

# OURJournal

Oregon Undergraduate Research

Volume 20, Issue 1, Winter 2022







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## Cover Art – “The Visitor”

Olivia Wilkinson\*, History, Folklore, Music, Scandinavian

Smaller things tend to go unnoticed, especially when they exist around us and touch our daily lives in minute ways. Crouch down, look up, or step closer, and there is a world of beauty and movement just about everywhere. Human beings are lifelong learners; we learn through observation, and through that observation, we test boundaries and make conclusions. These photos represent moments when I chose to slow down and listen. By doing so, we take steps toward a collective understanding of nature.

*Medium: Analog photography, Canon Rebel 2000, Canon EF 75-300mm lens. Taken on expired Kodak Gold 400 film.*

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\*Olivia Wilkinson is majoring in History and Folklore, with minors in Music and Scandinavian. Upon graduation, she plans on getting her Master's in Library and Information Science. She is a part of the student arts journal *Unbound*, where she is Creative Director and a Poetry Editor, and she is also a peer mentor for the TRIO program and member of the Swedish Fika Club on campus. In her free time, she loves digital painting and genealogy.



## Letter from the Editor

Taylor Sarah Ginieczki\*, Political Science and Global Studies

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Dear Readers,

As I reflect on my last year at the University of Oregon, it is clear that last fall brought us more than a return to in-person education. It also brought us the next chapter of the pandemic, one of learning how to integrate our day-to-day campus interactions into our lives as college students. If my roommate tested positive for COVID, do I go to class? If my roommate's professor's dog licked someone who tested positive for COVID, do I quarantine for five days or two weeks? If someone coughs on campus and no one is around to hear it, does it make a sound?

Digs at our collective pandemic fatigue aside, at OURJ, we have likewise continued to ask big questions of ourselves and each other as we approach the end of this school year. Yet six consecutive terms online with minimal opportunities to advertise — as well as the graduation of two established editors, the departure of two others, and the promotion of a third (myself) — left us with two cohorts of UO students who had never stepped foot on campus, let alone heard of OURJ. Our very small team has had some very big work cut out for us, revolving around a sobering question indeed: How can we ensure the journal's survival? Even further, OURJ does not exist in a vacuum; our organizational reckoning is taking place in parallel with a uniquely alarming point in human history, one characterized by an absolute loss of public faith in the scientific method itself. Facts and evidence are now debated as opinions once were, and the problem today has arguably become less who will do the research and more who will *believe* it.

It is in this climate of extreme uncertainty, underlined by the global public health crisis and existential threats to our planet's future, that we find ourselves situated. Yet it is returning to our roots — in *accessibility* and *interdisciplinarity* at OURJ, in *compassion* and *rigor* as citizens and scientists, and in *environmental justice* as climate crisis organizers — that we find ourselves at all. The challenges that OURJ faces ahead at our microclimate of a college campus — reconnecting to our broader community, making knowledge accessible across disciplines and backgrounds, advocating for meaningful engagement with research, and more — will lead us to solutions that are more-than-translatable to the real world. If (at least part of) the purpose of college is prepare students for this so-called real world, then we are well on our way, and I have total faith in the OURJ team to do all that is necessary. This issue would not have come together without Jay's proactivity and grit, Kyla's sharp attention to detail, nor Sarah's thoughtful and balanced perspective. Micah, thank you for your years with us, and Nicole, welcome to the team! And to Franny and Kevin: thank you for all you have done to bridge OURJ to the greater university and to support me as a student leader.

On behalf of the entire editorial board, I am elated to introduce this 20<sup>th</sup> issue of the *Oregon Undergraduate Research Journal*.

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\*Taylor is a senior at the University of Oregon, where she is completing degrees in political science and global studies after transferring from Swarthmore College. She is a research assistant with the Political Science Department, a Wayne Morse Scholar, and a poetry editor and Deputy Editor-in-Chief for the student arts journal *Unbound*. Taylor is currently co-authoring a paper on IR realist theory with Dr. Craig Parsons of the UO PS department, and her recent projects have included a national conference on science journalism (NUCSJ) and a publication on Yugoslav ethnonationalist conflict. Her research interests revolve around topics in international relations, including IR theory, nuclear issues, political culture, and ethnonationalism. Please direct correspondence to [tginiecz@uoregon.edu](mailto:tginiecz@uoregon.edu).



## Journal Editorial – “Reflecting on Accessibility in Scholarly Publishing”

Franny Gaede\*, Director of Digital Scholarship Services, University of Oregon Libraries

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The University of Oregon and the University Libraries support six open access journals, which is enabled via our Oregon Digital partnership with Oregon State University and the digital publishing expertise within the Libraries’ Digital Scholarship Services department. The editors of these journals are faculty, staff, and students from across the disciplines, working on a variety of platforms and seeking in their own ways to disrupt and augment the scholarly conversation in their areas.

However these goals may be achieved, the primary goal is always one of accessibility, but that word contains multitudes: from the need to be usable by those using assistive technologies, to be discoverable by those seeking their content, to be available to anyone regardless of their ability to pay, and perhaps to be intelligible to anyone with an interest to read. When we say we want our journals and their contents to be accessible, what is it that we seek to accomplish?

The Editor-in-Chief of [Konturen](#), Martin Klebe, offered a few thoughts on the subject, emphasizing the international and non-academic audiences of the journal:

Since its inception, the interdisciplinary German Studies journal *Konturen*, housed in the Department of German & Scandinavian, has embraced an open-access format in the belief that thoughts and ideas about phenomena involving borders and delimitations that are developed within the academy should circulate as freely as possible. This applies both to the various disciplines from which contributors to the journal hail, as well as readers beyond the academy. The key question of access and distribution connects many of the issues we have treated in special journal issues over the years (borderlines in political theology and in psychoanalysis, the problem of borders between territories, between humans and animals, the phenomenon of migration, etc.) with the concrete form that the results of scholarship and its reception take. We all should think about--and try to act in response to--the pressing question of how important knowledge that is generated in an academic context may effectively reach audiences, rather than remaining locked away or simply being overlooked.

Massimo Lollini, Editor-in-Chief of [Humanist Studies & the Digital Age](#), suggested that access for education also plays a vital role:

Being the editor of an open-access journal such as *Humanist Studies and the Digital Age* represents an extraordinary opportunity to disseminate academic research in a timely and effective manner to the point that it can be used as a source in current educational seminars at no cost to students. Furthermore, open access favors a broad process of encounters between

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\*Franny Gaede joined the University of Oregon Libraries as Director of Digital Scholarship Services in August 2017. She provides leadership and support for digital scholarship, digital collections, digital preservation, scholarly communication, and library-led open access publishing. She earned her MSIS and BA in History at the University of Texas at Austin and previously worked as the Scholarly Communication Librarian for Butler University. Franny’s professional interests include open access and social justice, digital scholarship project sustainability and preservation, and applications for digital scholarship work in research and teaching.

scholars and allows to deepen the research themes by starting a dialogue that grows continuously in real-time. Our journal has been the vehicle for publishing critical international conferences on the transformations of literature in the digital world. More recently, it has hosted interviews with leading media scholars such as Pierre Lévy, who specializes in the understanding of the cognitive implications of digital technologies and the phenomenon of human collective intelligence. The forthcoming issue, *Steps Towards the Future: More-Than-Human Humanism in the Age of Artificial Intelligence*, features theoretical reflections and research projects that employ innovative methods of artificial intelligence and digital technologies in studying the humanities. We intend to contribute to a better understanding of humanity and the humanities in light of the new information technologies of the past, present, and future.

As these information technologies that Dr. Lollini refers to continue to emerge, grow, and change, we must recognize our active role in these processes and ensure equity of access for all.





## Art Feature – “Tuning In”

Olivia Wilkinson\*, History, Folklore, Music, Scandinavian

Taken near Fisher Mountain, WY at my family’s cabin, this polyphemus moth sat like this on our screen door for over 24 hours. It was important to me to capture its because it was truly massive: its wingspan was at least as long as my hand from wrist to fingertip.

*Medium: Analog photography. Canon Rebel 2000, Canon EF 28-80mm lens. Taken on expired Kodak Gold 200 film.*



\*Olivia Wilkinson is majoring in History and Folklore, with minors in Music and Scandinavian. Upon graduation, she plans on getting her Master's in Library and Information Science. She is a part of the student arts journal *Unbound*, where she is Creative Director and a Poetry Editor, and she is also a peer mentor for the TRIO program and member of the Swedish Fika Club on campus. In her free time, she loves digital painting and genealogy.



## Meet the Editorial Board

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### JAY TAYLOR

Jay is a junior at UO majoring in linguistics and computer science and minoring in Spanish and Korean. They have served as the Financial Coordinator for the University of Oregon LGBTQA3 office and co-president of the UO Model United Nations club. Jay recently discovered a strong interest in research and presented on the topic of mental health in South Korea at the 2020 Oregon Undergraduate Research Symposium. They are passionate about learning new languages and teaching, and they hope to make the world a better place through education for all ages and individuals, regardless of background. In their downtime, they enjoy video games, hiking, and playing board games with friends.

### MICAH WOODS

Micah Woods is a junior in the Clark Honors College double majoring in environmental science and philosophy and minoring in biology. Their research interests include environmental philosophy, transgender theory, and issues in sustainable agriculture. Micah is a Presidential Scholar and currently serves as both a Writing Tutor at the UO Tutoring and Academic Engagement Center and a research assistant in the Cresko Laboratory at the University of Oregon, where they study evolutionary genomics in a variety of fish and work to promote science accessibility in the UO community. Outside of the UO, Micah interns at the Food for Lane County Youth Farm. Their non-academic interests include making music, spending time outdoors, and exploring Eugene on bike and skateboard.

### KYLA SCHMITT

Kyla is a first-year Clark Honors College student majoring in environmental studies and economics and minoring in English. At the UO, she is a Presidential scholar, a content assistant with OCIAS, and the Treasurer of the UO Society of Ecological Restoration. Beyond the UO, she assists with research efforts at the Massachusetts-based Immigrant Learning Center and the Portland Urban Coyote Project; she also volunteers with a wide range of organizations, many of which have an ecological concentration. Kyla's most current personal research project focuses on signal crayfish patterns in the Tryon Creek Watershed, and she looks forward to continuing her grant-funded data collection over the summer. Beyond academics, work, volunteering, and research, Kyla loves hiking and exploring, curating her dozens of Spotify playlists, working out, and caring for her houseplants.



## SARAH BEAUDOIN

Sarah is currently in her third year in the Clark Honors College, majoring in chemistry and also studying biology and science communication. Outside of classes, she lives in a sustainability-based and multigenerational co-op, volunteers for campus organizations such as the Climate Justice League and for the larger community of Eugene, and does research in the Boettcher Lab. In the lab, Sarah conducts electrochemical and physical chemistry experiments to better understand water electrolysis with the hopes of producing hydrogen fuel to mitigate the need for fossil fuels. Sarah is originally from rural Enterprise, Oregon, and she enjoys biking, gardening, sewing, backpacking, and ceramics in her free time.



# Effect of hesitation sound phonetic quality on perception of language fluency and accentedness

Tillena Trebon\*, Linguistics

## ABSTRACT

This study investigates the perceptual consequences of nonnative versus native hesitation sounds in evaluating male speech. When the phonetic quality of a hesitation sound is consistent with native speaker hesitation sounds, the hesitation sound is “native.” A hesitation sound with phonetic quality inconsistent with native speaker hesitation sounds is “nonnative.” In Experiments 1A and 1B, participants rated sentences for fluency and accentedness on a Likert scale. In Experiments 2A and 2B, listeners performed a forced choice task to evaluate speech for accentedness and fluency. In Experiments 1A and 1B, hesitation sound phonetic quality did not impact listeners ratings. However, in Experiments 2A and 2B, participants deemed sentences with nonnative hesitation sounds less fluent and more accented compared to those with native hesitation sounds. Results show that the hesitation sound phonetic quality can have perceptual consequences and that the type of task listeners performed to evaluate speech affected accentedness and fluency judgments. This study has important implications for how learners treat pausing when practicing their second language.

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## 1. INTRODUCTION

Despite popular culture narratives that pausing while speaking should be avoided (see e.g., Cohen, 2012; Riegel, 2018), research shows that pausing is an important part of linguistic communication. Broadly, there are two types of pauses: filled pauses, which are when a speaker makes a sound while pausing, and unfilled pauses, which are silent.

While definitions of native and nonnative speakers vary widely (see e.g., Davies, 2003; Davies & Elder, 2008), native speakers of a specific language are generally considered to be people who learned the language during childhood, and nonnative speakers are people who learned the language after childhood. Both native and nonnative speech contain pauses (Erbaugh, 1987; Goldman-Eisler, 1968). However, nonnative speech has different pausing patterns compared to native speech. Nonnative speech contains more frequent and longer pauses than native speech (Pickering, 1999; Riazantseva, 2001). Nonnative speakers produce more within clause pauses than native speakers (Riazantseva, 2001). Additionally, Erbaugh (1987) found that nonnative speakers display more individual variation in pausing patterns than native speakers. Variable proficiency may influence nonnative pausing patterns; less proficient speakers have longer and

\*Tillena Trebon, an undergraduate double majoring in Linguistics and Spanish, has been a member of the Speech Perception and Production Lab since 2018. For her honors thesis research, reflected in this paper, she has received the VPRI Undergraduate Fellowship, the Robert W. Young Award from the Acoustical Society of America, CURE Conference Travel Award, and the 2021 Undergraduate Linguistics Association of Britain Conference Best Poster Award. Please direct correspondence to [ttrebon@uoregon.edu](mailto:ttrebon@uoregon.edu).



more frequent pauses than higher proficiency speakers (Anderson-Hsieh & Venkatagiri, 1994; Iwashita et al., 2008; Kormos & Dénes, 2004; Riazantseva, 2001; Towell et al., 1996; Trofimovich & Baker, 2006).

Filled pauses, which are the focus of this paper, accomplish crucial linguistic work such as facilitating conversational turn-taking (Clark & Fox Tree, 2002; Maclay & Osgood, 1959), signaling to listeners what a speaker might say next (Brennan & Williams, 1995; Fox Tree, 2001; Watanabe et al., 2008), and giving speakers time to plan utterances (Clark & Fox Tree, 2002; Maclay & Osgood, 1959). Different languages use different sounds for filled pauses; this is described as phonetic quality. English speakers primarily use “uh,” the central vowel [ə] to hesitate (Maclay & Osgood, 1959), with brackets denoting the International Phonetic Alphabet (IPA)’s standardized system used by linguists to identify sounds. In contrast, Spanish speakers primarily use “eh” or [e] to hesitate (Campillos-Llanos & Plá, 2009; Cenoz, 1998; Erker & Bruso, 2017; Roggia, 2012). When the phonetic quality of a hesitation sound is consistent with a hesitation sound used by native speakers, the hesitation sound is “native.” A hesitation sound with phonetic quality inconsistent with a native speaker hesitation sound is “nonnative.”

