

**MICHIGAN STATE**  
UNIVERSITY

Honors College



# ReCUR

Red Cedar Undergraduate Research

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## About ReCUR

ReCUR is an annual publication of the Michigan State University Honors College that highlights the diversity and quality of our students' research and creative endeavors. Each issue of ReCUR accepts submissions from Honors College students and from participants in university-wide research and creative arts forums. In addition to providing students an outlet for publication of their work, ReCUR offers students an opportunity to learn about publication in a scholarly journal from multiple viewpoints: as a submitter, a member of the student editorial board, or editorial staff.

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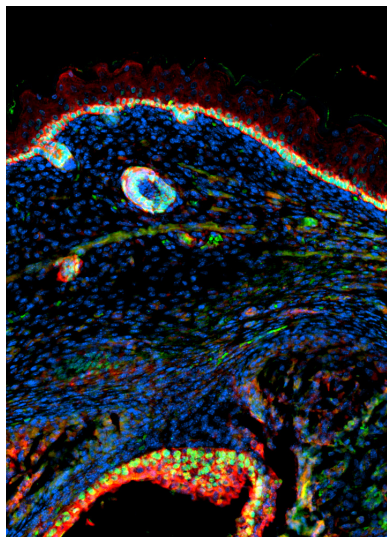
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## About the cover

### Immuno-Stained Skin



The image shows maturing skin immuno-stained for Interferon Regulatory Factor 6 (Irf6 - red) and Transformation Related Protein 63 (Trp63 - green). The skin has two layers, the epidermis and dermis. The top layer, staining for Irf6 and Trp63, is the epidermis. Below the epidermis is the dermis, where three hair follicles (circular red-green structures) are also staining for Irf6 and Trp63. Skin development is regulated by Irf6 and Trp63 expression.

-Youssef Kousa, Ari Philip Walter and Brian C. Schutte

## Call for Submissions

### HONORS COLLEGE STUDENTS AND UURAF PARTICIPANTS:

ReCUR is now accepting submissions for the next issue from Honors College students and UURAF participants. Send us any artwork, research, poems, prose, and more that you've been working on. Please visit our website, [recur.msu.edu](http://recur.msu.edu), for more information about how you could be featured in the next issue. If you have any questions, email us at [recur@msu.edu](mailto:recur@msu.edu).

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About the Contributors

# One Book, One Community

Craig Pearson

Department of English, Department of Biochemistry & Molecular Biology, and Neuroscience Program

## Kevin Powers

Kevin Powers was born and raised in Richmond, Virginia. In 2004 and 2005 he served with the U.S. Army in Mosul and Tal Afar, Iraq. He studied English at Virginia Commonwealth University after his honorable discharge and received an M.F.A. in Poetry from the Michener Center for Writers at the University of Texas at Austin in 2012. His book, “The Yellow Birds,” was selected as the Michigan State University and City of East Lansing One Book, One Community title for 2013. Craig Pearson (a dual-major senior in English and Biochemistry/Molecular Biology) interviewed Powers via phone, while Powers was in Italy.

**CP:** Since we’re at a university, I want to ask, what was your college experience like—especially having already served in the military?

**KP:** I had a really interesting, really satisfying college experience. When I first started as an undergraduate I was working full time and going to school at night, part time, taking evening classes. So the student body I started out with, I had a lot in common with: working people, sort of an older student body. So that was an interesting way to begin.

And then eventually I realized that I didn’t like the job I was doing. I knew that I wanted to study literature, writing—I knew that this had been my passion for my whole life, and I really wanted to give it a shot. So I quit my job and went full time. And it was great. I probably didn’t get the normal undergraduate experience, but I got some exposure to that. I felt like I had a certain amount of appreciation for the opportunities I had—the fact that I was able to be in interesting classes, talk to interesting people, and having conversations unavailable to me at that point, and, being older, to have some life experience.

**CP:** How long have you been writing? When did you know you wanted to be a writer?

**KP:** My mother used to take me every weekend. We’d go to this used bookstore in the town I grew up in. She’d let me get whatever books I was interested in. One day I happened to discover the collected poems of Dylan Thomas. I guess I was around 11 or 12, 13, some-



*Kevin Powers at a book signing for his novel, “The Yellow Birds.”*

thing like that. This was before my teenage years, and I just remember being so blown away by what could be done with language. It unlocked this whole new universe of possibilities, and my relationship to language changed, and my relationship to books changed. Everything about the way I thought about myself, what I wanted to do, changed when I read this book. And I started writing poetry right after that. A lot of teenagers try to write poetry, and I did too, and that led me to start reading other things. That really opened up, as I said, my relationship to language. I started writing poetry and stories at 12-13 and have been doing it ever since.

Taking it seriously as something I wanted to do, I mean, I had been doing it the whole time, but being a writer, you don’t have to publish to be a writer. Anyone can be a writer if they write. I entered the working world and was profoundly dissatisfied with that part of my

life. I ended up working at a credit card company, and I really hated it, as you can imagine. So I thought, this is what I've been doing since I was 12; this is the only thing I care about the way I should care about whatever my work would be. So I said, I'm going to quit my job and see if I can, quote-unquote, "make it" as a writer. I didn't even know how to do that—didn't know what steps I would have to take, but I figured the first thing I should do is try to go to school full time and get a degree. And to let other people see what I was writing, since I'd never shown it to anybody.

