficient laboratories and other equipment due to a lack of funding, the school sought to use the B-PASS grant to provide teacher education and to create relevant, rigorous curriculum for its students.

The new course curriculum was redesigned to include a traditional component, a lab portion to parallel classroom content, and a research portion. To prepare teachers to effectively lead students through the new coursework, professors from local colleges guided teachers through methods to teach STEM integration, problem-based learning, and hands-on learning[23]. The school then established relationships with three businesses for each of their science tracks: NASCAR for physical science, Miami Science Museum for life science, and LARC Technical Institute for math and computer science. Students interviewed during the program gave positive reviews: they expressed interest in the projects and one student remarked that she exceeded her own expectations for learning[23]. While this case is clearly not thorough enough to confirm the benefits of PBL, it and the implementation of similar programs in the future, along with reliable data, will further illuminate the benefits, and possible shortcomings, of a project-based STEM curriculum.

4.1.2 Global Knowledge and Competency

"The way that a teacher frames a topic in the curriculum can significantly shape its contribution to global competence"[12]. One example that PISA gives is asking students in a math class to apply knowledge about linear and exponential functions to population growth data[12]. This exposes students to global applications for abstract issues and helps to foster a global mindset. It is thus crucial that global knowledge discussions become commonplace outside of the context of social or international studies. To improve students' global knowledge and competency, teachers from all disciplines must commit to including international implications into their coursework. They must be willing to take abstract concepts and place them into international contexts. Globalization has ushered in an era in which global issues are relevant in all areas of study and employment, and the modern education system needs to reflect this fact.

4.1.3 STEM

One of the principle problems outlined in the data, above, is that many teachers do not have the skills or background necessary to effectively teach STEM courses to students. The issue of under-qualified teachers is a self-fulfilling prophecy. Teachers who do not have the skills to teach results in students who do not have the knowledge necessary to further their STEM education in college. This creates an even larger shortage of qualified STEM educators. To truly better the American STEM education system, this vicious cycle will need to be broken.

An option to encourage more STEM majors to pursue K-12 teaching opportunities is to increase wages for STEM educators. Paying STEM educators more than their art, language, and social studies peers recognizes the potential pay differential between STEM professionals and other professionals[33]. Oftentimes, STEM professionals with a bachelor's degree can achieve higher pay in the professional sector than similarly educated professionals in arts and humanities[33]. Recognizing this reality and accommodating for it in terms of teacher salaries could encourage STEM majors to consider a career in teaching. This option is, naturally, not perfect and has several moral, political, and practical issues. Paying STEM teachers more than their peers can easily been seen as elitist and begs the question: does paying STEM educators more send the message that their

subjects are more important and valued than other subjects? Schools pursuing this option would also need to consider the source of the funding for this type of this program. While an enticing and potentially lucrative option, it should be taken into consideration only in recognition of its serious drawbacks.

Another option to both encourage new STEM graduates to pursue teaching and to help current STEM educators become more proficient in their subjects is to develop continuing education programs for STEM educators and to increase minimum requirements to become STEM educators. Developing stringent requirements for STEM educators and providing continuing education opportunities for STEM teachers to meet the requirements creates a beneficial continuous cycle in STEM. Better qualified educators produce students who are more prepared and willing to tackle college-level STEM courses, fulfilling the need for better educated teachers and reinforcing the cycle.

As with any solution, there are potential challenges. Funding for continuing teacher education programs require extensive financial, time, and professional resources. Often, continuing education for teachers needs to be done during the school day or after school, taking away from student education or teachers' personal time. The task of providing resources for and completing these programs can often be daunting for both school districts and individual educators. However, studies have shown that teachers, and particularly STEM educators, are more effective after receiving continuing education through a well-structured program[34].

4.2 Conclusion

The nature of work and companies is rapidly changing in the growing knowledge economy and it is imperative that education systems follow suit. One marked change is the need for closer relationships and stronger communication between schools and companies. Universities have already been fostering relations with local and national companies. For example, Daniels College of Business at the University of Denver aims to incorporate real-world skills into course work by designing projects that require engagement with the community. Projects include: running a real stock portfolio, designing a digital app, and creating a business plan for a demonstrated community need[35]. However, more specialized skillsets for entry-level jobs requiring only a high school diploma extend this need to the K-12 level. Failure to implement structural change in the U.S. education system based off the needs of the companies its graduates serve, and with the flexibility to grow with the knowledge economy, will create serious economic issues within the American economy.

A major aspect for consideration is the increased interconnectedness of education disciplines. While STEM, the humanities, and language are still distinct, there is increased interaction between the disciplines. Furthermore, global competence, problem solving, and critical thinking are skills that need to be integrated into each subject area. In this respect, Project Based Learning and school-business partnerships are promising solutions for teaching in a way that integrates several subjects and critical thinking/global competence while providing a relevant education for 21st century work. It also ensures that students learn the skills that employers require to compete in the global marketplace. Whether or not PBL/ school-business partnerships become the prominent solutions for integrating coursework, schools need to investigate ways to engage students in critical thinking and global competency in every subject to fulfill employer needs and prepare students for future work. The broader implementation of critical thinking skills presents challenges for assessment. The data presented here does little to separate students' subject-matter knowledge and general critical thinking skills. Continual development of specific assessments to test the effectiveness of critical thinking components in subject-matter curricula will be crucial in the reformation of the education system.

The increased importance of knowledge capital demands businesses and schools to invest resources into the reformation of the education system. Citizens' well-being, and the state of American business and economy will require businesses to take special interest in the development of its most important asset: its people. Failure to heed the warnings of the data and reports from business leaders and international organizations will result in an American economy that is unable to perform competitively with peer nations in the knowledge economy. Educating American students is becoming more of a critical issue for businesses and citizens alike.

5 EDITOR'S NOTES

This article was peer reviewed.

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UKIP's Use of Valence Issues to Impact Attitudes Towards EU Membership

Madeline Kincaid[1], Lisa Conant[2]
[1]Student Contributor, University of Denver
[2]Advisor, Department of Political Science, University of Denver

1 INTRODUCTION TO VALENCE ISSUES

In the book Brexit: Why Britain Voted to Leave the European Union, Clarke, Goodwin, and Whiteley suggest that certain valence issues, or issues "on which there is a broad agreement among the people and parties about what the policy should be," are the determining factors that drove and continue to drive attitudes towards EU membership within the United Kingdom[1]. These two main valence issues, public perceptions on economic conditions and immigration, are the central factors that determined whether or not UK citizens wanted to remain or leave the EU. Understanding these two main issues, the United Kingdom Independence Party, or UKIP, capitalized on these popular concerns of UK citizens and perpetuated the negative perceptions surrounding these policy matters. As a result, UKIP was able to successfully sway the public opinion of EU membership and eventually secure the Brexit vote by focusing their message on the two main valence issues.

The first valence issue, the economy or the perception of the economy, is able to indicate the level EU support since "successful economic performance is likely to increase support for continued membership of the EU while mismanagement of the economy is likely to reduce support"[1]. Therefore, perceptions of the economy, evaluated through perceptions of the overall economic situation and unemployment at the state level, will indicate support for or opposition of EU membership. As people increasingly perceive a decline in the overall economy or a rise in unemployment rates, then support for EU membership will decrease accordingly. The more individuals that perceive a declining economy, whether or not the economy is actually declining, the more people that will vote to leave the EU.

The second valence issue, the perception of immigration, similarly demonstrates attitudes towards EU membership since "an overwhelming majority of voters think that the British government should be able to control immigration and there is a consensus that successive British Governments have failed to do so"[1]. Since valence issues essentially evaluate whether or not EU membership ultimately benefits the UK and successfully delivers on issues that have widespread support, this negative public perception on immigration will lead to more negative attitudes towards EU membership. As the negative perception of immigration increases, measured through the percentage of the UK population that thought immigration was one of the two most important issues rather than whether or not immigration rates are actually increasing, then more UK citizens will want to leave the EU due to their increasingly negative attitudes towards EU membership.