Pauses also have important perceptual consequences. The perceptual consequences of pause length, frequency, and location in nonnative speech have been well investigated. Longer pauses, more frequent pauses, and unfavorable pause placement (such as within a clause) increase accentedness ratings and decrease fluency ratings of nonnative speech (Bosker et al., 2013; Cucchiariini et al., 2002; Derwing et al., 2004; Kahng, 2018; Kang, 2010; Trofimovich & Baker, 2006; Wennerstrom, 2000).

However, research regarding the phonetic quality of second language hesitation sounds is limited. Studies suggest that second language speakers generally do not produce hesitation sounds with the same phonetic quality as native speakers, although proficiency and speech community are influential factors (Erker & Bruso, 2017; Hlavac, 2011; Rose, 2017). Rose (2017) found that native Japanese speakers learning English did not accurately produce the native English hesitation sound [ə]. However, higher-proficiency learners’ hesitation sounds more closely resembled the acoustic properties of native English hesitation sounds, indicating that mastery of the second language sound system may be important for producing native hesitation sounds. In a study of native Spanish speakers living in the US and learning English, Erker & Bruso (2017) found that native Spanish speakers were more likely to use English hesitation sounds instead of Spanish hesitation sounds when they: (1) frequently interacted with native English speakers, (2) had lived in the US for a longer period of time, (3) and spoke English often.

This paper asks whether the native or nonnative phonetic quality of a hesitation sound impacts listener judgments about fluency and accentedness. This study uses distinct experimental designs to investigate the perceptual consequences of Spanish versus English hesitation sounds in nonnative English speech produced by male speakers.

## 2. OVERALL METHODS

Four speech perception experiments were conducted to investigate how the phonetic realization of a hesitation sound (whether the nonnative speaker uses a native or nonnative

hesitation sound to pause) affects listener judgments about accentedness and fluency. While the term “fluency” has been defined in various ways (e.g. Bosker et al., 2013; Chambers, 1997; Lennon, 1990), in this study, fluency is used as a proxy for language proficiency. As described below, fluency was defined to participants as “how well someone speaks a language.” Two of the four experiments in this study, Experiments 1A and 1B, utilized a Likert scale rating task where participants listened to sentences and rated how accented or fluent the sentences sounded on a scale of 1 to 9. The other two experiments, Experiments 2A and 2B, utilized a forced choice task, presenting participants with pairs of sentences that were identical except that they contained different types of pauses. Participants heard three sentence pairs that had a native and a nonnative hesitation sound, a nonnative hesitation sound and a silent pause, and a native hesitation sound and a silent pause. Participants then chose which sentence of each pair sounded more fluent or more accented. All experiments are described in detail below.

### 3. STIMULI

Because this research was conducted during the COVID-19 pandemic, stimuli were drawn from the Archive of L1 and L2 Scripted and Spontaneous Transcripts and Recordings (ALLSTAR; Bradlow, n.d.). L1 designates a first or native language; L2 designates a second or nonnative language. ALLSTAR is a corpus of L1 and L2 speech that contains over 120 talkers in over 20 languages. Spontaneous speech in the ALLSTAR corpus was elicited via open ended prompts about the talker’s life and personal experiences as well as by asking participants to describe what happened in a series of cartoon pictures. The male voices utilized in the study had spontaneously produced native and nonnative hesitation sounds in the ALLSTAR corpus.

In this study, participants listened to spontaneous speech in English from eight male speakers who spoke Spanish natively and English as a second language. Male speakers and not female speakers were chosen for several reasons. First, studies show that male and female voices can be perceived differently (Boyle, 2015; Klofstad et al., 2012). To avoid factors that could confound the results of this study, and because there was more data in the ALLSTAR corpus available from L1 Spanish and L2 English male speakers than female speakers, only male voices were used to create stimuli. To conceal the research question, stimuli sentences contained both filled and unfilled pauses, and 12 filler sentences were created by identifying relatively short English sentences without pauses. Filler sentences were used only in the Experiments 1A and 1B due to their differing experimental designs compared to Experiments 2A and 2B. The possible effects of using filler sentences in Experiments 1A and 1B and not using filler sentences in Experiments 2A and 2B are addressed in the discussion section of this paper.

Stimuli sentences were created by identifying sentences in spontaneous English speech that contained one filled pause. Forty such sentences were identified. Then, prototypical English and Spanish hesitation sounds for each speaker were identified in English and Spanish spontaneous speech. Using Praat (Boersma & Weenink, 2020), a software program for analyzing and editing speech, either a Spanish hesitation sound, English hesitation sound, or a silent pause were edited into each of the 40 English utterances in the place of the naturally occurring hesitation sound. Thus, each sentence with a naturally occurring hesitation sound yielded three edited stimuli sentences: one with a native English hesitation sound (uh), one with a Spanish hesitation sound (eh) that is nonnative to English, and one with a silent pause. Speaker voices were never mixed;



that is, the hesitation sounds edited into the stimuli sentences always came from the same speaker who produced the sentence. Pause location was never altered from the original pause location produced in spontaneous speech.

All Spanish and English hesitation sounds used in this study had acoustic properties, specifically, F1 and F2 values, consistent with the prototypical English and Spanish vowels used to hesitate. The average F1 and F2 of Spanish hesitation sounds in stimuli were 474.7 Hz (SD = 58.7 Hz) and 1979.9 Hz (SD = 161.7 Hz), respectively, which are similar to those reported for the Spanish hesitation sounds' vowel [e] in Bradlow (1995). The average F1 and F2 of English hesitation sounds in stimuli were 631.5 Hz (SD = 93.9 Hz) and 1343.7 Hz (SD = 129.4 Hz), respectively, which are similar to those reported in Bradlow (1995) for the English [ʌ], a vowel that is perceptually similar to the vowel [ə] used to hesitate in English. Using Praat, stimuli and filler sentences were leveled for intensity (loudness) at 60 dB SPL.

## 4. OVERVIEW OF PARTICIPANTS

For all experiments in this study, no participant reported any speech or hearing impairments. Participants were required to use headphones to listen to speech and complete the experiment in a quiet environment. Participants were either MTurk workers, who were paid up to \$4.10 for their participation, or University of Oregon students from the Psychology and Linguistics Human Subjects Pool, who received credit to satisfy course requirements in return for their participation. Mturk participants were paid using funds provided by the Acoustical Society of America via the Robert W. Young Award for Undergraduate Student Research in Acoustics. Mturk participants and participants from the Psychology and Linguistics Human Subjects Pool were compensated regardless of the content of their responses. Although participant knowledge of linguistics and pausing may have varied, participants were instructed to make judgments based on perception and not based on knowledge. Each study participant only participated in one experiment.

After completing the experiment, participants completed a language background survey that asked about their native language and experience with other languages and nonnative accents. Data gathered in this survey was only used to ensure that participants were native speakers of English.

## 5. EXPERIMENT 1A

### 5.1. EXPERIMENT 1A: PROCEDURE

This experiment was administered online using Qualtrics (Qualtrics, Provo, UT). Over the course of approximately 30 minutes, participants listened to 40 stimuli sentences and 12 filler sentences for a total of 52 sentences in a randomized order and rated each one for fluency on a Likert scale of 1 to 9. Participants were given the following instructions regarding how to rate sentences for fluency:

In this experiment, you will listen to speech and make judgments about how fluent the speaker sounds in English in each sentence. You will rate English fluency on a scale of 1-9. Fluency means how well someone speaks a language.

It is important that you rate each sentence individually even if you think that you've heard the speaker's voice in a previous sentence.

1 = speaker does not at all sound fluent in English in this sentence (beginner in English)

9 = speaker sounds very fluent in English in this sentence (speaks English very well)

To ensure that a participant never heard the same utterance more than once, participants were randomly assigned to one of three conditions. In each condition, a participant heard only one of the three versions of the sentences that contained pauses and 12 filler sentences without pauses. Each condition contained an equal proportion of sentences with English filled pauses, Spanish filled pauses, and silent pauses.

## 5.2. EXPERIMENT 1A: PARTICIPANTS

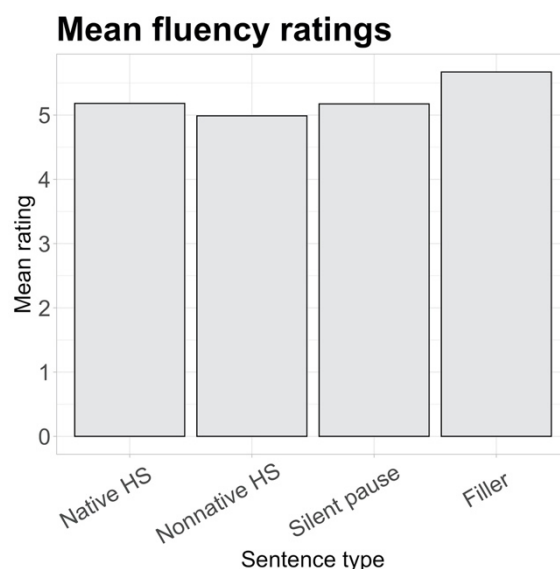
Fifty native English listeners participated in this experiment. Twenty-nine participants were female, 20 were male, and one participant chose not to disclose their gender. Participants had a mean age of 29.3 years and the age range for participants was 18 to 67 years. Twenty-one participants were Amazon Mechanical Turk (Mturk) workers, and all other participants were University of Oregon students from the Psychology and Linguistics Human Subjects Pool.

## 5.3. EXPERIMENT 1A: RESULTS

Data was analyzed in R (R Core Team, 2020) using linear mixed models analysis. The phonetic realization of the hesitation sound (whether the speaker used the nonnative Spanish “eh” or the native English “uh” to hesitate) did not impact listener judgments about fluency and was not a significant predictor of model fit ( $\chi^2 = 0.0815$ ,  $p = 0.7753$ ). Data analysis also shows that whether the pause listeners heard was filled or unfilled did not influence judgments about fluency ( $\chi^2 = 0.102$ ,  $p = 0.7495$ ). In addition, whether the sentence that listeners heard contained a pause was not a significant predictor of fluency ratings ( $\chi^2 = 1.6311$ ,  $p = 0.2015$ ).

In other words, Experiment 1A results reveal that whether the hesitation sound listeners heard in sentences was native or nonnative did not affect fluency ratings. Additionally, whether the pause listeners heard was filled or silent did not affect fluency judgments, and whether a sentence contained a pause or not did not impact listener ratings. Figure 1 below shows the average fluency ratings for sentences with each pause type. For Figure 1 and all other figures in this paper, HS stands for hesitation sound.





**Figure 1:** Mean fluency ratings for Experiment 1A

## 6. EXPERIMENT 1B

Research shows that nonnative speakers are more likely to produce longer pauses, pause more frequently, and pause within a clause compared to native speakers (Anderson-Hsieh & Venkatagiri, 1994; Iwashita et al., 2008; Kormos & Dénes, 2004; Pickering, 1999; Riazantseva, 2001; Towell et al., 1996; Trofimovich & Baker, 2006). These nonnative pausing patterns correlate with lower fluency ratings and higher accentedness ratings (Bosker et al., 2013; Cucchiaroni et al., 2002; Derwing et al., 2004; Kahng, 2018; Kang, 2010; Trofimovich & Baker, 2006; Wennerstrom, 2000). Because using nonnative hesitation sounds is also a pausing pattern found in nonnative speech, and because the phonetic realization of the hesitation sound did not affect listener fluency judgments in Experiment 1A, it could be predicted that the phonetic realization of a hesitation sound would not affect accentedness ratings. However, it is also possible that compared to fluency judgments, accentedness judgments would be more influenced by the acoustic differences between native and nonnative hesitation sounds. In order to investigate whether the phonetic realization of a hesitation sound affects accentedness judgments, a second Likert scale rating experiment, Experiment 1B, was conducted.

### 6.1. EXPERIMENT 1B: PROCEDURE

The procedures for Experiment 1A and Experiment 1B are identical except for the directions that participants were given to rate sentences. In Experiment 1B, participants were given the following instructions about how to rate sentences for accentedness:

In this experiment, you will listen to English sentences and make judgments about how accented each sentence sounds. You will rate accentedness on a scale of 1-9.

It is important that you rate each sentence individually even if you think that you've heard the speaker's voice in a previous sentence.

1 = speaker does not at all have a nonnative accent in this sentence

9 = speaker has a very strong nonnative accent in this sentence

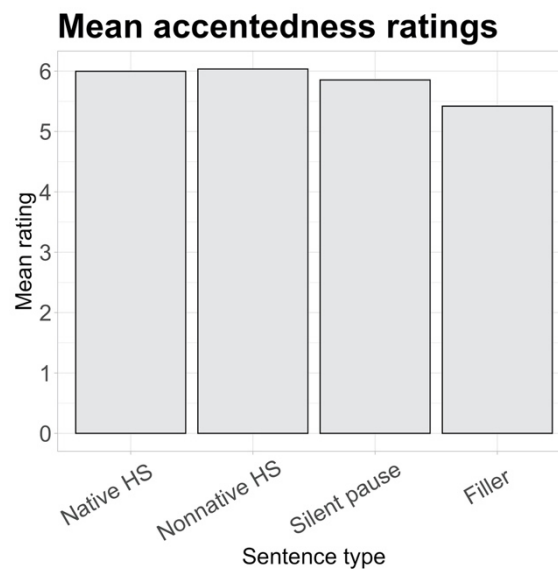
## 6.2. EXPERIMENT 1B: PARTICIPANTS

Fifty native English listeners participated in this experiment. When asked to self-report gender, 29 participants identified as female, 20 identified as male, and one participant identified as a transgender man. Participants had a mean age of 30.7 years, and the age range for participants was 18 to 65 years. Twenty-four participants were MTurk workers, and all other participants were University of Oregon students from the Psychology and Linguistics Human Subjects Pool.

## 6.3. EXPERIMENT 1B: RESULTS

As in Experiment 1A, data was analyzed in R (R Core Team, 2020) using a linear mixed models analysis. The phonetic realization of the hesitation sound (whether the hesitation sound was native or nonnative) did not impact listener judgments about accent and was not a significant predictor of model fit ( $\chi^2 = 0.0815$ ,  $p = 0.7753$ ). Additionally, whether the pause in the sentence was filled or unfilled did not impact listeners' accentedness ratings ( $\chi^2 = 1.0158$ ,  $p = 0.3135$ ). However, listeners judged stimuli sentences that contained a pause as more accented than filler sentences that did not ( $\chi^2 = 5.6127$ ,  $p = 0.01783$ ).

In summary, when participants listened to sentences and rated them for accentedness, neither the phonetic realization of the hesitation sound nor whether a pause was filled or unfilled impacted either fluency or accentedness ratings. However, whether a sentence contained a pause did impact listener ratings; sentences containing a pause of any kind were deemed more accented than sentences without pauses. Figure 2 shows the average accentedness ratings for sentences with each sentence type.



