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2018 GJMPP Monograph Series: Grace Jordan McFadden Professors Program

John McFadden
University of South Carolina - Columbia, jmcfadde@mailbox.sc.edu

Michael J. Walsh
University of South Carolina

Lauren A. Reid
University of South Carolina - Columbia

Marsha Dowda
University of South Carolina - Columbia

Melinda Forthofer

See next page for additional authors

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Grace Jordan McFadden Professors Program

John McFadden, PhD

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In addition to the authors of chapters, their mentors, and editorial reviewers, the following persons contributed significantly toward the preparation of papers for publication of this monograph, and are, therefore, acknowledged for their unique efforts of advice, reviewing, and literacy support.

Marva J. Larrabee, EdD

Kathy M. Evans, PhD

Rhittie L. Gettone, MEd

Marty Jencius, PhD

Zach Lukemire, MLIS, JD

Rashida H. McFadden, MBJ

Dr. Marva J. Larrabee, Professor Emerita, continues to render untiring commitment and support to the African American Grace Jordan McFadden Professors Program, which is integral to the publication of this monograph. Accompanied by Dr. Kathy M. Evans, these two colleagues extend an inordinate amount of talent and expertise ensuring that the monograph series maintains its scholarly reputation.

FOREWORD—SHARING THE GIFT

I am incredibly honored to have been asked to pen a Foreword for this illustrious monograph. "*That sounds like the right opening sentence, right*?" These thoughts and more raced through my head as I scrambled to think about how to introduce a publication that is the showcase for so many brilliant and talented minds. I struggled with what I might write for weeks. Then I received a gift.

I was invited to an event honoring Mrs. Rhittie Gettone, long the backbone and the heart of the African American Professors Program, now the Grace Jordan McFadden Professors Program. I watched as scholars old and new honored Rhittie with amazing displays of their talents and intellect. I listened as scholars described the incredible support and mentorship that the program offers. I felt as people poured their hearts into honoring a person that has come to represent the very best of what the Grace Jordan McFadden Professors Program has to offer.

As I watched, listened and felt, I reflected on the essence of the program. I reflected on the ways in which the program has fostered the spirit and, dare I say, the souls of scholars. I reflected on the power of that support. I marveled at the sheer amount of positive energy and love in that room. This, I realized, was the heart of the program. This, I realized, is what is possible when people come together to form a community of support and intellectual inquiry. This is what is possible when that support is expressed as love. That is the gift. I had an opportunity to be

surrounded by what is possible when love is put into motion and when love empowers people to find their own voices.

I have had the distinct honor and pleasure to be a very small part of AAPP/GJMPP activities over the years, from traveling to South Africa with a group of talented scholars, to participating in research presentation programs, to sharing ideas on teaching with scholars. These are experiences that I will cherish always. These experiences leave me reflecting on ways to pay forward these incredible experiences.

As you delve into the manuscripts in these pages, I invite you to share my excitement over the talent showcased herein. I invite you to share my excitement over the incredible ideas that you will find. I also invite you to reflect on ways that you may move the spirit of this program forward. I invite you to share the gift that the Grace Jordan McFadden Professors Professors Program has to offer. I invite you to share the gift of love. Please enjoy this edition and accept my thanks for the opportunity to share this gift with you.

Michael J. Walsh, PhD, LPC, CRC
Assistant Professor of Rehabilitation Counseling
Department of Neuropsychiatry and Behavioral Science
University of South Carolina School of Medicine

PREFACE

The Grace Jordan McFadden Professors Program (GJMPP), formerly the African American Professors Program (AAPP)/ Carolina Diversity Professors Program (CDPP) at the University of South Carolina, is honored to publish its seventeenth edition of this annual monograph series. GJMPP recognizes the significance of offering its scholars a venue through which they have the opportunity to engage in research and to publish their refereed papers that continually contribute to their respective academic areas. Parallel with the publication of their manuscripts is a venue to gain visibility among colleagues throughout postsecondary institutions at national and international levels.

Scholars who have contributed papers for this monograph are acknowledged for embracing the value of including this responsibility within their doctoral milieu. Writing across disciplines adds broadly to the intellectual diversity of these manuscripts. From neophytes to quite experienced individuals, the chapters have been researched and written with vigor.

Founded in 1997 through the Department of Educational Leadership and Policies in the College of Education, AAPP was designed originally to address the under-representation of African American professors on college and university campuses. Its mission is to expand the pool of these professors in critical academic and research areas. Sponsored historically by the University of South Carolina, the W. K. Kellogg Foundation, and the South Carolina General Assembly, the program recruits

doctoral students for disciplines in which African Americans and others are underrepresented among faculty in higher education.

The continuation of this monograph series is seen as responding to a window of opportunity to be sensitive to an academic expectation of graduates as they pursue career placement and, at the same time, to allow for the dissemination of products of scholarship to a broader community. The importance of this series has been voiced by one of our 2002 AAPP graduates, Dr. Shundelle LaTjuan Dogan, formerly an Administrative Fellow at Harvard University, a Program Officer for the Southern Education Foundation, and a Program Officer for the Arthur M. Blank Foundation in Atlanta, Georgia. She recently completed an appointment as Corporate Citizenship and Corporate Affairs Manager for IBM-International Business Machines in Atlanta and is currently a consultant with a focus on philanthropy and social impact. She is currently Assistant Vice President for Social Impact and Innovation at Emory University. Dr. Dogan has written an impressive Foreword for the 2014 monograph.

In a personal letter, which is cited in an earlier monograph, Dr. Dogan penned: "*One thing in particular that I want to thank you for is having the African American Professors Program scholars publish articles for the monograph. I have to admit that writing the articles seemed like extra work at the time. However, in my recent interview process, organizations have asked me for samples of my writing. Including an article from a published monograph helped to make my portfolio much more impressive. You were 'right on target' in having us do the monograph series" (AAPP 2003, Monograph, p. xi).*

The Grace Jordan McFadden Professors Program purports to advance the tradition of spearheading international scholarship in higher education as evidenced through inspiration from this group of interdisciplinary manuscripts. I hope that you will envision these published papers to serve as an invaluable contribution to your own professional and career enhancement.

John McFadden, PhD
The Benjamin Elijah Mays Distinguished Professor Emeritus
Director, Grace Jordan McFadden Professors Program
University of South Carolina
Columbia, South Carolina

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PART 1:

Arnold School of Public Health

MATERNAL SUPPORT FOR PHYSICAL ACTIVITY IN AFRICAN AMERICAN GIRLS

Lauren Reid[a], Department of Epidemiology and Biostatistics, University of South Carolina, Columbia, SC
Marsha Dowda[a], Department of Exercise Science, University of South Carolina, Columbia, SC
Melinda Forthofer[b], Department of Public Health Sciences, University of North Carolina-Charlotte, Charlotte, NC
Daheia J. Barr-Anderson, College of Education and Human Development, University of Minnesota, Minneapolis, MN
Ruth Saunders[a], Department of Health Promotion, Education, and Behavior, University of South Carolina, Columbia, SC
Russell R. Pate[a], Department of Exercise Science, University of South Carolina, Columbia, SC

Rates of overweight and obesity have become a public health concern in recent decades, particularly for African American women. According to the latest statistics of the National Center for Health Statistics (NCHS, 2016), 82.0% of African American women ages 20 and older are overweight or obese, and 56.5% of these women were in the obese category between the years of 2011–2014. African American women also are at an increased risk for health conditions associated with obesity, such as cardiovascular disease, type 2 diabetes, stroke, hypertension, and various cancers, according to the National Heart, Lung and

[a]Arnold School of Public Health; [b]College of Health and Human Services; [c]NHLBI Pre-Doctoral Fellow Diversity Supplement Grant to NIH Grant # 3R01HL091002-07S1 (See page 7 footnote)

Blood Institute (NHLBI, 2013). Health indicators for African American girls follow a similar pattern in that these girls are disproportionately overweight compared to their majority counterparts. Almost 22% of African American girls ages 6-11 are obese compared to 14.4% of Caucasian girls; however, 24.4% of African American girls ages 12-19 are obese compared to 20.4% of Caucasian girls in the same age group, according to the National Center for Health Statistics [NCHS], 2016). The Centers for Disease Control and Prevention (CDC, 2015) define over-weight and obese children as those with a Body Mass Index (BMI) equal to or greater than the 85th percentile.

Regular physical activity reduces the risk of obesity and diseases associated with obesity (NHLBI, 2013). Unfortunately, physical activity declines dramatically between childhood and adolescence (Nader, Bradley, Houts, McRitchie & O'Brien, 2008; Trost, et al., 2002) then continues to decline with age (Gordon-Larsen, Nelson & Popkin, 2004; Troiano, Berrigan, Dodd, Mâsse, Tilert & McDowell, 2008). The National Health and Nutrition Examination Survey found that 42% of 6 to 11-year-old children meet federal recommendations of obtaining 60 minutes of moderate-to-vigorous physical activity (MVPA) per day; whereas, only 8% of adolescents (12-19 years) reach that goal (Troiano, et al., 2008). Troiano et al. also found that African American girls followed this pattern. These researchers show that those children ages 6-11 years accumulated 87.4 minutes of MVPA per day, while those in the 12-15 age group accumulated only 26.4 minutes of MVPA per day, and teenagers within the 16-19 age group accumulated 18.1 minutes of MVPA per day.

Little is known about the factors that contribute to these low levels of physical activity in African American girls; however, for at least a decade efforts have been made through the CDC to broaden the research agenda to better understand this and other factors related to childhood obesity. The CDC's National Center for Chronic Disease Prevention and Health Promotion (NCCDPHP), 20 years after their founding, highlighted the critical intersection of maternal and child health with chronic disease prevention (Collins, Lehnherr, Posner, & Toomey, 2009). Furthermore, the Division of Reproductive Health (DRH), which is part of the NCCDPHP, has worked to heighten awareness and emphasize "the importance of early intervention and its implications for lifelong health" (p. 1), which includes an intergenerational approach to maternal and child health (Collins, et al., 2009). Collins and colleagues clarify that years of research provides documentation that behaviors established in childhood are a major contributing factor for lifelong health issues and that obesity in childhood is highly related to becoming morbidly obese in adulthood.

Since the prevalence of obesity among "African Americans and other racial and ethnic minority populations" (Kumanyika, et al., 2007, Abstract) is higher than among whites, the African American Collaborative Obesity Research Network (AACORN) initiated a focus on building and broadening the paradigm for obesity research to include new challenges for obesity researchers, including contextual factors (e.g., multigenerational relationships; e.g., Davis, McGonagle, Schoeni, & Stafford, 2008). Such efforts were anticipated to yield new solutions specifically for African Americans and other people of color (Kumanyika, et al., 2007). One of the subthemes within the core

areas of AACORN's focus was "Women as a central focus" as well as "community-specific environmental influences" under the Community and Family Life theme as well as the "historical importance of trust" regarding health-care in African-American communities (Kumanyika, et al., 2007, Table). Our recent study is aligned with the AACORN recommendations and the recent focus of the CDC's Division of Reproductive Health agenda.

Understanding the influences on African American girls' physical activity may help guide intervention development designed to increase these girls physical activity and to prevent negative health outcomes over time. There is evidence that social support from parents may be an important influence on youth physical activity in the general population. Recent related literature reviews indicate that, despite inconsistencies and measurement challenges, positive associations exist between youth physical activity and parents' tangible and intangible social support for physical activity (e.g., Beets, Cardinal & Alderman, 2010; Yao & Rhodes, 2015).