2 FIRST VALENCE ISSUE: ECONOMIC PERCEPTIONS

In the UK, the data demonstrates that there seems to be some sort of connection between perceived economic conditions of the country and overall optimism or pessimism of the EU's future. While the UK had declining economic perceptions starting around 2008 or 2009 depending on the perceptions of unemployment or economic conditions, which is the time of "the Great Recession and the eurozone crisis that followed the 2008 financial meltdown," the UK did not have majority pessimistic opinions about the future of the EU until 2011 (See Figures 1 and 2)[1]. However, according to Clarke et al, "public disapproval of the UK's EU membership soared after the crisis began"[1]. Pessimism toward EU membership increasing after the 2008 financial crisis and the 2009 Eurozone crisis further demonstrates how negative economic perceptions produced negative perceptions of the EU.

To corroborate the claim from Clarke et al, higher rates of dissatisfaction with the UK's economy appears to coincide with the higher rates of pessimism of EU membership the following years. Although this doesn't confirm whether or not economic concerns were the main valence factors behind EU membership support, it is clear that perceptions of the economy through perceived unemployment and overall economic conditions correlate with attitudes about the future of the EU. The perception of the UK's economic situation was rela-

tively negative after 2008 while the overall perception of the unemployment rate was most negative starting in 2009 (See Figures 1 and 2). More specifically, the perception of unemployment in the UK remained relatively negative from 2009 to 2013. From 2008 to 2013, citizens living in the UK reported that the economic situation and unemployment were some of the most important issues facing the UK today (See Figures 1 and 2). As seen in Figure 1, the greatest percentages of people who thought these issues were most important in the UK were 38 percent for the perceived economic situation in 2010 and 40 percent for the perceived unemployment in 2012[2].

During those peak times of economic discontent from 2010 to 2012 in the UK, the attitude of EU membership appears to reflect those perceptions. During the years 2010, 2011, 2012, 2013, 2016, and 2017, the UK as a whole was more pessimistic than optimistic about the future of the EU (See Figures 5 and 6). The highest percentages of either optimism or pessimism recorded were in 2011 and 2012. During those two years, 56 percent or a majority of UK citizens were pessimistic about the future of the EU (See Figures 5 and 6). The only other year that there was a majority attitude towards the future of the EU was in 2007 when 52 percent of UK citizens were optimistic about the EU's future. The majority optimism in 2007 occurred before the Eurocrisis beginning at the end of 2009 while the 2011 and 2012 majority pessimism occurred after the financial crisis (See Figures 5 and 6). This is supported by the claim that "those who are optimistic about economic conditions are more supportive of EU membership than those who are pessimistic" from Clarke et. al[1]. When UK citizens were more optimistic about the economy, UK citizens were seemingly more optimistic about the future of the EU (See Figures 2 and 6).

Date	Econ Situation	Unemployment
Oct. 2005	9	9
Sept. 2006	5	11
Sept. 2007	5	9
Oct. 2008	34	16
Oct. 2009		38
May. 2010	38	32
Nov. 2012	30	40
Nov. 2013	23	35
Nov. 2014	13	22
Nov. 2015	12	16
Nov. 2016	18	15
Nov. 2017	13	10
Nov. 2018	17	12
June. 2019	15	10

Figure 1. Percent of population that think the following are one of the two most important issues facing the UK[2]

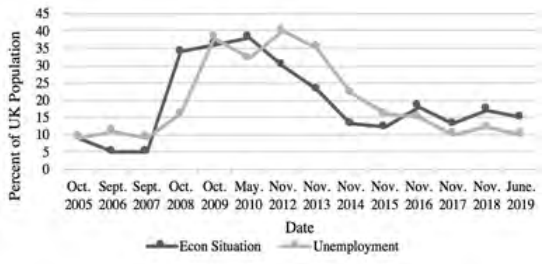

Figure 2. Percent of population that think the following are one of the two most important issues facing the UK[2]

3 SECOND VALENCE ISSUE : PERCEPTIONS ON IMMIGRATION

Immigration has remained a divisive issue in the UK, even though the UK has disproportionately accepted less refugees than other comparable EU member states. While the UK is not unique for harvesting anti-immigrant sentiments, the UK was ranked the tenth-most anti-immigrant member state out of the EU[1]. Unlike how the perceptions of the economy correlated with attitudes towards the EU, the percentage of the UK population that thought immigration was one of the two most important issues doesn't clearly indicate attitudes towards EU membership. The years with the highest percentages of the UK population that thought that immigration was one of the two most important issues facing the UK included 2006 to 2007 and 2014 to 2015 (See Figures 3 and 4). The highest percentage of the population that thought immigration was one of the two most important issues was at the end of 2015 at a record 44 percent, which can be explained by the Syrian Refugee Crisis that occurred during that time (See Figures 3 and 4).

Even with the record concerns with immigration in 2007, a majority of UK's population was optimistic about the future of EU at 52 percent in 2007 (See Figures 5 and 6). In fact, this was the only year with a majority of optimism from 2007 to 2019, and it was tied with 2009 for the lowest percentages of pessimism at 38 percent (See Figures 5 and 6). From 2014 to 2015, when immigration concerns were relatively high, a higher percentage of UK's population was optimistic about the future of the EU at 49 percent and 47 percent, respectively (See Figures 3 and 5). The percentage of pessimistic opinions towards EU membership increased slightly relative to 2007 but decreased relative to 2011 and 2012 (See Figures 5 and 6). This demonstrates that there may not be a clear correlation between this specific valence issue and attitudes towards EU membership. Unlike the perceptions of the economy, increased concerns regarding immigration don't seem to have an effect on attitudes towards the EU. In fact, when immigration concerns were at its peak in 2015 during the refugee crisis, more UK citizens were optimistic rather than pessimistic. When a

majority of UK's population was pessimistic from 2011 to 2012 at 56 percent, only 24 percent of the population thought that immigration was one of the most important issues facing the UK (See Figures 3 and 5). Despite the lack of correlation between increased concerns regarding immigration and negative attitudes towards EU membership, UKIP still capitalized on these underlying immigration concerns[1].

Date	Immigration
Oct. 2005	29
Sept. 2006	40
Sept. 2007	39
Oct. 2008	23
Oct. 2009	29
May. 2010	28
Nov. 2012	24
Nov. 2013	23
Nov. 2014	38
Nov. 2015	44
Nov. 2016	25
Nov. 2017	20
Nov. 2018	14
June. 2019	13

Figure 3. Percent of population that think immigration is one of the two most important issues facing the UK[2]

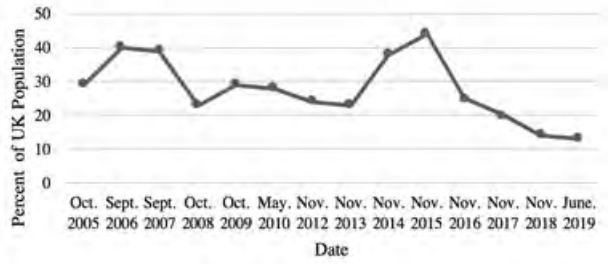

Figure 4. Percent of population that think immigration is one of the two most important issues facing the UK[2]

4 UKIP'S USE OF VALENCE ISSUES

UKIP was able to gain support in two separate waves, from 2009 to 2010 and 2014 to 2015. The first surge of support occurred when UK citizens indicated that the economic situation and unemployment rates were the most important issues, while the second surge of support occurred when UK citizens indicated that immigration was one of the most important issues facing the UK[1]. Considering that the factors that drove the support for UKIP "included Euroscepticism, hostility to immigration, dissatisfaction with the performance of the established parties and a pessimistic outlook on life," UKIP certainly exploited these popular concerns during particularly turbulent times[1]. During the Great Recession starting in 2008, the eurozone crisis at the end of 2009, and the refugee crisis starting in 2014, concerns regarding the overall economy and immigration rose. UKIP then used these concerns to secure public support considering "people's negative judgements about how the Government of the day performed on key issues such as the economy, immigration and healthcare, all worked to UKIP's advantage"[1]. UKIP capitalized on the nation's concerns regarding these key issues and offered leaving the EU as the solution.

