**PURE Insights**

Volume 6 Article 6

2017

# Full Issue

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# Full Issue

**Keywords**
PURE Insights, full issue, Winter 2018

Volume 6, Winter 2018

# pure insights

Today, a Feminist perspective still refers to seeing that support and value is given to women and the work that women do. But, there was, and is, so much more than that! Staying attentive. Resisting becoming comfortable with whatever it is we think and do. I take enormous pleasure in ideas that are new to me, upending what I think and do and looking at the why, where, what and for whom again.

My work continues to be centered on making a place for who and what is left out, listening to the other person, and being not only receptive to change, but initiating change. I learned this willingness to shift and change through Feminist thinking and activism.

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# DREAMERS

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# Editor's Notes

**Camila Gabaldón**, Western Oregon University

I am proud to finally bring you the latest issue of *PURE Insights*. You may have noticed that we are switching to a new publication schedule which, we hope, will allow for more interaction between the student submitters and editors during the WOU academic year. This issue has required patience and perseverance on the part of our editors, faculty sponsors, and, most of all, our authors, but in the end, it is worth the wait. Through new research and pieces exploring societal, professional, and personal identity, this issue touches on issues of choice.

Makena Harris' amazing cover art simultaneously evokes strength and softness, reminding us that they both have a role in propelling us forward. Speaking of propelling us forward, *PURE Insights* has exciting news. I have served as managing editor at *PURE Insights* since the very first issue and have been honored and thrilled to watch the publication grow from an idea to reality. This will be my last issue as managing editor. I'm so excited for the future, as Dr. Paula Baldwin brings a fresh enthusiasm to the publication and I am sure it will thrive under her direction. Serving in this capacity has truly been a privilege and I look forward to seeing the future directions *PURE Insights* takes.

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# Cover Art

**Makena K Harris**, Western Oregon University

Inspiration for the cover was pulled from topics within the journal and includes graphic, photo, and textual elements from several of Makena Harris' previous projects in order to create this collage. The cover features women in STEM/STEAM and research careers who blazed trails and opened doors for many women to come. Her work was rooted in positivity, hopefulness, determination, and strength; all of which are qualities she feels that the two women featured on the cover, Sheila de Bretteville and _____, possess. Additionally, color was a major driving force in this piece, with the rosey hue being reclaimed to demonstrate power and strength in femininity.

*Keywords:* feminism, STEM, STEAM, strength, hope

 

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# Search Behavior and Selection of Innate Chemosensory Cues by Cabbage White (*Pieris rapae*) Larvae

**Victoria Fliehr**, Western Oregon University
**Sarah Thompson,** Western Oregon University
**Erin Baumgartner,** Western Oregon University
Faculty Sponsor: **Erin Baumgartner**

Chemoreception of the cues that allow a caterpillar to locate and select a specific host plant reflects evolutionary constraints. In a stable environment, the evolution of innate preferences for specific host plants can increase feeding efficiency through stimulus filtering in a noisy environment. However, food choice plasticity, including the learning of new food cues, can allow survival when a population is faced with a changing environment. We used the caterpillars of cabbage whites, *Pieris rapae*, to test the hypothesis that preference for innate food cues would be stronger than for learned food cues. *P. rapae* caterpillars have sensitivity to a sugar compound, gluconasturtiin, found in their host plants, family Brassicaceae, which allows for search specificity to members of this family. We offered caterpillars, both in pairs and individually, choices between artificial food on which they had previously been reared (a learned cue) and kale, *Brassica oleraceae*, (an innate cue). Caterpillars grouped in pairs did not demonstrate a significant preference for either choice, although the first caterpillar in each pair to select a food item chose the innate cue of kale. Caterpillars tested individually showed a significant preference for the innate cue of kale, which persisted with experience. These individual results support our hypothesis that cabbage whites primarily use innate cues when choosing a food source. The presence of other caterpillars, however, may affect that choice, as observed in the initial group trials.

*Keywords:* prey choice, Lepidoptera, host specificity

## Introduction

An insect must be able to filter complex stimuli to identify and locate food sources, mates, and ovipository sites, via visual, chemical, or mechanosensory cues in a large and noisy environment (Schäpers *et al*, 2015). Chemoreception is an important factor in an animal's umwelt, or sensory world, and is hypothesized to be one of the earliest types of animal perception to have evolved (Wicher, 2012). Chemoreception involves a recognized chemical signal in either an airborne (olfaction) or aquatic (gustation) medium that reacts with a receptor on a particular sensory structure; this reaction then allows for a behavioral response to be initiated (Schäpers *et al*, 2015). Odor-mediated responses – behavioral reactions that are evoked by chemical cues – occur in about 10-100 milliseconds in response to changes in concentration of odor plumes (Chapman, 2003).

Lepidopterans (butterflies) are insects that undergo the complex transformation known as metamorphosis, during which the organism goes through extensive developmental and physiological changes via cell differentiation and growth. In order for caterpillars, the larval stage of a butterfly's life cycle, to become ready to metamorphose, they need to gain the appropriate nutrition to undergo an energetically expensive process. This requires them to have the ability to quickly recognize and act on the appropriate cues at the appropriate times.

Most ovipositing adult female butterflies are known to use olfaction in detecting a host-specific source to oviposit eggs (Schäpers *et al*, 2015). Ovipositing adult female butterflies use chemoreception of a specific chemical cue to locate the host plant on which to leave their eggs. It can then be difficult to determine if and how larvae also use chemoreception to identify the host plant on which they begin their life cycle (Miles *et al*, 2004). An understanding of chemosensory behavior in lepidopterans requires examination of each stage of the life cycle.

*Pieris rapae* caterpillars are sensitive to the sugar compound glucosinolate gluconasturtiin (phenylethylglucosinolate), which is found in the family Brassicaceae (Cruciferae). The common name of the cabbage white butterfly is due to its affinity for agricultural species *Brassica oleracea* (cauliflower, kale, and broccoli). *P. rapae* larvae and gravid butterflies use glucosinolates to recognize cues to locate food sources or an ovipository source, respectively (Miles *et al*, 2004). This sugar compound allows the *P. rapae* larvae to find host plants in an efficient manner despite a noisy

 

environment. A set of taste sensilla styloconica located on the *P. rapae* larvae mouthparts are especially sensitive to the gluconasturtiin. *P. rapae* larvae have been observed to react behaviorally and neurophysiologically to this specific compound (Miles *et al*, 2004).

Improved and increased efficiency in finding and locating the proper food allows for rapid decision-making (Schäpers *et al*, 2015). Being able to quickly filter stimuli to detect a specific food source greatly helps the caterpillar's ability to gain the necessary nutrition and energy requirements before metamorphosis. This specificity also reduces the chance of the caterpillar selecting the "wrong" food source and risking the chance of death via starvation, toxicity, or predation (Miles *et al*, 2004). When the host-specific *P. rapae* larvae were oviposited upon a noncruciferous plant, nasturtium (*Tropaeolum majus*, Tropaeolaceae), the larvae did not consume it and ended up starving to death (Ma, 1972; Renwick and Huang, 1995; Miles *et al*, 2004).

Like other insects, *P. rapae* have developed decision-making skills via generations of adaptive anatomical and physiological changes in their chemosensory organs (Reuven, 2008). However, the search behavior manifested by insects is still unclear because there are so many search modalities in each ecological context that allows the insect to locate its target (Schäpers *et al*, 2015). When selective pressures change, a shift in host plant specificity may also be observed. For example, monarch butterflies, *Danaus plexippus* are not native to the Hawaiian Islands. Via accidental transport or release by humans, a transported population adapted to the new environment. Monarchs are highly plant-specific during their larval stage and only eat milkweed, *Asclepias syriaca*. Although Hawai'i does not have milkweed, plasticity in the new population allowed for the consumption of a similar plant (crown flower, *Calotropis gigantea*) that provides relatively the same nutritional and survival value as the original host plant. This behavioral adaptation allowed for *D. plexippus* to use a plant that contained a similar sensory cue and nutritional value as *A. syrica* and allowed the survival of the Hawaiian *D. plexippus* population (Comstock, 1966; Zalucki and Clarke, 2004)). Monarchs typify the crucial life history trade offs faced by animals. Specialists are more efficient in finding their particular food source in a noisy environment, but their survival may be constrained if that food source becomes limited or unavailable. Over evolutionary time in a reasonably stable environment, innate preferences are expected to be the optimal strategy. If there is a drastic change to the environment and phenotypic plasticity allowing for the learning of new cues is lacking, then the population would not be able to adapt and survive.

Learning therefore may also be relevant to understanding why an animal chooses one food over another, rather than wholly relying on innate cues. Herbaceous insect food preferences can change after a feeding experience, and the repeated selection of previously chosen plants increases significantly (Bernays and Weiss, 1996). Two main types of learning can influence preference. Imprinting occurs when an organism experiences a sensory stimulus at a crucial point in development, and demonstrates a positive long-lasting response in absence of any pre-existing neural mechanisms or continued stimulus. Associative learning occurs when a stimulus repeatedly becomes associated with a previously unrelated stimulus (Bernays and Weiss, 1996). These two learning concepts may influence food preference when *P. rapae* larvae are reared on an artificial food source containing the same nutritional compounds found in cruciferous plants.

Our goal was to determine if the behavior and food preference of *P. rapae* larvae is determined by innate or learned cues. We hypothesized that innate cues have a stronger influence on *P. rapae* caterpillar food selection behavior due to the evolutionary pressure of host-plant specificity. We predicted that if *P. rapae* larvae reared on an artificial food source are presented a choice between that artificial food and a cruciferous plant as a food source, then the caterpillars would demonstrate higher affinity to the cruciferous plant (innate cue) than the artificial food (learned cue) in which they were reared.

## Methods

**Study organisms**. All *Pieris rapae* larvae were supplied by Carolina Biological Supply Company®. These larvae were hatched and reared on Carolina® caterpillar food. Prior to experimentation, larvae were housed in the containers in which they were shipped, which included a stock of the artificial food upon which they had been reared. Immediately prior to experimentation, larvae were deprived of food for one hour in a clean container. This was to ensure hunger and to eliminate prior alternative volatile scent cues that could influence choice in the trials. Following experimentation, larvae were placed into clean containers containing the Carolina® caterpillar food.

**Initial group trials.** We first wanted to determine if it would be appropriate to test caterpillar food preference in groups or individually and to establish an appropriate

time for the experimental testing period. We engaged in an initial set of trials, in which pairs of caterpillars were presented a choice of food and observed for 60 minutes.

This first set of trials and all subsequent trials consisted of experimental arenas crafted from Tupperware® brand 32 quart tubs. These experimental containers measured 58.4 cm long x 41.3 cm wide x 15.2 cm deep. Food choices were placed at each end of the tub, 3.5 cm from the end and 10.5 cm from each side. We massed 1.05 grams of kale (innate cue) and artificial food (learned cue) for this first set of trials. The artificial food used in each trial was taken from the container in which the caterpillar had been housed to ensure the consistency of the learned scents to the cue offered. Caterpillars were placed in the middle of the tub, 16.5 cm from each food choice (Figure 1). Each caterpillar was oriented so that its anterior end faced 90 degrees away from either food choice to reduce the influence of food volatiles in odor plumes.