**CP:** In researching this book, how far did you go beyond your own personal experience? Did you talk to other people, read any other books?

**KP:** Unintentionally, I had probably done a year's worth of research. You know, I didn't know that I was going to write about the war. Well, I knew I would write about it because that's how I process the questions that I have about my own experience, but I didn't know I would write about it in a way people would see. But when I started writing, I realized the story I wanted to tell was as much about the process of reflection as it was about the actual experience of being in the war. For me, the process of delving into my own experience and thinking about it became, in a way, something that I wanted to try to imbue the story with. I wanted to try to recapture these sort of disparate memories, experiences, and try to arrange them into a story that makes a kind of sense. In a weird way, the process of writing became what the book is, in large part, about. I didn't really do much research. I really didn't read any other books to kind of direct my own work. It was more reflecting about my own experiences.

**CP:** What sort of responses have you had from this book—both from civilians and from people in the military?

**KP:** Thankfully, most of the people who take the time to get in touch with me have responded really positively to the book. That's civilians and also a small number of vets and soldiers. But I feel like I've heard from many different categories of people. I've heard from people who have no relationship whatsoever to the war, no family members in it, not much understanding of what was going on over there—and they expressed a kind of appreciation for the insight I tried to provide in the book. I've been really powerfully moved by messages from families of veterans, the mothers and fathers and husbands and wives—maybe their loved one has a difficult time expressing what their experience has been like, but the book has given them some access to what that experience has been like, to understand the difficulties their family members have been going through.

But even some veterans, some guys in Afghanistan now, they say they're glad that people are talking, that books are being written about this, that people are trying to understand the experience of a soldier.

**CP:** More of a personal question: I work for a lab that does research on PTSD, and one of the treatments they're trying to develop is using narratives as therapy for people with PTSD. What do you think stories can do for people who have had traumatic experiences?

**KP:** When I was in Austin, I volunteered at the vet center, and I participated in what was basically like a poetry workshop for vets. And I would bring in poems, and there would be a counselor there, and we would read poetry, and if they felt like they wanted to write they could write about it. The insight I got from that experience—and this is probably true for any writing or fiction, that more personal type stuff—this idea that by naming something, you develop a kind of control or power over it. Your relationship to that thing changes. I think that the ability to control the story that you're writing can somehow affect the way you think of your own experience. It does open the possibility that you have some sort of power over your own life. You can understand your experience and not be controlled by it, but have some effect on it, on your relationship to your own past. I mean obviously I'm not a doctor or a counselor, but it does seem to me that it's a really powerful way of affecting people's relationship to their own lives and traumatic experiences they may have had.

**CP:** If one thing were to change in Iraq as a result of this book, what would you hope it would be?

**KP:** Specifically in Iraq, I don't know. I mean, I guess in a kind of larger sense I would hope that as a nation we would be very careful before we send our young men and women off to fight. It seems to me that should be the most important decision we ever make as a country. It's not that I think that everybody who was involved in that decision-making process was cynical or ignorant or anything like that, but I feel like it wasn't treated with the kind of gravity that it should be. Not that I think that one book can have that kind of impact, but if the momentum builds, we begin to recognize that these things should be undertaken only as a last resort. The idea we can do these things painlessly and quickly can be done away with. We should understand that when we send these people off to war, everybody is a casualty, everybody is going to be injured.

**CP:** What was the writing process like for this novel? Did you have workshops, or editors, or other people who helped you work through the idea?

**KP:** That process was really important for me. As I said, I'd been writing a long time before I stepped into that kind of environment. I think some people sort of don't like the idea of the workshop environment. I didn't have any preconceived ideas of what it would be like, so I went into it with a completely open mind, and I thought it was absolutely invaluable.

I would say the most important piece of advice I got in terms of workshopping is that you have to find your readers. So for instance, when I was in grad school, I was in a workshop with twelve people. And it's not that you could ignore anybody, but you could get a sense of the people who understood the material, your approach—there might be two or three people who would just get you. They would get what you were doing or what you were trying to do, and you could focus on those people and the trust you would have in their opinion. They'd say, "I think you're on the right track here," "I think this is good," or even just saying "this line seemed out of place"—those things were really important. Particularly for me, for this book, it is sort of structurally tricky; to get the structure right, you have to have some kind of balance between the time when they're at war and when they return. There were people who saw two and three drafts of the book and would say "I think this part is lining up now and building in a way it wasn't before."

**CP:** What are you working on now?

**KP:** I finished a poetry manuscript I was working on simultaneously with the novel. Now I'm so busy doing traveling and touring and publicity and stuff, that it's kind of hard to get a long stretch to sit down and work. Right now what I'm doing is still a lot of reading. I'm taking notes. I'm sketching out scenes. But it's funny: I think back, because particularly with "The Yellow Birds," the whole process was a learning experience. And it still is, and, in a way, I hope it's always like that—but I sort of understand what part of the writing process I'm in right now, because I've been here before.