Research specific to parental influence on African American daughter's physical activity is limited (Heredia, Ranjit, Warren & Evans, 2016). Of the studies that have examined the relationship between African American parents and their child's physical activity, many found few or no associations (e.g., Adkins, Sherwood, Story, & Davis, 2004; Nichols-English, et al., 2006; Webber & Loescher, 2013).

The African American culture is heavily maternal (Kumanyika, et al., 2007); therefore, exploring the influence of mothers' social support on their daughters' physical activity may be particularly important for promoting physical activity in a

manner that is appropriate culturally. This, in turn, may provide insight into preventing a continuation of current negative health trends for African American women. Accordingly, the purpose of this study was to examine the influences of both parent- and child-reported parent social support for physical activity, as measured in 5th grade year, as well as associations with objectively measured physical activity data collected among these African American girls in the 7th grade.

MATERIALS AND METHODS

The Transitions and Activity Changes in Kids (TRACK) study was a longitudinal study of the influences on changes in children's physical activity during the transition from elementary to middle school funded by the National Institute of Health (NIH) (Pate, et al., 2008). The sample selection and data collection methods yielded a subset of data for analysis for the current research report. The first author of this report received funding from NHLBI[1] through a Graduate Research Diversity supplement to complete the study reported here. Detailed methods have been previously reported (e.g., Taverno Ross, Dowda, Colabianchi, Saunders, & Pate, 2012) and are summarized in this section of the report.

Recruitment for TRACK took place in elementary and middle schools in two school districts in South Carolina during the 2010-2011 school year. In one school district 14 of 17

[1]National Heart, Lung, and Blood Institute/National Institutes of Health, Graduate Research Diversity Supplement to Physical Activity During the Transition from Elementary School to High School (Grant #3R01HL091002-0751); Pre-Doctoral Fellow Lauren Reid, MPH (PI: Russell R. Pate).

elementary schools and all seven middle schools served as data collection sites, and in the other school district all seven elementary schools and all six middle schools participated in the study. Trained research staff measured participants in the 5th, 6th, and 7th grades during scheduled visits to the schools. The measurement methods included a psychosocial questionnaire, anthropometric measurements, accelerometry, a physical activity recall, and a dietary screener. During each year of data collection, a parent questionnaire was sent home that was to be completed by a parent or guardian. Parents/guardians provided informed consent, and students provided assent to participate in TRACK. The Institutional Review Board at the University of South Carolina approved all protocols.

In the present study, data were analyzed from African American girls in the TRACK cohort using the 5th grade psychosocial questionnaire and parental survey data as well as 7th grade accelerometry data for each student in our sample. Baseline recruitment of participants yielded 200 girls who self-identified as Black/African American. Participants were excluded from our analysis if they did not have 5th grade questionnaire data (n=45), when the parent/guardian respondent to the 5th grade questionnaire was not the girl's mother (n=24), or if no accelerometry data in 7th grade (n=39) were available. The sample for final analysis included 91 African American girls (mean age in 5th grade =10.52±0.52 years).

Because this study is primarily a descriptive investigation of African American girls with specific data available in the TRACK database, no discrete hypotheses or research questions

are offered here. Measurement procedures and instruments as well as the research findings are described in sections that follow.

MEASURES

Child Reported Variables

Mother's support for physical activity was reported via a student questionnaire administered in the 5th grade. This questionnaire was self-reported, and the girls' responses were entered into a survey software database on laptop computers. Four questions from the student survey of the Amherst Health and Activity Study (Sallis, Taylor, Dowda, Freedson, & Pate, 2002) were used to assess perception of support for physical activity provided by the "female adult who you live with most of the time." These questions were previously validated for use in this population in the Trial of Activity in Adolescent Girls study (Webber, Catellier, Lytle, Murray, Pratt, Young, & Elder, et al., 2008). Questions were framed "During a normal week, how often has she…" followed by the following four questions: (a) "Done a physical activity or played sports with you?", (b) "Provided transportation to a place where you can do physical activities or play sports?", (c) "Watched you participate in physical activities or sports?", (d) "Told you that you are doing well in physical activities or sports?" A fifth question from the student survey of the Amherst Health and Activity Study (Sallis, et al., 2002) asked about support in the form of encouragement using the following question; "During a normal week, how often has she encouraged you to do physical activities or play sports?" Possible answers to the assessment included "None, Once,

Sometimes, Almost Daily, or Daily" and were coded as 0, 1, 2, 3, or 4, respectively.

Parent Reported Variables

Mothers reported their support for their daughter's physical activity through a parent questionnaire. Four questionnaire items taken from the Amherst Health and Activity Study assessed support (Sallis, et al., 2002). The items began "During a typical week, how many days do you…" and were followed by these 4 questions: (a) "Encourage your child to do physical activity or play outside?"; (b) "Play outside or do physical activity with your child?"; (c) "Provide transportation to a place where he or she can do physical activity or play?"; (d) "Watch your child participate in physical activity or outdoor games?" Response options were 0, 1-2, 3-4, 5-6, or 7.

Physical Activity Assessment

Physical activity was assessed objectively through measurement of "daily MET-weighted minutes of moderate-to-vigorous physical activity (MET-weighted MVPA), ...using accelerometry" (Webber, et al., 2008, Abstract). When the girls were in the 7th grade, waist-mounted ActiGraph accelerometers (GT1M and GT3X, ActiGraph, Pensacola, FL) were used to obtain this measure of daily MET-weighted MVPA. Each child was instructed to wear the accelerometer for seven consecutive days during all waking hours except while bathing, swimming, or sleeping. ActiGraph data were collected and stored in 1-minute intervals. Periods of 60 or more minutes of consecutive zeroes were considered to be non-wear time and were set to missing data. Moderate to vigorous physical activity (MVPA) was defined based on a cut point of 2200 counts per minute,

which corresponds to 4.0 metabolic equivalents (METs) (Freedson, Pober, & Janz, 2005). Physical activity was expressed as mean daily minutes per hour of wear time. Data for Sundays were excluded from analysis because of poor wear rates and low reliability, leaving 6 days for analysis. Multiple imputation using PROC MI in SAS software was used to estimate missing values for children with a minimum of eight hours of wear time on at least two days.

Body Mass Index (BMI) Assessment

The Centers for Disease Control and Prevention (CDC) "About Child and Teen BMI" website defines BMI as "a person's weight in kilograms divided by the square of height in meters" (para. 1). Trained data collectors measured participants' height to the nearest 1.0 cm using a portable stadiometer (i.e., ShorrBoard, Weigh and Measure, LLC [formerly Shorr Productions], Olney, MD) and weight to the nearest 0.1 kg using a portable digital scale (Seca, Model 880c; Hamburg, Germany; Chino, CA USA). We calculated body mass index (BMI=kg/m^2) and determined BMI percentiles using the CDC growth charts (Kuczmarski, et al., 2000).

DATA ANALYSIS AND RESULTS

Sample Descriptive Statistics

The mean age of the 91 African American girls in our sample at baseline was 10.52 years (SD = 0.52). Mean total physical activity in the 7th grade was 20.68 minutes per hour (SD = 3.93), and mean MVPA was 1.57 minutes per hour (SD = 0.79). The results of the measurement of the BMI of the sample indicates that 54.95% of participants had a BMI greater than the

85th percentile for girls of their age (i.e., in the categories considered as overweight and obese; CDC, 2015).

Data Analysis

The Pearson product-moment (i.e., Pearson *r*) correlations were used to examine the relationship between parent support of physical activity and parent encouragement to be active in 5th grade and physical activity in 7th grade. In addition, mixed model regression analysis with school as a random effect variable was used to examine the relationships between parent support variables and total physical activity. Regression analysis results (described below) were accepted at a significance level of $p \leq 0.05$.

Results

The Pearson *r* correlations for all variables are presented in Table 1. Child-reported mother's support and encouragement in grade 5 both correlated significantly with total physical activity

Table 1. Pearson *r* Correlation Coefficients

	Total PA		MVPA	
	Correlation	**P-value**	**Correlation**	**P-value**
Child Variables				
Parent support	0.30959	*0.0028	0.08973	0.3976
Encouragement	0.20638	*0.0497	0.12853	0.2247
Mother's Variable				
Parent support	-0.17794	0.0915	0.11123	0.2939

PA: physical activity
MVPA: moderate-to-vigorous physical activity
*Significance accepted at $p < 0.05$ indicated by *.

in grade 7 ($r = 0.30959$, $p = 0.0028$ and $r = 0.20638$, $p = .0497$, respectively). There were no significant associations between MVPA and these independent variables (Table 1).

In the mixed-model regression analysis for total physical activity, variables were removed from the models one by one until only significant values were left in the model (See Table 2, Appendix). Model 1 analyzed the association between total physical activity and all three parent-support variables. Mother's encouragement to be physically active was removed from Model 2, and Model 3 presents the association between parent support reported by the child in 5th grade and total physical activity in 7th grade. Parent support reported by the child was statistically significant in all three models ($p = 0.03$, 0.01, <0.01, respectively) (See Table 2, Appendix).

DISCUSSION AND CONCLUSIONS

This study examined the influence of parent social support for physical activity reported in grade 5 on physical activity measured in grade 7 for African American girls. Child-reported perceived support but not mother-reported parent social support for physical activity in 5th grade was significantly associated with total physical activity of the girls in the 7th grade. These findings suggest that perceived mother's social support may be a key factor for African American girls' engagement in physical activity.

These results also are consistent with a previous study in the general population that measured family support of girls' physical activity. In a longitudinal study that followed 421 girls from 8th to 12th grade (58% African American), researchers found that girls who reported lower family support at baseline had more rapid declines in physical activity as they aged (Dowda, Dishman, Pfeiffer, & Pate, 2007). Dowda and associates indicate that girls who reported higher levels of family support in the 8th grade had higher self-reported physical activity levels in the 12th grade, regardless of self-efficacy or perceived behavioral control scores.

To our knowledge, only one other study has assessed the influence African American mothers have on their daughter's physical activity. Nichols-English and colleagues (Nichols-English, et al., 2006) found no associations between the mothers' physical activity beliefs and their daughters' intentions to engage in physical activity; however, this cross-sectional study did not assess specific forms of social support or measure physical activity behavior directly.

In our study, child-reported mother support but not the parent-reported support in the 5th grade was related to total physical activity in the 7th grade. Forthofer and colleagues (2017) report discrepancies between child-reported support and parent-reported support, which contrasts with the findings of the present study on African American girls. They found that parent-reported but not child-reported social support for physical activity were protective against declines in physical activity for both boys and girls (Forthofer, et al., 2017). Future researchers may need to explore this discrepancy because it may have implications for evaluating use of family interventions.

A better understanding of the influence African American mothers have on their daughters' physical activity may be important for helping African American girls maintain appropriate physical activity levels. In a review of physical activity interventions with a family component targeting African American girls, the Barr-Anderson research team found that including primary family members, like mothers, shows promise in increasing physical activity in African American girls (Barr-Anderson, Adams-Wynn, DiSantis, & Kumanyika, 2013). Our conclusions based on this current study suggest that it may be important to involve the mother/primary female guardian in future physical activity interventions for African American girls.

More than half of the African American girls in this sample had a BMI greater than the 85th percentile of the CDC (2015) Growth Charts at baseline, indicating they are overweight or obese, which certainly is higher than the national average for all children. According to Ogden, Carroll, Kit and Flegal (2014),

36.9% (95% CI: 26.9-48.1) of African American girls ages 6-11 have a BMI greater than or equal to the 85% percentile.