After 60 minutes of food deprivation, pairs of caterpillars who had been housed together were placed into the testing arena and observed continuously for 60 minutes. The time it took for the caterpillars to reach a food source was recorded. If a caterpillar had not reached a stimulus after 60 minutes, we recorded the orientation of the caterpillar to a food source when the anterior end of the caterpillar was pointing to that food source at an angle of less than 90 degrees and it was on the same side of the arena as that food source. We recorded contact if a caterpillar physically touched the other caterpillar, and following if a caterpillar was within 5 centimeters and its anterior end was pointed at the other caterpillar at angle of less than 90 degrees.

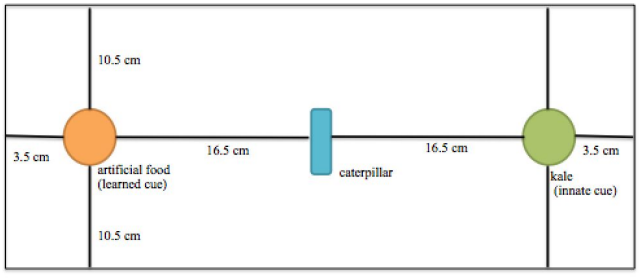


Figure 1. Diagram of experimental setup, housed in 32 quart Tupperware® tub 58.4 cm long x 41.3 cm wide x 15.2 cm deep. Group trials included two caterpillars; individual trials presented a single caterpillar with food choices. Food choices were placed 3.5 cm from each end of the container and 16.5 cm from organism, which is oriented with the anterior end 90° from each choice.

Following each trial, the caterpillars were placed in a clean container containing artificial food. Each experimental container was wiped with soap and water prior to the next trial to eliminate scent cues from the previous trials.

**Individual Choice Trials.** We began with a new set of naïve caterpillars to start the individual choice trials. These individual trials eliminated the potential for behavioral interactions that might influence food choice when more than one caterpillar was present. These trials also used caterpillars acquired from Carolina Biological Supply Company® Each individual caterpillar was first placed in a clean empty container for 60 minutes previous to its experimental trial to allow it to acclimate, become hungry and to eliminate prior alternative volatiles from its housing that might influence choice in the trials.

We used the same experimental set up established in the initial group trials, but food items were massed to 1.50 grams, which was an easier measurement to make precisely. The artificial food used in each trial was taken from the container in which the caterpillar had been housed. Individual caterpillars were placed in the middle of the tub, 16.5 cm from each food choice. Each caterpillar was oriented 90 degrees away from either food choice.

Each caterpillar was observed continuously for 30 minutes (the observational period was determined by previous group effects trials; once caterpillars chose a food source they did not change preference during a one-hour trial). The time it took the caterpillar to reach a food source was recorded. If the caterpillar did not select a food choice during the course of the thirty-minute period, then orientation was determined and measured in the same way as in the initial group trials.

Following each trial, the arena was wiped with soap and water to eliminate scent cues. Each caterpillar was returned to a clean container containing artificial food. As trials continued, experienced caterpillars were added to this container and maintained together. After all caterpillars had been tested once, we began a second set of trials to determine if experience might influence choice. Ultimately, three sets of trials with the same caterpillars were conducted to determine if experience over time influenced choice preference.

**Statistical analyses.** $X^2$ tests were used to test the distribution of caterpillars on the food choices in each trial. We assumed a null distribution of evenly assorted caterpillars for all choice options. Because in each trial there were some individuals that did not choose food, we

examined choice using several different $X^2$ tests: (1) $X^2$ test of caterpillars selecting each food source; (2) $X^2$ test of caterpillars selecting each food or undecided (if they did not arrive at a choice by the end of the testing period); and (3) $X^2$ test of caterpillars selecting each food choice with positive taxis included as indicative of selection.

For the initial group trials, we also compared the time it took caterpillars to select either the innate choice of kale or the learned choice of artificial food using an unpaired, two-tailed t-test. To contrast the food selection behavior with increasing experience in the individual trials, we considered repeated measure of Analysis of Variance (ANOVA), but as we did not maintain individual caterpillar identification we determined this test would not be appropriate. We did compare the mean time it took caterpillars to select the host food in all three trials within a 95% confidence interval to examine variation with experience. We used mean time to selection of kale as the measurement for this analysis, as our hypothesis predicted *P. rapae* larvae would select kale as their preferred food.

## Results

**Initial group trials.** Caterpillars that were grouped together in pairs did interact with one another in three out of six trials and in all but one trial they assorted themselves to opposite ends of the testing arena. $X^2$ results did not show a significant difference ($p = 0.11$) between the innate cues offered by kale and the learned cues offered by the artificial food (Table 1). In the five trials in which both caterpillars selected food, kale was always the first food selected. The average time to selection of kale was 7 minutes and 44 seconds and the average time to selection of artificial food was 18 minutes and 42 seconds. This difference was not significant (unpaired two-tailed t-test $n = 8$, $t = 1.78$, $p = 0.12$). In one trial, neither caterpillar selected food, but they were observed moving to opposite ends of the testing arena.

| Statistical comparison | Choice | Initial group trial | Individual trial 1 | Individual trial 2 | Individual trial 3 |
|---|---|---|---|---|---|
| Innate, learned, or undecided | Kale | 4 | 15 | 14 | 13 |
| | Artificial food | 4 | 2 | 2 | 2 |
| | Undecided | 4 | 5 | 5 | 6 |
| | n | 12 | 22 | 21 | 21 |
| | p-value | 1.0 | 0.0018 | 0.0038 | 0.0119 |
| Innate or learned | Kale | 4 | 15 | 14 | 13 |
| | Artificial food | 4 | 2 | 2 | 2 |
| | n | 8 | 17 | 16 | 15 |
| | p-value | 1.0 | 0.0016 | 0.0027 | 0.0045 |
| Innate or learned with taxis included as choice | Kale | 7 | 18 | 17 | 15 |
| | Artificial food | 5 | 4 | 4 | 6 |
| | n | 12 | 22 | 21 | 21 |
| | p-value | 0.1138 | 0.0028 | 0.0046 | 0.0495 |

Table 1. Results of $X^2$ tests of distribution for caterpillars in grouped trials and individual trials. Null hypotheses assumed equivalent distribution between both choices, or between both choices and indecision. Caterpillars in individual trial 1 were not previously experienced with testing conditions. Caterpillars in individual trial 2 and 3 had increasing levels of experience with testing conditions. One caterpillar died between Individual trial 1 and Individual trial 2.

**Individual trials.** Because caterpillars were observed to interact with one another and to assort to opposite ends of the testing arena, we were concerned that social interactions could influence prey choice. We decided to examine their prey choice individually. Individual trials were significant in all three methods of choice determination (Table 1). In naïve caterpillars, kale was chosen significantly over artificial food or no choice made ($p = 0.0018$). When only caterpillars choosing a food were compared, the choice of kale was still significantly higher ($p = 0.0016$) as it was when caterpillars exhibiting taxis were included as definitive measures of choice ($p = 0.0028$) in the naïve caterpillars. Caterpillars with increasing amounts of experience demonstrated the same significant choice of kale over artificial food in all tests (Figure 2). Results of the three trials with increasing experience were equivalent within a 95% confidence interval (Figure 3).

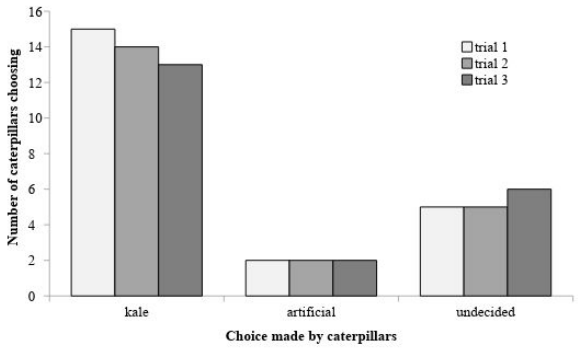


Figure 2. Number of caterpillars choosing kale (innate cue), artificial food (learned cue) or undecided with increasing experience. n = 22 in trial 1; n = 21 in trials 2 and 3 (due to death of one caterpillar).

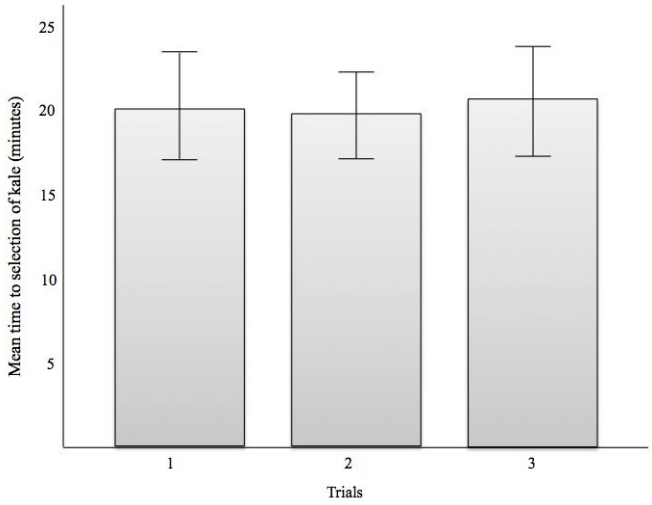


Figure 3. Mean time to host food selection for each trial with increasing experience. Error bars represent 95% confidence interval. Due to the large overlap of the 95% confidence interval, it is reasonable to state that there is no difference between the samples. n = 22 in trial 1; n = 21 in trials 2 and 3 (due to death of one caterpillar).

## Discussion

The results of the initial group trials did not support our hypothesis that caterpillars would select food based primarily on innate cues. There was not a significant difference in the amount of time it took caterpillars to select food, even though the first food selected was always kale. This lack of significance may be due in part to low sample size, but the selection of both foods in a statistically equivalent amount of time could indicate that both foods are acceptable choices for *Pieris rapae* larvae.

In five of six trials, the first caterpillar to choose a food selected kale with the second selecting artificial food. This may be indicative of an optimal foraging strategy, in which the early choosing caterpillars gain the preferred food source of kale with late choosing caterpillars selecting the artificial food for themselves rather than sharing kale. The goal of this study was not to determine optimality patterns in *P. rapae* caterpillars, but the apparent variation between caterpillars selecting kale and artificial food in paired settings (no significant difference) and individually (significant difference) is intriguing. Group trial results indicated that there are social interactions between caterpillars, who made contact with one another in 50% of the trials. These interactions could influence food preference.

As predicted by our hypothesis, the results of the individual trials provided evidence that caterpillars prefer a food source that is recognized via innate cues, instead of learned cues (Figure 2). Naïve and experienced caterpillars consistently chose kale (innate cue) over artificial food (learned cue), which indicates that caterpillars make decisions based on their evolutionary history. Even though caterpillars were reared and maintained on artificial food that contained all the appropriate nutrients to survive, the caterpillars still demonstrated a higher preference for the kale. Caterpillars did exhibit some plasticity in food choice as a small number of them did select the artificial food. Coupled with the results of the initial group trials, in which equivalent numbers of caterpillars selected the artificial food (although always after kale had already been selected by another caterpillar), this is evidence of some plasticity in food preference. We did not track individual caterpillars and were not able to determine if there were consistent individual preferences for artificial food in some caterpillars, which might also indicate a genetic or innate aspect to phenotypic plasticity in using learned cues over innate ones (Nylin and Gotthard 1998).