While economic theory bolsters the notion that immigration boosts a state's economy, "Nigel Farage, leader of UKIP, repeatedly claimed that the British Government was unable to control immigration because the EU mandates free movement of labour within the member states"[1]. Farage especially capitalized on this perceived lack of control during the refugee crisis of 2014 to 2015, which is reflected in the high percentage of UK citizens who claimed that immigration was one of the biggest problems facing the UK (See Figure 4). The rise in net immigration during these times "fueled public concern about the issue and increased receptivity to UKIP's argument that Britain had lost control over its borders"[1]. However influential it was to UKIP support, these increased concerns regarding immigration were not reflected in the overall pessimism or optimism regarding the future of the EU. That being said, "since the eruption of the refugee crisis, evidence of the increasing strength of the populist right in the EU has been clearly visible" including UKIP and other populist right parties[1]. As a result, the rise of UKIP was one of the most significant forces that lead to the 2016 Brexit referendum due to their ability to appeal to UK citizens who were concerned with these valence issues.

Date	Percent Optimistic	Percent Pessimistic
Sept. 2007	52	38
Mar. 2008	50	40
Oct. 2009	50	38
Nov. 2010	43	46
Nov. 2011	36	56
Nov. 2012	38	56
Nov. 2013	45	48
Nov. 2014	49	42
Nov. 2015	47	44
Nov. 2016	40	51
Nov. 2017	45	48
Nov. 2018	49	45
June. 2019	47	46

Figure 5. Percent of UK's population that are either optimistic or pessimistic about the future of the EU[2]

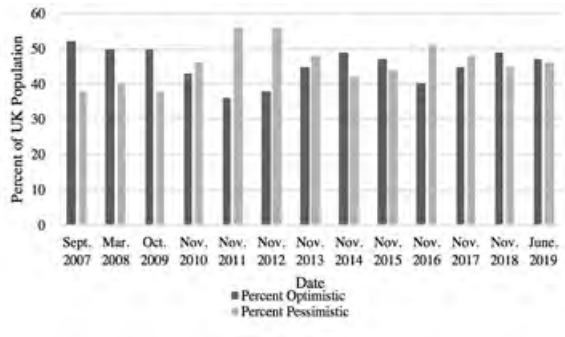

Figure 6. Percent of UK's population that are either optimistic or pessimistic about the future of the EU[2]

5 CONCLUSION

UKIP's ability "to attract voters who were unhappy with the Government's performance on these valence issues" was one of the main contributing factors that lead to the increasingly negative perceptions towards EU membership within the UK[1]. UKIP recognized and then capitalized on the fact that these two valence issues, perceptions of the economy and perceptions regarding immigration, were popular concerns among UK citizens. While there was a clear correlation between negative perceptions of the economy and negative attitudes towards EU membership, there doesn't seem to be as clear of a connection between increasing concerns on immigration and increasingly negative attitudes towards EU membership. As negative perceptions of the economy increased, measured through the percentage of citizens who thought that the economic situation and unemployment were one of the two biggest concerns facing the UK, pessimistic attitudes towards EU membership increased (See Figures 2 and 6). The second valence issue, perceptions on immigration, did not have this kind of parallel relationship. Rather, in the year when immigration concerns were at its peak in 2015 during the refugee crisis, more UK citizens were optimistic rather than pessimistic in regard to EU membership (See Figure 6).

Despite this, UKIP capitalized on both valence issues to secure party support. While time periods didn't quite align for immigration concerns as they did for negative economic perceptions, it's clear that the UK still harvested overall negative sentiments towards immigration. Consequently, the increasing immigration and refugee crisis in the years preceding the Brexit referendum in 2016 fed into UKIP's argument that the lack of border security was contributing to the UK's perceived economic decline. It is also quite possible that even though immigration wasn't always a top two concern from the perspective of UK citizens, the perceived effect of immigration could have manifested as economic concerns. This would be reflected when either unemployment or economic concerns were listed as the top concerns facing the UK, ebbing and flowing with when UK citizens had pessimistic attitudes towards EU membership. Either way, UKIP capitalized on these two valence issues and focused "on a syndrome of individual grievances based on economic marginalization and perceived threats from immigration and minorities" to affect attitudes towards EU membership and secure the outcome of the 2016 Brexit referendum[1]. While this much is determined, continued research on how UK citizens perceive these two valence issues since the finalization of the Brexit referendum could lend insight into how UK citizens might vote in the future, especially regarding issues where public perceptions on economic conditions and immigration are concerned.

6 EDITOR'S NOTES

This article was peer reviewed.

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Protocols for Rearing Fall Webworm (*Hyphantria cunea*) in a Colony and Basic Methods for Laboratory and Field Experiments

Maelah Robinson-Castillo[1], Audrey Mitchell[1], Amanda Fasching[1], Mayra C. Vidal[4], Mariana Abarca[5], Gina M. Wimp[5], Blyssalyn Bieber[3], Dhaval K. Vyas[3#], Shannon M. Murphy[2#]
[1]Student Contributor, University of Denver
[2]Advisor, Department of Biological Sciences, University of Denver
[3]Department of Biological Sciences, University of Denver
[4]Biology Department, University of Massachusetts
[5]Department of Biology, Georgetown University
#Co-Senior Authors

Abstract

Standardized protocols are an essential asset for research requiring the maintenance of live organisms. Ecological studies often involve collaborations between multiple teams that are spread across locations, and these collaborations benefit from sharing successful laboratory procedures. Our research team is studying the ecology of the fall webworm moth (*Hyphantria cunea*, hereafter FW) in North America for >10 years, during which time we have established reliable procedures for starting and maintaining FW colonies under laboratory conditions. FW is a North American species that has been introduced to Europe and Asia where it is a major pest. Here, we present a detailed review of the methods we use to find and collect FW caterpillars in the field, house and rear caterpillars in the laboratory, handle pupae, and initiate diapause for overwintering. We also describe how to end diapause the following summer, care for emerging adult moths and mate them, and tend to eggs. Lastly, we test the effectiveness of some of our protocols related to mating adult moths to determine whether fertile eggs are produced. FW is becoming a model study system for ecological and evolutionary studies related to diet breadth. As more researchers begin studying the ecology and management of FW, laboratory colonies will play an important role for these projects. Our protocols will provide guidance to inform the successful study of this important insect.

Keywords: colony maintenance, immune function, insect herbivore, Lepidoptera, natural enemies

1 INTRODUCTION

Herbivorous insects are one of the most diverse groups of organisms, accounting for nearly half of all terrestrial animal species[1;2]. Most insect herbivores have a narrow diet breadth and feed on only a few host plant species, whereas very few herbivorous species are generalists with a broad diet breadth that feed on many plants[3]. How herbivorous insects have diversified to become so incredibly specious and why so many of them have narrow diets are two key ecological questions. Indeed, specialization to specific host plants has been proposed to drive diversification[4]. A newly emerging model study system for ecological and evolutionary studies related to diet breadth is the fall webworm (*Hyphantria cunea*, hereafter FW[5;6;7]). Additionally, FW has become an agricultural pest in areas of Europe and Asia where it was introduced[8;9], so an understanding of life history and diet breadth is also necessary for biological control. As more researchers begin studying the ecology and management of FW, laboratory colonies will play an important role for these projects, and standardized protocols will be essential for the maintenance of FW colonies. Thus, we present a standardized protocol that we use to rear FW in Colorado.

FW is a broad-ranging North American moth species and has one of the broadest diet breadths of any insect herbivore on Earth, feeding on >400 plant species over its geographic range[9;10]. However, in some places such as Colorado, populations sometimes have a relatively narrow diet breadth and feed on few of the available host plants[5;11;12]. There are two morphotypes of FW that differ in their diet breadth, natural history, behavior, web architecture, geographic distribution, and ge-

netic makeup. These types are named by the color of the head-capsule of the caterpillar: black-headed and red-headed. In Colorado, we only observe the red-headed FW. When the two FW types occur in the same location, such as in the eastern United States, the black-headed FW can have two generations per summer and emerge earlier and later in the season than the red-headed FW, which usually has just one generation per summer; however, timing can vary greatly across geographic regions [10;13]. After FW caterpillars have completed their development, they pupate in the soil or trunk crevices and overwinter as pupae.

To properly comprehend how diet breadth evolves and how invasive generalist species could potentially be controlled, it is important to understand their dynamics with natural enemies. Fall webworm caterpillars can be heavily attacked by parasitoids, which act as important top-down controls of their populations [5;12;14]. Top-down controls can be especially important for the evolution of generalist herbivores, as they tend to be more heavily affected by top-down than bottom-up effects from their host plants [15]. Host plant use has also been shown to affect the immunological function of insect herbivores, which can affect their response to top-down controls [16;17;18;19;20]. As such, protocols to test the immune response of insect herbivores to parasitoids as well as identifying common parasitoid species that attack these herbivores will be necessary.