These results seem to suggest that many of the girls in this cohort already may be on a trajectory to perpetuate the current health trends of African American women toward increasing weight gain and deteriorating health. Multifaceted interventions may be needed particularly to help female African American children and teens participate in after-school programs similar to those Taverno Ross, et al. (2012) showed as resulting in significantly more physical activity and less sedentary behavior for African American youth compared to white children. Research on such efforts combined with maternal support factors, especially for minority girls, may yield a more clear positive impact on the future health of these girls.

Our study is unique because it examined the association between parent support for physical activity from both the mother's and the child's perspective in a longitudinal study design. It also focused on African American girls and their mothers because African American women clearly face health disparities in diseases related to low physical activity levels (Bland & Sharma, 2017).

A limitation of the study is that we did not examine other sources of parental influence on physical activity such as parent role-modeling. While several studies have found parent role-modeling to be unassociated with child physical activity in African American girls (e.g., Nichols-English, et al., 2006; Pate, Trost, Dowda, Ott, Ward, Saunders, & Felton, 1999; Polley, Spicer, Knight, & Hartley, 2005; Yao & Rhodes, 2015), others have observed an association (Madsen, McCulloch, & Crawford,

2009). Future studies examining how African American mothers influence their daughter's physical activity should evaluate other measures of parental influence and perhaps consider potential interventions that are in accord with AACORN's community-specific environmental influences (Kumanyika, et al., 2007) that recently have emerged as impacting the activity levels of African American children positively (e.g., Taverno Ross, et al., 2012).

In conclusion, it is clear that African American girls' perceptions of their mothers' support for physical activity may be related to higher levels of physical activity over time. This may be an important factor for consideration by health professionals who are working to prevent declines in physical activity and to increase physical activity in African American girls. Long term, understanding this relationship may help change current health trends of African American women. Clearly, further research is needed to evaluate this relationship.

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Appendix

Table 2: Results of mixed model regression for total physical activity in 7th grade

	Model 1		Model 2		Model 3	
	β-estimate (95% CI)	P-value[a]	β-estimate (95% CI)	P-value[a]	β-estimate (95% CI)	P-value[a]
Child Variables						
Parent Support	0.96 (0.10-1.81)	*0.03	1.13 (0.35-1.91)	*0.01	1.20 (0.43-1.97)	*<0.01
Encouragement	0.40 (-0.41-1.21)	0.33				
o Mother's Variable						
Parent support	-0.68 (-1.62-0.26)	0.15	-0.65 (-1.59-0.29)	0.17		

[a]P-values are from Rao-Scott Chi Square Test, significance accepted at p<0.05. (*indicates significance)
Model 1 –parent support & encouragement reported by the child, and parent support reported by mother
Model 2 –parent support reported by the child, parent support reported by the mother
Model 3 -parent support reported by the child

PART 2:

College of Arts and Sciences

AN INTRODUCTION TO GÖTTSCHE'S CONJECTURE

Candace A. Bethea

Department of Mathematics

Many mathematical applications rely on finding simultaneous solutions to multiple polynomial equations. Solving systems of polynomial equations remains a classic problem to solve in mathematics (Sturmfels, 2002). Sturmfels notes that such polynomial models are applicable across numerous fields of science and that solution sets "to a system of polynomial equations is an algebraic variety" (Abstract). It is useful to study properties of these sets of solutions, which will be referred to as *varieties* for the purposes of this introduction. For example, varieties include $\{(x, y): y-x^2=0\}$, a parabola defined by one equation, and $\{(x, y): y-x^2 = y-1=0\}=\{(-1,1), (1,1)\}$, two points defined by two equations, in the xy-plane.

Algebraic geometry is the study of varieties (Sturmfels, 2002), and understanding geometric properties of a variety gives us insight into the polynomial functions of interest. Algebraic geometry is one of the oldest subjects in mathematics (Landsberg, 2014) and has applications in string theory and robotics. In algebraic geometry, the 2-dimensional sphere is called the *projective plane* and is denoted as $\mathbf{P}^2$. It is an example of a *surface,* or a 2-dimensional variety. One natural area of study in algebraic geometry is to study sets of curves, or 1-dimensional varieties, on surfaces such as $\mathbf{P}^2$ and answering

enumerative questions about curves. Figure 1 shows an example of curves on a surface; in this case, lines are on a surface that is defined by a polynomial in three variables.

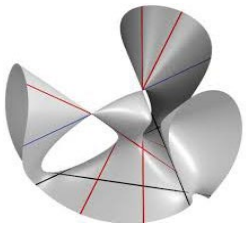

Figure 1: Lines on a Surface

The goal for this exposition is to introduce a classical enumerative question that was proved recently by Y. Tzeng (2012) called Göttsche's conjecture. I will present an accessible and intuitive introduction to the necessary background information, give a practical overview to Göttsche's conjecture with an example, and explain multiple ways to understand the result in a specific case.

BACKGROUND

As a basic and abridged introduction, the necessary definitions and background information needed to understand Göttsche's conjecture will be presented. All definitions and facts have been simplified from their original versions. For a technically correct treatment, see Hartshorne's (1977) textbook; thus, technical citations are not used in the explanations and illustrations that follow.

To begin, I will work over the complex numbers, denoted **C**. Recall that the complex numbers as a set can be described as

$$\mathbf{C}=\{a+ib\colon i^2=-1 \text{ and } a \text{ and } b \text{ are real numbers}\}.$$

Algebraic geometry is generally field-neutral, meaning one can work over other fields such as the real numbers or rational numbers, but the most natural entry point is over **C**. As noted in the introduction, a *variety* over **C** is the set of solutions to a collection of polynomials. More precisely, a *variety* over **C** is a set equipped with a topology:

$$X=\{z \in \mathbf{C}\colon f_1(z)=f_2(z)=\cdots=f_n(z)=0\}$$

A topology on a set can be thought of as a rule that defines open sets on which one can define functions and mimic their properties over **C**. In the introduction, two examples were given: $\{(x, y)\colon y-x^2=0\}$ and $\{(x, y)\colon y-x^2 = y-1=0\}=\{(-1,1), (1,1)\}$, which were both examples over the real numbers. An example over **C** includes $\{z\colon |z| = 1\}$, the unit circle in the complex plane.

Recall that the projective plane is a 2-dimensional sphere. As a set, projective space can be described as:

$$\mathbf{P}^2=\{[x, y, z]\text{: not all of } x, y, z=0\}$$

under the equivalence relation that $[x, y, z]=[\lambda x, \lambda y, \lambda z]$ for any complex number $\lambda\neq 0$. One can think of projective space as the set of lines through the origin in **C** with each line identified to a point. As a general rule, it's easier to work with varieties embedded in $\mathbf{P}^2$ than in the complex plane because $\mathbf{P}^2$ is compact, which means that functions can't "go off to infinity." Intuitively, this is because functions whose graphs are on a sphere must, of course, stay on the sphere. The dichotomy between functions in $\mathbf{P}^2$ and functions in the plane can be seen in Figure 2 below.

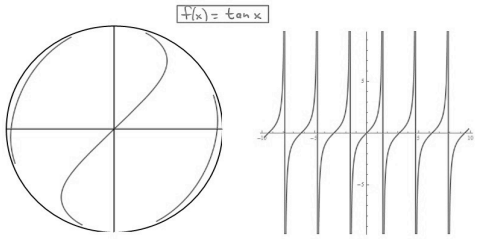

Figure 2: Projective plane vs. plane

Varieties in the projective plane can be defined in the same way as varieties in the ordinary complex plane with one caveat. In order for solutions to polynomials to be well defined in the projective plane, the polynomial must be *homogeneous*. A polynomial is said to be homogeneous if every monomial term has the same degree. For example, the polynomial $f(x, y, z) = xy + y^2 + z^3$ is not homogeneous because the monomials xy and y^2 have degree 2, but the monomial z^3 has degree 3. The polynomial $f(x, y, z) = xy + yz + xz$ is homogeneous because each monomial term has degree 2. A variety that is defined in the projective plane will be called a *projective variety*. For example,

$$X=\{[x, y, z] \in \mathbf{P^2}: x^3 + y^3 + z^3 = 0\} \subseteq \mathbf{P}^2$$

is a projective variety called the Fermat cubic. One point in X is [1, -1, 0] since $1^3 + (-1)^3 + 0^3 = 0$, and a point that is not in X is [1, -1, 1] since $1^3 + (-1)^3 + 1^3 = 1 \neq 0$.

Göttsche's conjecture involves observing enumerative properties of collections of curves in $\mathbf{P}^2$. Curves are 1-dimensional varieties, and in projective space, a *projective curve* is a just a homogenous polynomial in three variables. For example, the Fermat cubic defined above is a projective curve. From this point in this monograph chapter on, any curve will be assumed to be a

projective curve. Examples are $\{[x, y, z]: xy + yz + xz = 0\}$ and $\{[x, y, z]: x^2 - y^2 = 0\}$. It is worth noting that in the last example, not all of x, y, and z appear in the defining equation. It leads to an interesting question about the geometric differences between curves depending on their defining equations.

Given a pair of curves *(f, g)* with d_1 as the degree of *f* and d_2 as the degree of *g*, the pair is said to be *generic* (i.e., *f* and *g* are said to *intersect generically*) if *f* and *g* intersect in $d_1 \cdot d_2$ distinct points. Example: If *f*= $x^2 + y^2 - z^2$ and $g = x^2 - \frac{1}{2}y^2 + \frac{1}{3}z^2$, *f* and *g* intersect generically because they intersect in the $2 \cdot 2 = 4$ distinct points:

$$[1, \sqrt{8}, 3], [1, -\sqrt{8}, 3], \left[\sqrt{\frac{1}{8}}, \sqrt{\frac{8}{9}}, 1\right], \left[-\sqrt{\frac{1}{9}}, \sqrt{\frac{8}{9}}, 1\right] \in \mathbf{P}^2.$$

Given a generic pair (*f, g*) of curves, the *pencil* of curves spanned by f and g is $\{f + tg: 0 \leq t \leq \infty\}$. By definition, a pencil of curves is a collection of infinite curves, each curve being obtained by specifying a particular value of *t*. For another example, let $f(x, y, z) = x^2 + y^2 + z^2$ and let $g(x, y, z) = 3x^2 + 7y^2 - 8z^2$. We think of the pencil $\{f + tg: 0 \leq t \leq \infty\}$ as a collection of curves sitting inside of $\mathbf{P}^2$ with each value of t giving us a different curve. An example is the curve $4x^2 + 8y^2 - 7z^2$ when $t = 1$.

GÖTTSCHE'S CONJECTURE

To begin this more formal introduction of Göttsche's conjecture, an example is used. The formal statement of the conjecture can be found in Tzeng's work (Tzeng, 2010; 2012).

As in the previous example, let $f = x^2 + y^2 + z^2$ and $g = 3x^2 + 7y^2 - 8z^2$. Let $\mathrm{C} = \{f + tg : 0 \leq t \leq \infty\}$ be the pencil spanned by *f* and *g* in $\mathbf{P}^2$. Denote by C(t) the curve in C that is specified by a particular value of *t*. A natural question to ask is the following: For how many values of *t* does the curve C(t) have a nodal singularity? A curve is said to have a nodal singularity if there exists a point at which the curve crosses itself and looks like a pair of intersecting lines (see Figure 3). Algebraically, a function *h(x, y, z)* is singular at a point *p* if *h(p)=0* and the partial derivatives at p also vanish, i.e., $\frac{\partial(f+tg)}{\partial x}(p) = \frac{\partial(f+tg)}{\partial y}(p) = \frac{\partial(f+tg)}{\partial z}(p) = 0$; thus, a nodal singularity is just a particular type of singularity.