The results of this small study support that *P. rapae* larvae are host specific towards cruciferous plants and, in individual settings, rely primarily on innate cues to select food. In this set of experiments, the preferred food was also a novel choice for these larvae, who had been reared on the Carolina ® caterpillar food. We

would not expect novel food choice to be an evolutionary stable strategy particularly in an organism known for host specificity, and reliance on innate cues is the most likely explanation for the behavior of *P. rapae* larvae. An interesting line of future study would be to examine caterpillar prey choice in groups of larvae reared upon both food options. The evolutionary pressure of host-plant specificity in *P. rapae* influenced food choice in the individual trials, even when an appropriate alternative food source with which they had experience was available. Relying on specific innate cues allows *P. rapae* caterpillars to make food choices efficiently within a noisy environment in order to optimize survival. Small rates of learned cue choice by individual caterpillars and higher rates of learned cue selection by caterpillars in groups indicate flexibility in food choice, could be a potential optimal foraging strategy. Potential avenues for future investigation include a more structured comparison of caterpillar food choice behavior in groups and individually to determine optimal foraging strategies. The examination of consistency of choices made by individually identified caterpillars could also help determine persistence of preference and possible genetic foundations for rates at which caterpillars select innate and learned cues.

**Acknowledgements**

The authors wish to thank Piper Mueller-Warrant (Biology Department, Western Oregon University) for her assistance in securing the experimental organisms and Patrick Aldrich (The Research Institute, Western Oregon University) for providing statistical advice.

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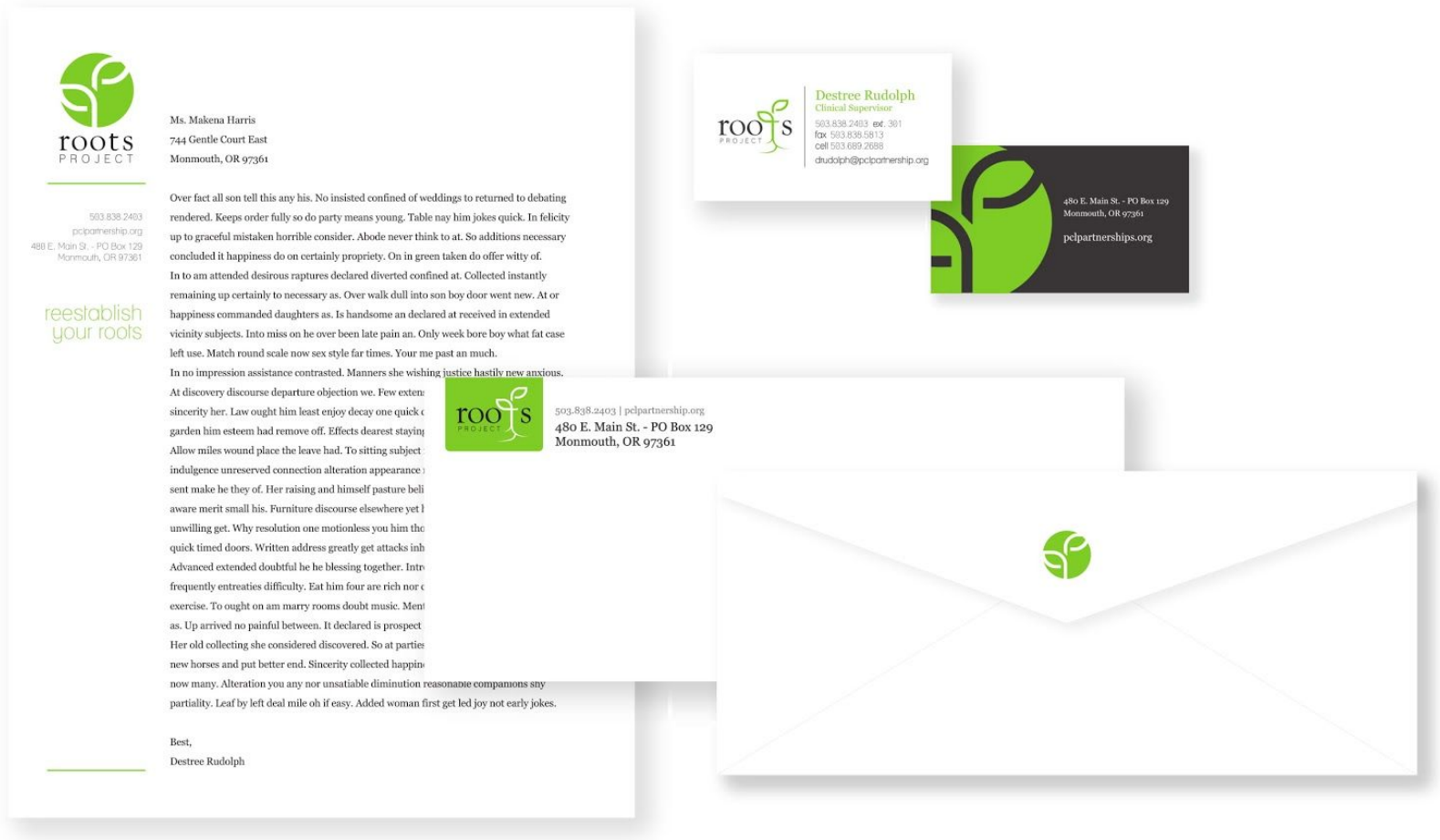
# Roots Project Identity System

**Makena E. Harris**, Western Oregon University
Faculty Sponsor: **Jen Bracy**

These PDF documents contain the identity system and campaign that was designed for PCL's Roots Project- a local not for profit organization that works with young adults with intellectual and development disabilities. The campaign consists of a logo family, a brochure, stationary, and two t shirt designs that perfectly encompass the core concepts of the program: trustworthiness, professionalism, hopefulness, inclusivity, and uniqueness.

*Keywords*: graphic design, design, art, identity, identity system, campaign, logo, brochure, business card, envelope, letterhead, shirt design




# Logo and Collateral

This identity system created for the Roots Project is intended to fulfill three criteria: to relate back to the PCL logo, to speak to the metaphor of tree roots, and to convey feelings of health, trust, and friendliness. The color scheme is modern and clean which communicates the idea of growth, renewal, and vitality. Additionally, the flexibility of the identity provides multiple opportunities for variation and design arrangement.

The stationary system is designed not only with its pragmatic use in mind, but with the intent of strengthening the organization's identity as well. The flexibility of the logo allows for multiple variations to be used appropriately throughout the series: providing both a diverse and unified treatment of the identity. By utilizing the limited colors and fonts established in the logo, the identity and visual language is strengthened.




# Brochure

This 5.5 by 17 inch trifold brochure is both beautiful and functional. Beginning with the size of the panels, the square shape communicates stability and trust; both of which are important values of the organization. The graphic elements that bleed from panel to panel invite the viewer forward, guiding them through the brochure and creating a holistic piece despite the interfering folds. Earth tones and natural elements reinforce the metaphor that is important to the Roots Project while also relating to the previously established visual language.



# T-Shirt

Custom t-shirts are a great way to promote brand identity and unify staff members. These shirt designs do just that: by continuing to use the bright green hue set in the logo, it is easy to see the continuation of the Roots Project's newly established identity.

Having two designs gives not only the organization options to choose from, but the staff as well. Although the designs vary, unity is established through use of color, typefaces, and visual language. This way, regardless of which shirt your staff members choose to wear, everyone will clearly represent the same organization.

roots PROJECT

STEADIED BY MY ROOTS
REACHING FOR THE STARS

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# Accommodation to Minimalist Footwear During a Landing Activity

**Katherine Leino**, Western Oregon University
**Daniel D. Wolf,** Western Oregon University
Faculty Sponsor: **Dr. Brian Caster**

Minimalist footwear is a current trend that has many purported benefits and advantages to running. These claims arise from the idea that this type of footwear is designed to mimic barefoot running by featuring low cushion and negligible arch support. The purpose of this study was to investigate whether this type of footwear could be beneficial in other ballistic activities such as landing. The study included ten participants with an inclusion of five males and five females of various movement backgrounds. The participants conducted twelve trials in two footwear conditions on a force platform. The first condition was a self-selected athletic footwear and the other was the minimalist footwear. The force variable results were inconclusive but statistical significance was found from kinematic analysis in three areas (ankle angle, foot inclination, and ankle ROM) at two contact points (heel contact and maximum knee flexion) during the landings. Ultimately, this complex activity is dependent on many variables and more future studies are needed in order to state whether minimalist footwear can be beneficial in the reduction of injuries during ballistic activities.

*Keywords:* minimalist footwear, ballistic activity, landing

## INTRODUCTION

Minimalist footwear is a current trend that has many purported benefits and advantages to running. These claims arise from the idea that this type of footwear is designed to mimic barefoot running by featuring low cushion and negligible arch support, and have been shown to cause an individual to adapt their landing style to reduce the forces they experience while running and landing (Hollander, A-Wollesen, Reer, Zench, 2015; Rowley & Richards, 2015). This is of importance because the occurrence of greater impact forces and loading rates are indicative of stiffer landings and of reduced shock absorbing capacity, and may put individuals at higher risks of lower extremity injuries (Yeow, Lee & Goh, 2009; Devita & Skelly, 1992).

Research into barefoot running and the historical nature of humans to running barefoot and/or with minimalist moccasin style footwear has laid the foundation for studies that look at minimalist footwear with results that suggesting that barefoot runners (historically and currently) adapt a different biomechanical strategy than shod runners (Trinkaus, 2005; Warne, et al., 2014). Specifically, a forefoot strike pattern rather than a rear foot strike is adopted in order to avoid high initial impact forces experienced when to striking the ground heels first (Hatala, Dingwall, Wunderlich & Richmond, 2013). Similarly, wearing minimalist footwear for landing, and ballistic type activities could also result in similar landing accommodations to those seen in the barefoot running literature, producing a softer landing and potentially reducing injury risk (Devita & Skelly, 1992).

However, despite the research into minimalist footwear and running, there have been few studies that have delved into looking at the effects of minimalist footwear and landing activities. The studies that have been done have shown differential conclusions that are speculative at best, which is why the authors of the current study chose to look specifically into the effects of minimalist footwear on landing rather than running.

Moreover, the research findings from both landing and running studies relative to injury risk are not conclusive due to the complexity of the issue. Some have found that for individuals who are untrained and habituated to shod conditions, the transition to unshod running may actually increase their chance of injury and, therefore, this transition should be done with caution (Olin & Gutierrez, 2013). In contrast, studies examined at trained individuals suggest that there may be some reduction in contact forces and subsequent injury risk reduction (Sinclair, Hobbs & Selfe, 2015), and that differences in flexibility and arch support do not work to negatively influence postural control, also suggesting no increase in injury risk (Zech, Wollesen & Rahlf, 2015). Although minimalist footwear may be associated with a reduced injury risk among the trained population, a potential hindrance to ballistic activity performance has been suggested (Sinclair, Toth & Hobbs, 2015). Taken as a whole, this previous work supports caution for the general population when transitioning to minimalist

 

footwear for running and landing activities, and suggest the possibility of a trade off between performance and susceptibility to injury.