Ecological studies often involve collaborations between multiple teams that are spread across locations, and these collaborations benefit from sharing successful laboratory procedures. Our research team has been studying the ecology of FW in North America for >10 years, during which time we have established reliable procedures for starting and maintaining FW colonies under laboratory conditions and for conducting field research. Here, we present a detailed review of the methods used to find and collect FW caterpillars in the field, house and rear caterpillars in the laboratory, handle pupae, and initiate diapause to overwinter individual pupae. We also describe how to end diapause the following summer, care for emerging adult moths, mate adults, and tend to resultant eggs. Additionally, we include our protocols to assay immune function of caterpillars, identify the most common parasitoid taxa that attack FW, and store immatures for morphological studies. Lastly, we test the effectiveness of some of our protocols related to mating adult moths and determining the optimal container size for successful mating. Our protocols will provide guidance to inform the successful study of this important insect.

2 PROTOCOL METHODS AND EFFICACY

We successfully use these methods to rear FW in the laboratory, find them in the field, and conduct both lab and field experiments. Our research experiences with FW are in Colorado, but our methods likely apply to populations elsewhere. Small details in our protocols may need to vary from one geographic area to another to follow environmental conditions of different locations. In particular, the light regime that we use for rearing caterpillars to induce diapause will need to follow the day length of each place the researchers are maintaining the caterpillars. Some variables might be different in different geographic locations, but the overall protocols we present here are general enough to be applicable to a variety of locations. We start by describing our laboratory protocols and then our protocols for field research.

2.1 Laboratory Protocols

2.1.1 Diapause for FW Pupae

In late October or early November, we put lab-reared pupae in containers with peat moss to overwinter in growth chambers (Percival) at 4°C and 0:24 (light:dark) photoperiod as described in Loewy et al. [11]. We obtain the lab-reared FW pupae from the previous year following the methods explained in this protocol below. We mist the pupae and peat every 6 weeks during the winter to make sure they do not desiccate. In early spring, we start to take the pupae out from the growth chambers so they can emerge from diapause. We usually remove pupae from the chambers every other day and remove about 80 males and 80 females each time, which results in a manageable number of moths emerging at any single time. We remove the pupae from peat and place them in new clean containers (0.5*l*) with a moistened filter paper; some containers can have multiple pupae. We keep track of which date the pupae were removed from the growth chamber and we line them up on a lab bench from earliest removal to latest removal so that we can estimate when the FW moths will begin to emerge for each group. We also organize the containers by geographic location and sex, which helps to select appropriate mating pairs. It is important to keep the pupae moist, so we spray them with water if the containers look dry. We conduct daily checks of every pupal container to see if any moths have emerged. In this process, we check both the bottom and top of the filter paper because moths may blend with the white background. When the adults emerge (Figure 1A and 1B), we record the females and males that emerged on that day (Figure 2A).

2.1.2 Maintaining Mating Chambers

We pair adult moths for breeding depending on their emergence date within each geographic location, and no siblings are paired together to avoid inbreeding. After removing any newly emerged moths from the pupal container, we also remove their chrysalis so that it does

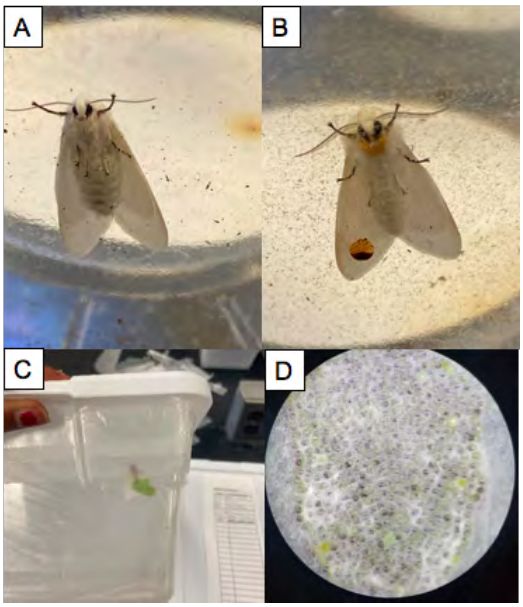

Figure 1. Images of FW depicting how to identify the sex of adult moths. **A)** Female moth with a broader abdomen and more filamentous antennae; **B)** Male moth with a thinner abdomen and more plumose antennae; **C)** Female moth inside a mating container in the process of laying eggs (green); **D)** Eggs right before they are about to hatch when the caterpillar head capsule becomes visible.

not interfere with any later emerging moths and we again moisten the filter paper if it is dry. Adult moths, especially males, can fly quickly, so care is taken when removing moths from containers so as not to lose them; we keep an insect net in the lab in case moths need to be retrieved from the ceiling.

To mate FW, we use plastic shoebox containers and line the entire container with wax paper, including the lid; it is best to wrap as much of the container as possible with a single piece of wax paper so that moths cannot get stuck under an edge of the wax paper. FW are very sensitive to light and will not mate overnight if the lights are left on, so it is important to turn off all of the lights when not in the vicinity. Once a female and male are chosen for mating, we place them inside the mating container; if we have an abundance of males, sometimes more than one male can be included to increase chances of mating in case females are overly choosy. On each mating container's lid, we record the female and male maternal line identification numbers and the county from which they were collected (Figure 2). The females oviposit on the wax paper (Figure 1C), and we cut around the egg mass and patch the hole with a piece of wax paper and tape. There should not be any holes in the wax paper allowing access to the container's surface; eggs laid directly on the plastic container cannot be retrieved without damage.

When checking the mating containers, it is important to understand what to expect inside before opening it as moths can quickly fly out of the container (Figure

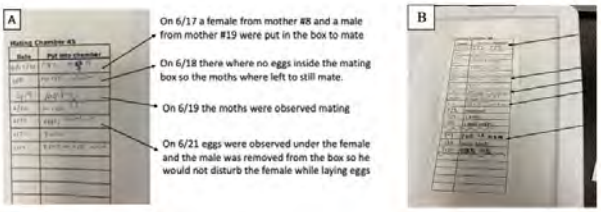

Figure 2. Mating container labels for FW. **A)** How to read the mating container lids and what information should be recorded; **B)** A label for a container that has been used multiple times for different pairs of moths; the arrows indicate each time a new pair was put into the container.

2). First, we look from the outside of the container to see if any egg masses can be seen on the inside of the container, often with a female moth sitting on them (Figure 1C). Then, if necessary, we carefully open the lid to avoid any moths escaping and locate the moths. We then record the following information on the datasheet located on the lid of the mating container: date mating was first observed, date female begins oviposition, if the male has escaped or died and is replaced with another male, and if all moths died in the mating container. If the male is dead in the container but the female is alive and did not lay eggs, we add another male from the same county to give him a chance to mate with the female. When the female has laid eggs, we carefully remove the male to not disturb the female, and record that the male was removed on the lid datasheet. If both moths have died, the container can be cleaned out by removing the dead individuals and wiping out any frass, and is then restocked with new moths (Figure 2B).

As the size of the container could affect moth behavior, we assessed the effect of container size on mating success. We tested 3 container sizes: small deli container ($0.5l$, $n = 34$), medium deli container ($2l$, $n = 21$), and a large plastic shoebox ($6l$, $n = 162$). We included a total of 217 containers and used a Chi-squared test in JMP Pro version 14 to compare the percentage of fertilized eggs produced by successfully mated females housed in the three different container sizes. We found no significant effect of container size on mating success, estimated as the proportion of fertile eggs produced ($\chi^2 = 1.56$, $df = 2$, $p = 0.46$; Figure 3). This may be due to an unbalanced design in which we had 162 large containers yet only 34 small and 21 medium containers. Although differences among treatments were not statistically significant, we found that large and medium containers produced 50% more fertile eggs than small containers, which is biologically relevant for rearing efforts.

2.1.3 Monitoring Eggs

We monitor the mating chambers daily to look for the presence of eggs (Figure 1C). Females are often found with eggs they have laid, and we allow females to re-

Figure 3. Percentage of egg clusters with fertile eggs depending on the size of the container in which the adult moths were mated.