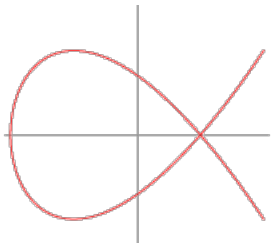

Figure 3: A nodal singularity

It turns out that the number of curves in C with nodal singularities, which will be called *nodal curves* for simplicity, is equal to 3 over the complex numbers, and the nodal curves occur when $t = \frac{-1}{3}, \frac{-1}{7}$, and $\frac{1}{8}$. One way to see that there are 3 nodal curves in this example is to recall that the original curves *f* and *g* intersect in four distinct points because *f* and *g* were chosen to

intersect generically. Since nodal singularities geometrically look like two lines, the question of how many C(t) are singular actually amounts to asking: How many ways can one draw two distinct lines through four distinct points? This can be done by hand, and the answer is 3. The ways to draw two lines through four points is illustrated below in Figure 4.

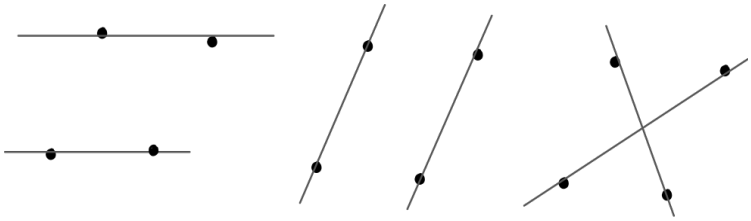

Figure 4: Pictorial depiction of 3 nodal conics in C

Another way to see that there are three nodal curves in $\mathrm{C} = \{f + tg : 0 \leq t \leq \infty\}$ for $f = x^2 + y^2 + z^2$ and $g = 3x^2 + 7y^2 - 8z^2$ is the following. For each value of t, the equation $f + tg$ defines a bilinear form with Gram matrix $[f + tg]$.

$$\beta(t): \mathbf{C^3} \to \mathbf{C^3} \text{ by}$$

$$(x, y, z) \mapsto ((1 + 3t)x^2, (1 + 7t)y^2, (1 - 8t)z^2,)$$

The nodal conics in C will correspond to the values of t for which the bilinear form $\beta(t)$ is singular. $\beta(t)$ is singular if, and only if, the determinant of $[f + tg]$ is equal to 0. Since $[f + tg]$ is a 3x3 matrix and f and g intersect generically, the determinant of $[f + tg]$ will be equal to zero for three distinct values of t. The conclusion is: There are exactly three distinct nodal curves in C.

Göttsche's conjecture in its original form states that given any two curves f and g of arbitrary degree on a surface, the

number of nodal curves in the collection {f+tg: $0 \leq t \leq \infty$} can be expressed as a polynomial in terms of *characteristic classes*, which are geometric invariants that can be computed algebraically (Göttsche, 1998). The previous two proofs were outlined to show that the number of nodal curves in $\mathrm{C} = \{f + tg: 0 \leq t \leq \infty\}$ for $f = x^2 + y^2 + z^2$ and $g = 3x^2 + 7y^2 - 8z^2$ do not work in general for a number of reasons. In the example, the work was shown under the restrictions that f and g were both degree 2; therefore, they only intersected in four points, and also that the surface was $\mathbf{P}^2$ (i.e., a surface is a 2-dimensional variety).

In general, the curves may have arbitrary degrees, so they may intersect in an arbitrarily large number of points, and the curves can be in embedded in any surface (i.e., not just $\mathbf{P}^2$). For any given example, one of the previously used two proof methods may work, but in general the numbers grow very quickly and neither is computationally efficient. A pictorial example of a pencil of curves is shown in Figure 5.

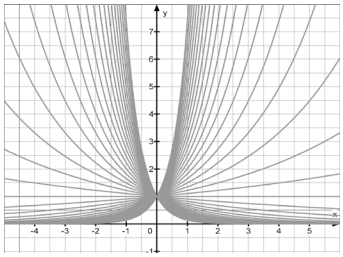

Figure 5: A pencil of curves

Tzeng proved Göttsche's conjecture in her 2010 doctoral dissertation, using techniques from topology (Tzeng, 2012). The number of nodal curves is not always 3, but it is finite and

computable by a polynomial in the *characteristic classes* of a variety called the incidence variety of the pencil. The incidence variety of the pencil of curves $\mathrm{C} = \{f + tg : 0 \leq t \leq \infty\}$ for any f and g is a sub-variety of $\mathbf{P}^2 \times \mathbf{P}^1$ whose points are pairs (C(t), t). Pencils of curves are complicated in general, and the incidence variety gives us a hands-on geometric object from which we can extract information about the pencil. In particular, the incidence variety encodes information and all the curves C(t) and how they "fit together" as t varies from 0 to ∞. The *characteristic classes* of a variety, or a topological manifold more generally, are algebraic invariants that encode enumerative information (Milnor & Stasheff, 1974). An introduction to characteristic classes in general and how Tzeng uses them is beyond the scope of this exposition, but they are generally computable and can be used to give a polynomial that computes the number of nodal curves in a pencil.

FURTHER WORK

Göttsche's conjecture is one example of many classical enumerative questions that is stated and proved over the complex numbers, **C**. Working over the real numbers, **R**, instead of **C** seems innocuous but poses many challenges. For example, consider the variety

$$\mathrm{X} = \{(x, y) : x^2 + y^2 + 1 = 0\}.$$

Over the real numbers, the equation $x^2 + y^2 + 1 = 0$ has no solutions. This is because solving $x^2 + y^2 + 1 = 0$ is equivalent to solving $x^2 + y^2 = -1$. Since any real number squared is a positive number and the sum of two positive numbers is positive, $x^2 + y^2$ must always be positive. In particular, $x^2 + y^2 \neq -1$ for any real numbers x and y; however, over the complex

numbers this equation has infinitely many solutions. The pair (i, 0) is a solution because $i^2 + 0^2 = i^2 = -1$, and so is (0, i). In this same way, one can find arbitrarily many solutions. So when the variety X is viewed over **R**, X has *no* points. Furthermore, when the variety X is viewed over **C**, x has *infinitely many* points. Any question about varieties that can be asked over **C** can be asked over **R**, but even in the most basic cases the answer probably will be very different.

The question of counting nodal curves in a pencil of curves is very different over **R** than Göttsche's conjecture. To illustrate the difference, let f and g be polynomials that intersect in the following four points:

$$b_1 = [1,0,0], b_2 = [0,1,0], b_3 = [1,1,i],$$

$$b_4 = [1,1,-i] \in \mathbf{P^2}.$$

For this explanation, we will call this set of four points B to simplify notation. Over the complex numbers, we know that the number of nodal curves in C= $\{f + tg: 0 \leq t \leq \infty\}$ is 3; however, because not all of the points in B are real (i.e., the last two points have imaginary components) there is a chance that not all of the pairs of lines that can be drawn through B are defined over **R**. A standard fact is that a line is real only if it is sent to itself under conjugation (i.e., changing of signs).

To count the number of nodal curves that are defined over **R** (i.e., which is the number of nodal curves that do not have *any* points with imaginary components) it is necessary to count the number of pairs of lines through the intersection points that are mapped to themselves under conjugation.

Note that b_1 and b_2 map to themselves under conjugation, b_3 maps to b_4 under conjugation, and b_4 maps to b_3 under conjugation. Just knowing where the b_i can be mapped under conjugation allows us to determine where the three pairs of lines are mapped under conjugation. Only one pair of lines, the first pair in the figure below, is mapped to itself under conjugation. This indicates that even though there are three nodal curves defined over **C**, there is only one nodal curve defined over **R**. Figure 6 shows how the pairs of lines are mapped under conjugation:

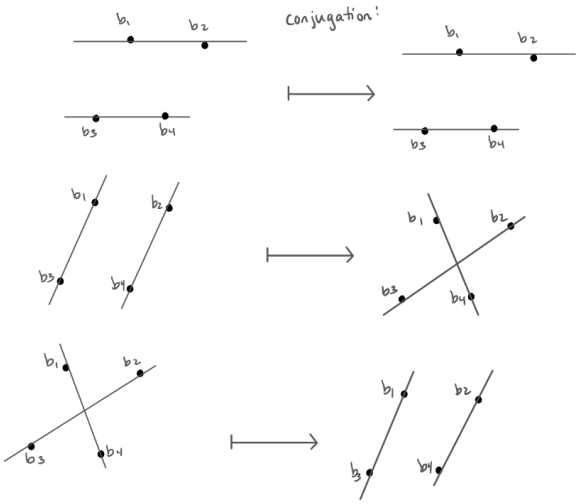

Figure 6: Pairs of lines under conjugation

There is a way to count nodal curves over **R** from nodal curves over **C**, but it requires a deeper knowledge of geometry than can be given in this exposition. Fulton's (1977) book, *Intersection Theory*, provides more details regarding nodal curves.

Just as one can ask how Göttsche's conjecture changes when asked over the real numbers, one also can ask how the conjecture changes over even more restrictive fields such as the rational numbers, $\mathbf{Q} = \{\frac{a}{b} : a, b \in \mathbf{R}\}$. Currently, the answer is unknown over arbitrary fields.

CONCLUSION

In this introduction to Göttsche's conjecture, which was proved by Tzeng (2010; 2012), definitions, explanations and illustrations were provided to provide readers assistance in understanding of this question over the real numbers using equivariant homotopy theory, a subject that can be thought of as the study of invariant properties under continuous deformation of spaces with a specified symmetry. In addition, I also have dealt with the question more generally for degree 2 curves. To answer the question for polynomials of arbitrary degree and for arbitrary fields such as **Q** or finite fields, an equivariant version of Tzeng's characteristic classes computation can be constructed using equivariant Milnor numbers. See Roberts (1985) for a summary of what is known for equivariant Milnor numbers.

Because polynomial models are applicable across so many fields of science and the solving of polynomial equations remain as a classic problem to be solved in mathematics (Sturmfels, 2002), it is hoped that the explanations, illustrations and examples in this introduction to Göttsche's conjecture will be helpful to aspiring mathematicians as well as others whose curiosity and basic knowledge is above the norm. Clearly, for those of us who aspire to teach, systematically creating this

explanation may be considered a worthwhile experience in preparation for my future career.

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A PROBABILISTIC FRAMEWORK FOR ASSESSING DRIVING PERFORMANCE

Jonathan C. Rann

Department of Psychology

We live in an environment that is rich with information. It is so rich, in fact, that people have built in cognitive functions that help us to ignore distracting information while focusing on relevant information, particularly when carrying out a task in changing circumstances (Young & Regan, 2007). This is especially true for complex tasks which demand constant attention, such as driving. Although driving helps people to get to where they need to go in a timely and efficient manner, the National Highway Traffic Safety Administration (NHTSA, Undated) affirms that the consequences of being inattentive to the road can be disastrous.

In order to help make navigating the roads safer and more intuitive, informative cues of major events are placed in the path of the driver under the auspices of the NHTSA and a variety of state government entities. These cues often are presented as street signs that indicate upcoming stops, hazards, curves and other conditions (e.g., events) further down the road. When an informative cue is encountered while on the road, it is intended for drivers to react by adjusting driving behavior to accommodate for the upcoming event. This reaction can be modeled from a Bayesian perspective (e.g., van Hinsbergen, van Lint, Hoogendoorn & van Zuylen, 2009). Using this perspective,

drivers' reactions can be defined as, and measured by, the differences between their prior and posterior beliefs regarding the probability that cues, which they observe in the driving environment, are accurately predictive of the event that they preclude.