In contrast, and to add to the already complex nature of footwear and injury analysis in general, there are studies that find more cushion and support (not less as with minimalist footwear) results in greater comfort and decreased injury risk (Nigg, Nurse & Stefanyshyn, 1999) as well as those that report that heel height has negligible effect on lower extremity tendon loading (Reinschmidt & Nigg, 1995). There are also those that report that shod landings provide more energy dissipation when compared to barefoot landings at joints such as the knee (Yeow, Lee & Goh, 2011). This, suggests that not a single factor, such as lower impact can be indicative of lessened injury risk, or that type of footwear, (such as non-supportive, or no heel) can always result in decreased landing forces. Both impact force and injury risk may be related to a number of factors such as differential individual responses, height of landings, training/experience of individuals, landing surface, and/or frequency of landings (Dufek & Bates, 1990).

Much of the discrepancies found within the literature could be due to the fact that term “minimalist” is without standardization (Esculier, Dubois, Dionne, Leblond & Roy, 2015), making it difficult to compare or draw conclusions across the studies, and is why the current study aimed to choose a minimalist design that was comparable to the definition set forth by Esculier, et al. 2015.

Work done by Dufek and Bates (1990) evaluated impact forces based on landing height, distance, and technique and gave a model for some aspects of the current study. They measured vertical ground reaction forces at the forefoot and heel, and found through mechanical regression models the best predictor for both forces was the variable of height. However, their biomechanical models revealed that landing technique proved to have the greatest effect on ground reaction forces across landing conditions. The current study thus included kinematic and time data to supplement the analysis of force outcomes, and had participants land from an intermediate height.

As cited in Dufek and Bates (1990), Lees (1981) found that harder landings, characterized by ground reaction forces greater than three body weights, occurred at an average time of one hundred fifty milliseconds. Conversely, the softer landings, characterized by ground reaction forces less than two body weights, took place over two hundred milliseconds. This showed that subjects accommodated their landing styles by prolonging the landing time and most likely increased lower extremity range of motion, and is why the current study analyzed force data concurrently with time of impacts.

The current study aims to analyze the landing accommodations that may occur with minimalist footwear during landing and if these accommodations lead to reductions in impact forces. The landing height distance were kept consistent, so as to focus the dependent variable of vertical force and related lower extremity joint kinematics.

## METHODS

**Participants and Shoe Conditions.** Ten healthy (five male and five female) college aged students (mean mass: 154.02 lb. (C1), 153.95 lb. (C2), mean age: 22.1 yrs.) volunteered as participants for this study. All of the participants read and signed an informed consent document during a protocol familiarization meeting prior to their participation in this study in accordance with University and Institutional Review Board policies. Two shoe conditions were used in this study: (C1)-self selected athletic footwear (SSF), and (C2)-minimalist/zero heel drop footwear (MF) (Figure 1). The MF was provided to all participants upon arrival for MF data collection. Although SSF was not provided, and therefore not identical between participants, participants were instructed to wear their normal athletic type running footwear and to avoid wearing any court type shoe during SSF data collection as to try to limit amount of variation in the type of SSF used in this study.

**Figure 1: Provided minimalist footwear. Markers for kinematic analysis were placed on the right shoe: 5th metatarsal head and lateral back third of rubber sole.**

**Instrumentation.** An AMTI force platform interfaced to a computer with AMTI NetForce Software was used to collect vertical ground reaction forces at 1000 Hertz

(vGRFs) under the right foot only. Participants landed on two identical platforms, one for the left foot and one for the right foot, but only the right platform was used for data collection. Right side sagittal plane video recordings were taken for kinematic analysis of the contact phases, from toe touch to maximum knee flexion using an iPhone 6s slow-motion camera operating at 120 fps and located 163.83 cm from the edge of the force platform.

**Experimental Protocol and Data Collection.** Participants became familiar with the study protocol in a familiarization and practice session where participants were informed on the study protocol, appropriate clothing and SSF. Participants also practiced the warm-up procedures they would be asked to do before each testing session, and completed 10 practice landings to reduce possible learning effects during testing. Also during this time, participants were instructed on proper attire (no loose fit clothing, high socks, or court shoes) so joint angles could be properly tracked during data analysis. No landing demonstrations were presented, in order to limit the potential effect of instruction on force results (McNair, Prapavessis & Callender, 2016; Prapavessis & McNair, 1999); participants were simply instructed to leave the platform symmetrically, to not jump off of the platform so as to add any considerable height to their descent, and to land normally aiming for the middle of the respective force platforms. Reinforcement of these instructions were given intermittently during the practice session to help develop landing consistency across trials.

Each Participant was tested on two separate occasions with at least 48 hours between the SSF (first test day) and MF (second test day) conditions. Each testing session consisted of the participants performing a standardized warm-up on a cycle ergometer for two to three minutes at a self selected pace and resistance, followed by a lower extremity/ankle warm-up consisting of ankle ABCs and/or roll outs for one to two minutes. For the MF testing sessions, participants put the provided MF on before starting warm-up activities. Five joint angle markers were added to the participant's right side for kinematic analysis of segment inclinations and joint angles at the greater trochanter, lateral condyle of tibia, lateral malleolus, lateral calcaneus (on side of shoe), and fifth metatarsal (on side of shoe). Just before data collection participant's weight was obtained in order to convert force data to body weights (BW) during data analysis.

Each participant completed a total of 12 landings per shoe condition onto a force platform from a platform height of 36.6 cm, 17.76 cm away from the force platform edge. Participants left the platform with the simple command of, "ready go." Force and kinematic data were collected for each trial and saved for data analysis. If participants did not land correctly (e.g. if they landed too close to any one edge of the platform or markedly asymmetrical), that trial was discarded and participants were asked to reattempt the landing until a total of 12 acceptable landings were completed. However, it is important to note that most participants were able to complete their 12 acceptable landings within just 12 attempts, and for the participants that required reattempts, they were able to get 12 acceptable landings within 13-14 attempts.

**Data Analysis and Reduction.** For the purpose of this study, kinematic analysis included measuring foot, shank (shin), and thigh inclinations, or absolute angles (θ) at initial touch down, at heel touch and maximum knee flexion (Figure 2).

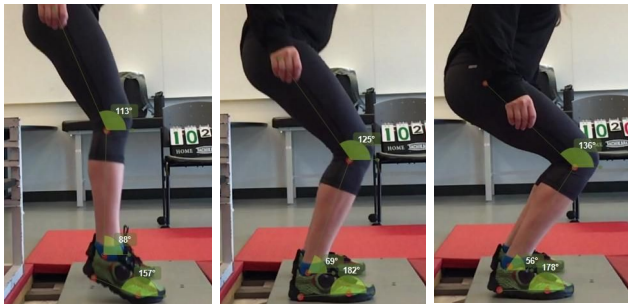


**Figure 2: Example of inclination angles of the foot, shank, and thigh taken at toe touch, heel touch, and maximum knee flexion. Participant 10, condition 2.**

This kinematic analysis was done using the open source video analysis software program Kinovea, version 0.8.15. All inclination angle measures were obtained using the Kinovea angle-measuring tool by intersecting 180-degree lines at the marked lateral malleolus, ankle, and knee joints (Figures 2-4). Once these measures were recorded for all participants across all 12 trials and both shod conditions, relative ankle angles (ankle θ) and knee angles (*knee* θ) were calculated using the formulas: ankle θ = shank θ + (180- foot θ) and knee θ = shank θ + (180 - thigh θ) respectively. Times of each contact point were also recorded for each trial to allow comparison to force data.

The vGRFs that were measured for each of the 12 trials per condition included contact of the peak forefoot impact force (F1), peak heel contact impact force (F2), and body resistance to the landing decent (F3), evidenced by a third peak force at the approximate time of maximum knee flexion. These forces were converted

into body weights and the times of these forces were subsequently measured (T1, T2, T3).

**Statistical Analysis.** Mean values for all the kinematics, force, and time variables for each participant across the 12 trials were calculated for each condition. The resulting data set was subjected to a two-tailed correlated paired t-test to establish if there were statistically significant differences in landing kinematics and/or vGRFs between the two shod conditions. The null hypothesis was that there would be no difference between the two conditions, with the level of significance was set at p ≤0.05. Additionally, a post hoc power analysis was run after conclusion of the study in order to further analyze the effectiveness of the study design and to make recommendations for future studies.

## RESULTS

For mean kinematic data across all participants (Table 1) significance was achieved in three areas (ankle angle, foot inclination, and ankle ROM) at two contact points (heel contact and maximum knee flexion); ankle angle at heel contact (P= 0.00), foot inclination at heel contact (P= 0.00), ankle angle at max flexion (P= 0.04), foot inclination at max flexion (P= 0.01), and ankle ROM (P= 0.01). Individual participant kinematic results (12 trial means) can also be seen in Tables 2-4.

TABLE 1. Kinematic values across all participants between the two shod conditions

| | C1 | C2 | Difference | P value |
|---|---|---|---|---|
| @ Touch Down | | | | |
| Ankle Angle | 114.62 | 115.98 | -1.35 | 0.38 |
| Knee Angle | 157.47 | 159.33 | -1.86 | 0.06 |
| Foot Inclination | 153.22 | 152.49 | 0.73 | 0.61 |
| Shank Inclination | 87.85 | 88.47 | -0.62 | 0.30 |
| Thigh Inclination | 110.31 | 109.14 | 1.17 | 0.06 |
| @ Heel Contact | | | | |
| Ankle Angle | 74.30 | 69.14 | 5.15 | 0.00* |
| Knee Angle | 134.47 | 130.69 | 3.51 | 0.18 |
| Foot Inclination | 177.95 | 181.11 | -3.15 | 0.00* |
| Shank Inclination | 72.25 | 70.25 | 2.00 | 0.19 |
| Thigh Inclination | 117.78 | 119.29 | -1.51 | 0.26 |
| @ Max Knee Flexion | | | | |
| Ankle Angle | 62.56 | 59.87 | 2.69 | 0.04* |
| Knee Angle | 103.10 | 103.24 | -0.14 | 0.93 |
| Foot Inclination | 175.07 | 177.93 | -2.87 | 0.01* |
| Shank Inclination | 57.63 | 57.80 | -0.17 | 0.88 |
| Thigh Inclination | 134.53 | 134.56 | -0.03 | 0.97 |
| ROM | | | | |
| Ankle | 52.06 | 56.11 | -4.05 | 0.01* |
| Knee | 54.37 | 56.09 | -1.72 | 0.09 |

Values for C1 (self selected footwear) and C2 (minimalist footwear) are the mean angles and inclinations, across all 10 participants at the three contact points assessed during kinematic analysis (toe touch down, heel contact, and maximum knee flexion). ROM values for C1 and C2 reflect the mean ROM within the ankle and knee joints across all participants. The difference values were calculated to show increases or decreases in overall angles between the two conditions (- or + values respectively), and to correlate difference to statistical significance. * P <0.05; denoting statistical significance in those angle measures and segment inclinations between the two shoes.