**Figure 2:** Mean accentedness ratings for  
Experiment 1B

## 7. EXPERIMENT 2A

The results of experiments 1A and 1B show that neither the phonetic realization of a hesitation sound nor whether a pause was filled or unfilled impacted listener judgments about accentedness or fluency. In order to investigate whether listener judgments would change if participants completed a different task to evaluate sentences for accentedness and fluency, two experiments with a forced choice task were designed and conducted after analyzing the results of Experiments 1A and 1B. In Experiments 2A and 2B, participants listened to two versions of the same sentence with different types of pauses and chose which sentence sounded more fluent or more accented.

### 7.1. EXPERIMENT 2A: PROCEDURE

As described above, the process for creating stimuli yielded three variations of the same sentence: one with an native (English) hesitation sound, one with a nonnative (Spanish) hesitation sound, and one with a silent pause. In Experiment 2A, participants listened to two variations of the same sentence (each sentence contained a different pause type) and chose which sentence made the speaker sound more fluent. Participants were given the following instructions:

In this experiment, you will listen to speech and make judgments about how fluent the speaker sounds in English in each sentence. Fluency means how well someone speaks a language.

You will listen to two versions of a sentence and decide which version makes the speaker sound more fluent in English.

During each trial, the participants were asked, “Does the speaker sound more fluent in English in sentence 1 or sentence 2?”

In total, participants heard 20 pairs of sentences that contained an English and a Spanish pause, 10 pairs of sentences that contained a silent and an English pause, and 10 pairs of sentences that contained a silent and a Spanish pause. No filler sentences were used in Experiments 2A or 2B.

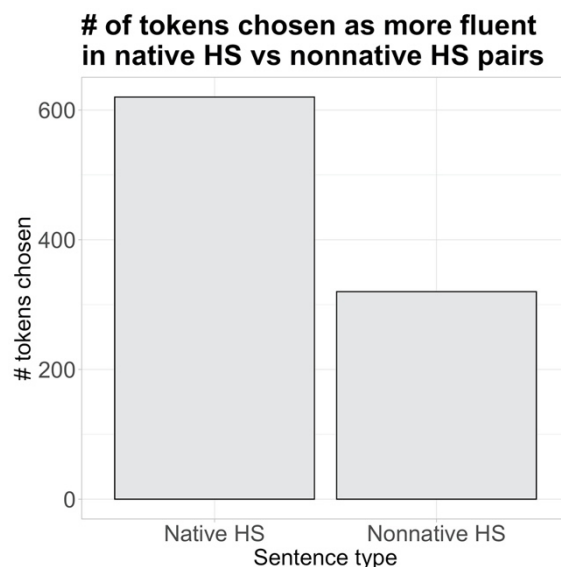
### 7.2. EXPERIMENT 2A: PARTICIPANTS

Forty-seven native English listeners participated in Experiment 2A. Thirty-seven participants were female, nine were male, and one participant identified as non-binary. Participants had a mean range of 23.3 years and the age range for participants was 18 to 67 years. Eleven participants were MTurk workers, and all other participants were University of Oregon students from the Psychology and Linguistics Human Subjects Pool.

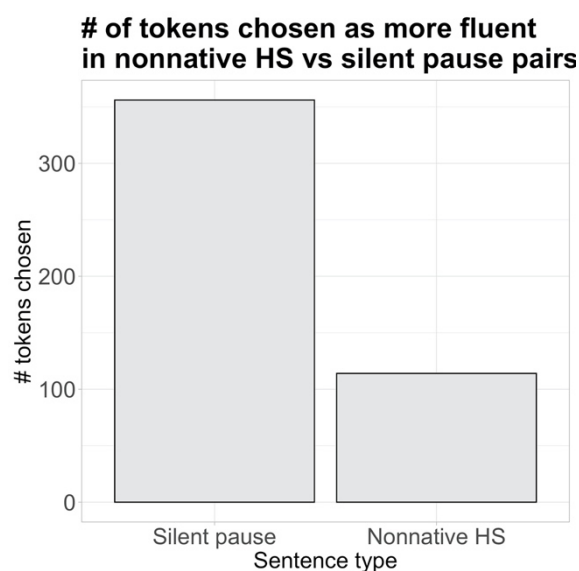
### 7.3. EXPERIMENT 2A: RESULTS

Data were analyzed using chi-squared tests in R (R Core Team, 2020). Listeners judged sentences with native (English) hesitation sounds as more fluent than sentences with nonnative (Spanish) hesitation sounds ( $\chi^2 = 95.745$ ,  $p < 0.001$ ). Participants also judged sentences with silent pauses as more fluent compared to sentences with Spanish hesitation sounds ( $\chi^2 = 124.6$ ,  $p < 0.001$ ). In addition, sentences with silent pauses were judged as more fluent than sentences with English hesitation sounds ( $\chi^2 = 17.234$ ,  $p < 0.001$ ).

In other words, the results of Experiment 2A show that in a forced choice task where listeners were asked to evaluate sentences for fluency, the phonetic realization of hesitation sounds did influence listener judgments. Sentences with native (English) pauses were considered more fluent than sentences containing nonnative (Spanish) pauses. Additionally, sentences with silent pauses were judged as more fluent compared to sentences with nonnative hesitation sounds. Also, compared to sentences that contained native filled pauses, sentences with silent pauses were deemed more fluent. Figures 3 through 5 show the number of sentences with silent pauses, nonnative hesitation sounds, and native hesitation sounds that were chosen as more fluent in each pair type.

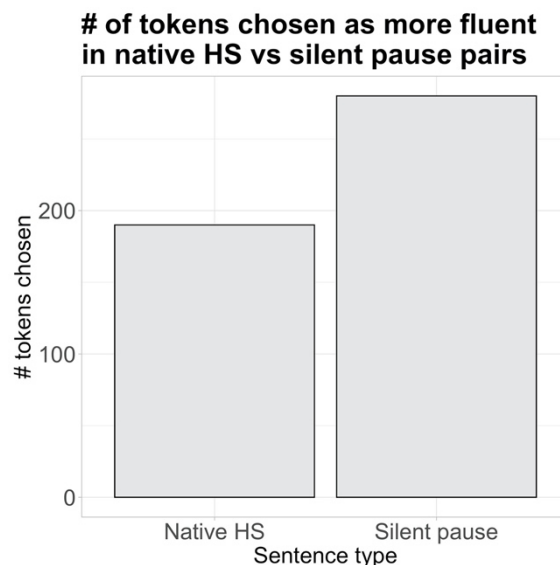


**Figure 3:** Number of sentences (tokens) selected as more fluent in native/nonnative hesitation sound pairs in Experiment 2A





**Figure 4:** Number of sentences (tokens) selected as more fluent in nonnative hesitation sound/silent pause pairs in Experiment 2A



**Figure 5:** Number of sentences (tokens) selected as more fluent in native hesitation sound/silent pause pairs in Experiment 2A

## 8. EXPERIMENT 2B

Experiment 2A shows that nonnative hesitation sounds decreased fluency ratings. To investigate whether the phonetic realization of a hesitation sound also affected perceptions about accentedness, a second forced choice task experiment, Experiment 2B, was also conducted.

### 8.1. EXPERIMENT 2B: PROCEDURE

The procedure for Experiment 2B was identical to Experiment 2A's procedure except that participants were instructed to choose which sentence sounded more accented. Participants received the following instructions:

In this experiment, you will listen to speech and make judgments about how accented each sentence sounds.

You will listen to two versions of a sentence and decide which version makes the speaker sound like they have a stronger nonnative accent.

During each trial, participants were asked, "Does it sound like the speaker has a stronger nonnative accent in sentence 1 or sentence 2?"

### 8.2. EXPERIMENT 2B: PARTICIPANTS

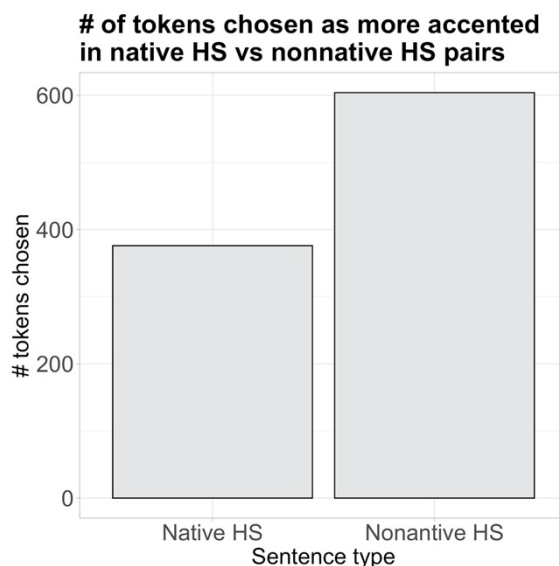
Forty-nine native English listeners participated in this experiment. Forty participants were female, eight were male, and one participant identified as non-binary. Participants had a mean age of 25.3 years and the age range for participants was 18 to 54 years. Sixteen participants were

MTurk workers, and all other participants were University of Oregon students from the Psychology and Linguistics Human Subjects Pool.

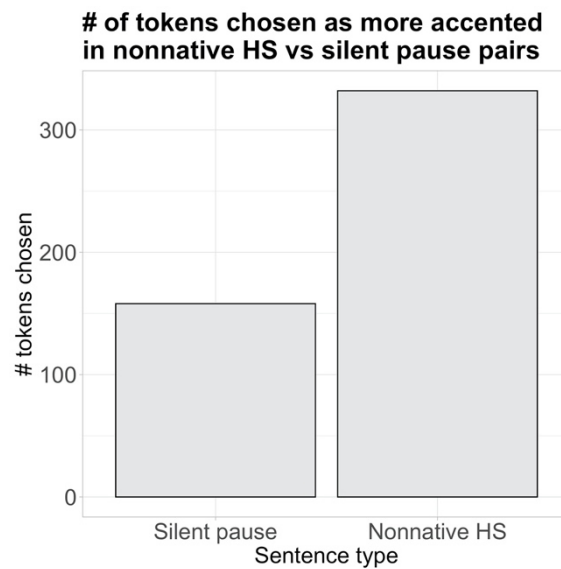
### 8.3. EXPERIMENT 2B: RESULTS

As in Experiment 2A, data was analyzed using chi-squared tests in R (R Core Team, 2020). Listeners judged sentences with nonnative (Spanish) hesitation sounds as more accented than sentences with native (English) hesitation sounds ( $\chi^2 = 53.045$ ,  $p < 0.001$ ). Listeners also deemed sentences with a nonnative (Spanish) hesitation sound to be more accented than sentences with a silent pause ( $\chi^2 = 61.788$ ,  $p < 0.001$ ). There was not a significant difference in accentedness judgments for sentences that contained an English hesitation sound versus a silent pause ( $\chi^2 = 2.3592$ ,  $p = 0.1245$ ).

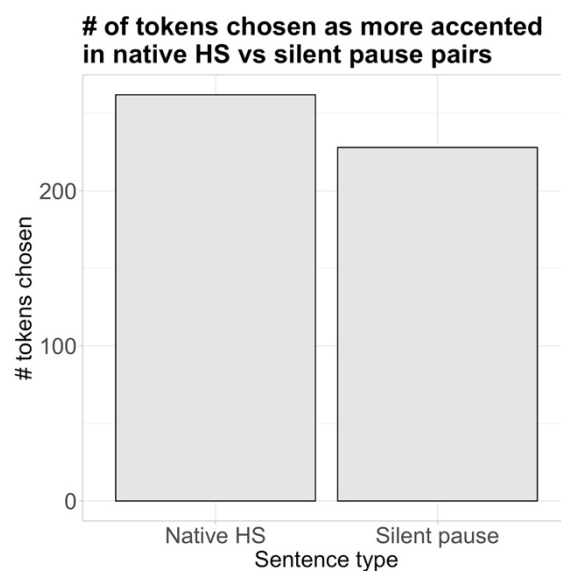
Data analysis reveals that when participants were asked to choose which sentence sounded more accented in a forced choice task, listeners judged sentences with nonnative (Spanish) hesitation sounds to be more accented compared to sentences with native (English) hesitation sounds. Listeners also judged sentences with nonnative (Spanish) filled pauses as more accented compared to sentences with silent pauses. However, listeners judged sentences with native hesitation sounds and silent pauses similarly. Figures 6 through 8 show the number of sentences with silent pauses, nonnative hesitation sounds, and native hesitation sounds chosen as more accented in each pair type.



**Figure 6:** Number of sentences (tokens) selected as more accented in native/nonnative hesitation sound pairs in Experiment 2B



**Figure 7:** Number of sentences (tokens) selected as more accented in nonnative hesitation sound/silent pause pairs in Experiment 2B



**Figure 8:** Number of sentences (tokens) selected as more accented in native hesitation sound/silent pause pairs in Experiment 2B

## 9. DISCUSSION

This study asks: Does the phonetic realization of the hesitation sound influence listener judgments about accentedness and fluency? In other words, how does using native versus nonnative hesitation sounds impact listener accentedness and fluency judgments? To answer these questions, four speech perception experiments were conducted. Two of the four

experiments, Experiments 1A and 1B, utilized a Likert scale rating task where listeners heard sentences with native (English), nonnative (Spanish), and silent pauses in addition to filler sentences that did not contain pauses. Listeners rated sentences for fluency and accentedness in Experiments 1A and 1B, respectively. The results of Experiments 1A and 1B reveal that the phonetic realization of the hesitation sound did not impact accentedness or fluency ratings.

However, in Experiments 2A and 2B, the phonetic realization of the hesitation sound did impact listener judgments about accentedness and fluency. In Experiments 2A and 2B, which utilized a forced choice task, participants heard two sentences that were identical except that they contained different types of pauses. Participants heard sentence pairs with a native and a nonnative hesitation sound, a native hesitation sound and a silent pause, and a nonnative hesitation sound and a silent pause, respectively. Listeners chose which sentence from each pair sounded more fluent in Experiment 2A and which sounded more accented in Experiment 2B. The results of Experiments 2A and 2B reveal that listeners judged sentences with nonnative hesitation sounds as less fluent and more accented than sentences with native hesitation sounds. The difference in results between Experiments 1A and 1B and Experiments 2A and 2B indicates that the different tasks used in these experiments affected how listeners made fluency and accent judgments.

One explanation for the difference in results between these experiments is that pauses were more salient to listeners in the forced choice task than they were in the Likert scale rating task. In each trial of the forced choice experiments, participants heard two sentences that were identical except that each sentence contained a different type of pause. That the two sentences heard in sequence only differed in the type of pause they contained perhaps made the pauses more prominent to listeners. Also, structural aspects of the Likert scale rating task in Experiments 1A and 1B could have decreased the relative salience of pauses and lessened the influence of pauses on listeners' ratings. During the Likert scale rating task, participants heard distinct sentences in a randomized order. Unlike Experiment 2A and 2B participants, Experiment 1A and 1B participants never heard the same sentence more than once, let alone the same sentence consecutively with a different pause. Also, listeners who completed the Likert scale rating task heard filler sentences that did not contain pauses in addition to those that did contain pauses. In contrast, forced choice task participants only heard sentences with pauses. Increased pause salience in the forced choice experiments could have made the type of pause more influential in listener judgments; decreased pause salience in the Likert scale rating task could have made the pause less influential.