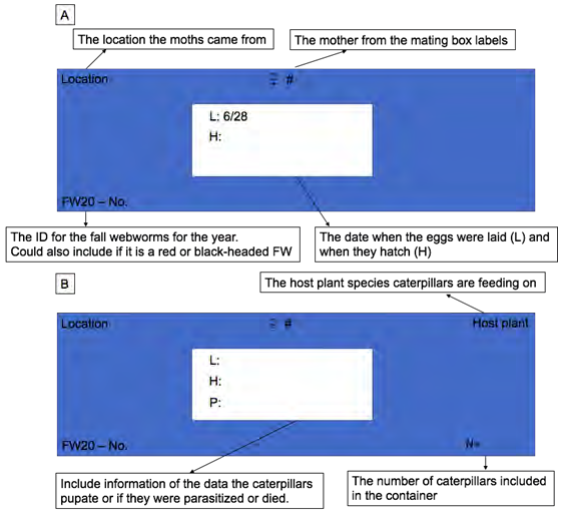

Figure 4. Example of how to make a label for a caterpillar container on lab tape that goes on the lid of the container. **A)** The label when only the eggs are in the container and includes a date when the eggs were laid (L) by the female moth; **B)** The label after the eggs have hatched and that now includes the date the eggs hatched (H) and in the future the date that the caterpillar pupates (P). Label colors differ among host plants such that all caterpillars on a single host have the same color label (e.g., choke cherry is always pink).

main on their eggs for up to 3 days after eggs are first observed. Once the female dies or she has been on her eggs for over 3 days, we remove the egg cluster from the mating chamber by cutting the wax paper lining the container with an X-acto knife and transfer it to a 0.5*l* container using forceps to avoid damaging the egg cluster. We then assign each egg cluster a new container with a label including a unique identification number and information about its provenance (Figure 4A). Before putting the lid on the container, we spray a mist of water into the air, then scoop the container upwards into the mist to get a small amount of moisture into the container; we repeat this egg misting every day. We store the eggs in chronological order to be able to anticipate when head capsules would be visible (Figure 1D), which indicates that the eggs will hatch soon. The eggs of red-headed FW take about 14 days to hatch[11]. We check eggs underneath a dissecting microscope to determine whether the dark coloration was head capsules emerging or if the eggs are starting to decay. When the eggs are decaying, they will often become concave or shrivel, and develop a yellowish color. We dispose of any egg clusters that are dead.

Once an egg cluster has visible head capsules (Figure 1D), we can split it using Castro-Viejo scissors if this is required for the experiment. We frequently split egg clusters into 4 equal parts in order to rear a single maternal line on four different host plant species to test for factorial differences in genetic lineages. We place the egg masses in 0.5*l* containers with a host plant leaf and a moistened filter paper disc to maintain the correct humidity (Figure 5A and 5B). Laying the leaf flat on the bottom of the container allows us to carefully place the piece of egg cluster flat on the leaf, which helps to ensure the cluster will not fall off the leaf accidentally. It is important for the hatching eggs to be immediately near host plant foliage because wild FW emerge from the eggs directly onto a leaf, so we try to replicate this in the lab.

We use different colors of laboratory tape to be able to easily identify different experimental conditions (e.g., host plant species) and organize containers so that we can feed all of the caterpillars from a single host plant species at once. Each label has the following information: the date the egg clusters were split, the date they hatched, host plant species, the identification number of the maternal line, and county or the word 'lab' if lab reared from our colony (Figure 4A).

2.1.4 Maintaining FW Caterpillars

As the FW caterpillars emerge, we give them leaves with small portions of the branch attached as a food source. When adding leaves to the containers, we check the leaves thoroughly for other animals, such as predators (e.g., spiders, hemipterans, etc.). We collect plants from the field as branches and store them in vases filled with tap water. We cover the tops of vases with plastic bags and place them in the fridge to reduce wilting of the leaves. The water in the vases is checked daily and water should be replaced before the leaves start to desiccate.

From the time of emergence until day 10, the caterpillars remain together in a 0.5*l* (16 *oz*) deli container with filter paper placed in the bottom. In each of these containers, we place a few leaves to supply an ample food source for the small FW and minimize caterpillar handling at this sensitive stage (Figure 4B). We check the containers thoroughly twice a week with spot checks in between to ensure the FW caterpillars always have enough fresh foliage to eat. During the thorough feedings, we inspect the containers for mold on the leaves or

excessive moisture on the sides. If there is any mold, we carefully remove caterpillars from the molding leaves using soft forceps and place them back into the container with fresh foliage. If there is an excess of condensation on the sides of the container, we wipe it off using paper towels to reduce the chances of leaves molding. FW often skeletonize leaves, so we remove leaves without any green parts remaining and replace the filter paper if it has mold or is falling apart. We clean the containers of frass during the thorough cleanings, at least once per week. While it is important to ensure the FW caterpillars have enough food, it is also critical that the containers are not overstuffed so they have room to move.

At 10 days old, FW caterpillars are large enough to be moved easily. Using soft tweezers or our fingers (pulling on webbing, not the caterpillars), we transfer the caterpillars to other containers and divide them into smaller groups; by the time the FW caterpillars are 3 weeks old there should never be more than 5 caterpillars in a container. Depending on the experiment, we either split caterpillar groups up into smaller groups and keep them in $0.5l$ containers or move them to larger $1l$ (32 *oz*) containers. Each container needs to have a moist filter paper on the bottom to keep the humidity level appropriate and keep the plants from desiccating. We place new leaves with portions of the branches attached (to help avoid desiccation) in each of the larger containers. As caterpillars are split into new containers, we duplicate labels using the same tape color to ensure all original information is maintained through the subdivision process (Figure 4B); as caterpillars grow, new information will be added to the label and as containers are split, the number of caterpillars in each container should be noted in the lower left corner (Figure 4B). All of the information on the labels is also recorded in a logbook that contains a row of information for each FW caterpillar that is reared in the lab; our logbooks often have thousands of entries. While the logbook is a paper record of our data used in the lab, we also scan it frequently and make digital copies for permanent records. FW caterpillars are similar to the moths in that they are sensitive to lights; if lights are left on in the lab overnight, they receive a photoperiod cue that tells them to not enter diapause and it is therefore extremely important to turn off the lights in the laboratory every evening.

When the caterpillars pupate, they form a cocoon with their body hairs around where they will form their pupa. Ten days after pupation, we remove the pupa from their cocoon and determine the sex of each pupa based on Loewy et al.[11]. We then place them in peat in a $0.5l$ container (Figure 5C) and spray the container with water. If individual information is not necessary for future experiments, we can include more than one pupa in the same container, making sure that they are from the same maternal line, fed on the same host plant, and of the same sex. If more than one pupa is included in a container, we write the number of pupae on the container, and their individuals' log numbers. These pupae will be placed into diapause as explained above.

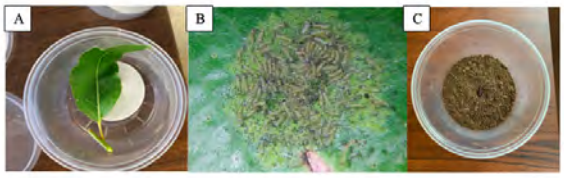

Figure 5. Different stages of the FW life cycle housed in deli containers. **A)** The deli container with leaf and moistened filter paper right before eggs are put into it; **B)** FW caterpillars in container; **C)** The pupal stage in peat before being misted with water and put into a growth chamber set for winter conditions.

2.1.5 Immunological Protocols

Immunological protocols are important tools to understand caterpillar response to parasitoid attack. We use two main methods for assessing the immune function of FW caterpillars: nylon filaments and hemocyte counts. We insert filaments into the interstitial body cavity, between the cuticle (skin) and intestinal tract, and remove them 24 hours later to measure the proportion of the filament that has been melanized by the caterpillar's immune system. High levels of melanization are associated with a strong immune response[20;21]. Counting the hemocytes gives us an additional measure of immune response; an abundance of hemocytes indicates an increased immune function.