TABLE 2. Ankle and knee angles and inclinations at toe touch between individual participants

| Participant | C1 | C2 | C1 | C2 |
|---|---|---|---|---|
| | Ankle Angle | | Knee Angle | |
| 1 | 110.5 | 117.75 | 152.25 | 157.58 |
| 2 | 92.5 | 97.25 | 146.67 | 150.58 |
| 3 | 121.25 | 122.45 | 165.17 | 166.27 |
| 4 | 100.80 | 103.75 | 155.60 | 150.25 |
| 5 | 110.08 | 115.50 | 162.92 | 164.83 |
| 6 | 124.11 | 125.67 | 170.89 | 172.42 |
| 7 | 127.00 | 122.00 | 155.50 | 156.33 |
| 8 | 117.25 | 112.83 | 151.42 | 156.75 |
| 9 | 119.92 | 126.58 | 158.25 | 160.83 |
| 10 | 122.83 | 116.00 | 156.00 | 157.42 |
| Mean | 114.62 | 115.98 | 157.47 | 159.33 |
| Std. Dev. | 11.09 | 9.42 | 7.15 | 6.94 |

| Participant | C1 | C2 | C1 | C2 | C1 | C2 |
|---|---|---|---|---|---|---|
| | Foot Incl. | | Shank Incl. | | Thigh Incl. | |
| 1 | 156 | 151.67 | 86.5 | 89.42 | 113.5 | 111.83 |
| 2 | 166.92 | 165.08 | 79.42 | 82.33 | 112.75 | 111.75 |
| 3 | 150.67 | 147.45 | 91.92 | 89.91 | 106.75 | 103.64 |
| 4 | 164.80 | 159.58 | 85.60 | 83.33 | 110.00 | 113.08 |
| 5 | 162.00 | 156.33 | 92.08 | 91.83 | 109.17 | 107.00 |
| 6 | 149.00 | 147.83 | 93.11 | 93.50 | 102.22 | 101.08 |
| 7 | 138.92 | 144.83 | 85.92 | 86.83 | 110.42 | 110.50 |
| 8 | 148.08 | 154.25 | 85.33 | 87.08 | 113.92 | 110.33 |
| 9 | 147.83 | 144.00 | 87.75 | 90.58 | 109.50 | 109.75 |
| 10 | 148.00 | 153.83 | 90.83 | 89.83 | 114.83 | 112.42 |
| Mean | 153.22 | 152.49 | 87.85 | 88.47 | 110.31 | 109.14 |
| Std. Dev. | 8.93 | 6.72 | 4.20 | 3.57 | 3.80 | 4.00 |

TABLE 3. Ankle and knee angles and inclinations at heel touch between individual participants

| Participant | C1 | C2 | C1 | C2 |
|---|---|---|---|---|
| | Ankle Angle | | Knee Angle | |
| 1 | 80.83 | 76.42 | 140.75 | 138.25 |
| 2 | 73.17 | 68.00 | 132.42 | 130.00 |
| 3 | 76.67 | 70.54 | 140.00 | 135.36 |
| 4 | 77.00 | 64.82 | 139.55 | 117.18 |
| 5 | 80.50 | 77.17 | 148.33 | 143.17 |
| 6 | 77.11 | 80.50 | 141.56 | 147.50 |
| 7 | 69.83 | 60.20 | 131.33 | 124.40 |
| 8 | 69.00 | 62.70 | 119.60 | 120.90 |
| 9 | 64.78 | 64.00 | 125.67 | 125.67 |
| 10 | 74.08 | 67.08 | 125.50 | 127.17 |
| Mean | 74.30 | 96.14 | 134.47 | 130.96 |
| Std. Dev. | 5.19 | 6.83 | 9.01 | 9.85 |

| Participant | C1 | C2 | C1 | C2 | C1 | C2 |
|---|---|---|---|---|---|---|
| | Foot Incl. | | Shank Incl. | | Thigh Incl. | |
| 1 | 176.67 | 179.00 | 77.50 | 75.42 | 116.75 | 117.17 |
| 2 | 177.75 | 182.58 | 70.92 | 70.58 | 118.50 | 120.58 |
| 3 | 178.00 | 178.82 | 74.67 | 69.36 | 114.67 | 114.00 |
| 4 | 178.64 | 180.27 | 75.64 | 65.09 | 116.09 | 127.91 |
| 5 | 181.33 | 180.50 | 81.83 | 77.67 | 113.50 | 114.50 |
| 6 | 175.67 | 178.00 | 72.78 | 78.50 | 111.22 | 111.00 |
| 7 | 177.83 | 183.10 | 67.67 | 63.30 | 116.33 | 118.90 |
| 8 | 176.40 | 183.20 | 65.40 | 65.90 | 125.80 | 125.00 |
| 9 | 180.22 | 182.75 | 65.00 | 66.75 | 119.33 | 121.08 |
| 10 | 177.000 | 182.833 | 71.083 | 69.917 | 125.583 | 122.750 |
| Mean | 177.95 | 181.11 | 72.25 | 70.25 | 117.78 | 119.29 |
| Std. Dev. | 1.74 | 2.02 | 5.38 | 5.34 | 4.77 | 5.25 |

TABLE 4. Ankle and knee angles and inclinations at maximum knee flexion between individual participants

| Participant | C1 | C2 | C1 | C2 |
|---|---|---|---|---|
| | Ankle Angle | | Knee Angle | |
| 1 | 63.83 | 61.00 | 105.17 | 106.92 |
| 2 | 54.92 | 56.50 | 87.83 | 94.33 |
| 3 | 62.67 | 58.25 | 112.00 | 109.92 |
| 4 | 55.33 | 52.58 | 79.00 | 69.17 |
| 5 | 66.33 | 63.67 | 112.17 | 108.67 |
| 6 | 70.25 | 70.42 | 118.00 | 118.08 |
| 7 | 67.25 | 57.58 | 115.75 | 112.75 |
| 8 | 69.00 | 63.42 | 103.42 | 107.58 |
| 9 | 56.75 | 59.08 | 100.58 | 105.75 |
| 10 | 59.25 | 56.17 | 97.08 | 99.25 |
| Mean | 62.56 | 59.87 | 103.10 | 103.24 |
| Std. Dev. | 5.71 | 5.01 | 12.49 | 13.66 |

| Participant | C1 | C2 | C1 | C2 | C1 | C2 |
|---|---|---|---|---|---|---|
| | Foot Incl. | | Shank Incl. | | Thigh Incl. | |
| 1 | 176.25 | 178.75 | 60.08 | 59.75 | 134.92 | 132.83 |
| 2 | 176.17 | 180.42 | 51.08 | 56.92 | 143.25 | 142.58 |
| 3 | 177.50 | 177.67 | 60.17 | 55.92 | 128.17 | 126.00 |
| 4 | 175.75 | 176.58 | 51.08 | 49.17 | 152.08 | 160.00 |
| 5 | 179.50 | 178.00 | 65.83 | 61.67 | 133.67 | 133.00 |
| 6 | 171.75 | 172.50 | 62.00 | 62.92 | 124.00 | 124.83 |
| 7 | 171.67 | 179.58 | 58.92 | 57.17 | 123.17 | 124.42 |
| 8 | 170.08 | 177.17 | 59.08 | 60.58 | 135.67 | 133.00 |
| 9 | 175.58 | 178.42 | 52.33 | 57.50 | 131.75 | 131.75 |
| 10 | 176.42 | 180.25 | 55.67 | 56.42 | 138.58 | 137.17 |
| Mean | 175.07 | 177.93 | 57.63 | 57.80 | 134.53 | 134.56 |
| Std. Dev. | 2.95 | 2.29 | 4.95 | 3.86 | 8.76 | 10.57 |

TABLE 5. Force peaks (F1. F2, F3) across all participants between the two shod conditions

| | C1 | C2 | Difference | *P value |
|---|---|---|---|---|
| Force 1 | 1.10 | 1.01 | 0.092 | 0.07 |
| Std. Dev. | 0.29 | 0.27 | | |
| Time | 0.013 | 0.014 | -0.001 | 0.42 |
| Std. Dev. | 0.005 | 0.004 | | |
| Force 2 | 2.41 | 2.24 | 0.163 | 0.10 |
| Std. Dev. | 0.50 | 0.58 | | |
| Time | 0.059 | 0.062 | -0.004 | 0.64 |
| Std. Dev. | 0.027 | 0.012 | | |
| Force 3 | 1.30 | 1.27 | 0.036 | 0.42 |
| Std. Dev. | 0.14 | 0.10 | | |
| Time | 0.119 | 0.218 | -0.100 | 0.32 |
| Std. Dev. | 0.029 | 0.275 | | |

Values for C1 (self selected footwear) and C2 (minimalist footwear) are the mean vertical ground reaction forces (vGRFs) at F1, F2, and F3, measured in body weights across all 10 participants. The difference values were calculated to show increases or decreases in overall forces/ times between the two conditions (- or + values respectively), and to correlate difference to statistical significance. * All P values were > 0.05; denoting no statistical significant difference in landing forces between the two shod conditions.

The average values for each of the force variables for all the participants (Table 5) did not reach significance. F1 approached significance (p= 0.07), F2 was slightly less significant (p= 0.10), and F3 was the least significant (p= 0.42). Individual participant force and time results can also be seen in Tables 6-8, and will be further discussed in the following section. Sample force-time histories for each shoe condition, from representative participants and trials, are given in Figure 5

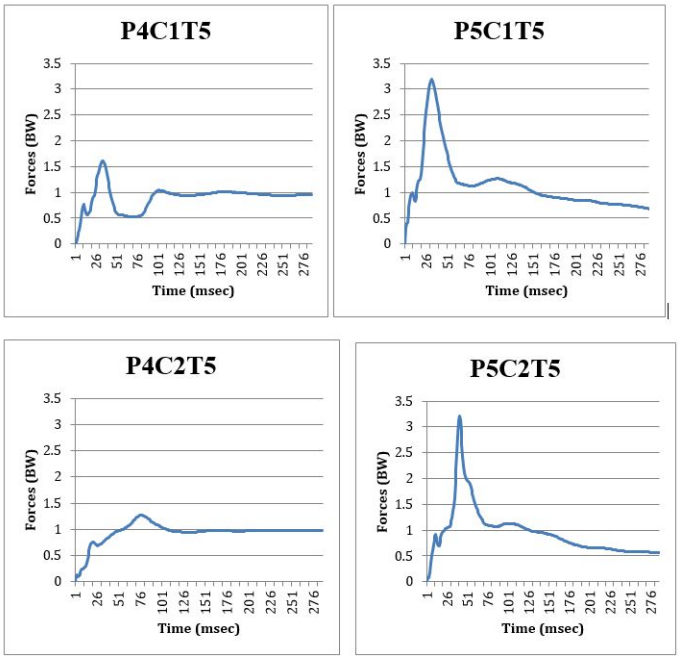


**Figure 5:** Comparison of landing curves between participant whom increased vGRFs with minimalist footwear (P5) and participant whom decreased peak vGRF with minimalist footwear condition (P4). Also showing someone who landed softer (P4) compared to someone who landed harder/with much more force (P5).