Another explanation for the contrasting results in Experiments 1A and 1B and Experiments 2A and 2B is that listeners made more holistic judgments in the Likert scale rating task and more fine-grained judgments in the forced choice task. That is, listeners in the Likert scale rating task may have used top-down cues that caused pauses to have less influence on their judgments. In contrast, forced choice listeners may have made more bottom-up judgments that caused pauses to have more influence. In other words, in the Likert scale rating task, participants perhaps made holistic decisions about fluency and accentedness based on their general impression of the sentence. Conversely, forced choice participants may have examined individual parts of each speech signal, identified what differentiated them, and based their judgment on the differentiating feature.



The results of this study suggest that when listeners make holistic judgments about nonnative speech — or in situations where nonnative speech is not scrutinized — using nonnative hesitation sounds is unlikely to negatively impact listener opinions about a nonnative speaker's accent or how well they speak a language. This finding has important implications for how learners treat pausing when practicing their second language and for how nonnative speech is perceived in real-world situations. Research shows that practicing speaking a second language is one of the best ways to increase proficiency (Izumi et al., 1999; Toth, 2006; Valezy & Spada, 2006). Yet research also shows that speakers are more likely to pause when speaking their second language (Pickering, 1999; Riazantseva, 2001). As learners' proficiency improves, it is likely that their pausing patterns will come to resemble those of native speakers (Erker & Bruso, 2017). This study suggests that learners should pause however it feels natural to them, especially in everyday situations where speech is unlikely to be closely examined. However, this study also suggests that in situations where listeners judge nonnative speech in a fine-grained way, using nonnative hesitation sounds may lead to negative perceptions about a speaker's accent and fluency. Therefore, education about the phonetic quality of hesitation sounds may be a useful addition to language teaching curriculum.

This study demonstrates the need to reduce stigma around pauses, especially regarding nonnative speech. This study also has important implications for future work investigating perception of nonnative speech. Results show that both the context in which listeners hear nonnative speech and the task that listeners perform to evaluate speech affect listener judgments. The effect of task on the perceptual consequences of filled and unfilled pauses should be further investigated. Additionally, the results of this study add complexity to speech perception literature suggesting that filled and unfilled (silent) pauses have different perceptual consequences. For example, it has been found that unfilled pauses negatively affect listener perceptions about accentedness and comprehensibility (Kang, 2010). However, the results of Experiments 1A and 1B showed that whether a pause is filled or unfilled did not affect listener judgments about accent or fluency. Yet, Experiment 2A and 2B results showed that sentences with native (English) filled pauses were judged as less fluent and more accented than silent pauses. More research is needed to fully understand the perceptual effects of filled versus unfilled pauses in all speech. Additionally, because this project was limited to the perception of male speech, future studies should investigate the effect of hesitation sound phonetic quality on the perception of non-male speech.

## 10. CONCLUSION

This study examined the effect of hesitation sound phonetic quality on perception of language fluency and accent. In two of the four experiments conducted (Experiments 1A and 1B), the phonetic realization of hesitation sounds did not impact listener judgments about accent or fluency. However, in the other two experiments conducted (Experiments 2A and 2B), which utilized a different experimental design, sentences with nonnative hesitation sounds were judged as less fluent and more accented than sentences with native hesitation sounds. Two explanations are offered for the differing results between experiments. It is possible that pauses were perceived as more salient in Experiments 2A and 2B than they were in Experiments 1A and 1B and the salience of pauses affected listener judgments. It is also possible that listeners made fine-grained

or holistic judgments depending on the task they performed to evaluate speech. The results of this study suggest that the type of task that listeners perform to evaluate speech affects listener judgments about fluency and accentedness. With some tasks, nonnative hesitation sounds can cause speech to be perceived as less fluent and more accented. The results of this study also show that the phonetic realization of a hesitation sound can have significant perceptual consequences.

## ACKNOWLEDGEMENTS

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# The Sacred and the Holy in Tolstoy's *Hadji Murád*: Irreconcilable Tensions Between War and God

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## ABSTRACT

Twentieth-century French thinker Emmanuel Levinas' distinction between the sacred and the Holy — the spiritual journey “du sacré au saint” — is key to understanding his philosophy. While the sacred emanates from religiously-justified violence, the Holy manifests in the ethical relationship with “the other.” This essay explores the fundamental distinction between the sacred and the Holy in relation to Leo Tolstoy's novella *Hadji Murád*. Adopting a Levinasian view, the author unravels Tolstoy's moral message: the sacred violence of war fuels the totalization of the other, which blinds its perpetrators to its un-Godliness and facilitates the continuation of violence. Even when narratives of war implicate God to glorify violence, war is the un-Holy. To signal the sacred, the author extracts examples from Tolstoy's novella of the Holy emerging from humans' selflessness. Through the story of *Hadji Murád*, Tolstoy begs his reader to revive God in all his Holiness, which entails an ethical surrender to the other. Today's reader must re-interpret the Divine as Levinas does, for collective peace depends on it.

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## 1. INTRODUCTION: LEVINAS' PHILOSOPHY & TOLSTOY'S *HADJI MURÁD*

*À la guerre, comme à la guerre*<sup>1</sup> — these words, casually announced at a dinner among nobility in Russian writer Leo Tolstoy's (1828-1910) novella *Hadji Murád*, haunt the reader of the 21<sup>st</sup> century, a century which seems to be perpetually infested with violence. While *Hadji Murád* is eerily absent of the dominant moral figure typically present in Tolstoy's works, Tolstoy's depiction of the Caucasus War is far from amoral and urges the reader to consider how religion is exploited and politicized by self-interested Muslim and Christian leaders. In resonance with French philosopher Emmanuel Levinas' (1906-1995) distinction between the sacred and the Holy, *Hadji Murád* offers an ethical lens through which one can meaningfully reflect on tensions between war and religion. Furthermore, Levinas' conceptualization of the sacred — which emanates from religiously-justified violence — and the Holy — which manifests in the ethical and

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<sup>1</sup> Author's translation: “All is fair in love and war.”

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selfless relationship with the other — is the moral narrative underpinning Tolstoy's novella. War is entirely un-Holy, no matter how much its leaders implicate the Divine, who is God, to legitimize and glorify their violence.<sup>2</sup> This sacred violence of war hinges on the dehumanization of the "other," which facilitates the continuation of war and blinds its perpetrators to its pure un-Holiness. Like Levinas, Tolstoy proposes that to attain the Holy (and thus surpass the sacred), one must not sacrifice the other for a religious-political system but must instead surrender entirely to the other's needs.

As this work's mentor Dr. Steven Shankman writes in his essay "The Posteriority of the Anterior," both Tolstoy and Levinas "posit a self that is primordially haunted by the other" (161). Because they write in different epochs, it is intriguing to examine the overlap in both writers' works. Levinas, who integrated phenomenological analysis with insights from Jewish spirituality, considers the ethical relationship between "the self" (whom he refers to as "I") and the other (who is any person other than the self). Such a relation centers on the self's never-ending responsibility for the other. Importantly, this responsibility is asymmetrical, because the self must act for the other without expectation of being supported and served in the same way. Certainly, the self meets a multiplicity of others throughout a lifetime — including individuals of different nationalities, religions, ethnicities, and backgrounds — but Levinas emphasizes the singular other to show that humans encounter others one at a time. Levinas summarizes that the ethical responsibility "is the principle of absolute individuation" and that "I am responsible for a total responsibility" (Levinas, *Ethics and Infinity* 81, 99). The self bears an infinite duty to serve the other and even undertake the other's responsibilities, which marks the self's true "individuation" — that is, the self's ability to exist as an ethical human independent from others. If the self rejects this ethical responsibility, they do not individuate themselves as a unique individual. Moreover, religion in its non-politicized form has the power to remind the self of its individual responsibility; for instance, Levinas claims that the Holy Scriptures can awaken the self to act morally (117-8). This moral awakening solidifies the self's subjectivity, which signifies the self becoming an absolutely individuated, ethical agent.

Central to Levinas' understanding of ethics and religion is the distinction between the sacred ("le sacré") and the Holy ("le saint"), which is relevant to digest Tolstoy's *Hadji Murád* through a moral lens.<sup>3</sup> While the sacred is religiously-justified violence, the Holy refers to the Divine nature of ethics. Levinas writes, "the sacred envelops and transports man beyond his powers and his wills. The numinous cancels the relationships between people by making beings participate, even in ecstasy, in a dark drama that these beings did not want, in an order in which they are damaged" (Levinas, *Difficile Liberté* 28-29).<sup>4</sup> Levinas conceptualizes the sacred as what disintegrates the subjectivity of individuals; consequently, it disintegrates the ethical relationships between them. The sacred is a paradigm of force and violence that blurs the differences between the self and the other, reducing both to faceless pawns of a totality — the formation of a group identity at the

<sup>2</sup> In this paper, the author uses "God" and "the Divine" interchangeably, with the understanding that not all religious communities refer to their Divine figures with the name "God." The author capitalizes "Divine" just as "God" is capitalized.

<sup>3</sup> Although Levinas does not consistently capitalize "Holy" in his works, the author does so in this paper to emphasize the fundamental distinction between the sacred and the Holy, since the former is the violent un-divine whereas the latter is most intimately connected to God, hence the capitalization.

<sup>4</sup> Unless otherwise noted, quotes are the author's own translations.

expense of individuals' unique and complex identities. The sacred space simplifies humans, transforming them from individuated, ethical agents into so-called "beings," as if puppets on a string. Levinas pushes the Holy as a remedy for the ethical evasiveness that the sacred entails, equating the constant pursuit of ethical conduct to the "exigency of [H]oliness" (Levinas, EI 105-106). Describing the Holy, Levinas writes that "the rigorous assertion of human independence, from one's intelligent presence to intelligible reality" can destroy the sacred and introduce the Holy. Only through this process can "man rise to the spiritual notion of the Transcendent" (Levinas, DL 30)<sup>5</sup> (Levinas uses "the Transcendent" synonymously with "the [H]oly"). True spirituality stems from the individuated self maintaining their own agency, defining reality through a commitment to ethics whilst actively contesting sacred violence. By accepting a responsibility for the other's wellbeing, the self demonstrates subjectivity at the highest level (Holiness), where the sacred shatters and the Holy awakens.

Russian writer Tolstoy also hints at the ethical duties leading to true spirituality in *Hadji Murád*, which was published posthumously in 1917. The novella, based on Tolstoy's military service in the nineteenth-century Russian campaign to conquer the Caucasus Mountains, recounts the journey of the skilled Avar chieftain, Hadji Murád, who allies with the Russians after breaking with the Chechen leader, Imám Shamil. The story takes place in mid-nineteenth century Russia, a period during which the Russian military indeed embarked on an imperial conquest to expand their empire by confronting, fighting, and conquering indigenous Chechen populations. Through appalling descriptions of Russian Christian Emperor Nicholas I's autocratic rule, Chechen Muslim leader Shamil's ruthless leadership, and the one-dimensional Russian nobility's moral blindness, Tolstoy evokes an honest critique of a society at war. Although he does not employ the same vocabulary as Levinas (i.e., "sacred" and "Holy"), Tolstoy describes in gruesome detail the inhumane realities of violence to emphasize the truth of the religiously-justified war: its un-Godly sacredness. Leaders on both the Russian and Chechen sides participate in this sacred conflict by exploiting God's name as they attack and oppress. Sensing that their religio-political identities are threatened by the other, these brutal leaders each attempt to suppress the other's *otherness* — that which separates these individuals from one another. In the nineteenth century, Russians and Chechens alike employed violent measures such as forced assimilation and dehumanization, but a hundred years later, leaders of today's countless wars continue to employ these strategies to silence and harm individuals while using sacred justifications. Yet Tolstoy also shows that there are people who simply enjoy violence for the sake of violence, unconcerned about securing sacred meaning, which Tolstoy criticizes as a deeply un-Godly wound in humans' moral conscience.

In resonance with Levinas' philosophy that ethics lead to Holiness, Tolstoy suggests that the human conscience's recognition of the moral and the immoral can (and often does) override religious mandates and open the path to true spirituality. Through his portrayal of simple and selfless characters who are not outwardly religious, including a humble Chechen villager and a Russian soldier's peasant mother, Tolstoy demonstrates that true spirituality and prophetism emerge through the enactment of one's responsibility for the other, not through religious rule nor ritual. In today's world filled with constant political conflict, sectarian violence, and human rights

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<sup>5</sup> Author's translation



violations, Tolstoy and Levinas' messages offer key insights. If analyzed with a Levinasian focus on the Holy, *Hadji Murád* offers an opportunity to reflect on and re-interpret the Divine as the conscious application of ethics rather than the blind practice of tradition.

## 2. THE SACRED VIOLENCE OF WAR: WEAPONIZING GOD'S NAME

From the very first pages of *Hadji Murád*, Tolstoy pushes his reader to understand war as destructive violence that devours the other's identity to preserve a greater totality, which renders war sacred, according to Levinas' thought. As Tolstoy's narrator walks through some wild fields, he notices a so-called "Tartar" thistle mutilated by a plough. The narrator personifies this "Tartar" plant, describing how "it stood twisted to one side, as if a piece of its body had been torn from it, its bowels had been drawn out, an arm torn off, and one of its eyes plucked out" (Tolstoy 4). In humanizing the plant's mangled form through personification, Tolstoy makes a moral statement by forcing images of war's physically destructive impact into the reader's mind. The narrator reflects, "what a destructive creature is man... How many different plant-lives he destroys to support his own existence!" (4). War hinges on the perpetuation of a totality's existence (whether this totality is Russia or Chechnya, Christianity or Islam, and so on), so it fuels violence against the other who does not fit within that totality. In the case of the Caucasus War, imperial Russia attempts to expand the self by conquering others (Chechens) in the sacred names of the Orthodox faith and the nation. Indeed, Levinas asserts, "the sacred that envelops and transports me is violence" (Levinas, DL 29)<sup>6</sup>. Sacred narratives, whether about religion or the empire, position imperial actors within violent physical and mental spaces, and this posits grave consequences for those who do not conform to the totality.

Ultimately, the novella highlights the outrageous human toll of Russia's imperial project. While reflecting on *Hadji Murád*, readers must ask themselves: How many Chechens will the Russians kill in their invasion? How many Muslims will the Christians kill? How many others will one kill to support their own existence? These questions resonate with Levinas' reflection: "by being, by persisting in being, do I not kill?" (Levinas, EI 120). Those who kill are not only combatants but also civilians who passively accept war. As Tolstoy's narrator continues walking across the fields, he comments on a "lifeless black field," which anticipates the cruel Emperor Nicholas I's "lifeless gaze" and the brutal Imám Shamil's "immovable stony expression" (Tolstoy 4, 88, 110; emphasis added). War is incited by the lifeless people who believe they will benefit from violence, for their subjectivities — that is, their ethics and application of those ethics to reality — are asleep. Like the ploughed field, the world today may soon become lifeless if the un-Holy violence continues. This opening scene is Tolstoy's ethical call against all destruction and death that war unleashes onto humans, who, like the festive flowers painting the novella's first page, are beautiful, colorful, and full of light and life.