Safe and successful driving often relates to the amount of attention the driver gives to the task at hand. While driving, attention must be split between the physical act of operating a motor vehicle (e.g., including observing the behavior of other drivers on the road) and maintaining awareness of obstacles in the driving environment (e.g., road signs, weather conditions and pedestrian behavior) (Young & Regan, 2007). Depending on new information that is made available, Young and Regan indicate drivers also must be able to switch between passively observing and aggressively reacting to certain obstacles and events. They also concluded that because of the repetitive and expected events learned in the driving environment, many aspects of driving often become automated with experience. Young and Regan also note that this automation results in the ability of drivers to divide their attention between concurrent tasks without seriously deteriorating their driving performance. Furthermore, this ability comes at a cost. When a driver's attention is stretched too thin, it can be compromised, resulting in lower driving performance and a subsequent increase in the probability of encountering negative consequences (e.g., collisions, speeding tickets, etc.). For almost twenty years, studies of the problems of distracted driving have been conducted (e.g., Strayer & Johnston, 2001); yet, it is unclear whether such research has impacted the problem in any substantive way.

Clearly, in addition to maintaining attention on navigating the road, drivers also must be attentive to the road signs, which provide them with information about road conditions further down the road. Written tests administered in all states contain questions that evaluate potential drivers' knowledge of road signage (National Driving School, 2011). There are a variety of signs used to inform drivers, with some of the more common ones include stop signs and speed limit indicators (Horberry, Anderson, Regan, Triggs, & Brown, 2006). The consequences of not properly adhering to the road signs vary greatly; therefore, it is important for signs to be informative and predictive of upcoming events in the road. For instance, drivers are required legally to adhere to speed limit signs that set maximum and/or minimum speeds for safety reasons. Consequences for not maintaining the indicated speed limit can result in being ticketed by a law enforcement officer or causing a traffic accident. Additionally, other signs alert drivers to physical qualities of the road ahead, such as signs warning of upcoming curves and turns (Charlton, 2007). Just as with all other road signs, failure to adhere to these types of signs can lead to various negative consequences.

When presented with informative road signs, drivers choose how to react, which is not a single-task decision. Driving decisions often are quite complex, and dual-task studies were evident in driving research more than 15 years ago (e.g., Strayer & Johnston, 2001). Clearly, part of this and other studies (e.g., Strayer, Drews, & Johnston, 2003) of drivers' reactions involves the physical operation of the vehicle to adjust for the indicated upcoming road event, while the other part is the time that it takes to make that adjustment (i.e., reaction time). With regard to

driving and road signs, reaction time is the time a driver takes to react to a presented road sign (i.e., cue) (Lee, Lee, & Ng Boyle, 2009). The cue indicates the upcoming event, such as a left or right curve in the road, and the driver reacts accordingly. More specifically, in the case of a left curve event, the drivers are predicted (and expected) to slow their speed and drive closer to the side of their lane furthest from the curve. What adjustments are made, and how they are made differs from person to person. For example, some people may slam their brakes quickly to adjust for an upcoming curve, while others may slowly decelerate. Some drivers may maintain driving performance, while some may not. The reason for these differences could be due to factors related to reaction time, such as decision-making processes and driver cognitive load (Almor, 2008; Strayer & Johnston, 2001). Another reason involves drivers' anticipation of events given their prior experience.

Levels of anticipation are important characteristics that may help drivers to automate some aspects of their driving behavior (Stahl, Donmez, & Jamieson, 2014). Generally, familiar events indicated by predictive cues are not regarded as causing an increase in cognitive load for the driver. For instance, when drivers see a sign indicating *Sharp Curve Ahead*, they would likely slowdown in anticipation and preparation for the upcoming sharp curve with little effort. This anticipatory behavior can be due to many factors, such as drivers' experience with a particular sign, and their belief in the accuracy of the sign. In recent research, highly experienced drivers were able to interpret cues correctly and take appropriate anticipatory action, which was associated with "high mileage driving and longer years of licensure" (Stahl, Donmez, & Jamieson, 2014, p. 611).

Hazard perception (HP) is noted as an important aspect of driving behavior (Jackson, Chapman, & Crundall, 2009), and HP research with safety implications continues using driving simulator data collection (e.g., Crundall, et al., 2012; Crundall, 2016). Of course, experience typically is linked to drivers' anticipatory behavior due to such things as drivers' knowledge of the consequences of not heeding a sign or cue as well as the probability that they may encounter one or more of those consequences.

Regardless of what the driver anticipates, there are many instances in which drivers encounter unexpected events some of which may be related to perception of road hazards. Certainly, unexpected or unanticipated events are considered just as important to driving as expected events, and they represent risks that may require more of a driver's attention when encountered. The term *Surprise* has been used to explain these effects (Itti & Baldi, 2009).

Surprise is a well-understood concept, which can take many forms (e.g. novelty, saliency and level of expectation), and it can relate to a wide variety of concepts, including associative learning (Waelti, Dickinson, & Schultz, 2001) and driving reaction time (e.g., Crundall, et al., 2012). Surprise is even considered to be an important mechanism in neuroscience, sensory processing, attention and learning (Itti & Baldi, 2009). For example, within the environment of the driver, introduction of certain unexpected events may cause a driver to be "very surprised," such as when a pedestrian suddenly runs into the path of the driver's car. Other events, such as light rain, may elicit a "small amount" of surprise. What exactly constitutes a surprising event? Surprisingly, there appears to be a lack of

computational and theoretical understanding of the concept (Itti & Baldi, 2009). Itti and Baldi investigated the concept of surprise from a Bayesian perspective, defining it as the measure of distance between what one believes before and after an event given one's assumptions about the world.

Additionally, Itti and Baldi viewed surprise as a measure of how data affects an observer. Definitions of *surprise* seem to indicate that (a) it can only occur when the observer is uncertain, and (b) it is dependent on the perspectives of each individual and his or her assumptions about the world. What this means, in general, is that the same data can cause varying amounts of surprise for different observers; it also means that the same data can cause varying amounts of surprise to the same observer, given the right circumstances. Importing this idea into the world of driving can lead to a better understanding of driver reaction to the cues and events in the driving environment. One example is what occurs when a driver encounters a *right turn* after encountering a sign indicating that a *left turn* was ahead on the road. Does the driver hesitate to act, or smoothly correct for the new information? What occurs when there is an absence of cues in the driving environment? Regardless of the specifics of each scenario, each one hints that drivers' reactions are based upon the difference between their prior and posterior beliefs about the driving environment, which may further hint that how drivers respond to surprise may fit a Bayesian framework of probabilities. This framework has been applied in previous research relevant to operating vehicles (e.g., Molenaar, 2014; van Hinsbergen, et al., 2009).

A PROBABILISTIC APPROACH TO COMPLEX REACTIONS OF DRIVERS

In the Bayesian framework, probabilities correspond to subjective degrees of beliefs in hypotheses (Gopnik & Wellman, 2012). These beliefs are updated as data are acquired using Bayes theorem as the fundamental tool for transforming prior belief distributions into posterior belief distributions shown below (1):

$$P(H|E)\ \alpha\ (P(E\,|\,H)P(H))) \qquad (1)$$

This theorem describes the probability (*P*) that a hypothesis (*H*) generated the evidence (*E*) that is observed, or *P*(*H*/*E*). Given this formula, it should be noted that the *P*(*H*/*E*) is proportional to *P*(*E*/*H*) and *P*(*H*); meaning that the probability that a hypothesis generated a pattern of evidence is proportional to the probability of evidence given the hypothesis and one's initial estimate of the probability of the hypothesis (Gopnik & Wellman, 2012). Each part of this equation has a standard name: (a) the probability of a hypothesis once the evidence is considered, or *P*(*H*/*E*), is called the *posterior*; (b) the probability of encountering observed evidence if the hypothesis is in fact true, or *P*(*E*/*H*), is the *likelihood*; (c) and the probability of the hypothesis before evidence was observed, or *P*(*H*), is the *prior*. Gopnik and Wellman apply the standard names to Bayes rule, which can be stated as the *posterior* being a function of the *likelihood* and *prior* as shown below (2):

$$(Posterior)\ \alpha\ (Likelihood\ x\ Prior) \qquad (2)$$

Bayes rule, in fact, can be applied to the driving scenario that has been discussed since the driver is an agent who acts on the variable driving environment. Of course, drivers can accelerate or decelerate the vehicle, and they can stop the vehicle

altogether if desired (or needed). Drivers also interact with one another on the road, as each agent (i.e., driver) has a role that he or she plays within his or her interaction platform (i.e., within traffic at any given time, during the journey from start point to destination).

Readers who are unfamiliar with Bayesian inference may find it helpful to read a simple explanation of the basic concepts of Bayesian inference that are presented in an online publication titled *Seeing Theory* (i.e., Chapter 5), which is a prize-winning project developed by Brown University's Daniel Kunin (2017). "Bayesian inference techniques specify how one should update one's beliefs upon observing data," (Kunin*, Seeing Theory*, Chapter 5, para. 1). This visually presented e-book introduction is followed by an explanation of Bayes' Theorem using an example illustrating its use in everybody's life (i.e., receiving a medical diagnosis). One way of interpreting Bayesian inference is as subjective degrees of belief, and this can be a helpful approach to studying driver behavior. In fact, Xie, Hongbo, Huang, Qian, and Wang (2018) recently published a driving behavior awareness model based on Bayesian inference methods. They studied three driving behavior awareness (DBA) models and concluded that the model in which their distributed genetic algorithm was used to optimize the structures in the Bayesian models being studied produced the best results. Additional explanations of use of Bayesian inference concepts is available online (e.g., Brooks-Bartlett, 2018; Kunin, 2017).

CONCLUSION

Based on national statistics regarding increased highway fatalities and the problem of increasing numbers of distracted

drivers (NHTSA, Undated; Young & Regan, 2007), it seems clear that the main ideas from Bayesian inference that may be applied to studies of driver behavior as discussed within this monograph chapter include: (a) driver belief based on observed evidence, (b) driver hypothesis updating, and (c) informative cues of varying predictability. In related proposed research addressing driver behavior, surprise can be defined in Bayesian terms as the difference between driver prior and posterior beliefs regarding cue predictiveness (Itti & Baldi, 2009), which can be measured from the high temporal resolution data output obtained from a driving simulator. Use of Bayesian constructs such as belief updating and surprise factors, perhaps, may elucidate reaction mechanisms in drivers that will reveal meaningful data.

Considering related research involving probabilistic approaches to measuring driving performance, this author supports using a Bayesian inference kind of framework for future studies of complex driver behaviors that may help to improve overall driver safety. Of course, the usefulness of such an approach could have implications for driver training and perhaps even future changes to warning signs and alerts. It seems clear that a Bayesian framework for studying continually changing complex driving behaviors that involve driver distraction could have potential for positively impacting highway safety statistics as well.

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PART 3:

College of Education

CRITICAL THEORY PEDAGOGY IN COUNSELOR EDUCATION

Anthony T. Carr

Department of Educational Studies

In developing and using a personal method of pedagogy (i.e., teaching and supervising clinical practice) in counselor education, it was essential to answer a foundational question. What is the purpose of education? The debate on this question seems never ending (Strauss, 2015). When I was younger, I would have responded that the purpose of education was to get a good job and to make money, which is a prevalent belief among American parents (Slapik, 2017). Education, it seems, cannot guarantee either outcome, since many recent college graduates are unable to find employment and, as a consequence, return to living with their parents after graduation (Goodman, 2015). Conversely, many American billionaires never completed a college education (Bertoni, 2012).