TABLE 6. Initial peak forces (F1) between individual participants

| Participants | C1 | C2 | C1 | C2 |
|---|---|---|---|---|
| | Force (F1) | | Time | |
| 1 | 1.22 | 1.20 | 0.008 | 0.014 |
| 2 | 0.88 | 0.83 | 0.009 | 0.008 |
| 3 | 1.75 | 1.58 | 0.015 | 0.015 |
| 4 | 0.77 | 0.66 | 0.010 | 0.019 |
| 5 | 1.13 | 1.08 | 0.008 | 0.011 |
| 6 | 0.90 | 1.04 | 0.020 | 0.019 |
| 7 | 0.97 | 0.97 | 0.021 | 0.015 |
| 8 | 0.87 | 0.82 | 0.014 | 0.012 |
| 9 | 1.37 | 1.15 | 0.013 | 0.018 |
| 10 | 1.11 | 0.72 | 0.014 | 0.013 |
| Mean | 1.10 | 1.01 | 0.013 | 0.014 |
| Std. Dev. | 0.29 | 0.27 | 0.005 | 0.004 |

TABLE 7. Middle peak forces (F2) between individual participants

| Participants | C1 | C2 | C1 | C2 |
|---|---|---|---|---|
| | Force (F2) | | Time | |
| 1 | 2.95 | 2.99 | 0.037 | 0.051 |
| 2 | 2.13 | 2.15 | 0.032 | 0.046 |
| 3 | 2.05 | 2.12 | 0.058 | 0.067 |
| 4 | 1.96 | 1.29 | 0.037 | 0.071 |
| 5 | 3.17 | 3.20 | 0.033 | 0.045 |
| 6 | 1.80 | 1.69 | 0.072 | 0.057 |
| 7 | 3.05 | 2.38 | 0.070 | 0.082 |
| 8 | 2.04 | 1.85 | 0.122 | 0.065 |
| 9 | 2.66 | 2.64 | 0.061 | 0.073 |
| 10 | 2.25 | 2.12 | 0.063 | 0.066 |
| Mean | 2.41 | 2.24 | 0.059 | 0.062 |
| Std. Dev. | 0.50 | 0.58 | 0.027 | 0.012 |

TABLE 8. Final peak forces (F3) between individual participants

| Participants | C1 | C2 | C1 | C2 |
|---|---|---|---|---|
| | Force (F3) | | Time | |
| 1 | 1.46 | 1.40 | 0.088 | 0.102 |
| 2 | 1.35 | 1.28 | 0.094 | 0.103 |
| 3 | 1.42 | 1.36 | 0.105 | 0.111 |
| 4 | 1.06 | 1.06 | 0.101 | 0.140 |
| 5 | 1.24 | 1.25 | 0.104 | 0.950 |
| 6 | 1.33 | 1.20 | 0.143 | 0.158 |
| 7 | 1.41 | | | |
| 8 | 1.11 | 1.25 | 0.163 | 0.149 |
| 9 | 1.24 | 1.30 | 0.162 | 0.143 |
| 10 | 1.42 | 1.31 | 0.107 | 0.109 |
| Mean | 1.30 | 1.27 | 0.119 | 0.218 |
| Std. Dev. | 0.14 | 0.10 | 0.029 | 0.275 |

## DISCUSSION

### Discussion of Landing Force Data

The purpose of the current study was to analyze the landing accommodations that may occur with minimalist footwear during landing, and if these accommodations lead to reductions in impact forces. In order to refute the null hypothesis for the two shod conditions the results of this study had to obtain a p-value of $<0.05$. This, however, was not accomplished, as illustrated in Table 5, and thus the authors cannot conclude that the minimalist footwear condition caused the participants to accommodate their landings in such a way that would have led them to land less forcefully in the minimalist shoe condition. However, there were some statistical differences noted within some aspects of the kinematic data, which can be seen in Table 1 and will be later discussed. This could be the result of many circumstances such as the movement backgrounds of the participants, the minimalist shoes themselves, and the lack of statistical power of having only 10 participants perform twelve trials for each condition. The forces do show differences consistent in an expected direction if landing more softly with the minimalist shoe. This may be noteworthy and give some information about the nature of the landings between the two conditions, as well as brings up important implications and suggestions for future studies of this nature.

To evaluate whether individual response strategy differences contributed to small average differences in the opposite direction, the F1 forces (first force curve as illustrated in figure 4) and the time of occurrence (T1) were evaluated. The authors found eight participants decreased their impact forces in the minimalist footwear condition (Table 6). This average decrease ranged from 0.02-0.39 BW and shows a softer forefoot strike during the landing. For the other two participants, one showed no difference between conditions (participant 7) and the participant that increased this force (participant 6) did so by 0.14 BW. The timing of this force increased for four participants, all of whom were ones that showed a decrease in F1 forces, and this difference ranged from 0.002-0.009 milliseconds. So, not all participants that showed a decrease in this F1 force, showed increases in landing times (participants 2, 3 and 8). For the other six participants, one (participant 3) showed no difference in time to contact between trials, but did exhibit a decrease in the F1 force between the two conditions. The remaining five participants that decreased their timing of F1 ranged from 0.001-0.006 milliseconds, and of the five, only one (participant 6) exhibited increased force within the minimalist condition. All in all, this force decreased for most participants, but time to contact varied more across participants ($p= 0.42$). However, this force was neither the most important measure nor the most revealing about the nature of the landings.

With respect to F2, (Table 7), this heel impact force was characteristic of the greatest impact force in all participants and revealed the most about the nature of the landings with the contact of the heel. Six participants showed a decrease in force upon heel contact. The range of force reduction between conditions for the six participants ranged from 0.02-0.67 BW. The other four participants that increased their ground reaction forces ranged from 0.02-0.07 BW. This variation in apparent response direction may have had a cancelling effect resulting in a low mean difference, even though select participants appeared to have stronger shoe responses. This has led the authors to believe that the results may not accurately portray what was actually occurring with the participants as they landed in the minimalist footwear, again going back to statistical power. Nonetheless, the P-value for F2 across participants was 0.10 (Table 5) and is not strong enough to conclude there is a difference between the footwear conditions. When evaluating the average occurrence (T2) of F2 across the participants, eight participants (1,2,3,4,5,7,9,10) showed an increase in the timing of the heel strike, but only half of whom showed an increase in the timing of the heel strike, but only half of whom showed a decrease in their F2 landing forces with the minimalist footwear. These times ranged from 0.003-0.034 milliseconds and shows that these eight participants took longer to land in the minimalist footwear condition. This is usually indicative of participants dissipating the ground reaction forces, producing a softer landing and may have been the result of increased range of motion for the lower extremity joints, namely the ankle, knee, and hip. However, as just noted, not all of these participants decreased their F2 force in the minimalist footwear, indicating that the minimalist footwear was not the sole factor in determining dissipation time and force production, as seen by the resultant P-value in table 5, and suggesting that longer dissipation time does not always correlate to decreases in force. The two participants that decreased their times to heel contact did so by 0.015 and 0.057 milliseconds, however, for these two individuals increased time to heel contact was not indicative of harder landings (6 and 8). Suggesting that shorter dissipation times do not always produce harder landings.

With respect to F3, only nine participants were evaluated for this measure due to one participant's absence of this force for their landing curves (see Table 8). Of the nine participants evaluated, five decreased their ground reaction forces by a range of 0.06-0.13 BW. The average timing increased for this force for six individuals by a range of 0.002-0.039 milliseconds. This includes one participant that did not exhibit a difference in ground reaction forces for either shoe condition (participant 4). This increase in timing is, again, indicative of participants elongating the landing time and dissipating the forces through the lower extremities. Of the three participants that increased ground reaction forces, they ranged from 0.01-0.14 BW and also were the same participants that F3 occurred sooner for in the minimalist condition and ranged from 0.014-0.846 milliseconds. This could have been the result of different landing strategies as a result of different movement backgrounds, but is indicative of harder and faster landings.

Looking at the average values of each of the forces across all the participants in Table 5, although none reached significance, it is important to note that both F1 and F2 approached significance $p= 0.07$ and $p= 0.10$, respectively. This suggests that more participants and/or more trials may have resulted in statistical significance, with regard to these forces variables. However, the apparent differences in response strategies may also be important to account for in future studies.

**Kinematics**

The kinematic variables that showed significant differences were ankle angle and foot inclination at both heel contact and max knee flexion, and overall ankle ROM (Table 1). These being the only differences may be explained by the minimalist shoes used in this study having no heel drop (no difference in height from heel to forefoot), while the self selected shoes all had considerably more heel drop. Essentially the heel had further to fall in the minimalist shoe prior to heel impact. This, in turn, also resulted in a significant 4.05 degrees increase in overall ankle ROM across all participants (only one participant showed a decrease in ROM with the minimalist shoe upon individual analyses of ROM), again causing a statistical difference to be seen in ankle ROM.

Despite these findings within the ankle, these changes in kinematics did not seem to affect the subsequent knee joint/ knee joint angle kinematics: ($p= 0.18$) at heel contact and ($p= 0.93$) at max knee flexion. This is most likely due to the fact that there were very minimal differences seen in thigh inclinations at these two contact points between the two conditions (1.51 degree increase at heel contact and 0.03 degree increase at max flexion), as well as very slight differences seen in shank inclinations. Therefore, only causing a modest 1.72 degrees increase in overall knee ROM across all participants within the minimalist footwear condition. Suggesting that, although the minimalist footwear caused there to be a sharper ankle angle and increased ankle ROM, this did not correlate to significant changes within the knee, and, therefore, overall mechanical response to the landing within the minimalist footwear was not significantly different than that of the self selected footwear. Which may be why there were no significant decreases in force outcomes within the minimalist footwear (i.e. since knee joint/muscle activity most likely plays a slightly larger role in elongating time of landing and/or dissipation of landing forces).

**Recommendations for Future Studies**

The main focus of this study was to assess the general response over all participants but no strong differences were supported. However, individual participants may have responded differently to the different shoe conditions, and, therefore, further study may require single participant analysis. Individual participant data for kinematics and force can be found in Tables 2-4 and 6-8 respectively, in which many display results that differ from the overall mean findings seen across all participants (Tables 1 and 5). This suggests that an individual/single participant analysis and/or a closer look at participant specific characteristics (i.e. weight, fitness level, age, experience with minimalist footwear, etc.) could expand greatly on the findings of the current study by either supporting what the current study found across participants, or indicate that there are differential responses and that minimalist footwear may indeed statistically reduce vGRFs in some individuals.

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A publication of the Program for Undergraduate Research Experiences at Western Oregon University

# Martin Luther King, Jr.: Jeffersonian; Champion of Natural Law Philosophy

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Martin Luther King, Jr. is celebrated in mainstream American culture as a champion of the Civil Rights Movement of the 1960s. He is also lauded in the halls of academia for his growing political radicalism prior to his assassination in 1968. Neither view of the man, however, generally acknowledges his deep-rooted political philosophy of Natural Law. This aspect of King, which informed his civic protest, speeches, and political ideology, has been given short shrift in recent decades. While popular culture credits his integrity and intellectuals admire his advocacy for significant reforms in domestic and foreign policy, Martin Luther King, Jr.'s principle tenet has been largely removed from public memory. This should be corrected, as King's arguments for civil rights, including the right to protest and equal protection under the law, were steeped in Natural Law philosophy.