Before a filament can be inserted into a FW caterpillar, the caterpillar must be large enough to survive the filament insertion process; caterpillars typically reach this body size approximately 25 days after hatching. Host plant identity can affect the development time and thus the length of time necessary before the caterpillar reaches a large enough size. Using sandpaper, we sand monofilament fishing line to create grooves along the filaments, tie knots every $3mm$, and cut the line into pieces that are 3mm in length with the knot off-center. This way, each line has a knot surrounded by two ends (Figure 6A), one short, that we call the "head," and one long that we call the "tail;" if both ends are equal in length (Figure 6A, top) the filament should not be used because it cannot be inserted deep enough into the caterpillar's body for the assay. A range of filament diameters is necessary if caterpillars of different sizes are being tested. We use smaller diameters (e.g., $0.1mm$ or $0.15mm$) for smaller caterpillars and larger diameters (e.g., $0.2mm$) for larger caterpillars. To ensure there are enough filaments for an experiment when caterpillars reach the appropriate size, we begin tying filaments in early spring, before any caterpillars are reared; there

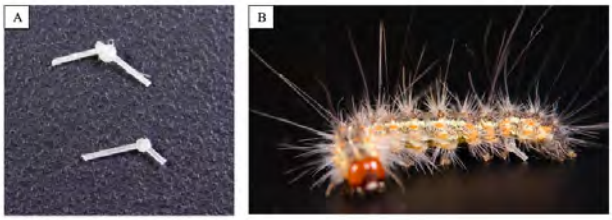

Figure 6. Examples of 0.2*mm* filaments. **A)** Filament that is not cut well and cannot be used because both ends are equal in length and there is no long end to insert into a caterpillar (top), and filament that is cut well with a shorter "head" end and a longer "tail" end that can be inserted into the caterpillar (bottom); **B)** A filament inserted into a FW caterpillar.

can never be too many filaments, so we always make as many as possible.

To insert a filament, we first remove a caterpillar from its container using soft forceps and restrain it under the microscope using wax paper. The wax paper can be laid perpendicular on the caterpillar to minimize the caterpillar's ability to move during insertion. The caterpillar is restrained on its side so that the filament is properly inserted. Once the caterpillar is restrained, we pierce it with an insect pin (size 1 or 0) next to its penultimate prolegs; we always use the same spot to ensure that we remember where the hole is in which to insert the filament (Figure 6B). Using forceps, we pick up the filament by the head end and insert the tail end of the filament into the caterpillar through the hole made by the insect pin. The knot and head of the filament should be external and visible outside of the caterpillar (Figure 6B). We use care because if the filament is inserted too harshly the caterpillar will not survive. We insert filaments at an angle that is parallel with the length of the caterpillar; perpendicular insertions risk rupturing the gut, which will contaminate the hemocyte sample. We then place the caterpillars with inserted filaments into separate, labeled Eppendorf tubes to be certain they are not mixed up with the rest of the colony and also to make sure no other caterpillar jostles the filament out of the focal caterpillar. We do not provide any plant food as the small piece of cut plant material desiccates in the Eppendorf tubes; caterpillars are able to survive without food for 24 hours. We secure the caterpillar inside the tube using cotton instead of the tube's lid as the cotton allows air flow.

After 24 hours, we first check for movement to make sure the caterpillars survived. Using forceps, we take the caterpillar from the tube and place it under the microscope; wax paper can again be used to restrain movement. We use forceps to grab the "head" of the filament above the knot and gently pull the filament from the caterpillar; this movement should be done smoothly to avoid harming the caterpillar. Once the filament is extracted, we dry it, if necessary, by laying a KimWipe flat on a table and placing the filament on top for 1-2 seconds. We then place the filament back into the Eppendorf tube to be frozen until we have time to measure percent melanization, which can be many months later; the tube should be labeled on the top of the cap and side of the tube with the caterpillar identification number. To measure how much of the filament was melanized while inside the caterpillar, we first photograph each filament on a sterilized watch glass under 40X magnification on a compound microscope. We use the image processing program Fiji[22] to quantify both the part of the filament that is melanized and the total area of the filament so that we can get the proportion of filament that is melanized. The sample section that we use (1.5*mm* x 0.17*mm*) is centered in the filament and helps to avoid shadows created during the photographic process.

In addition to filaments as a method for assessing immune function of FW, we also count the number of hemocytes in a sample of hemolymph to better understand the immune response; an increased number of hemocytes indicates a greater immune response. Before inserting the filament into a caterpillar, hemolymph can be extracted and used for hemocyte counts. First, a tub of ice is necessary to keep materials cold, a beaker of anticoagulant solution placed in the ice, a 10-microliter micropipette, and an Eppendorf tube; these items are chilled for about 30 minutes. Using the micropipette, we place 4 microliters of anticoagulant solution into an Eppendorf tube and place the Eppendorf tube in the ice to keep it cold. After piercing the caterpillar with the insect pin as explained above, a bubble of hemolymph will emerge from the hole. We use a micropipette to extract 2 microliters of hemolymph from the caterpillar and add it to the same Eppendorf tube with the anticoagulant solution, for a total of 6 microliters of solution. To mix the hemolymph and solution, we set the micropipette to 6 microliters and draw and expel the hemolymph and anticoagulant solution into the tube multiple times. Once the solution is mixed, we use the micropipette to transfer the liquid to a hemocytometer in order to count the hemocytes under magnification; we use a compound microscope at 40X. We count both granulocytes and plasmatocytes; granulocytes are a more rounded shape while plasmatocytes resemble an oval shape with pointed ends. Both granulocytes and plasmatocytes are important for cellular immunity and are involved in immune function. After counting, we record the number of hemocytes on a data sheet.

2.1.6 Caterpillar Blanching for Morphological Studies

A common way of preserving immature specimens for permanent collections is to freeze them overnight and subsequently store them in 80 or 95% ethanol. While this is a humane and effective way of preserving caterpillars, it results in shrinkage, which is problematic

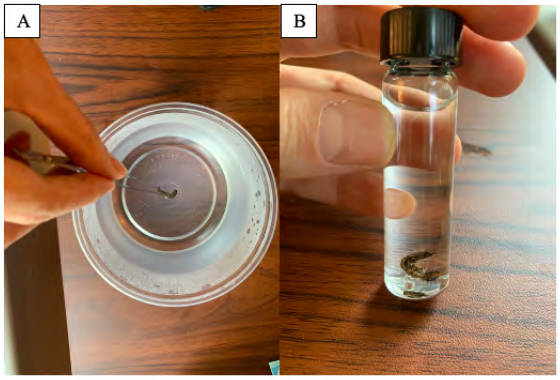

Figure 7. Caterpillar blanching. **A)** Submerging the FW caterpillar in hot water; **B)** Storing the blanched caterpillar in a glass vial with 95% ethanol.

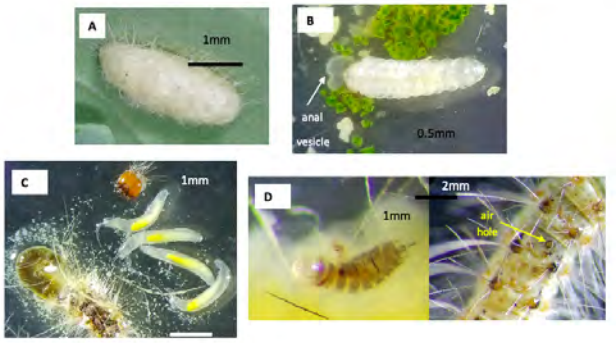

Figure 8. Distinguishing characteristics of four families of parasitic insects that attack FW. **A)** The white cocoon; **B)** Immature larva of braconid wasps; **C)** Yellow stomach contents of immature ichneumonid wasps; **D)** Speckled cuticle and black mouthparts of immature tachinid flies (left); tachinid fly larvae also create air holes that are visible on the outer skin of fall webworm caterpillars (right).

when conducting morphological studies and when designing permanent displays. To preserve a caterpillar's original shape, it must die while being dipped in near boiling water. To do this, we boil water, remove it from the heat source and submerge caterpillars in the water for at least 60 seconds (Figure 7A). Water from standard hot water dispensers is typically over 90°C and can be used for blanching. Because both water temperature and duration of immersion can affect the rate of post-mortem decomposition and larval volume[23], we recommend consistency in both of these variables when conducting comparative studies. Moreover, it is important to dip the caterpillars in enough water so they die instantly; 200*ml* will suffice for FW but 400*ml* may be needed for species of larger size. After hot water exposure, caterpillars can be stored in 80-95% ethanol (Figure 7B). To minimize stress, it is important to fully submerge caterpillars in the water; fuzzy caterpillars tend to float, so we use forceps to push and submerge them individually. We avoid pinching or squeezing the caterpillar because pressure during blanching alters their shape. Debris (e.g., FW hairs, feces) can accumulate in the ethanol, so we replace the ethanol about a week after blanching and subsequently if needed to keep the caterpillar submerged.