Some may say that the purpose of education is to help people think; however, research seems to show that even that goal is elusive. Too often, secondary education is based on a system that rewards the memorization of rote facts and figures with little concern given as to whether students learn the material (Orlin, 1998). Also many top achieving students, who may spend hours studying hard for tests, cannot access the information after the examination. This failure may be due to students' need to retain a vast amount of material coupled with a low probability of

seeing this information again. Some students learn the tricks of test taking and do well on tests but are able to do a minimum of studying (Belleck, 2011).

One of my good friends in high school was the valedictorian of our class. He never earned a grade lower than a 4.0 during his entire high school career. I asked him what his secret was. It turns out that he had an eidetic memory (i.e., once he read something, he could quickly answer any question on a multiple-choice test or essay or any platform an instructor could give him). He still had to work very hard, because if he did not read the material, he would not have been able to access it later. He never had to struggle in high school; however, he mostly stayed quiet in literature class discussions because knowing the words of Hamlet and interpreting Hamlet are two different skills.

Students like my friend and those mentioned earlier actually benefit from a grading system where they are rewarded for mastery of the facts. Of course, when test scores, rather than critical thinking are rewarded, it is necessary to ask questions about the nature of learning. A primary question is whether learning is memorizing for the exam or understanding the material.

In a recent comprehensive review of all refereed journal articles published by the American Counseling Association (ACA) and its divisions from 2001-2010, 230 articles were identified as containing content related to pedagogy (i.e., teaching and learning; Barrio Minton, Wachter Morris, & Yaites, 2014). Over that decade of professional counseling publications, Barrio Minton and colleagues identified only 9.13% (n=23) of articles that dealt with any pedagogical practices. Articles focusing on the processes of teaching and learning in general

were even more rare (6.52%, n=15) even though the Council for Accreditation of Counseling and Related Programs (CACREP) was in the process of changing some of their national standards particularly as they relate to evaluation of student learning (e.g., CACREP, 2009), which could reflect whether counselor education practice is focused on the students being "vessels" into which knowledge is poured, or whether they are active learning participants (i.e., becoming *thinkers* who are active participants in problem solving). In their process of determining whether publications were grounded in educational research or learning theory, Barrio Minton, et al. (2014) identified Freire's liberation pedagogy as one of many categories for which they searched in their literature review. They found only 14.78% (n=34) of the articles in the field of counseling had a clear grounding in either instructional research or learning theory. Of course, in developing my own approach to becoming a professional educator in the field of counseling, it seemed essential to pursue a learning theory and research-based path that also addresses communication and diversity issues; therefore, I returned to my study of Paulo Freire's (1968) liberatory pedagogy.

In his critique of the educational system, Freire (1970) rejected the model where students were considered as merely recipients of knowledge and were not required to participate actively in their own education. He called this a "banking model" of education, using the metaphor of students as vessels into which knowledge is poured (Freire, 1968). In addition, Freire critiqued the system for requiring students to be compliant in order to receive knowledge and to become successful. Of course, obedient students become compliant employees of the workforce (Picower, 2011); however, Freire believed that both

students and instructors have something to offer in the educational system (Aubrey & Riley, 2016). According to Freire, the purpose of education is not to get a good job with high pay. Instead, it is to positively transform society, provide a space for students to challenge their presuppositions, and to learn to think critically. Such an approach, which was stated as beneficial to employers and for society (Freire, 2016), also seemed important to consider from the perspective of a developing counselor educator.

CRITICAL PEDAGOGY

Freire's writing was translated from Portuguese and difficult to understand from an American perspective, but bell hooks'[1] writings, such as *Training To Transgress* (1994) and the rest of her critical pedagogy trilogy, which includes *Teaching critical thinking: Practical wisdom* (2010), are helpful to assist Americans in understanding Freire's (2016) critical pedagogy. She emphasizes the importance of building community in the classroom and of introducing an African American and a feminist perspective. She also highlights the importance of using non-oppressive language in educational applications (hooks, 1994).

In my personal interpretation of critical pedagogy, power must be shared to reject the traditional *banking* view of education. Instructors must give up their role as the arbiter of all truth and allow students to bring their own experiences into the classroom. Due to their limited knowledge or experience,

[1] bell hooks is the pen name of Gloria Watkins, a famous African American feminist writer. She writes her pen name in lower case and after looking at many articles in APA referencing her, they continue to use lower case in the body of the papers and in the reference sections.

sometimes instructors must challenge students' beliefs in erroneous information. While facts typically are not debatable, if students question the facts, it is the role of the instructor to facilitate student growth and lead them to resources to help them gain more complete knowledge; however, there is always room for discussion and dialogue when a well-worn truth may have subsequently been proven false or at least it's veracity may be up for debate. In such processes, both teaching and learning become an interconnected, dynamic process (Rodriquez, 2008). This kind of discussion can be a time in which critical learning can happen.

Freire discusses three ways to encourage critical thought, identifying generative, topical, and academic themes (Shor, 1992). Generative themes come from students' experiences and can introduce a topic that students then are asked to address. This theme is instrumental in fostering critical discussion. Topical themes are issues of social importance, but they come from the instructor's perspective. Instructors would need to ensure that the theme comes from a mutual understanding with students to avoid disrupting the power dynamics that are followed by critical pedagogy instructors. The academic themes come from formal bodies of knowledge or from experts in the field.

Critical pedagogy is considered a mix of critical sociology and social construction, which Kincheloe (2005) refers to as critical constructionism that connects knowledge to power. Critical sociology includes questioning societal norms, which can demonstrate a need for social change; while social construction refers to ideas that are accepted by a society to mean one thing when they may mean different things to different people. In other words, it is important to understand that what may be believed by the larger society actually may not be real,

but the implications of these beliefs certainly are real. One example that this type of belief exists is evident with regard to *race*. Race is a social construct rather than a scientific fact (Smedley & Smedley, 2005). Even considering external cosmetic differences, all humans are of the species *Homo sapiens*. Race is a construct that society has imposed on *Homo sapiens*. Racism, a by-product of the social construct of race, is real. It has had real-life implications for all races but particularly negative ones for people designated as members of non-White groups (Smedley & Smedley, 2005). In fact, racism has such powerful societal and cultural norms that it has impacted every aspect of American culture (M. L. Bryan, October 26, 2017).

In critical pedagogy, the instructor would take on the role of "educator advocate" to help students become aware of their own racism—their biases and misconceptions. Using these concepts, instructors provide an environment for growth through dialogue and through challenging misconceptions and flaws in logic.

Part of this critical discussion is to acknowledge gender, race, sexual orientation and expression, national origin, and other areas of diversity. The conversations may be difficult at first, but they could bring insight and subtlety that might be missed when only the dominant culture's point of view is understood (Allen, 2004). The purpose is not to discredit or bury the voice of the dominant culture (Leonardo, 2002). Rather, the purpose is to lift voices not usually heard, insuring that different perspectives are included for a more substantial and productive discussion.

A question also must be asked—Does critical pedagogy work on homogeneous or predominantly white campuses or programs (Sleeter, 1995)? Many people of color and cultural minorities learn to understand their own culture as well as the

dominant culture to be successful, and this exposure to cultures besides their own benefits white students by broadening their perspectives as well. Challenging the dominant culture must be done with sensitivity and care for students to grow through this new experience (Allen & Rossatto, 2009).

INSTRUCTIONAL METHODS

The choice of critical pedagogy as the basis for instructional methods in counseling graduate programs made sense to me because the goal for counselor educators is to develop reflective practitioners who use what they have learned to address complex cognitive processes in their work (i.e., metacognition's importance in learning, Nelson & Narens, 1994; Mazzoni & Nelson, 1998). Furthermore, it seems particularly important for learning at the doctoral level. Professional standards for the preparation of doctoral-level counselor educators (CACREP, 2009) recently were updated/expanded in the area of teaching (i.e., CACREP, 2015) from six to ten standards, which now include the word *pedagogy* as well as relevant "instructional, design, delivery, and evaluation methods" (p. 39), mentoring, and "assessment of learning" (p. 39). Although the changes seem minimal, counselor educators should engage in specific strategies that fully engage students in their learning to be effective; thus, adapting the principles of Freire's (2016) critical pedagogy can enable counselor educators, especially those teaching doctoral students, to increase their effectiveness. Most importantly, to implement these kinds of procedures a high level of trust and safety is needed in the classroom. Orlin (1998) indicates that such trust begins with asking students to establish their own ground rules for a safe environment when teaching

methods include personal sharing. The material that follows is my own application of critical pedagogy in counselor education learning settings.

Since critical theory is based on discussion and dialogue, class participation must be part of the student's grade. To be implemented properly in courses, this requirement should be in the syllabus and stated clearly on the first day of class. To be consistent with this approach, students should have opportunities to express their individual points of view whether instructors use a full class discussion, small group discussion, or individual presentations.

One of the first assignments in beginning a course would be to have students tell their own stories from the perspective of the course in which they are enrolled. For example, students enrolled in a research course would discuss their experience with research. They would also consider issues they do not want to face and those they want to learn more about (Shor, 1987).

Guiding questions will need to be provided in advance and will be a part of every class session. In this way, students who are introverted or who need more time to process ideas will have an opportunity prepare for the discussion. The instructor would ask questions to help students go deeper rather than simply giving "the right answer" because there is no single "right" answer. Typically, the instructor would acknowledge during the first day of class that this procedure might be new to some students but learning to dialogue is part of the educational experience (Rodriquez, 2008). Freire (2016) calls this critical dialogue *concientizacao* (i.e., coming to conscientiousness through the practice of integrating personal reflection with critical theory). Certainly, instructors can choose a liberating

educational approach that rejects the status quo and the "banking" model of education for Freire's (1970) problem-solving approach in which both students and instructors develop their critical conscientiousness that power dynamics in society impact some groups more favorably than others. Rather, the instructor can create a learning environment in which knowledge is posed as "a problem for mutual inquiry" (Shor, 1992, p. 33); therefore, students are involved through a dialogue in which they are encouraged share personal experiences that are related to the things they are learning.

Instructors may wish to connect theory to the present by addressing topics in the news that may have an impact on the subject matter. It is important that each class session be 60% discussion and 40% presentation of new material or review of reading material. Readings would come from textbooks, relevant articles and supplemental material to give students perspectives from diverse populations. In some classes, students will be assigned readings from opposing points of view in which they will struggle with both sides of the issues and then articulate their own perspective. For some discussions, special guests may be introduced to give real-life examples of views not found in students' books.

ASSESSMENT OF STUDENT LEARNING

Most universities have guidelines on student learning assessments, and those instructions must be respected and used. In addition, student assessment would be based on the student's ability to develop a comprehensive understanding of the teaching materials. This understanding would come through students incorporating the feedback from reflection papers and essays as

well as their growth from class conversations. Rubrics will define the differences between excellent, good, fair, and unsatisfactory work. To assess growth the instructor observes student reactions based on a number of factors (e.g., how a student accepts feedback) and notes differences between participation at the beginning of classes and at the conclusion of the classes.

CONCLUSION

A search of the literature covering the last 15 years (i.e., updating Bario Morris, et al., 2014) revealed that of 133 articles with content on teaching and learning in the last five years, only nine articles have been published on pedagogy in counselor education journals (Barrio Morris, Wachter Morris, & Bruner, 2018). Clearly, a need exists for increasing research related to pedagogy in counselor education. My use of Freire's (2016) critical pedagogy in the classroom has provided some fruitful conversations but also includes frustration in pushing students to move away from the *banking* model of education. More is expected of students in critical pedagogy, but more also is expected from an instructor as an educator (Shor, 1987). This teaching approach requires that students know more than the content of the material; they must interact with the material. Such an approach addresses the need in higher education for promotion of inclusivity and diversity in pedagogy, especially at the graduate level (Danowitz & Tuitt, 2011). In conclusion, it is important for me to continue with conducting research in this area and developing ways to incorporate critical pedagogy into teaching graduate students about counseling and the teaching and supervision processes.