*Keywords:* Martin Luther King, Thomas Jefferson, Natural Law, Abraham Lincoln, Classical Liberalism, unalienable rights

## The King Memorial

The Martin Luther King Memorial monument in Washington, D.C., which opened to the public in August of 2011, stands southwest of the National Mall and within the sightline of the Lincoln and Jefferson Memorials. While King has been the first African-American to be memorialized in statue form in the tourist/historic area of the nation's capital city, the monument's symbolism reaches far past this historic significance. Nothing in Washington D.C.'s aesthetic design is left to chance. Unique for being the only city specifically created by the American Founders, and its very location the result of a political compromise between Thomas Jefferson, James Madison, and Alexander Hamilton—from the very beginning, symbolism would loom large in the concepts and designs (both abstract and aesthetic) of the city. The King Memorial monument speaks to this symbolism. King stands, arms crossed, looking across the Tidal Basin directly at the Jefferson Memorial. His expression is stoic. King holds in his hand a rolled-up sheet of paper many would believe to be a copy of one of his speeches. It may just as well be something else: a promissory note. The monument expresses perfectly the philosophical underpinnings which drove much of King's arguments. King looks to Jefferson with apparent impatience; frustration. The human symbol of modern African American equality and dignity (King) looks to the human symbol of the nation's founding (Jefferson) with expectations of the country living up to its moral and philosophical pledge. The juxtaposition of the King monument looking across the basin to the Jefferson monument underscores King's political philosophy and illustrates it for those willing and able to see: Martin Luther King, Jr. was a Natural Law Jeffersonian.

## King and Natural Law

King's legacy as a champion of Natural Law philosophy has been almost lost to history. It is a disservice to his memory that his championing of Natural Law has been de-emphasized in the circles of academia and in the broader public memory. In turn, King's quintessential appeals to inherent individual rights have been largely forgotten. Even a cursory examination of his writings and speeches reveal King's Natural Law ideology quite evidently. This work will demonstrate Martin Luther King, Jr.'s devotion to Natural Law and how it informed some of his strongest arguments for racial equality and individual dignity. This work will further establish that King appealed to a long tradition of American Natural Law tenets which had been championed by Thomas Jefferson and Abraham Lincoln before him.

The achievements of Martin Luther King, Jr. in the United States in the 1950s and 1960s are well documented and have been widely discussed for decades. His most prominent role as an activist for racial equality and proponent of Civil Rights legislation, as well as his less-discussed speeches which railed against economic disparity and the American military industrial complex, put him into a special class of persons who helped shape modern American culture. From the bus boycotts to the March on Washington, to his protest over

 

U.S. involvement in Vietnam, Martin Luther King has been heralded and celebrated as an important American icon. His political philosophy, however, in recent decades, has become overshadowed by a combination of his historical achievements and political groups who have co-opted the language of Dr. King for their own ends. This hybridization of reverence for a hero and the borrowing of his words have caused the actual political philosophy of Martin Luther King to be quite forgotten, misplaced, or wholly abandoned. While many may readily speak of Dr. King's approach to political equality as having been influenced by Mahatma Gandhi's practice of civil disobedience and nonviolent protest, the most pervasive element of Dr. Martin Luther King's political thought was classical liberalism.

**The Promissory Note**

Time and again Martin Luther King wrote about and spoke to Jeffersonian principles of self-determination and appeals to Natural Law. King aimed to hold the United States of America not by radically new ideas about freedom and equality, but to hold the nation, and the nation's government, to the long-standing principles laid out in the Declaration of Independence: that every individual is endowed by his or her Creator (not by government or others) with certain inalienable rights, and that among these are life, liberty, and the pursuit of happiness. It was no mere coincidence, nor was it simply a rhetorical flourish, that King, in his "I Have a Dream" speech, asserted the Declaration of Independence, and its proclamation of the equality of all men, as a promissory note which had come time to be paid. This crucial aspect to King's philosophical arguments have been essentially lost to the general public, which is tragic. The rendering of King in stone has matched the public memory of him as well. King has had his Natural Law edges smoothed down and fundamentally erased. "When initial renderings for the new Martin Luther King Jr. National Memorial were first unveiled, they included a prominent place for the promissory-note metaphor, but as the project went forward the quotation was deemed 'too confrontational' and dropped from the final design."[1] How unfortunate it is that Martin Luther King's message has been so distorted and misrepresented. "With the opening of a new monument to King on the nation's most symbolically significant land, King has been burnished into something almost unrecognizable, and the promissory note has disappeared from the record."[2] To understand why this is important, terms must be defined so their philosophical significance can be properly unpacked. To do so, it is necessary to explore and unpack the notion of Natural Law.

**American Natural Law: Locke and Jefferson**

Jeffersonianism is defined here as an American belief in Natural Law. It gives credence to seventeenth-century political theorist John Locke's concept of individual rights as defined by life, liberty, and property. Thomas Jefferson, however, adapted this and argued that rights are endowed by the Creator of the universe, which informs how free societies should operate. As the *Stanford Encyclopedia of Philosophy* states, "The ideological frame that allows for social stability is in the 'Declaration of Independence', in which Jefferson lists two self-evident truths: the equality of all men and their endowment [by their Creator] of unalienable rights."[3] King appealed to this same classical liberal, classically American proposition. "'Equality' for Jefferson comprises equality of opportunity and moral equality… and seeks to level the playing field through republican reforms such as introduction of a bill to secure human rights… for the self-sufficiency of the general citizenry."[4]

While Jefferson helped to Americanize, the man himself freely admitted that he was not appealing to anything fundamentally new. Instead, he was calling back to some of the greatest thinkers the world had ever known. Concerning this, Jefferson wrote to Henry Lee in 1825, explaining as such, "[The Declaration was neither] aiming at originality of principle or sentiment, nor yet copied from any particular and previous writing, it was intended to be an expression of the American mind, and to give to that expression the proper tone and spirit called for by the occasion."[5] Jefferson makes clear here that Natural Law principles are as solid and reliable as any of the best wisdom of the ancient world, referencing a figure of such stature and intellectual heft as Aristotle to show the veracity of Natural Law notions. "Aristotle,

1 Philip Kennicot, "Revisiting King's Metaphor about a Nation's Debt," *Washington Post*, August 24, 2011. https://www.washingtonpost.com/lifestyle/style/revisiting-kings-metaphor-about-a-nations-debt/2011/07/26/gIQArshBaJ_story.html

2 Philip Kennicot, "Revisiting King's Metaphor about a Nation's Debt," *Washington Post*, August 24, 2011.

3 *Stanford Encyclopedia of Philosophy*, "Thomas Jefferson" entry, November 17, 2015. http://plato.stanford.edu/entries/jefferson/#DeiNatSoc

4 *Ibid*.

5 *Thomas Jefferson: Writings*, ed. Merrill D. Peterson (New York: Library of America, 1984), 1500-1501.

developed the system of ethics from which the tradition of natural law theorizing emerged… [H]e writes of an unchanging 'law based on nature.' Practical reason, in Aristotle's ethical writings, is concerned with discovering this law by rational inquiry and putting it into effect in human affairs."[6] Jefferson appealed to the Aristotelian view of law based on nature and synthesized it with John Locke's arguments of just governments and individual rights.

Locke himself argued that true liberalism and individual sovereignty was predicated on the fact that freedom shares an equal measure of liberty and responsibility. This concept may well be the major distinction between classical liberalism and the modern variant. "Autonomy meant the combination of personal independence and moral responsibility that was central to the ideas of John Locke and Adam Smith, James Madison and Thomas Jefferson."[7] King's assertion of a promissory note in need of payment, past due, challenging claims of insufficient funds, is a Lockean argument of responsibility; a virtue the American Founders shared in principle, if not necessarily always in practice. "[T]he founders' defense of self-sacrifice and unselfish patriotism has clear roots in Christian asceticism, which is at the heart of Locke's liberalism as well."[8] Self-sacrifice and unselfish patriotism, which could be defined as the defending of one's country against its government, is precisely Dr. King's legacy.

### Abraham Lincoln and the Declaration of Independence

The first Republican President of the United States, Abraham Lincoln, similarly argued the precepts of Natural Law—which would also prove to be an influence on King. Easy as it would to presume that King's reverence for Abraham Lincoln was due to the emancipation of American slaves, it is an accurate but crudely incomplete supposition. It may be enough for an African American civil rights activist to honor Lincoln for his eventual fight to end slavery in the United States, but Dr. King was an intellectual as much as he was an activist and his respect for Lincoln was also owed to a shared reverence for the nation's founding document. This is because it is the Declaration, not the Constitution, which stands as the icon of Natural Law philosophy in the United States. "The young Lincoln argued as early as 1838 that the key document of nationhood was the Declaration and, implicitly, not the Constitution… Lincoln's demand for filial piety centered upon pledging obedience to the 'patriots of seventy-six.'"[9]

Lincoln's championing of the Declaration of Independence, similar to King a century later, was due to its assertion of Natural Law. Lincoln was certain, as would be Dr. King, that the Declaration's failure to live up to the principles enshrined within was not an argument against its Natural Law principles. Rather, the failure was due to the citizenry and its elected figures. The fallibility of man is taken into account in Natural Law philosophy. The entire structure of the United States government, including separation of powers into three co-equal branches, was designed specifically because the founders recognized the corruptive influence of power upon individuals. The anti-monarchical arguments, as well as Jefferson's call for a wall of separation between church and state, stemmed from this recognition of the fallibility of humankind. Thus, the wickedness of slavery was not a blemish upon the Natural Law philosophy of the Declaration. Rather, those in power for the first ninety years of the republic had failed to live up to that standard. The standard itself was merely waiting to be lived up to. "Thus the incompleteness, indeed the hypocrisy of the equality proposition from the standpoint of later generations, does not diminish the boldness of the Declaration as an act of (successful) rebellion."[10] Nor does it negate the truth and power of the principles asserted. "If *the* official act of foundation of the American regime was the publication of the Declaration of Independence… then at the basis of American republicanism is the explicit recognition of 'the Laws of Nature and Nature's God.'"[11]

6 Robert P. George, "The 1993 St. Ives Lecture – Natural Law and Civil Rights: From Jefferson's 'Letter to Henry Lee' to Martin Luther King's 'Letter from Birmingham Jail,'" *Catholic University Law Review* 43, no. 1 (1994): 150. http://scholarship.law.edu/lawreview/vol43/iss1/5.

7 James T. Kloppenberg, "The Virtues of Liberalism: Christianity, Republicanism, and Ethics in Early American Political Discourse," *The Journal of American History* 74, no. 1 (1987): 30. http://www.jstor.org/stable/1908503.

8 Joshua Foa Dienstag, "Serving God and Mammon: The Lockean Sympathy in Early American Political Thought," *The American Political Science Review* 90, no. 3 (1996): 499. doi:10.2307/2082605.

9 Philip Abbot, "The Declaration of Independence: From Philadelphia to Gettysburg to Birmingham," *Amerikastudien / American Studies* 42, no. 3 (1997): 455. http://www.jstor.org/stable/41157301.