Blanched caterpillars can also be preserved in small glass containers filled with gel hand sanitizer. We use this technique when designing displays for outreach and to facilitate observation under the microscope. However, we do not recommend this method for long-term storage of research specimens because it leads to degradation of the larval tissue over time.

2.1.7 Identifying FW Parasitoids in the Laboratory

FW are attacked by numerous parasitic flies and wasps (i.e., parasitoids) that target FW eggs, caterpillars, and pupae[24;25;26]. Adult parasitoids lay their eggs inside or on the FW eggs or caterpillars, which are then consumed by the immature parasitoid. We suspect that at least one parasitoid attacks FW eggs and emerges from the FW caterpillar to form a white cocoon on or next to the caterpillar host (Figure 8A). Field-collected FW can be either unparasitized or parasitized, but parasitism status is often unknown for field-collected FW. We observe most of our parasitoids after they have emerged from the caterpillar as adults, but we can also observe them inside a FW caterpillar as larvae if we dissect the caterpillars under a microscope.

We begin dissections by placing the caterpillar on its ventrum on a clear base, such as a glass petri dish. Next, we decapitate the caterpillar immediately behind the head. Once the head is removed, we add 1-2 drops of water where the head used to attach to the body. We hold the caterpillar's posterior end with forceps and place the dissecting scissors across the dorsum above the anus. We then move the scissors towards the anterior end while gently pressing down to squeeze out the internal contents. Internal contents will begin to flow out, beginning with the foregut, into the water droplets. We remove the remainder of the internal contents by restraining the posterior end with scissors while pulling the foregut with forceps. We then cut open the empty skin so that the internal cuticle is fully visible, and inspect the water and cuticle for immature endoparasitoids.

We identified three taxonomic categories of endoparasitoids that attack FW: braconids (Hymenoptera), ichneumonids (Hymenoptera), and tachinids (Diptera). Each taxonomic category has distinct features that help with identification. Braconid offspring are distinguished by their translucent bodies that are segmented (Figure 8B). Young braconids have mandibles and a pointed caudal "spike." As they grow, braconids develop a round structure called the anal vesicle (Figure 8B). Ichneumonid offspring have a slender body with

a yellow-colored gut and a long tail (Figure 8C). Tachinid offspring have black spines on their cuticle and the mouthpart is a black pointed structure that often moves back-and-forth (Figure 8D). Tachinids are often attached to the inside of the FW cuticle and create an airhole that is visible on the outside of the FW skin (Figure 8D). Once parasitoids are identified, we discard the endoparasitoid and the data are stored in record books. We preserve adult parasitoids as dry specimens in display boxes.

2.2 Field Protocols

2.2.1 Field Transects

As FW becomes a model system to understand diet breadth evolution of insect herbivores, a major part of studying FW involves quantifying the diet breadth of each population in the field. To determine which plant species are available and used by FW, we use a transect method to assess relative abundance of plant species. First, we identify a focal host plant that contains a FW web in areas where we know they occur (e.g., iNaturalist or historical records) or by haphazard sighting. We measure the host plant diameter at breast height (DBH) using a soft meter tape or diameter tape. We measure the diameter by wrapping the tape around the tree trunk at a height of $1.35m$. If the tree has multiple trunks, we measure the diameter below where the trunks separate. When the host plant is a shrub, we note it as "shrub" on our data sheets and do not record a DBH. In addition to recording the species identity of the host plant, we also record the sampling date, the number of webs found on the host plant, the location (both GPS coordinates and town/county), as well as other relevant notes, such as any information that can help locate this transect and any information relevant to FW studies (e.g., presence of spiders and other predators in the FW web).

FW are almost always found along the edge of a habitat, whether it be a forest fragment, riparian corridor, property line, utility corridor, roadway, or neighborhood sidewalk. Thus, we set our transects along the habitat edge where they occur and record the abundance of host plants that would be available to FW along this transect. On each side of the focal host plant, we use a $10m$ transect tape and set it on the ground parallel to the habitat edge; we align the zero mark of the transect tape with the focal host plant and then record transect information for two transects, one to the left of the focal host plant and one to the right of the focal host plant (for a total $20m$ transect). For each transect, starting from the focal host plant moving toward the $10m$ mark, we annotate every plant species that we find, within a $2m$ area perpendicular to the transect tape; thus, the transect area on each side of the host plant encompasses $20m^2$. For each plant species along the transect, we record the identity of the plant species, its linear distance from the host plant in meters (noted from the transect tape), and if this plant has any FW webs on it. If the plant species is not known to us, we use a unique identifier to mark it in the data sheet (e.g., unknown 1), and collect a voucher that can be identified by a specialist later. This plant voucher should preferably have reproductive organs (flower or fruit), should be pressed as soon as it is collected, and should have a label with the same identifier used in the transect data sheet along with sample location data. We only include plant species in our transect data that are known to be used by FW and do not record any plants that are known to not be used by FW such as grasses, gymnosperms, forbs[12].

2.2.2 Deploying Caterpillars in the Field

When choosing a field site for FW deployment for experiments to test bottom-up and top-down effects in the field, it is important to avoid placing FW near heavily trafficked areas like parking lots, trailheads, and trails. Many times, the caterpillars we deploy into the field are hidden enough in the host plant that people will not notice them, but it is better to avoid any intentional or unintentional field sabotage by people recreating near the field sites.

Deployment strategies vary slightly depending on whether it is FW eggs or webs that are being placed into the field. In order to fasten egg clusters onto host plants, we place the eggs facing outwards, so the wax paper is flush against the underside of the leaf, and eggs are not sandwiched in between the wax paper and leaf. It is important to attach the eggs on the underside of the leaf as this is where FW females often lay their eggs and also so that the eggs do not desiccate in the sun. We use metal hair clips (Sally Beauty Supply) to fasten the wax paper containing the egg cluster to the leaf, being careful that the hair clip does not touch or crush any eggs, but also making sure that the wax paper is held firmly in place on the leaf. We individually number the metal hair clips using white lab tape and a medium point Sharpie so that we can follow and monitor individual clips easily in the field. We use one or two clips to anchor the wax paper with an egg cluster to the host plant, often with one clip on each end of the wax paper along the longitudinal axis of the leaf (parallel to the major leaf vein). We fasten the webs to the host plant in a similar way (Figure 9A), but we attach the edge of the web to the petiole of the leaf, which is stronger than the leaf and can support the weight of a web. To do this, we clip the entire web that the FW caterpillars created in the lab (including any leaves they may currently be feeding upon) to the leaf petiole so that we disturb the FW caterpillars as little as possible. If the webs are large, we often use several hair clips and attach them to both the petiole and the tree branch to ensure the web is

Figure 9. FW caterpillars deployed in the field for field experiments. **A)** A student attaching a FW web to a choke cherry plant with a hairclip; **B)** A mesh net bag on a broadleaf cottonwood with FW caterpillars housed inside that are protected from predators and parasitoids. The net bag is tied onto the branch tightly so caterpillars cannot escape.

secure on the host plant. For some experiments, we deploy FW caterpillars into the field and need to exclude parasitoids and predators so that we can measure the effects of host plant alone without the effect of natural enemies. We use net bags made of green netting (7 holes per *cm*; Barre Army Navy Store, Barre, VT) and secured with a nylon drawstring (Figure 9B).

We deploy FW eggs and webs in the field trying to mimic how they would be found in nature. For instance, FW webs are never found at the bottom of a plant and thus we place ours at about shoulder height or above, because this is how they are typically found in the field. Often FW webs in some canyons are found on the south-facing slope, so we try to deploy our webs similarly. FW webs are usually found on outer branches of the host plant; thus, we fasten our eggs and webs onto the leaves close to the very end of the branch, but some large webs have to be tucked further into the tree where there are thicker branches to support their extra weight.