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PART 4:

College of Hospitality, Retail and Sport Management

INTEGRATING LIFE COURSE PERSPECTIVE AND FUNDAMENTAL CAUSE THEORY TO EXAMINE ATHLETE CAREER TRANSITIONS: A CONCEPTUAL FRAMEWORK

Victor D. Kidd

Department of Sport and Entertainment Management

Sport retirement and career transition have received empirical and theoretical attention in professional literature over many years (e.g., Allison & Meyer, 1988; Ballie & Danish, 1992; Beamon, 2012; Kuettel, Boyle & Schmid, 2017). The majority of this literature has been situated in Olympic or elite athlete research settings, while research in college sport settings has failed to garner the same attention (Erpič, Wylleman, & Zupančič, 2004; e.g., Eisenberg, 2013; e.g., Werthner & Orlick, 1986). Previous literature examining sport retirement within "big-time" college-sport research settings has focused on the individual risk factors that are present during athlete career transitions (e.g., Senecal, 2017; Singer, 2008), with most inquiry neglecting other fundamental causes or macro-level influences that potentially affect healthy athlete career transition outcomes (Beamon & Bell, 2011; e.g., Murphy, Petitpas & Brewer, 1996; e.g., Raabe, Zakrajsek, Bass, & Readdy, 2017).

When narrowing the research focus to revenue-generating black college athletes (e.g., Southall & Weiler, 2004), there has been minimal exploration of external factors that affect their career transition experiences. Such neglect of college athletes, who are more likely to belong to vulnerable populations, while

placing a premium on athletic pursuits, can become problematic for the individual college athlete, college sport leagues (e.g. NCAA, NAIA), colleges and universities, and the communities that former college athletes re-enter once their sport eligibility is exhausted. In addition, most transition research is Eurocentric (Ryba & Schinke, 2009). Furthermore, in career counseling literature, which includes career transition research, it not only is labeled Eurocentric but referred to as an unethical approach to research (Brown, 2003); thus, all such transition research neglects to offer diverse techniques for studying black college athletes.

The aim of this paper, therefore, is to examine literature related to investigating the differences in sport retirement and transition experiences between white non-revenue generating and black revenue-generating college athletes. Additionally, this conceptual framework examination is intended to establish a call to apply a life course perspective to examine the sport retirement of college athletes, to contextualize risk factors, and to identify fundamental causes that adversely affect athlete career transitions (Erpič, et al., 2004; Murphy, et al., 1996).

RESEARCH SETTINGS

Recent media accounts have chronicled former college athletes' transition experiences (Chadiha, 2012). Showtime's depiction of University of Nebraska's running back, Lawrence Phillips difficulties, *Running for His Life: The Lawrence Phillips Story* (Greenburg, 2016), personified parental neglect, impaired behavioral health, disappearance of social stature, and increased suicidal ideation, resulting in a traumatic post-athletic career

transition (Kerr & Dacyshyn, 2000). Such traumatic experiences led to Phillips committing suicide in 2016 while serving a 31-year prison sentence for felony assault with a deadly weapon and domestic assault while facing additional murder charges (Breech, 2016; Brown, Glastetter-Fender & Shelton, 2000).

While anecdotal accounts like that of Phillips garner wide-spread attention, transitional difficulties of most former college athletes historically are unreported or under-examined (Coakley, 1986; Link & Phelan, 1995) and apparently continue to garner little attention in professional literature as well. Furthermore, this account of Lawrence Phillips' individual challenges incorporates fundamental causes that affect his life course trajectory and career transition, invoking another important question. How can sport retirement research examining college athletes encompass concepts of the life course perspective and the fundamental causes of transition outcomes through empirical inquiry?

The *big-time* college sport industry (Coakley, 1986; Frey, 1982) provides a unique setting in which post-eligibility transitions involve younger retirees, and—in the case of college athletes—individuals who often have faced personal alienation and isolation within their work settings (Southall, Eckard, Nagel, & Randall, 2015). Consequently, revenue generating college athletes, often black, are at heightened risk of experiencing transitional difficulties than their white non-revenue generating athlete counterparts (Park, Lavallee, & Tod, 2013; Stambulova, Alfermann, Statler, & Côté, 2009; Wylleman & Reints, 2010).

Acknowledging previous literature that examined athletic career transition (e.g., LaMonica & Baumbach, 2012; Schulz & Northridge, 2004; Singer, 2008), authors provide new perspectives in examining sport retirement and athlete career

transitions; however, the intent of this author's review is to focus on big-time college sport retirement and athletes' career transitions by implementing Link and Phelan (1995) and Phelan, Link, & Tehranifar's (2010) *fundamental cause theory*, along with the Elder, Jr, Johnson, and Crosnoe (2004) and Settersten's (2015) *life course perspective*. After discussing previous sport retirement and athlete career transition literature with summaries of these two theories and their integration into an expanded conceptual framework proposed for future research, this monograph chapter concludes with theoretical and practical implications focused on better understanding of the sport retirement and transitions of all athletes.

REVIEW OF RELATED LITERATURE

Sport Retirement and Athlete Career Transition

Researchers have examined the athletic-career transitions of former elite Olympic athletes (e.g., Eisenberg, 2013), female gymnasts (e.g., Keyes, 2003), soccer players, and alpine skiers (Kuettel, et al., 2017). Building upon Adler and Adler's previous work (1989, 1991), Beamon (2008, 2012), Beamon and Bell (2011), and Cummins and O'Boyle (2015) recently have examined former black, revenue-generating college athletes' career transitions. They found that due to a focus on high-level sport participation from a very young age, many of these athletes are not prepared for successful post-athletic transitions, and are not invested in non-sport career aspirations. When examining white non-revenue generating athletes, Allison and Meyer's (1988) results indicated that white participants found transitions were less traumatic and viewed the transition as an opportunity

to re-establish themselves in more positive social roles. Furthermore, it is theorized that escalation of the athletic role to a position of prominence can hinder college athletes' ability to experience a successful post-eligibility transition. In addition to being role engulfed (Adler & Adler, 1991), if former college athletes are inadequately prepared for a life after sports, they may be more likely to experience difficulties while constructing their new non-athletic identities (Beamon, 2012).

Decades ago, Schlossberg (1981) defined a transition as "an event or non-event, which results in a change in assumptions about oneself and the world and requires a corresponding change in one's behavior and relationships" (p. 5). Transitioning out of college sports can be difficult for college athletes who are unwilling or unable to modify their attitudes and perceptions about retirement and to develop alternative career aspirations (Adler & Adler, 1991; Beamon & Bell, 2011). The end of a college athlete's career can be especially challenging, particularly if an athlete has lower academic attainment, insufficient social development, and unsustainable occupational skills (Adler & Adler, 1991; Coakley, 1983, 1986; Frey, 1982); as Coakley (1986) notes, the ending of athletic participation has many retirement elements, since it is a "process of transitioning from participation in competitive sport to another activity or set of activities" (p.1). In addition, retiring from competitive sports is often abrupt, regardless of whether it is involuntary (e.g., significant injury or de-selection/getting dropped from a team) or voluntary (e.g., deciding to explore other opportunities or aspirations or just wanting to stop competing). For a college athlete, retirement marks the beginning of a transition from a highly competitive and visible existence to an uncertain future, often devoid of a

clear career path (Baillie & Danish, 1992; Blinde & Greendorfer, 1985; Taylor & Lavallee, 2010).

Extending Adler and Adler's (1991) *athletic role engulfment* framework, Beamon (2012) utilized the concept of *identity foreclosure,* and Cummins and O'Boyle (2015) similarly used the *human adaption to transition model* (i.e., Pearson & Petitpas, 1990; Schlossberg, 1981). These recent studies actually extended Singer's (2008) work on the benefits and detriments of athletic participation among former black Division I Football Bowl Subdivision (FBS) players. Both Cummins and O'Boyle (2015) and Singer (2008) identified athletic devotion and performance expectations as resulting in an imbalance between academic and athletic roles among college athletes, with these imbalances being exacerbated by university athletic departments that neglect to support current and former college athletes in addressing their resulting athletic career transition difficulties. Consistently, Division-I FBS and men's basketball players have been found to experience difficult athletic career transitions, which can negatively affect their quality of life after athletic participation has ceased (Beamon, 2012; Beamon & Bell, 2011; Edwards, 2000).

Beamon and Bell (2011) indicate that many of their study participants expressed "feeling depressed and reported feeling a loss liken [sic] to personal death, the loss of a body part, or the loss of a family member" (p. 41) and also expressed social alienation because of a "loss associated with [no longer] being an athlete" (p. 41). Beamon and Bell identified that a lack of career preparation by former college athletes hinders their progression, but they failed to collect data on specific factors that might contribute to these athletes' unpreparedness for athletic career

transitions (e.g., parents' educational attainment level and hyper-socialization with their *athletic role* as an adolescent) as well as the family's socioeconomic status (SES) prior to the student athlete's college enrollment. Furthermore, the aforementioned studies explore individual factors that impact athlete career transition but neglect to examine some other macro-level influences of sport retirement experiences (Beamon & Bell, 2011). Researchers apparently believe applying concepts from fundamental cause theory to inform the life-course perspective is an appropriate lens by which to examine athletic career transition differences between white non-revenue generating and black revenue generating college athletes.

Successful Athletic Career Transitions

While Cummins and O'Boyle (2015) determined conceptual underpinnings for successful athletic career transition, successful athletic career transition is still somewhat subjective. Knights, Sherry, and Ruddock-Hudson (2016) conducted a systemic review of elite athletic career-transition and introduced the term *flourishing* to explain characteristics of individuals who experienced a successful athletic career transition. Knights, et al. also noted that individuals who display characteristics associated with *flourishing* are optimistic about their lives, experiencing psychological and social well-being. Individuals who experience successful transition perceive their transition as normative (i.e., expected; Stambulova, et al., 2009), which can lead to a former college athlete deeming this personal transition as successful. To operationalize the definition, Knights, et al. (2016) explained that a flourishing individual will possess the following attributes: Positive emotions, engagement/interest, meaningful purpose,

self-esteem, optimism, resilience, self-determination, and positive relationships. The attributes introduced by Knights, et al., as well as Adler and Adler's (1991) athletic role engulfment, offer parameters that help conceptualize an empirically elusive phenomenon: Athletic career transition.

Fundamental Cause Theory

Initially used to examine the association between socioeconomic status (SES) and mortality, the fundamental cause theory was included in this review for two reasons: It is (a) an interpretive framework to examine the reasons people are exposed to certain risks and protective factors and (b) to establish the social happenings in which risk factors are incubators for disease (Link & Phelan, 1995). Within the context of college sport and sport retirement, risk factors can include mental health challenges (Beamon & Bell, 2011), lack of psychosocial support (Edwards, 2000), negative perceptions of the sport retirement and athlete career transition experiences (Adams, Coffee, & Lavallee, 2015), and hyper-socialization with sport-related identity or activity (Beamon, 2012; Elder Jr, et al., 2003).

Introduced by Link and Phelan (1995), the fundamental cause theory is comprised of two guiding tenets, contextualizing risk factors and fundamental causes. Applying the framework to examine the relationship between SES and mortality, Link and Phelan proposed that individual behaviors should be conceptualized within the context in which a person operates. In addition, contextualization is positioned to provide understanding and awareness of individual health behaviors and life circumstances that can shape a person's exposure to risky health

behavior, while accounting for the sociocultural and socio-economic factors conducive to risky health behavior. Of course, understanding the importance of contextualizing risk factors, without consideration of the context of environments, actually places the responsibility solely on an individual's micro-level risks, neglecting other macro-level risks that also affect health behavior.