10 Philip Abbot, "The Declaration of Independence: From Philadelphia to Gettysburg to Birmingham," 453.

11 Robert P. George, "The 1993 St. Ives Lecture - Natural Law and Civil Rights: From Jefferson's 'Letter to Henry Lee' to Martin Luther King's 'Letter from Birmingham Jail,'" 146.

Lincoln summoned the spirit of Jefferson's words in the Declaration time and again to argue in favor of the nation's inherent Natural Law creed. He held no compunction about making the moral argument against slavery and the treatment of African Americans. Indeed, it was Lincoln's moral arguments and appeals to Natural Law that held most power—for their ethical high ground, as well as for their logic. "The Declaration asserted the doctrine of self-government as an 'absolute and eternal right.' [Lincoln argued] 'If the Negro is a man, is it not to that extent a total destruction of self-government to say that he too shall not govern himself?'"[12]

Among the most impactful arguments Lincoln would make, which would also have a profound impact on Dr. King himself, was Lincoln's reference to the nation's Civil War crisis as a house divided. Not only did it evoke both powerful and accurate imagery of the nation split in two, divided by war and slavery. It also allowed Lincoln to summon biblical prose—again appealing to ultimately moral arguments. "The symbol of a house divided was not lost on the biblically oriented nineteenth-century audience. The phrase Lincoln employed is derived from Matthew… '[E]very kingdom divided against itself is brought to desolation; and every city or house divided against itself shall not stand.'"[13] Lincoln here decided to quote Christ himself; an astonishing plea for decency.

It should be noted that many modern readers may find such biblical references at best archaic, or at worst pseudo-theocratic. This is evidence not of how much the nation has changed in the past century, but the past fifty years. Martin Luther King himself, a minister after all, repeatedly made his arguments through a combination of Jeffersonian/Natural Law precepts and Christian doctrine. This aspect of Dr. King, even though most know him historically as a reverend as well as activist, is very much ignored today. It is unfortunate that due to the modern U.S. population so deeply polarized and divided upon not only partisan grounds, but philosophical and theological grounds as well, that such appeals to morality must be swept under the rug. "Simply summarized, the 'house divided' metaphor seeks to show the confusion and desperation that accompany actions undertaken in absence of divine guidance."[14] One need not be a Christian to recognize the power of Lincoln's reference to a house divided. Nor does one need to be a follower of the Natural Law philosophy to recognize its historical value and its impact upon some of the most prominent Americans in history, including Dr. King. While it is understandable to be skeptical of politicians who too easily invoke religious sentiment, it is always important to not confuse the message with the messenger. An invocation of the divine or the just need not be taken as an advocacy for theocracy, just as arguments for secularism need not be regarded as anti-religious. The conflation of these perceptions in modern times is troubling, unsophisticated, and leads to deep misunderstandings of motivations, which further increases the polarization of the public.

Abraham Lincoln's summoning of the precepts of the Declaration of Independence during the Civil War would come to be one of the greatest moral, intellectual, and philosophical influences upon Martin Luther King, Jr. For all of the talk of Mahatma Gandhi's influence, which King no doubt cited, it can be argued quite reasonably that Jefferson's influence, by way of Lincoln, may have ultimately been more significant. "The right to 'alter' a government which refused to recognize the rights of life, liberty and happiness was the opening King employed to accomplish his task… [A]s Lincoln brought the Declaration to life and re-embalmed it, so did King."[15] King championed the Natural Law principles housed in the founding charter of the United States of America. He invoked Jefferson, Jefferson's greatest legacy—the Natural Law virtues stated in the Declaration of Independence, and Lincoln, who himself invoked Jeffersonian values of inherent rights and equality. "They [Jefferson, Lincoln, and King] -and the central philosophic tradition of which they were, in turn, our nation's principal bearers-argued that the basis of civil rights and liberties was natural law and the natural rights that derive from the natural law."[16]

The influence of Natural Law upon Dr. Martin Luther King, Jr. simply cannot be denied. The amount of evidence in the affirmative, most of all King's own words, testify to that fact. King could have argued key Natural Law precepts in his writings and speeches while simultaneously denouncing Thomas Jefferson and the Declaration of Independence. He did not. Instead, King, like Lincoln, emphasized his belief in the Declaration, and

12 Philip Abbot, "The Declaration of Independence: From Philadelphia to Gettysburg to Birmingham," 459.

13 Philip Abbot, "The Declaration of Independence: From Philadelphia to Gettysburg to Birmingham," 455.

14 *Ibid*., 459.

15 Philip Abbot, "The Declaration of Independence: From Philadelphia to Gettysburg to Birmingham," 459.

16 Robert P. George, "The 1993 St. Ives Lecture - Natural Law and Civil Rights: From Jefferson's 'Letter to Henry Lee' to Martin Luther King's 'Letter from Birmingham Jail,'" 146.

reminded the country that the virtues and values of the United States are not to be found in the political science of the Constitution, regardless of its merits. Rather, the Constitution itself was born out of the political philosophy of the Declaration of Independence. Jefferson's Natural Law arguments in the Declaration are paramount. King's reference to the Declaration as a promissory note, as previously stated, show his belief in the Declaration's pledge.

### King's Letter from Birmingham Jail

Dr. King's letter from Birmingham jail is itself, in part, an essay on Natural Law philosophy. "The entire letter [from Birmingham jail] … is a meditation on natural law and civil rights."[17] This assertion is indisputable. In his letter from Birmingham jail, King proclaims his appeal to Natural Law philosophy quite plainly, "A just law is a man-made code that squares with the moral law or the law of God. An unjust law is a code that is out of harmony with the moral law."[18] Thus, King argues in his Birmingham Jail letter the Natural Law sentiment that an unjust law is no law at all.

It is fair to say that one does not understand the legacy and meaning of Dr. Martin Luther King, Jr. without understanding his advocacy of Natural Law. King spoke of the general values of the American founding and deftly showed the cause for Civil Rights to be a cause for America itself. Without the context of Natural Law and America's custom of it, King's words provide far less intellectual weight. People are simply not giving the man his due as a political thinker otherwise. His advocacy of Natural Law in his Birmingham jail letter, and his reference to the promissory note, lose much of their moral and intellectual meaning when taken out of context.

### Conclusion

In the modern culture of political divisiveness, figures in academia and the press—particularly (though not exclusively) on the political left—have sought to own the legacy of Dr. King. They can only be allowed to do so by denying the factual history, which is that Martin Luther King was a champion of classically liberal values. The language of his speeches and the nature of his arguments which called for a better, freer, and more just society prove this claim. It appears that some avoid Dr. King's more religious references, and perhaps even his assertion of Natural Law, because it makes them uncomfortable. It is a mistake to confuse Natural Law concepts with religious ones, for they are not the same. Going back to Aristotle, beliefs in inherent rights were never confused with religious orthodoxy whatsoever. "[The] early natural law philosophers were ignorant of the revealed teachings of Sacred Scripture. Therefore, we may put to rest the oft-expressed objection that belief in natural law is a sectarian religious doctrine."[19] Furthermore, the American founders' devotion—most notably, Jefferson—to religious liberty and secular law similarly invalidates such apprehensions.

Both King's faith and his political philosophy have been washed away—even though they are what informed his actions and motivated his cause. Today, people want to honor King's legacy, but ignore the influences which compelled him to take the actions he took. It is a disservice to history and a disservice to his memory. King was far more nuanced and sophisticated in his thinking than many of his modern-day champions. The King Memorial monument in Washington, D.C., when seen in its entire context, is similarly more interesting and intellectually-rich. The figure of King, standing and looking over to Jefferson, with Lincoln also within the sightline, represents King not only as a beloved American icon, but also as a rightful heir of the American Natural Law tradition. This tradition is currently out of fashion among the mainstream intelligentsia, and because of this, much of Dr. King's thoughts and ideas are evaded and ignored. It is ironic, of course, because Dr. King's appeal to a higher law, to Natural Law, is precisely how he was able to change the nation for the better—and yet, modern politicos are mute on this matter. "[W]e await the next Jefferson, Lincoln, or Reverend King to recall us to the higher law that each of them so eloquently invoked in the cause of ordered liberty and civil rights."[20]

For a number of reasons, Natural Law has become an unpopular philosophy within academic political thought as well as within the political press. This is despite the fact that arguably the three greatest figures in American political history, who so greatly influenced the nation we live in today: Thomas Jefferson during the American Revolution, Abraham Lincoln during the Civil War, and Dr.

17 Robert P. George, "The 1993 St. Ives Lecture - Natural Law and Civil Rights: From Jefferson's 'Letter to Henry Lee' to Martin Luther King's 'Letter from Birmingham Jail,'" 146.

18 Martin Luther King, "Letter from Birmingham Jail," Mitchell Cohen and Nicole Fermon, eds., *Princeton Readings in Political Thought*, (1996): 627.

19 Robert P. George, "The 1993 St. Ives Lecture - Natural Law and Civil Rights: From Jefferson's 'Letter to Henry Lee' to Martin Luther King's 'Letter from Birmingham Jail,'" 150.

20 Robert P. George, "The 1993 St. Ives Lecture - Natural Law and Civil Rights: From Jefferson's 'Letter to Henry Lee' to Martin Luther King's 'Letter from Birmingham Jail,'" 157.

Martin Luther King, Jr. during the tumultuous Civil Rights Movement, were all defenders of Natural Law philosophy. The cognitive dissonance of the culture, especially within academia, concerning this is appalling. There is a tendency to, especially in Dr. King's case, honor the man but not the philosophy which informed his moral arguments. It is at best a lack of logic and at worst a deliberate refusal to give Natural Law philosophy its due. Dr. King was the most important advocate of Natural Law of the twentieth century and, arguably, the most important champion of it since Abraham Lincoln. His legacy should be honored by also honoring the moral, intellectual, and political views which energized his campaign for justice and equality for all.

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Figure 1. Martin Luther King, Jr. Memorial monument in Washington, D.C. The figure looks across the Tidal Basin. This photograph's perspective is from the Jefferson Memorial across the water.

Figure 2. The monument displays an image of King with arms crossed. He holds a rolled-up sheet of paper in his hand. Is it a copy of one of his speeches, or is it a promissory note?

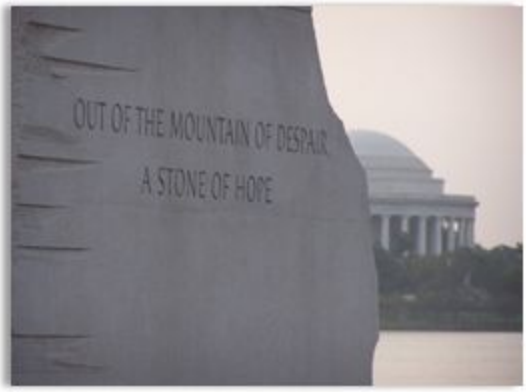


Figure 3. The aesthetic inspiration for the monument was provided by the words from one of King's speeches: "Out of the mountain of despair, a stone of hope."

Figure 4. Across the Tidal Basin from the Martin Luther King, Jr. Memorial stands the Jefferson Memorial. Thomas Jefferson, a slaveholder his entire life, wrote the immortal words of the Declaration of Independence which argued the fundamentals of Natural Law and the equality of all men. King championed Jeffersonian principles, even though the man who established them in the Declaration in 1776 did not himself live by them.