Yet just as today's world leaders often ignore this moral appeal in their quest for hegemonic power and influence, so too do the Russians waging war in *Hadji Murád*. Fueling this sacred war is the exploitation of religion as an imperial instrument to oppress and persecute the other, which corrupts the notion of God. Tolstoy mentions the Russians' attempts to punish the "mutinous peasants who did not wish to accept the Orthodox faith" (Tolstoy 93). Ethics are evidently absent

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<sup>6</sup> Author's translation

in these forced and violent conversions. The Russian Empire persecutes and attacks those who refuse Russian hegemony in the form of the Orthodox religion. In this case, the empire resembles the totality as Levinas understands it — as a violent system that attempts to synthesize the other. But the other is inherently *beyond* the Orthodox totality, for Levinas says, “the other is essentially what is unforeseeable” (Levinas, EI 67). The other is unable to be completely known because no system can define and account for every individual in all their complexity and uniqueness. The Muslim peasants are beyond the Russian Empire and the institution of the Orthodox faith because these totalities cannot comprehend their identities. Hence, the peasants’ existence outside the Russian and Christian labels proves that the totality cannot truly be achieved, and thus, their otherness threatens Russian totality. By forcing Muslim peasants to adopt the Orthodox faith, Russian officials use conversion to suppress the other’s unique identity, which is a sacred form of violence. In the process, the Orthodox faith loses its true spiritual value.

Unsurprisingly, most Russian and Chechen leaders in *Hadji Murád* do not prioritize true spirituality even when they feign piety. High-ranking military official and Russian nobleman Mikhail Vorontsón, for instance, wears the White Cross of the Order of St. George around his neck, but this cross does not inspire him to advocate for peace (Tolstoy 51). Rather, Vorontsón focuses on his wealth and power, actively supporting Russian expansion through his senior leadership position in the war. Ultimately, the cross — the very symbol of the Christian institution — does not awaken Vorontsón’s unique responsibility for the other. He does not respond to his duty to protect the other from war’s harms, which would lead him to true spirituality since individuals’ ethical commitment is the “exigency of [H]oliness” (Levinas, EI 105). Echoing this point, Tolstoy ridicules the superficial faith of the merciless Russian Emperor Nicholas I, who says his prayers “without attaching any kind of meaning to the words he uttered” (Tolstoy 87). These Christian leaders do not derive moral inspiration from religious symbols nor rituals. Reduced to a meaningless routine and inserted into the lives of self-interested humans, religion rots when absent of the Holy. Tolstoy’s readers must consider whether religion preserves a Holy essence in their day-to-day lives or whether it has lost its ethical significance altogether.

Based on Levinas’ assertions, exploitation of the Divine’s name to justify violence indicates that religion has become amoral. The weaponization of the Divine is a sacred paradigm, perpetuating violence and fueling the erroneous notion that self-interested politics help achieve Divine-approved justice. When legitimized by evoking God’s name, violence becomes more alluring. This is why Emperor Nicholas I is a dangerous man: he presents himself as a representative of God’s words while advocating for bloody measures. For instance, he decides to sentence a young Russian to run the gauntlet twelve thousand times by closing his eyes until, supposedly, a “spirit moved him [...] as though an inner voice had told him what to do” (Tolstoy 91).<sup>7</sup> This “spirit” seemingly serves as a celestial voice, as though Nicholas I were a prophet communicating with God to decide how to punish the youth. In this way, Nicholas I implicates the ostensible “spirit” in the torture he inflicts upon the other, which epitomizes Levinas’ understanding of the sacred.

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<sup>7</sup> “Running the gauntlet” is a corporal punishment during which a person is forced to run between rows of people striking with weapons.

Very similarly, Chechen leader Imám Shamil “supposedly listen[s] [...] to the voice of the Prophet, who spoke to him and told him what to do” (Tolstoy 113). This assertion links Shamil’s ruthless acts to Allah’s approval as if He truly supported Shamil’s political violence. Because the sacred violence instrumentalizes religion to wage wars against religious others, leaders like Shamil and Nicholas construe Islam and Christianity — as well as Allah and God — as fundamentally incompatible with one another. This myth reinforces the dichotomy between Chechens and Russians and inspires the polarizing rhetoric employed to justify religious war. Yet ultimately, the Muslim and Christian leaders of the Caucasus wars are not so different in their practices, as both reduce the Divine to an exploitable tool for violence. We see this sacred tactic continue today across our contemporary world. The most salient example may be modern terrorists who profess religious motivations and goals in their acts of violent extremism, blind to the truth that the Divine is in the ethical — not the sectarian violence.

Furthermore, Tolstoy shows how the sacred nature of politicized religion entrances people like Imám Shamil and Emperor Nicholas I, drawing them into a selfish “order in which [relationships between people] deteriorate” (Levinas, DL 29).<sup>8</sup> Religiously-justified violence corrupts the human-to-human connection. Naturally, the politicization of religion betrays morality when it is not “checked and criticized starting from the ethical” (Levinas, EI 80). The politicized Divine risks becoming — and in Tolstoy’s novella, does become — entirely unethical and therefore entirely un-Holy. For example, Shamil’s violent application of Sharia law radiates unethical sacredness, resulting in two people’s hands cut off and one man beheaded (Tolstoy 112). Even today, various countries in the Middle East, Asia, and Africa utilize the Sharia legal system in full or in part. However, Sharia law’s violent application does not represent true Holy law and does not ensure Holy justice because it violates ethics, and practicing violence in any religious context is an abuse of religion. As Levinas explains, the Holy Scriptures “command all the gravity of the ruptures where in our being the good conscience of its being-there is put into question” (Levinas, EI 117-8). The Holy texts inspire the self to question their “being,” which Levinas associates with the stagnant spirituality of a person who conforms to unethical sacred totalities. Levinas would extend the Holy Scriptures to comprise the Islamic texts because “ethical truth is common” to all religions (115). The Bible and the Quran are Holy because they awaken the ethical conscience of their readers. Thus, the violent implementation of Sharia law inherently misconstrues the meaning of the Quranic texts and corrupts Islam, drawing Allah’s ethically pure name into the violent terrain of the sacred.

Another connection concerning the sacred can be made between the violent practice of Sharia law and the biblical episode at Mt. Moriah with Abraham and his son. As Shankman describes in *Other Others*, the sacred manifests at Mt. Moriah where Abraham builds an altar upon which he intends to kill his son, after having presumably been commanded by God to do so. When conceived as a place of murder, this altar “trembles with the dark mysteries of the sacred” (Shankman 18). In a similar manner, Sharia law’s violent application is entirely sacred, for it authorizes the murder of the other in the Divine’s name. However, in the biblical episode at Mt. Moriah, the altar ultimately “becomes a site of the holy” since Abraham does not kill his son in the name of God and instead honors his responsibility to protect the other from death (18). In this

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<sup>8</sup> Author’s translation

sense, resisting the violent application of Sharia law by protecting and cherishing the other's life and wellbeing may well shatter the sacred.

Yet the sacred is not the only inspiration for violence done onto the other. To further condemn the Caucasus War led by the imperial Christian Russians against the Muslim Chechens, Tolstoy ridicules the perpetrators who enjoy violence for the sake of violence, presenting an ugly image of humankind in which all notions of religion are absent. Tolstoy portrays the Russian commander Poltorátsky as a career-focused character void of spiritual consciousness, as he does not call to God or any spiritual ideology to justify the violence that entertains him. His actions are void of both the Holy and the sacred. Upon meeting some Chechen fighters, Poltorátsky decides to "arrange for a battle that will be simply delightful" (Tolstoy 30). In characterizing the battle as "delightful" despite its deadly implications, Poltorátsky dismisses his ethical duty to protect the human beings in both his own troop and the Chechen troop. While Levinas believes that "the fear of the death of the other is certainly at the basis of the responsibility for him," Poltorátsky is trapped in the self-interested being and remains heedless of his responsibilities in the landscape of war (Levinas, EI 119). The "delightful" battle results in the young soldier Peter Avdéev's death, which does not perturb Poltorátsky, for he is disturbingly out of touch with the real suffering he causes. Poltorátsky is unfazed by the death of Peter Avdéev, who is on Poltorátsky's "side" of the imperial totality.

However, Tolstoy also insinuates that even if Poltorátsky had been inspired by sacred narratives about the Orthodox faith and the Tsar's empire, it is doubtful that he would have cared about the death of his young soldier. After all, even as leaders like Emperor Nicholas I and Imám Shamil flaunt their religious identities, they treat their own followers' lives with impunity. The sacred is useless in war, Tolstoy proves, because it results in the same destruction and death as the non-sacred. Any justification of violence is hence immoral. Arguably, Poltorátsky's non-sacred (and absolutely un-Holy) violence is more honest than the sacred violence of Nicholas I and Shamil, since Poltorátsky does not try to legitimize his actions with God's supposed approval. He does not force God's name into the corrupt landscapes of the battlefield. Tolstoy shows that for self-interested humans like Poltorátsky, life is cheap not only in the other's troop but also in one's own.

Still, Poltorátsky — like all the leaders in the modern world who have neglected their ethical duties in favor of power — lays claim to what is beyond him: the other. This is a profound moral crime, Levinas would argue, for it totalizes the other's unique otherness. By treating Peter Avdéev's singular and precious life like a game piece with which to amuse himself, Poltorátsky denies Peter Avdéev his identity, one which is intrinsically alien to Poltorátsky. This blurs the distinction between the self and the other, a key characteristic of the violent totality. To connect this discussion of the metaphysical to an example of the purely physical, modern militaries reproduce this violence in today's world order, as officials often legitimize civilian casualties as ugly necessities in war. In the process, they steal the lives of their others as if those lives were their own to instrumentalize. Levinas would argue that this is the mindset of the "being;" "Should I be dedicated to being?" he prods (EI 120). Through descriptions of Poltorátsky's morally reprehensible behavior, Tolstoy implicitly offers a response: one must not be dedicated to "being," since this self-interested state results in the deaths of many others. Levinas insists that "one cannot think God and being together," meaning that true spirituality cannot be enacted through

this stagnant, non-ethical “being” (77). Clearly, Poltorátsky is far from God as he perpetuates his irresponsible “being” that denies life to many. Presenting this ugly image of humanity, Tolstoy urges a revival of God in His ethical meaning — instead of the sacred one — so that others do not continue to die senselessly in this world.

If immoral and therefore un-Holy commanders like Poltorátsky continue ruling humanity, the violent paradigm of war will continue reducing the other to a piece of a whole, forcing them into the totalizing experience of the sacred. In *Other Others*, Shankman explains that Levinas associates the sacred with “the experience of participation in a cosmic whole,” which places an emphasis on “a participation in a totality of which you and I are mere parts” (Shankman 13). Reproducing the Levinasian understanding of the sacred, the letter announcing Peter Avdéev’s death to his family details that “Peter had been killed in the war, defending his Tsar, his Fatherland, and the Orthodox Faith” (Tolstoy 48). This immediately links Peter Avdéev’s senseless death to an empire and a religion, which flawlessly exemplifies the sacred experience of the subject subsumed by the political-religious totality. Peter Avdéev’s complex and unique individuality is negated when his life is reduced to a part of the empire’s sacred narrative of defense and glory. The letter announcement described in *Hadji Murád* reconstructs Peter Avdéev’s life as specifically crafted for the Tsar’s consumption. The Holy is absent in unjustifiable deaths caused by leaders’ understanding of murder as acceptable, and even desirable, for the totality’s expansion.

Similarly, the army’s official summary that “two privates were slightly wounded and one killed” during Poltorátsky’s “delightful” battle further dehumanizes Peter Avdéev (Tolstoy 44). Peter Avdéev — who Levinas would say is uncontainable because he is a unique human other — is reduced to “one killed” for the cosmic whole. He becomes a nameless, faceless, and soulless word that will soon be forgotten. He is not Peter, not Peter Avdéev, but “one” who will soon become no one. This is the result of the sacred; to sustain itself, the Tsar’s imperial totality mercilessly consumes humans both outside and inside of it. Although they may convince the other to join a battle, sacred narratives do not protect the other. Rather, they construe the other as a pawn and drag them into violence. This aggressive militaristic consumption of the other has not halted over time. Today, millions of others — both military and civilian — have been killed by totalities waging sacred wars against one another for the sake of a mission, whether sectarian, political, or both.

During these sacred wars, leaders employ dehumanization to facilitate violence, as it blinds its perpetrators to the other’s unique otherness. In *Hadji Murád*, Imám Shamil diabolizes the Russians by insisting that “it is better to die in enmity with the Russians than to live with the Unbelievers,” which categorizes an entire group of others on the sole basis of *non-religious* and denies each their individual human uniqueness (Tolstoy 112). The dehumanizing and generalizing label of “Unbelievers” paints Shamil’s movement as a sacred *jihad* (“holy war”), coating the war’s violence with religious justification. Civilian Chechens also participate in dehumanization, although Tolstoy portrays them with more sympathy. One Chechen villager reports that “the Russian dogs burnt the hay in the Mitchit [village]” (Tolstoy 7). This villager laments the destruction inflicted upon his community by the Russians, but his language is not innocent and perpetuates animalization of the other. Animalization, as a form of dehumanization, has been a common element of genocide that has been seen both historically and in the present day. Like the swine, the dog is considered to be impure and devilish in Islam. By equating the Russian human



to a non-human being, this villager denies the other's humanity. Although civilian Chechens hold less power than the war's military leaders, they still have ethical responsibilities to the other that they dismiss in their dehumanizing rhetoric. However, these Chechen villagers are the true victims of the Caucasus War, which legitimatizes their defense against imperialism and, therefore, does not render their violence sacred in the way that Imám Shamil's is.

Considering the power imbalances in the Caucasus War, dehumanization by the immense Russian totality has even bloodier human consequences than the Chechen villagers' rhetoric. During an atrocious raid on a village, a Russian officer named Butler passes a corpse, but he "only saw with one eye the strange position of the waxen hand and a dark red spot on the head, and did not stop to look" (Tolstoy 99). Here, dehumanization manifests in the refusal to look at the other's face since this symbolizes a refusal to acknowledge the human identity in the other. The bloody corpse evokes the image of the mutilated Tartar plant in the novella's first chapter, a reminder of the destructive forces of imperialism. Levinas explicates that "the face is what one cannot kill, or at least it is that whose meaning consists in saying: 'thou shalt not kill'" (Levinas, EI 87). By only looking "with one eye" at the human impact of warfare, Butler perpetuates the irresponsible killing, for he does not absorb the face's reflection of the Holy commandment against murder. Unacknowledged, Butler treats the dead other as faceless, extracting the humanity from their body. When he turns away from the dead other's face, Butler disconnects from the truth of war, which is its absolute sacredness and un-Godliness, because to recognize this truth means to recognize that he has failed the Holy commandment to protect the other from death. Butler refuses to become an individuated self and thus refuses true spirituality. The dead other is forgotten because the living man does not acknowledge them.