Along with contextualizing risk factors, Link and Phelan (1995) define fundamental causes as social conditions that are responsible for the presence of disease. Succumbing to the intersectionality of political, historical, and sociocultural factors, fundamental causes are stubborn and persistent in sustaining healt-risk factors while serving as a barrier to protective factors against negative health behavior and conditions. Fundamental causes are significant because such causes cannot be eradicated by either individual or micro-level interventions. The resources indicated in Link and Phelan's fundamental cause theory include socioeconomic status, social power, transference of familial wealth, education, and social support or cohesion. Within a sport context, such fundamental causes can have an impact on the sport retirement and athlete career transition experience. Former college athletes are faced with integration once completing their collegiate playing careers, with most black revenue-generating college athletes returning to communities that lack the resources needed to combat disease (e.g., Shapiro, Meschede, & Osoro, 2013). In the case of the college athlete, community resources also are lacking for the challenges associated with sport retirement (Adler & Adler, 1991; Elder, Jr, et al., 2003).

Following the foundational framework provided by Link and Phelan (1995), Phelan, et al. (2010) revisited the framework with

the intention to reassert original concepts while providing additional components to fundamental cause theory. Continuing the examination of SES and mortality, Phelan, et al. (2010) proposed fundamental causes have four features that include various disease outcomes, various risk factors impacting disease, availability of protective and proactive resources, and the longitudinal reproduction of association between fundamental causes and health. Reestablishing themes from the original framework, Phelan, et al. (2010) propose that readily accessible resources for people based on socioeconomic status and social class are significant when examining fundamental causes of disease. Specifically, individuals who are privy to resources and who can activate resources while experiencing negative health ramifications possess flexible resources (Shapiro, et al., 2013). Phelan, et al. (2010) state that flexible resources such as education, income, and social connectedness "…can be used in different ways in different situations" (p. S29).

Relating the concept of flexible resources to sport retirement, collegiate-athletes who are equipped with better resources would be able to experience a healthy career transition. In relation to sport, flexible resources are preparation services for sport retirement, socialization in other non-sport activities or career paths, and for the development of diverse social connections. Finally, the fundamental cause framework proposes flexible resources are present on both individual and contextual levels to form micro- level health behaviors based on available resources. Furthermore, when examining sport retirement and athlete career transition, fundamental causes are major components for a college athletes' life after sport. The discussed components are

important to understand as they inform concepts proposed in the life course framework.

Life Course Perspective

The life course perspective is a multidisciplinary theoretical approach to viewing life span development (Erpič, et al., 2004; Giele & Elder, Jr., 1998). Initially viewed as a longitudinal approach to life history, the life course perspective is a framework used to examine an individual's life through social pathways, trajectories, and turning points (Erpič, et al., 2004). Specifically, often used as the theoretical orientation; social pathways, trajectories, and turning points insert the overarching aim of the framework, which is self-examination of the sequence of events in one's life. Social pathways are the social norms, career paths, educational attainments, and family structures that shape the lives of individuals or groups. Typically shaped by historical context, a majority of pathways have been communicated by social and political institutions. Typically, individuals attempt to exercise agency over their life decisions, but social pathways ultimately dictate and constrain opportunities, referred to as trajectories that arise during one's life span (Pallas, 2004). Trajectories are a "sequence of roles and experiences" (Elder, Jr, et al., 2003, p. 8), consisting of changes in roles, each of which is called a transition. Trajectories are important as former college athletes experience transitions throughout their athletic careers. Elder Jr. et al. also state that trajectories modify identity, both personally and socially; thus, trajectories are key components when examining athlete career transition experiences. Turning points, which are significant changes in one's life trajectory, can modify the social pathways

that allow an individual to experience a positive life trajectory. Acknowledging the foundational tenets of life course theory, when examining athlete career transitions, authors could provide key principles to integrate into an expanded conceptual model.

The life course perspective includes six principles that guide empirical inquiry. These principles include: (a) life span development, (b) agency, (c) time and place, (d) timing, and (e) linked lives (Erpič, et al., 2004). For developing an updated conceptual framework appropriate for sport retirement and career transition research, this author is focusing on the principles of "agency" and "linked lives."

The principle of *agency* is the power individuals possess to shape their own life courses and decision-making processes. When combining this principle with the concept of fundamental causes, it is reasonable to assume that historical context, socioeconomic status, and education all affect one's power to exercise agency over one's life. Such fundamental causes could have dire effects for former college athletes as they make transitions; therefore, the principle of agency should be applied to athlete career transition research.

Another component that would be appropriate to integrate with fundamental cause theory, is Erpič and colleagues' (2004) principle of *linked lives*. According to their life course perspective, linked lives are interdependently connected or shared relationships, which can shape an individual's trajectory. Essentially, within this framework, a person's ability to succeed in life is largely rooted in an individual's social network. Of course, such turning points can lead to establishment of new healthy relationships, which serve as social pathways to predict one's trajectory. Former college athletes must establish diverse

social connections to assist with their transition out of their sport. Diversifying social connections can lead to a former college athlete obtaining gainful employment, returning back to school for a graduate degree, or building social support to navigate sport retirement.

This author believes these two adopted theoretical frameworks are appropriate for an updated conceptual framework to examine sport retirement and athlete career transition by considering some primary contextual variables that would be useful in understanding specific phenomena associated with the current college-athletic environment. In the following section, an integration of these frameworks is proposed for further research.

AN INTEGRATIVE CONCEPTUAL FRAMEWORK

Sport retirement and athlete career transition have received empirical attention particularly within elite and Olympic settings (e.g., Keyes, 2003; Kuettel, et al., 2017; Tshube & Feltz, 2015); however, within big-time college sport, retirement and career transition research have failed to garner a similar kind of attention. Lack of attention can be a result of athletic role engulfment (Adler & Adler, 1989; 1991), lack of time to address personal concerns outside of sport, or experiencing of isolation from mainstream students on college campuses. Acknowledging the challenges college athletes face (Beamon, 2008, 2012; Beamon & Bell, 2011; Kerr & Dacyshyn, 2000), there is a need to examine the disparities in sport retirement and athlete career transition among white non-revenue generating college athletes and black revenue-generating college athletes. Specifically, what

are the factors that impact the quality of these athletes' career transitions? In this integrative conceptual framework, the current author integrates fundamental cause theory with a life course perspective to provide some theoretical insights on how to examine such phenomena in future research. Based on the theories and previous research studies, future researchers who examine sport retirement and athlete career transition could provide more comprehensive studies by adopting the following methods: (a) contextualizing risk factors of former college athletes during athlete career transition; (b) examining social conditions and pathways that affect former college athletes' agency when faced with transition; and (c) exploring trajectories, turning points, and linked-lives influence resource allocation during sport retirement and athletes' career transitions. Furthermore, the following methods will be explained and established as an appropriate lens to examine sport retirement and athlete career transition.

Contextualizing Risk Factors During Former College Athletes' Career Transitions

To recognize the differences between career-transition experiences of white non-revenue generating and black revenue-generating college athletes, the pre-existing risk factors that potentially affect the quality of transition need to be identified. Although some risk factors were identified more than 20 years ago (Wooten, 1994), research on the helping model proposed by Wooten was not conducted, yielding more factors potentially now needing to be addressed. Appropriate factors include education on the transition process, transition resources available from colleges and universities, viable professional networks, and

social and psychosocial support during the transition, which should be contextualized to understand the actual access college athletes have to flexible resources (Cummins & O'Boyle, 2015).

Based on fundamental cause theory, these flexible resources can assist with a healthy transition because of the college athlete's *agency* to use the available services. If a college athlete does not have the resources, fundamental cause theory can help explain how resources, or lack thereof, are situated in broad contexts (Phelan, et al., 2010). Such contextualization also will assist researchers in understanding how the sociocultural and socioeconomic (SES) background of college athletes impacts their transitions. Contextualization of risk factors is likely to provide an accurate depiction of the resources that are available for a college athlete during his or her transition, and such contextualizing risk factors also can allow researchers to view each instance as an individual and unique experience.

Social Conditions and Pathways Affect Former College Athletes' *Agency* in Transitions

According to this new conceptually integrated framework, researchers also should examine social conditions that can determine social pathways for success after sport retirement. According to fundamental cause theory (Link & Phelan, 1995), social conditions, or fundamental causes, can hinder or assist with healthy sport retirement outcomes (e.g., Yao, Laurencelle, & Trudeau, In press). For instance, if individuals come from a socioeconomically challenged neighborhood, they may need a different set of services to navigate their transitions. In contrast, individuals who come from better quality neighborhoods and higher SES backgrounds are privy to flexible resources to use

during a career transition. Edwards (2000) says the differences are evident between black and white communities. Blacks typically come from lower SES areas (Shapiro, et al., 2013) and tend to focus on fewer athletic pursuits than their white counterparts (Edwards, 2000). The effects of Edwards' declaration are exacerbated by other social conditions that determine a former college athlete's agency and can restrict available social pathways. Understanding the previous claims, researchers should be able to determine if former college athletes are able to use their agency to overcome factors that potentially can constrain decision-making during sport retirement.

Trajectories, Turning Points, and Linked Lives Influence Resource Allocation During Athlete Career Transitions

Previous literature has neglected the importance of trajectories, turning points, and the significance of what life course theory calls *linked lives* (Sinclair & Orlick, 1993). In this conceptual framework, researchers need to incorporate the significance of relationships during the transition process when examining sport retirement. Relationships, or linked lives, are essential to identifying and allocating resources to assist with a career transition. For instance, a former college athlete could be on the job market after college and the determining factor to securing the job maybe his social network or the linked lives that have an impact on his job search. The linked lives could be relationships with previous professors, academic advisors, and other social connections. These individuals may work interdependently to ensure a healthy career transition for an athlete. Linked lives also can serve as turning points in a former

college athlete's life, ultimately changing health, career, and social trajectories after sport retirement. Such turning points are important, as former college athletes have to reshape not only their dominant identity (Beamon, 2012) but also their roles and responsibilities.

IMPLICATIONS AND CONCLUSIONS

Based on the review of literature provided in this monograph chapter, concerns about the retirement and career transitions of athletes were identified decades ago, and researchers have investigated many aspects of these transitions with elite and Olympic athletes. Evidently, the career transitions of college athletes have not been well researched, and contextual factors that apply for large numbers of college athletes need to be addressed, particularly to assist them in sport retirement and in career transitions.

It is the belief of this author that the integration of these two theories (i.e., *Fundamental Cause Theory* and the *Life Course Perspective*) will serve as an appropriate lens to examine not only all athletes' career transitions but also as a basis to conduct more research studying college-athletes career transitions. Futhermore, theoretical implications indicate that researchers should adopt the three life history identity methods (i.e., social pathways, trajectories, and turning points; Erpič, et al., 2004) previously discussed when examining sport retirement and career transitions of former college athletes. These methods will allow researchers to explore possible reasons for the disparities between white non-revenue generating and black revenue-generating college athletes. This approach also will encompass

broader contextual factors that can potentially affect athlete career transition, a consideration that has often eluded empirical inquiry.

Another theoretical implication indicates a shortcoming of sport retirement literature, which tends to examine micro-level behaviors within sport retirement and athlete career transition without recognizing the macro-level events. Such neglect fails to hold academic and social institutions responsible for their role in the transition process for these students; thus, the implementation of the integrative conceptual framework proposed in this work could be the basis of developing research approaches that would yield helpful information to foster better understanding of how to assist athletes with sport retirement and career transitions.

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