It is important to take rigorous field notes when deploying FW so we can find them again in the field, and also so that we can communicate with others about web location. We always record GPS coordinates, but also note landmarks near the webs (e.g., a distinctive rock or street signs). We also sometimes take pictures of the FW in the field to better locate the branch where they were deployed. In addition to information to find them in the field, the notes also include which colonies were deployed, how many caterpillars were deployed in each web (these can be counted in the lab and marked on their deli container to save time in the field), the dates and locations for each deployment, and the dates on which they were monitored. It is important to monitor deployed FW webs at least every other day if not every day because FW sometimes move their webs short distances; these short distances can be tracked if FW webs are closely monitored, but if are left on their own for a few days it is easy to lose track of the webs that we have transferred. If a FW web moves, the individually numbered hair clip should also be moved with it, and we record that it moved in our field notes. On the day that FW eggs and webs are collected from the field, we put each one in its own individually-labeled deli container with moist filter paper and host plant leaves from its host in the field. Once the FW are safely back in the lab, we count how many caterpillars were recovered so that we can calculate percent survival.

3 DISCUSSION

Recently FW have emerged as a model study system for ecological and evolutionary studies related to diet breadth. When rearing FW in a colony it is very important to have a system of organization and a consistent set of protocols. We have learned over the past 10 years through a series of trial and error which methods lead to the highest survival of FW in our colony. We have learned that it is essential to have consistent labeling and data management systems so that everyone in the lab knows which caterpillars are being used for different experiments and how to feed and care for them. Unfortunately, we have also suffered through many errors in the past and our protocols presented here will help other labs to avoid the same pitfalls. For instance, we have found that if FW females are allowed to lay eggs on the plastic container with no wax paper, then it is almost impossible to remove these eggs without damaging them, and when the eggs hatch it is hard for them to find food which leads to starvation. We have also learned how sensitive FW are to ambient light conditions. For adult moths to mate, they need to be exposed to twilight and they cannot be left in a room with the lights on all of the time. Similarly, FW caterpillars are equally sensitive to lights being left on in the lab and if they receive this extended photoperiod cue, they will not enter diapause and will instead emerge as adults in autumn when it is too late to complete another generation before the leaves fall.

We found no statistical differences in the percentage of successful matings that led to fertile eggs across the three container sizes. However, while the differences were not statistically significant, there was a trend where moths that were mated in medium and large containers had 50% more fertile egg clusters compared to moths mated in the small containers. Thus, although our results are not statistically different, this is a good example of a situation in which biological relevance still matters. When rearing FW, every successful mating helps keep the colony going and using containers that result in 50% more fertile eggs is important when so much time, effort, and money is invested into rearing. Thus, we recommend that researchers invest their resources wisely and avoid the use of small containers for mating.

Our field protocols have been used by us and other

researchers for many years. Besides studies from our own research team in Colorado[5;12], the transect method to assess the plants available for FW was used by Mason and collaborators[27] on the east coast. The deployment of caterpillars in the wild to measure predation and parasitism has also been used for other systems[28], and we have also previously tested with FW (unpublished data). Although some of our protocols have recently been used for FW by our research group, we have adapted many of these methods from other systems and they are general methods used in entomological studies. The immunological methods are based on Carper et al.[29], but we have optimized these methods for the last few years. Thus, there is ample evidence that our protocols are generalized methods that work well for FW.

Our findings create opportunities for future FW researchers to improve and standardize their research, as well as propose ideas that refine our methods. As FW becomes more common as a model organism for ecological research, standardized rearing protocols reduce variables that cause disagreement between studies. For example, using different mating containers can affect the probability of reproductive success, which can have subsequent impact on experiments relying on fertilized FW eggs that yield caterpillars. Our results will benefit researchers that rely on manipulating numerous aspects of FW biology, including separating siblings, performing crosses between maternal lines, and conducting reciprocal transplants of FW between geographic locations.

An important trade-off in ecological work is found in the amount of time and effort spent performing detailed observations and experiments in a given locality compared to saving time and effort by using coarse methods to evaluate processes at the regional level. Increasing collaboration among research groups from different institutions allows for the expansion of detailed measurements across larger areas, facilitating a deeper understanding of regional processes. Notably, to compare experimental data gathered by multiple people in different groups requires methodological standardization. Detailed protocols like the one we present here are thus an indispensable tool to enable collaboration.

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5 EDITOR'S NOTES

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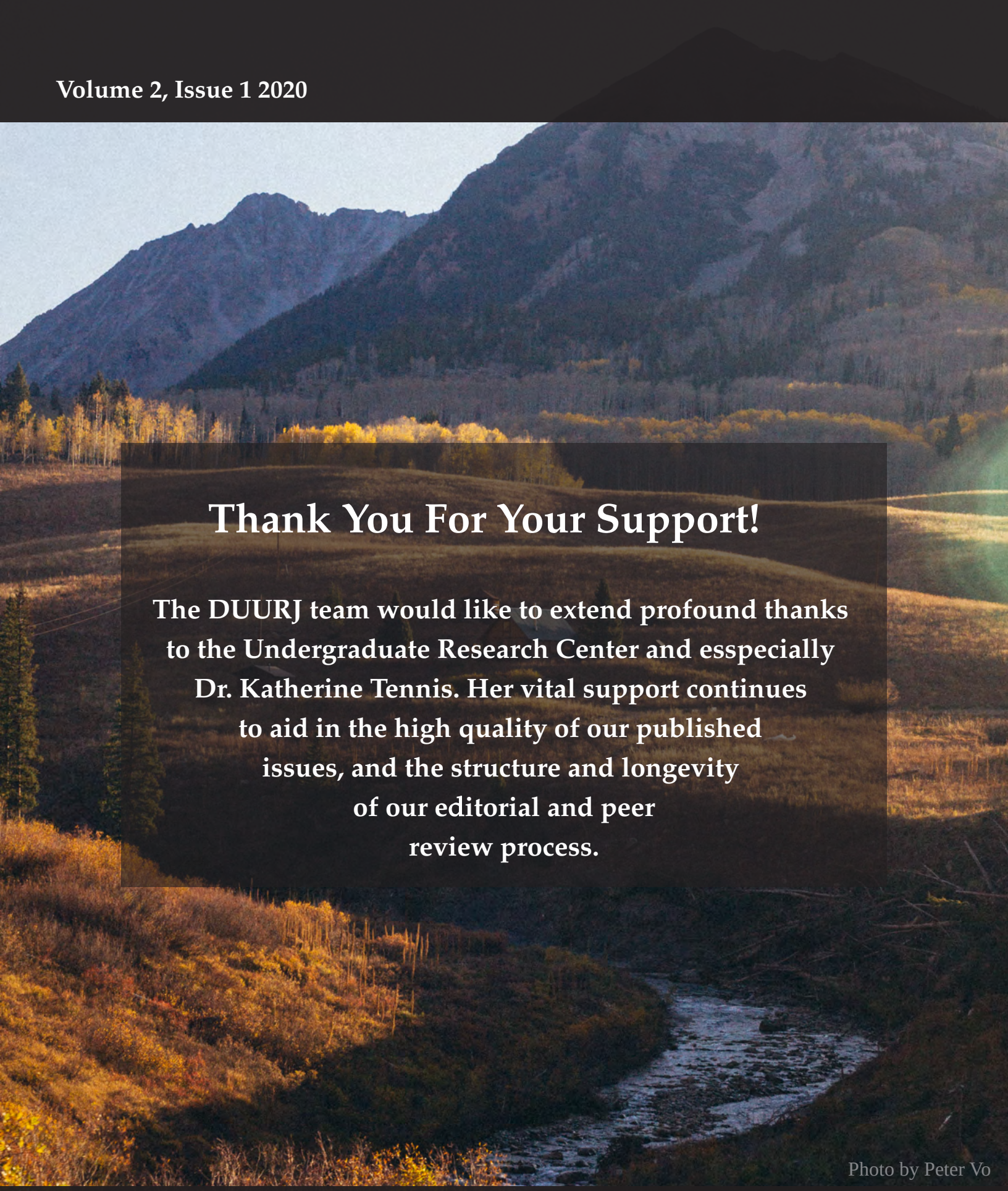

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Photo by Peter Vo