Although Tolstoy's contemporary reader may not be a soldier on the battlefield, they may still overlook and forget the dead other's face shown everywhere in modern media, newspapers, books, and television. However, Tolstoy's novella makes it clear that the dead other must be confronted. Privileged with ignorance, most civilians are complicit in today's corruption, famines, and wars, since Levinas argues "I am responsible for a total responsibility" (EI, 99). In *Hadji Murád*, Tolstoy forces his reader to face war's traumatic effect on innocent humans, filling the reader's conscience with the "wailing of the women and the little children who cried with their mothers" (Tolstoy 101-2). The Russians' enthusiastic perpetration of violence to expand and defend their sacred Christian Fatherland is far removed from the Holy. Amid Butler's violent raid, the women's wails, and the children's cries, God is absent. Over a century after *Hadji Murád*'s publication, Tolstoy's raw depiction of war leaves the reader of the twenty-first century horrified. Yet ideally, it also leaves them far more attuned to all of the Godless conflict that is still devouring Earth — and far more impassioned to bringing about its end. The sacred impedes the formation of a strong, united humanity. Tolstoy begs for humans to re-orient their lives to prioritize the ethical, which will lead to the emergence of the un-politicized Divine and truest spirituality: the Holy.

### 3. SPIRITUAL RUPTURES: WHERE THE SACRED BECOMES THE HOLY

Amid the un-Holy violence submerging Tolstoy's novella, some characters come alive by engaging in an ethical dynamic that contrasts with war's selfishness. Secondary characters woven throughout Tolstoy's narrative epitomize the Holy in their acts of kindness. For instance, a Chechen villager named Sado internalizes a complete responsibility for the other. This makes him

a true self, as he breaks from the self-centered being (which is a passive, non-individuated, and non-ethical being) via his commitment to ethics. When the novella's hero, Hadji Murád, seeks refuge after escaping from Imám Shamil, Sado — knowing the dangers of serving the other — opens his home to him anyway. In fact, "he considered it a duty to protect his guest though it should cost him his life, and he was proud and pleased with himself" (Tolstoy 11). The possibilities of punishment and death do not frighten Sado, for he desires to sacrifice his life for the other. In resonance with Levinas' belief that an awoken subject "is more and more extended with regard to the other, extended up to substitution as hostage," Sado becomes a self who transcends his passive being and approaches Holiness through his willingness to substitute his life with the other's (Levinas, EI 108). Sado eagerly becomes Hadji Murád's champion, valuing Hadji Murád's survival more than his own.

Sado's altruism introduces the ethical dynamic of Holiness that differs radically from the typical selfish desire for self-preservation that dominates war. Sado places the other's life above his own, and this selflessness founds the ethical relationship Levinas understands as the never-ending responsibility for the other, no matter the real-world consequences on the self. Despite the dangerous risk, Sado feels "exceptionally bright and animated" when serving Hadji Murád, as if he were more alive when sacrificing his life for the other (Tolstoy 11). Indeed, Levinas would comment that Sado is more alive because he accepts his ethical responsibility for the other, which makes him not just a being but an individuated self. In the moral realm, Sado's subjectivity awakens, which contrasts with Shamil and Nicholas I's "lifeless" gazes that remain void of individuation.

Levinas would explicate that the "Infinite," which symbolizes the self's infinite responsibility for the other, encourages Sado's ethical awakening. According to Levinas, this Infinite "commands and in this sense it is interior," so that the self's responsibility for the other is "that reverting in which the eminently exterior [...] concerns me and circumscribes me and orders me by my own voice" (EI 110). With this, Levinas suggests that the commandment to serve the other — who is "eminently exterior" because the self cannot know the other — becomes an interior voice urging the self to acknowledge the other. This interior voice is the human conscience, which focuses the self outwards so that, ultimately, the inward self is pushed to serve the external other. As Sado hears his conscience, he is called away from his interiority that worries for his selfish survival; instead, he responds to the external other (Hadji Murád) who needs his service. This again reminds us of Levinas' question: "Do I have the right to be?" Unlike Butler and Poltorásky, Sado refuses to "be." He understands that his being is worth sacrificing because doing so aids Hadji Murád to live. This is the Holy work, which can be honored and replicated in all humans' lives no matter their religious affiliations, as it concerns a responsibility that is not sectarian but ethical.

The other characters in *Hadji Murád* who honor the Holy are women who are inspired by their conscience, rather than by the name of God, to enact their unique responsibilities for the other. In Mrs. Avdéev's selfless relationship with her son, the Holy emerges. In opposition to her stingy husband, Mrs. Avdéev insists on sending Peter Avdéev money while he is away, which demonstrates her care for him despite her modest means. Mrs. Avdéev does not act kindly because she believes God orders her to but rather because she genuinely cares for her son. In a letter to him, she writes, "my darling child, my sweet dove, my own Peterkin! I have wept my eyes out

lamenting for *thee, thou* light of my eyes” (Tolstoy 48; emphasis added). Despite having limited time and means as a working peasant, she places enormous consideration on Peter Avdéev’s wellbeing, and her heart is with him. The Tartar language commonly employs “thou” to refer to the other with welcoming kindness, but this is less common in the Russian language. Levinas would later explain that, by instinctively addressing her darling Peter with “thou,” Mrs. Avdéev unknowingly honors the Holy. Just as institutionalized religion can be independent of Holiness, so too can Holiness be independent of conventional religious ritual and practice. The true Holy manifests in Mrs. Avdéev’s loving words that come so naturally from her conscience, for “the exigency of [H]oliness” is intrinsically the never-ending duty to serve the other (Levinas, EI 105).

The Holy again manifests in Mrs. Avdéev’s actions when she undertakes a responsibility for Peter that continues after he dies. To honor his death, Mrs. Avdéev has a requiem chanted for her son and distributes holy bread to all church attendants “in memory of Peter the servant of God” (Tolstoy 49). By actively taking these measures to serve her son beyond the end of his life, Mrs. Avdéev honors and humanizes him — in contrast to the military officials, who minimize Peter to “one killed” (44). In her dedication of rites to him, Mrs. Avdéev does not allow Peter to fade away as he does in the military’s impersonal report. This illustrates Mrs. Avdéev as a responsible, ethical, and individuated subject, which is integral to the Holy. She practices true spirituality in her ongoing response to her son, who is her other. She relies on religious rituals not to honor God but to honor her son. This is ultimately the Holy work.

Mrs. Avdéev epitomizes maternity as “the relationship of the ego with a selfsame ego who is nonetheless a *stranger* to the ego” (Levinas, EI 71-72; emphasis added). Mrs. Avdéev does refer to Peter as “*my* sweet dove, *my own* Peterkin” to recognize her relation to him (Tolstoy 48; emphasis added). However, she does not attempt to possess Peter. Indeed, she sees him as someone beyond both the Avdéev family and the military, which she demonstrates by referring to him as “Peter the servant of God” (49). She imagines him as grander than the identities of son and soldier, surpassing the confining totalities of family and empire to connect Peter Avdéev to God, who is infinite. In this way, Mrs. Avdéev spiritually overcomes the sacred violence of the imperial narratives perpetuated in the names of the Russian Tsar, Fatherland, and Orthodox faith.

In line with Levinas’ philosophy, these individuals enacting the ethical relationship are true prophets. Since Levinas understands prophecy as the “unlimited ethical exigency” — that is, continuously prioritizing one’s ethics and, by extension, continuously serving the other over all else—the prophet pushes humanity in a *universally moral* rather than *institutionally religious* direction (EI 114). As a prophet calling for the Holy, Hadji Murád’s mother also protects the other from violence and death. After her son Akhmet dies because she nurses another child, Hadji Murád’s mother refuses to become a wet nurse when Hadji Murád is born. She clings onto her responsibility for Hadji Murád and insists, “I should again kill my own son; and I will not go [to nurse]” (Tolstoy 62). Unlike Poltorátsky, whose conscience is asleep in the face of violence, Hadji Murád’s mother is fully awake and recognizes the consequences of her actions. She grasps her responsibility as an ethical self and understands the harm her actions may cause to the other; she demonstrates this by immediately taking responsibility for the death she could cause to her son.

This scene is similar to the biblical episode at Mt. Moriah, as both cases concern the potential death of a child. But unlike Abraham, who at first accepts the idea of sacrificing his son Isaac and

accepts Holiness later on, Hadji Murád's mother refuses the possibility of harming her son from the start. Her motherly intuition and her ethical conscience reject this prospect. As she commits to preserving baby Hadji Murád's life, the Holy shines. After all, "the incarnation of human subjectivity guarantees its spirituality" (Levinas, EI 97). Led by their conscience to care for their children, mothers like Hadji Murád's and Peter Avdéev's are the novella's true prophets. They honor the Divine through an openhearted maternal relationship rather than through religious practices and rituals. These characters show the pure Holiness of the ethical, which contrasts sharply with the sacredness of religiously-justified violence. People in today's world must also see their others as sons and daughters to establish a selfless relationship of giving and nurturing, tenderness and patience.

Finally, Mary Dmítrievna also serves as an awakened prophet when she recognizes and resists the un-Godly violence done onto the other during war. Seeing Hadji Murád's dead face for the first time after his murder, Mary Dmítrievna cries out to the men around her, "[Y]ou're all cutthroats! ... I hate it!" (Tolstoy 140). Unsurprisingly, Officer Butler responds, "[T]hat's war," which demonstrates how those who absently accept the violence perpetrated by a totality will readily consume and reproduce the religious and political narratives constructed by the same totality. State and military officials across the globe today certainly reinforce this passive attitude of "à la guerre, comme à la guerre."<sup>9</sup> This attitude epitomizes the lifelessness of the non-individuated human. With her awoken subjectivity, Mary Dmítrievna exclaims, "War indeed! ... Cutthroats and nothing else. A dead body should be given back to the earth and they're grinning at it there!" (140). Not only does she acknowledge that a dead body merits a proper burial and must not be disrespected by being tossed around like a trophy; she also recognizes the unjustifiable nature of the sacred war. She sees the cruelty of the commanders and soldiers who fight to expand the Russian religiopolitical totality to which she belongs. While she cannot serve Hadji Murád, for he is dead, she still challenges the violence of war, embodying a "rigorous affirmation of human independence, of its intelligent presence in an intelligible reality" that Levinas associates with Holiness (Levinas, DL 30).<sup>10</sup> Turning away from the selfishness of being, Mary Dmítrievna acts as an individuated self with a clear conscience. In this way, she realizes the truth of war: its un-Godliness. Levinas comments, "there is prophetism and inspiration in the man who answers for the Other" (Levinas, EI 113). When she sees Hadji Murád's face, Mary Dmítrievna becomes a prophet, breaking away from the imperial totality and begging her male counterparts to move in a moral direction.

This scene with Mary Dmítrievna demonstrates a Holy eruption amid a widely accepted war. Mary Dmítrievna is neither an emperor nor a priest, yet her moral gesture is Holy. No matter their positionalities, all people can serve as prophets in this modern world. One does not need to have religious knowledge to enact true spirituality — only an ethical conscience. In fact, the simplest individuals with the fewest resources can be the most spiritual. The prophets of Tolstoy's novella call to leaders and civilians of the twenty-first century to revive a Holy mission, one that preserves the ethical relationship with the other and resists hegemonic totalization. The sacred has brought

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<sup>9</sup> "All is fair in love and war"

<sup>10</sup> Author's translation

immense destruction, dehumanization, and death to this world. To support a future of peace, all humans have a Holy responsibility to dedicate their lives to the other's wellbeing.

#### 4. CONCLUSION

While decades have passed since Levinas re-imagined God to establish a direct relation between ethics and the Holy, his philosophy remains incredibly pertinent today. As ideology-justified movements ranging from Zionist political violence to Islamic jihadism continue to cause great harm in the world, humans must consider how these are sacred movements perpetuating totalities, void of the Holy as Levinas understands it — as the ethical. In *Hadji Murád*, Tolstoy begs his reader to revive God in all His Holiness. Capturing Levinas' distinction between the sacred and the Holy, Tolstoy suggests that to attain the Holy, one must put the other's wellbeing first instead of overlooking, dismissing, or even attacking the other to protect one's insulated identities. In this way, humanity may transition from the sacred to the Holy, a transition which is desperately needed to avoid a world as lifeless as the empty black field Tolstoy deplores in his first chapter. A future of collective peace requires this selflessness.

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# Effects of flow velocity and settlement location on growth rates of early juveniles of the pedunculate barnacle *Pollicipes polymerus* Sowerby, 1833

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## ABSTRACT

The intertidal lepadomorph barnacle *Pollicipes polymerus* lives gregariously, preferentially settling on conspecifics. This study asks if and how *P. polymerus* individuals gain in overall fitness from gregarious settlement. The study addresses two questions: 1) Is the growth rate of early juveniles dependent on the velocity of the water in which they feed? and 2) Does settlement on conspecifics benefit early juveniles by increasing growth rate? Two treatment groups (solitary and gregarious) and an experimental velocity gradient were studied in marina and tank environments, with *P. polymerus* individuals ranging in size from 1 to 3 mm (measured by rostro-carinal length). For the trials carried out in a marina environment, growth rates ranged from 0.1 to 1.2 mm per week at any given velocity. For the trials in a tank environment, individual growth never exceeded 0.6 mm per week. Overall results indicate that neither current velocity nor settlement location had consistent effects on early juvenile growth rates. In the tank environment, where food concentrations were lower, velocity had a significant negative effect on the growth rate of gregarious but not solitary juveniles. Meanwhile, settlement on a conspecific had a significant positive effect on average juvenile growth in one of the four trials. The absence of consistent trends within and across trials indicates that velocity and settlement location for early juveniles may not be primary factors in gregarious settlement of this barnacle. The results also have important implications for aquaculture; they suggest that *P. polymerus* juveniles do not require specific flow speeds or adult substrata to cultivate newly-settled barnacles.

## 1. INTRODUCTION

Anyone who has wandered the rocky intertidal of the Oregon coast surely will have noticed a creature who, along with others of its species, aggregates in irregular- to rosette-shaped clusters on the underlying rock substrata. This unmistakable species, known as the gooseneck barnacle or *Pollicipes polymerus*, has a range along the coast of the Northeastern Pacific from Siskiyew, British Columbia to Baja California Sur (Pilsbry 1907, Cimberg 1981). Their intertidal occurrence overlaps primarily with that of the bivalve *Mytilus californianus*, the upper range of their seastar predator, *Pisaster ochraceus*, and the lower range of acorn barnacles, *Chthamalus* sp. and

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*Balanus glandula* (Barnes and Reese 1960). European gooseneck barnacles (*P. pollicipes*) are regarded as a culinary delicacy, particularly in Spain, which is commonly referred to as *percebes*. The meat of fresh *Pollicipes* can command as much as 80 USD per kilogram, and the price only continues to climb (López et al. 2010, Gardiner 2015). Due to their high economic value (Bingham et al. 2017, Romersa 2018), gooseneck barnacle populations are subject to overharvesting. This practice poses a significant threat to the population's ability to restore itself for the unique reason that *Pollicipes* cyprids almost exclusively settle on the peduncle of conspecifics, or members of the same species.

Although such scenarios are rare, *P. polymerus* juveniles have also been known to settle in small cracks and crevices that resemble, at the microscopic scale, the interscalar spaces in which they typically settle (Barnes and Reese 1960). Aggregative or gregarious settlement behavior is seen across a plethora of species, though the mechanisms by which such settlements are achieved and the ecological benefits behind them vary by species. For gregarious settlement behavior to evolve, natural selection should provide some benefit that would not otherwise be achieved through a solitary lifestyle, such as to defend against predators (Riipi et al. 2001) or promote cross-fertilization (Wu 1981).

In the case of *P. polymerus* populations, no scientifically-supported benefit is known for early juveniles whose larval cyprid settles on larger conspecifics. The resulting rosette-shaped clumps are an apparent outcome of their gregarious settlement, but the answer as to what these clumps offer an individual or a population remains elusive. Potential benefits notwithstanding, research has shown that the species possesses certain mechanisms which ensure that gregarious settlement perpetuates. Lewis (1975) found lab-reared *P. polymerus* larvae could only be stimulated to settle in the presence of a healthy, adult conspecific. Hoffman (1988) pondered the cirripede's ability to settle on peduncle-like substrate after observing that *P. polymerus* juveniles colonized a settlement plate only after acorn barnacle spat had accumulated on the plate. Helms (2004) studied the precise placement of *P. polymerus* spat around an adult's peduncle and proposed a mechanism of capitular hydrodynamics which traps conspecific larvae in an eddy, directing them toward the adults' capitular-peduncle junction.

Still, questions remain. Do these clusters prevent desiccation, discourage predation, and/or create more favorable micro-environments in which juveniles can thrive? Furthermore, do the potential advantages of gregarious settlement change from one life stage to the next? Finally, can the realized benefits, whatever they may be, even be measured? Ultimately, it is important to know whether the overall fitness of *P. polymerus* individuals improves due to gregarious settlement. *P. polymerus* individuals are highly vulnerable in the early stages of life, and so their need for environmental mediation may be at its highest during this period of development. Answering these questions could support the production of efficient aquaculture systems as an alternative to harvesting natural populations.

This study examines the growth rate of juveniles through mimicry and manipulation of a hypothetical environment within a cluster to determine if any benefit results from gregarious settlement. The study addresses two questions: 1) Is the growth rate of early juveniles dependent

on the velocity of the water in which they feed? and 2) Does settlement on conspecifics benefit early juveniles by increasing juvenile growth rate? The corresponding hypotheses are that 1) The growth rates of early juveniles will be slower at the lowest experimental velocities and 2) The growth rates of early juveniles will be greater for individuals settled on adult conspecifics.

## 2. MATERIALS AND METHODS

### 2.1. SPECIMEN COLLECTION

Specimens were collected from wave-exposed rocks in the intertidal zone near the entrance to the Coos Bay estuary (43°21'00.3"N, 124°19'54.2"W). Collection occurred between May and July of 2021. The boulders on which the *P. polymerus* clusters resided, in addition to the *P. polymerus* clusters themselves, were chosen at random. Clusters surrounded by or next to mussel beds (*Mytilus* spp.) were excluded. A crowbar and hammer were used to separate clusters, including some of the rock surface, from the boulders to avoid rupturing or otherwise compromising the peduncles of *P. polymerus* adults. Harvested specimens came from the edge of clusters, and no more than one-third of a cluster was removed per harvest. Collected organisms were placed in a sea table at 11°C with air stones and constant supply of unfiltered seawater for four days to confirm survivorship. Forty-six individuals were subjected to the solitary treatment (explained below) in each trial, while an additional 46 individuals were subjected to the gregarious treatment (explained below) in each trial.

### 2.2. EXPERIMENTAL VELOCITY GRADIENT

To create a velocity gradient in which to place the barnacles, an apparatus consisting of a 60 cm plexiglass disc connected at its center by an axle and bearings to a variable speed motor was constructed. The apparatus was oriented so that the disc was horizontal and below the surface of the sea water, with the shaft extending up out of the water to connect with the motor (Figure 1a).

Four plexiglass strips (27 cm x 2.5 cm x 0.5 cm) were attached with screws to the underside of the plexiglass disc to create four equidistant spokes (Figure 1b). Two of the strips, located opposite each other, had inverted 1.5 mL microcentrifuge tubes; these tubes were attached by superglue to the strips at 2 cm intervals. Individual *P. polymerus* juveniles were attached by superglue to the widest part of the conical end of the microcentrifuge tube. These individuals were part of Treatment 1 and are referenced throughout the study as solitary juveniles. On the other two strips, *P. polymerus* adults were attached directly to the plexiglass strip with superglue, each placed 2 cm apart from the others. Juveniles living on the peduncle of the fastened adults were part of Treatment 2 and are referred to as gregarious juveniles. All organisms were attached to their substrata in the same orientation, ensuring their extended cirral fans would face oncoming water. Barnes and Reese (1960) found that the species consistently achieved capitular orientation, always facing the rush of water subsequent to a wave breaking. While this suggests that the organisms could have achieved the preferred orientation themselves, the timeline and data necessary for this project required that optimal capitular orientation for feeding be established at the start of the experiment. During a trial, organisms were fully submerged for the entirety of the trial. Trials lasted between two and three weeks.

To calculate the free-stream flow velocity ( $v$ ) experienced by a *P. polymerus* juvenile at any given distance from the disc center ( $r$ ), each juvenile's distance along the disc radius was recorded, as was the time elapsed for one complete rotation of the disc ( $t$ ). Velocity was thus calculated using the following equation:

$$v = \frac{2\pi r}{t}$$

The experimental free-stream velocities ranged from +15 cm/s to +180 cm/s. The upper end of the velocity gradient was limited by the equipment available. The local velocities experienced at the level of the cirral fans were less than the free-stream velocities due to the presence of the boundary layer and the possible entrainment of the water by the rotating disc, but the precise local velocities were not measured.

### 2.3. FOUR TRIALS EXAMINING GROWTH OF JUVENILES

Trials 1 and 2 were performed in the field at the Charleston Marina in Charleston, OR (43°20'44.0"N, 124°19'41.7"W). The motor and shaft were secured to a floating dock. The plexiglass disc rested horizontally in the water column 20 cm below the surface of the water. At the lowest low tide of the season, the disc was positioned 0.5 m above the ocean floor. A 2-m oil-sorb semicircle attached to the dock on either side of the disc prevented the collection of flotsam drawn in by the vortex from the spinning disc.

To control for the potential of marina pollutants to affect the growth of the study organisms, Trials 3 and 4 were performed in a rectangular tank (1.7 m x 1 m x 0.4 m) at the Oregon Institute of Marine Biology (OIMB) campus. The horizontal disc was situated in the center of the tank, 15 cm below the surface of the water and 15 cm above the tank bottom. Fresh filtered seawater at 10°C was continually pumped into the tank. The contents of a 20-minute plankton tow with a 130 µm net were added to the tank as a food source on a daily basis. The tow was performed at the outer end of F-dock of the Charleston Marina one hour prior to high tide.

### 2.4. GROWTH RATE

Three days prior to the commencement of a trial, the initial rostro-carinal length ( $RC_i$ ) of each juvenile was recorded to the nearest 0.1 µm using the calibrated reticle on a dissecting microscope. The size of the experimental individuals ranged from 1-3 mm RC. Treatment 1 juveniles (solitary) were removed from adult peduncles by dissecting forceps. Once measured, juveniles were attached with superglue to the inverted microcentrifuge tubes and floated in a sea table for three days to confirm survivorship. Treatment 2 juveniles (gregarious) were located along the stalk of adult conspecifics. Non-target juveniles were preened from the adult's peduncle so that the number of target juveniles on a stalk never exceeded two. Upon completion of a trial, the barnacles were preserved in 70% EtOH and stored in the dark at room temperature. Mortality was documented and considered as absence of the individual or  $RC_f$  lengths that were equal to or less than the individual's initial RC. The final rostro-carinal measurements ( $RC_f$ ) were recorded within

five days of trial completion. Growth rates (GR) in this study are quantified as millimeters of RC growth per week determined by:

$$GR = \frac{RC_f - RC_i}{\# \text{ of weeks in trial}}$$

## 2.5. DATA ANALYSIS

For Treatments 1 and 2 (solitary and gregarious), growth rates of *P. polymerus* juveniles from each of the four trials were graphed as a function of flow velocity on separate scatter plots. Correlation coefficients and two-tailed p-values were calculated for each scenario (Zar, 1984). The analysis did not control for differences in  $RC_i$  lengths because juveniles on either end of the size spectrum exhibited some of both the highest and lowest observed growth rates.

Because the water velocity only impacted growth of one treatment of only two trials, the growth data for each trial was analyzed with a t-test, comparing treatments (solitary versus gregarious) using JMP statistical software.

## 3. RESULTS

### 3.1. EFFECT OF VELOCITY ON GROWTH RATE

Growth (change in RC/week) was highly variable in both treatments and for all four trials. While mortality occurred (36% for solitary treatment; 39% gregarious treatment), it was not disproportionately related to a particular velocity or range of velocities. In addition, because overall mortality was higher for gregarious juveniles, it was assumed that mortality seen in solitary individuals was not a result of the transplant process. For both treatments, there was either no effect of velocity on RC growth or a negative effect at higher velocities for one of the two treatments in a trial. In Trials 1 and 2, growth rates ranged from 0.1 to 1.0 mm/week, while in Trials 3 and 4, growth rates ranged from 0.1 to 0.6 mm/week. In Trials 1 and 2 (Charleston marina), there was no significant effect of velocity on growth for either of the two treatments. Growth rates in Treatment 1 of Trial 2 had the lowest correlation to velocity compared to all other trials (Table 1 and Figure 2).

In Trials 3 and 4 (rectangular tank), growth rate of individuals in Treatment 1 did not vary with flow velocity. However, individuals in Treatment 2 had significantly slower growth rates at higher flow velocities in both trials (Table 1, Figure 2).

In all other models, positive and negative correlations between growth and velocity were nonsignificant (Table 1), a finding which suggests that growth rate in *P. polymerus* juveniles was not impacted by the velocity of the water in which they feed.

### 3.2. EFFECT OF SETTLEMENT LOCATION ON GROWTH RATE

Because of the limited effect of flow velocity on juvenile growth rate, the data for each treatment were treated as population samples, and the mean growth rates were compared

between treatments within trials. For three of the four trials (Trials 1, 3, and 4), there was no significant difference in growth rate between the two treatments (Table 2). The only statistically significant difference in growth as a function of settlement location occurred in Trial 2 (marina environment), during which juveniles in Treatment 2 demonstrated greater growth rates than those in Treatment 1. *Pollicipes* juveniles grew at a given rate regardless of whether they settled on the primary substrate or the peduncle of a conspecific (Table 2).

## 4. DISCUSSION

### 4.1. EFFECT OF FLOW VELOCITY ON EARLY JUVENILE GROWTH RATE

The results of this study show that continuously submerged *P. polymerus* juveniles grew at a rate that was independent of the flow velocity of water in their immediate environment. The temperature and nutritional conditions during the study were similar to those of the natural environment, with water temperatures around 9°C (NERRS 2021) and a range of flow velocities between +15 cm/s and +180 cm/s. The growth rates observed in this analysis (0.1 to 1.2 mm/week) were greater than those reported in other studies of *P. polymerus* juveniles in similar environmental conditions: 0.2 to 1.2 mm RC growth per month (Jacinto et al. 2015, Lewis and Chia 1981, Paine 1974). Hoffman (1988a, 1988b) reported juvenile growth rates between 4 and 9 mm per month in the warmer coastal waters of southern California at approximately 20°C.

Page (1986) found that the average capitulum height growth rate of permanently-submerged *P. polymerus* adults on offshore oil platforms was 3.5 times that of coastal individuals subject to tidal fluctuations. The specimens in this study were fully submerged for the entirety of the trial. Although no literature exists corroborating the relationship of *P. polyermus* capitulum height (length from base of capitulum to top of tergum) growth with RC growth, it stands to reason that there is a positive correlation between the two. Based on this assumption, one could deduce that RC growth rates are slower in cold-water, tide-influenced populations and increase in warm-water, permanently-submerged populations.

It is also possible that water quality in the marina environment in Trials 1 and 2 negatively impacted RC growth in comparison to what could be achieved in a system with a lower level of human influence. Even so, this study's growth rates were higher than intertidal juvenile rates reported by Paine (1974) and Lewis and Chia (1981), supporting the use of the Charleston marina as a viable substitute for in situ water parameters.

In the tank environment, the average growth rate for both treatments was half that for individuals in the marina environment. The slower growth seen in individuals from the tank trials (Trials 3 and 4) was likely a result of insufficient amounts of food. Although supplementary phytoplankton (>130 µm in diameter) was added to the tank on a daily basis, the diets of *P. polymerus* juveniles sized 1 to 6 mm RC consist primarily (92%) of organic particulate matter with diameters less than 10 µm (Lewis 1981). Not only are juvenile feeding appendages in this size class smaller than those of adult conspecifics, but they also employ an entirely different mode of feeding called pumping, which is often also observed in acorn barnacles of all sizes (Lewis 1981). The frequency of pumping in *P. polymerus* juveniles decreases in faster currents, eventually



ceasing altogether and being replaced by continuous extension of the cirral fan as seen in adult conspecifics (Lewis 1981). However, Lewis did not specify what constituted a fast current, so the exact threshold at which pumping ceases remains unknown.

It is possible that Lewis' threshold was surpassed in this particular experiment, since the "fast current" in the Lewis study was described as being faster than the "calm water of laboratory tanks." It is not clear at what velocity the juveniles switch feeding behavior or whether feeding behavior changed along the experimental range of velocities, though Trager et al. (1990) found that the acorn barnacles *Semibalanus balanoides* switched from active pumping to passive cirral extension at water velocities of 3.10 cm/s. Furthermore, it is unclear whether the switch in behavior is a response to greater concentrations of particulates passing the organism in a given amount of time or to faster currents preventing pumping behavior in some way. Interestingly, Barnes and Reese (1960) found that stimulation of cirri by a water jet yielded a prompt capitular reorientation response from *P. polymerus* populations, so it is likely that the juveniles' cirri are receiving some form of input from the faster current and responding to it by means of reorientation. Due to how 1) this study did not record the mode of feeding utilized by juveniles at each experimental velocity, 2) there are no studies comparing the feeding efficiency of the two modes, and 3) there are no studies yet determining the feeding mode of juveniles in clusters in situ, it is difficult to know how the mode of feeding effected the growth rates of experimental individuals, if at all.

Across an experimental velocity gradient of +15 cm/s to +180 cm/s in a tank environment, flow velocity seemingly had no effect on the growth rate of continuously-submerged, solitary *P. polymerus* juveniles (Treatment 1). The growth rate of gregarious juveniles (Treatment 2), however, appeared to have been negatively affected by increased flow velocity. Upon factoring in the dominant particle size of available food ( $> 130 \mu\text{m}$ ), it appears that growth rates of gregarious juveniles decrease as current velocity increases when appropriately-sized food abundance is low. If the immediate proximity of adult conspecifics, whose diet consists of particulate ( $< 10 \mu\text{m}$ , 52%) and large ( $> 10 \mu\text{m}$ , 40%) organic matter is taken into consideration, it is possible that, in some way, the adults negatively impact nearby juvenile growth, with the effects increasing in magnitude as current velocity increases.

The hypothesis that growth rates of early juveniles would be slower at lower current velocities was additionally based on previous findings suggesting that *P. polymerus* individuals have specific habitat preferences. The average maximum speed of breaking waves for a wave-exposed, rocky intertidal ranges from 4.26 to 4.41 m/s (Marchinko 2003), so the higher end of the experimental velocity gradient was intended to mimic moderate flow velocities experienced in situ. The lower end of the gradient was meant to simulate flow velocities slower than what would typically be experienced in the natural environment. Eckmann and Duggins (1993) reported no change in growth rate of *P. polymerus* adults over a narrow velocity gradient (2 to 14 cm/s) and interpreted this as unsurprising, given that *P. polymerus* individuals are known to inhabit exclusively high-energy environments.

Additionally, the shelter provided by a conspecific cluster leads one to question the conditions and microenvironment present within a *P. polymerus* cluster, an environment in which current speeds are moderated by eddies, shear, and boundary layers. While my study did not examine the microenvironment surrounding solitary or gregarious juveniles specifically, it was designed to mimic and manipulate a potential circumstance within the cluster. Whether or not a microenvironment with moderated velocity exists remains to be seen. As a hypothetical facet of the microenvironment, however, moderated (i.e., slower) flow alone does not positively affect early juvenile growth rate to the degree that it is a driving force for either evolution or the maintenance of gregarious behavior.

#### 4.2. EFFECT OF SETTLEMENT LOCATION ON EARLY JUVENILE GROWTH RATE

The effect of settlement location on early juvenile growth varied between trials. Only one of the four trials, Trial 2, was significant (Table 2), with faster growth occurring on conspecifics. However, growth rates of solitary or gregarious juveniles were not different in the other three trials. Unlike the relationship between flow velocity and growth rate found in the tank trials (Trials 3 and 4), this result occurred in the marina (Trial 2).

Although the overall analysis did not demonstrate a relationship between growth rate and settlement location — and thus, did not support the hypothesis — the significant results from Trial 2 suggest that further research must still be completed in this area of scholarship. For one, the substantially-larger sample size of Trial 2 not only bolsters the credibility of the probability value, but also calls into question the results of the other trials. In other words, Trials 1, 3, and 4 may have been insufficiently powered to detect a true difference between groups, suggesting a comparison of larger populations may have garnered different results.

Another possible explanation for the observed results is that the duration of the trial was too short to see any significant trends in growth rate. Cirripeds are known for the phenotypic plasticity of their cirral fans and subsequent propensity to alter fans in response to the flow of their environment (Marchinko 2003b). The range in balanomorph plasticity is much greater than that of gooseneck barnacles, as acorn barnacles inhabit a variety of environments subject to different degrees of wave-exposure. Even so, 92% of variation in *P. polymerus* leg length can be explained by water velocity (Marchinko 2003a). This plasticity is achieved by molting, a process that begins to occur in *P. polymerus* adults eight days after perturbation in experimental systems, with subsequent molts occurring in excess of thirty days later (An et al. 1971, Page 1983). Given these temporal relationships between adjustments in cirral dimensions and the resultant increase in feeding efficiency for a given flow environment, trials in this study would have had to last at least 30 days to see if the effects of the various treatments would translate into increased growth rates, assuming that *P. polymerus* juveniles molt at least as often as adult conspecifics. If my trials (two- and three-week durations) had lasted longer, the juveniles may have adjusted their cirral fan dimensions in accordance with the conditions of their settlement location and flow velocity, and greater growth rates may have been observed. Waters with in situ nutritional concentrations would be crucial according to Page's (1983) findings that ration alone can influence molting frequency between 31 and 40 days.

Finally, it is unlikely that the gregarious treatment adequately simulated naturally-occurring conditions in a *P. polymerus* cluster. It would be difficult to recreate the conditions of the inside of a cluster and maintain the experimental design while measuring the original variables (RC growth with respect to flow velocity). The methodology behind this particular study allowed me to achieve a simulation of the conditions at the edge of a cluster. Helms (2004) found that juveniles grew faster when settled on adults at the edge of a cluster than when settled on adults in the center of clusters. Ideally, effects would be more immediately discernible by attempting to simulate edge-like conditions. Because this study did not examine the growth rates of juveniles surrounded by more than one conspecific, it is difficult to say whether the faster growth rates associated with edge-like conditions were present. It also raises the following question: Does having fewer adult conspecifics in the immediate vicinity result in faster growth? Further examination of this hypothesis may help ecologists understand the costs and benefits of gregarious settlement at the early juvenile life stage.

The second hypothesis of this study was that the growth rate of early *P. polymerus* juveniles would be greater for individuals settled on adult conspecifics. It was postulated that gregarious settlement would be preferred to solitary settlement in early life stages because of the benefit of immediate proximity to an adult conspecific; this would increase fitness by increasing a juvenile's growth rate. However, the results of this study suggest that further investigation with modified parameters is necessary to conclusively determine whether attachment or proximity to an adult conspecific improves early juvenile fitness to the effect that it boosts growth beyond what is seen in solitary juveniles.

## 5. CONCLUSION

A gregarious lifestyle, common among some biota, is thought to increase individuals' overall fitness, and thus, the likelihood that they successfully reproduce. In this study, growth rate was used as a proxy to measure increased or decreased fitness of early *P. polymerus* juveniles. Both flow velocity and settlement location were manipulated to assess the dependence of growth rate on either factor. The experimental velocity gradient, containing both natural and unnatural water speeds, proved inconsequential to the growth rate for juveniles in a marina environment, a finding which did not support the initial hypothesis. In an environment with limited nutritional resources, increased velocity negatively affected gregarious juvenile growth, while growth of solitary juveniles remained independent of flow velocity. Excluding velocity as a contributing factor, a comparison of average growth between solitary and gregarious treatments proved significant in only one of the four trials. Across all trials, analysis suggests that settlement on a conspecific does not improve the growth rate, and therefore fitness, of *P. polymerus* juveniles. Improved growth rate at early *P. polymerus* life stages may not be a direct benefit of gregarious settlement.

### 5.1. FUTURE DIRECTIONS

The findings of this study reveal there is still much to be uncovered about the evolutionary pressures which selected for gregarious settlement in *P. polymerus* juveniles. Further

investigation into areas such as the conditions and dynamics of the microenvironment in a cluster, the effects of different feeding modes in juveniles, and the effects of the density of conspecifics in a juvenile's immediate vicinity could be very beneficial for ecologists' collective appreciation of the minutia at play. Furthermore, modifications to this particular experimental design could prove incredibly useful. These modifications could take the form of extending the trial duration, increasing the sample size, or creating a treatment where juveniles are at the primary substrate level rather than up on a promontory (which would more closely simulate conditions of the cyprid settling on rock substrata). Ultimately, answering the questions posed in this article will help point the scientific community toward the best parameters for a barnacle aquaculture system, which would in turn eliminate the need to harvest natural *P. polymerus* populations. It would also help educate potential barnacle harvesters on the most sustainable practices to avoid population destabilization and/or extinction.

## 6. TABLES AND FIGURES

### 6.1. TABLE 1

Trial	Treatment	R <sup>2</sup>	r	n	df	p-value
1	1	0.075	0.274	22	20	<0.50
1	2	0.008	0.0894	20	18	>0.50
2	1	0	0	30	28	>0.50
2	2	0.003	0.0548	35	33	>0.50
3	1	0.015	0.122	21	19	>0.50
3	2	0.262	0.512	32	30	<0.01*
4	1	0.062	0.249	26	24	<0.50
4	2	0.156	0.394	31	29	<0.05*

Linear regression for each trial and associated treatments comparing effect of flow velocity on juvenile rostrum-carinal growth rate. Note: Trial 1 and Trial 2 (marina environment), Trial 3 and Trial 4 (tank environment), Treatment 1 (solitary juvenile), and Treatment 2 (gregarious juvenile).

\* represents a significant result.

6.2. TABLE 2

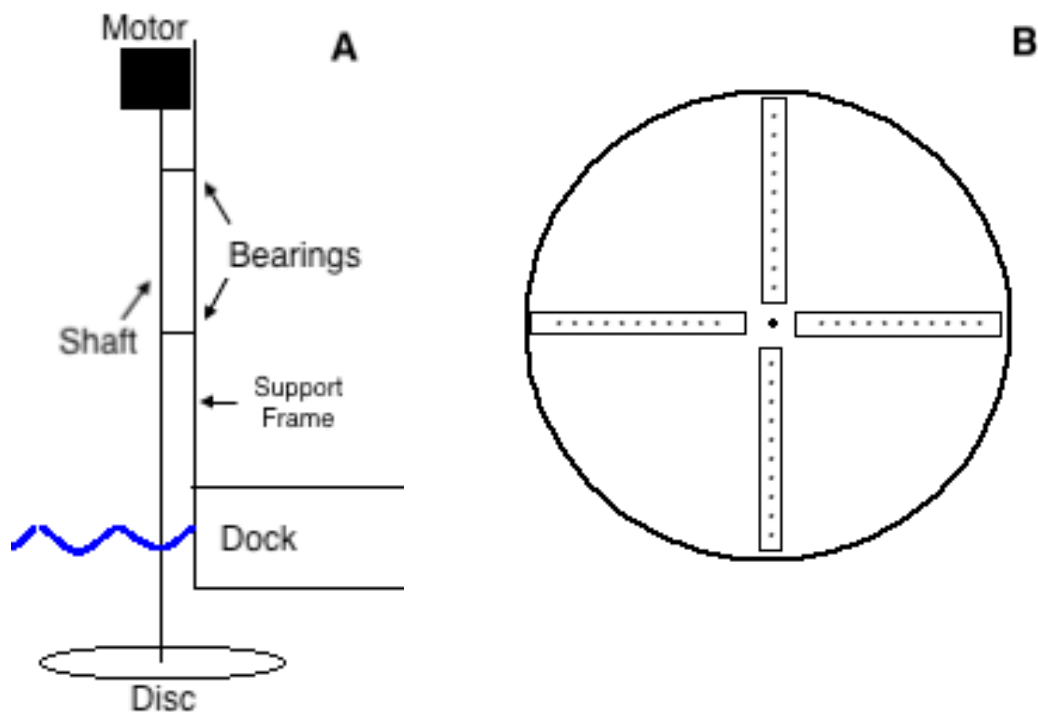
Trial	df	t-ratio	Prob >  t
1	40	-0.0005	0.9996
2	65	3.848	*0.0003
3	53	-0.0755	0.9402
4	55	1.534	0.1308

Results from two-tailed t-Tests on RC growth (mm/wk) by treatment for each trial.

*Note:* Trial 1 and trial 2 (marina environment); Trial 3 and Trial 4 (tank environment).

\* represents a significant result.

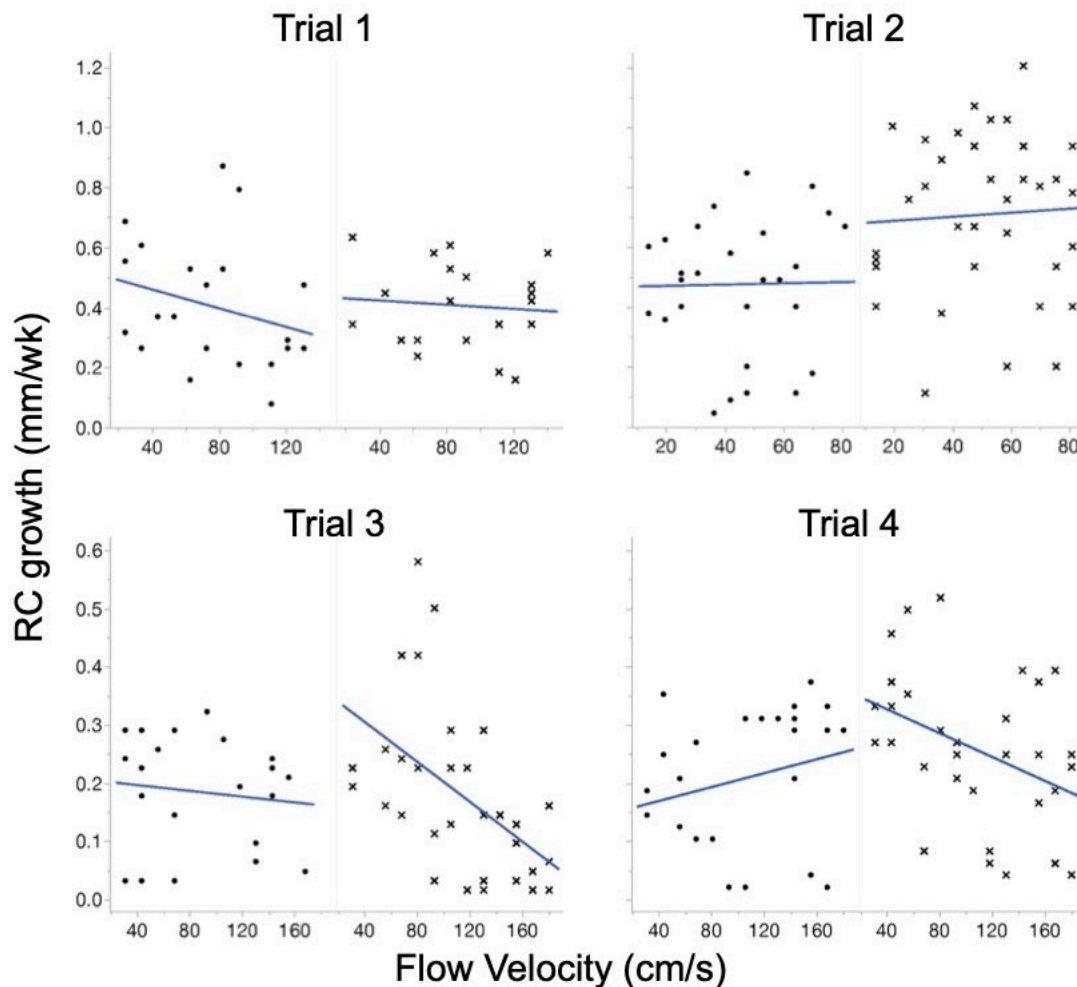
6.3. FIGURE 1



Schematic of the apparatus and plexiglass disc constructed to create the experimental velocity gradient.

*Note:* (A) Side-view schematic of spinning disc apparatus. Setup is depicted in the Charleston Marina environment. (B) Underside view of plexiglass disc and the four attached plexiglass strips to which the barnacles were adhered.

## 6.4 FIGURE 2



*Note:* Scatter plots for all four trials. Note: Blue Line models linear regression. Treatments in like trials are shown on the same graph side-by-side; Treatment 1 left panel (•); Treatment 2 right panel (×).

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