## Katherine Boo

Katherine Boo is a staff writer at *The New Yorker* and a former reporter and editor for *The Washington Post*. Over the years, her reporting from disadvantaged communities has been awarded a Pulitzer Prize, a MacArthur "Genius" grant, and a National Magazine Award for Feature Writing. Her book, "Behind the Beautiful Forevers," was selected as the Michigan State University and City of East Lansing One Book, One Community title for 2012.

**CP:** Since we're at a university, I guess the first thing I wanted to ask would be: What was your college experience like, and how did you get into everything/writing?

**KB:** Well, my college career was complicated because when I was a teenager I got quite sick. And so I didn't go to college after high school; I was just dealing with my illness. And then, eventually I went to community college and studied there just at night. I remember I took one course, and then I went to another commuter college, and then I, you know, took a few more courses, and then I started working during the day as a secretary, and then eventually I was like, okay, now I'm ready to go to full-time college. I applied to Barnard College, and the reason I did was because I heard that there was a lot of support for people who had physical difficulties, and at the time I did have quite a few, and so I went there, and actually it was this totally mortifying thing because I went there and I was like, it took me so long to college, I was so happy to be there, then I get there and the first thing that's on the door of my room is "Welcome from the Office of Disabled Students." And then it turns out, it was like this disabled ghetto, like they had them all on one side; it was this horrible thing, and everybody was knocking on the door like, "so what do you have? What do you have?" It was just the opposite of what I had imagined. But they were still incredibly supportive.

**CP:** So what led you into journalism?

**KB:** A typing job, actually, because I was working. While I went to school, I had a job typing at the *Columbia Daily Spectator*. And I was good at English and good at writing, and my mom is a great reader. I think we have this kind of editing gene in us. So I was typing for the newspaper, and then of course I would see these problems that I would rewrite. And then, I was like, "ah, I'm good at this." Then they elected me the editorial page editor, so I was writing editorials. I got out of college and I thought, "well, I'm going to go to graduate school." I was interested in studying philosophy or something. I heard this guy named Charlie Peters on the radio. And he was this editor of this maga-



*Katherine Boo, author of “Behind the Beautiful Forevers” the choice for one book one community for 2012, speaks with Residential College in the Arts & Humanities students on Monday August 27, 2012.*

zine *The Washington Monthly*. He was talking about civic space, civil society—he was actually talking about baseball stadiums, and how everybody was together on the benches. I wondered what that magazine was, and I started reading it, and I thought this is a really interesting magazine. Eventually I wrote my first piece as a journalist, and my first reported piece.

**CP:** What was it on?

**KB:** It was on—well, there was actually one thing they made me write. But the first thing I conceived of on my own was a piece about DC, and about the public parks system. Because it was this thing that really bothered me, because you had these wealthy neighborhoods that had the most beautiful parks and recreation, like, they had pools, and all this stuff—but nobody ever went to those, because those rich kids went to private clubs. Then you had these parks in the projects that were just, like, you know, people had stolen the swing sets ten years ago, and nobody ever did anything about it. I mean, it was just horrible. Even then, I was really interested in not just saying, “oh, isn’t this a terrible juxtaposition,” but looking at the money, looking at who got what where. And so I went and I got the nine-volume budget from the DC public library—it was so big it was really hard to get home—and I did this piece on why these are our priorities. It was just a little piece, really short, but I felt like, “oh, this thing that’s bothered me—I can put it out there.” It wasn’t like with the editorials and you were sort of reacting to whatever the news was. I learned then that I didn’t want to react to the thing that was important this week. I wanted to react to something else—more of the things that might not be making news. Then a guy named Jack Schafer,

who has become a prominent media critic, but at the time he was writing the *Washington City Paper*, he called me and said, “well, you’ve only written this one piece, but I’ll hire you for three months and then I’ll fire you.”

**CP:** At the end of “Behind the Beautiful Forevers,” you mention that you were afraid to write it because you aren’t from India. Can you tell us a little more about what made you take on the project, and what it took to get it started?

**KB:** The fear was so real because my husband is Indian and because his group would be mocking mercilessly people who’d be writing these things, basically. Or they’d be like, “with great authority, having just flown in and out.” So I was very much in that world, where people were making fun, and I’d ask myself “why would I put myself, subject myself to that?” And he was like, “no, because you work differently, you work harder, you could do that.” Then, as I said in the book, I had this night where I thought, I’ll try. I also think that it’s, like, my own nature. I mean, I think it’s hard to put yourself in a situation where you think you’re going to fail. And I did think that I was going to fail for quite some time. But I thought, “it’s good for me, it’s fine. It’s okay if I fail.” Early in my journalism career, I always had something—and I really didn’t have money, but I always had something, and I don’t know how to put it lightly: an “F You” fund. I always saved; I never spent. I saved a little bit so I could always walk away from a job if they were pushing me to do something else. It’s something my mother was telling me when I was growing up. She said: “Learn to type, because you’ll never starve.” And even my hands were messed up, but I still could type, and I always felt like I would never be in a situation as a journalist where somebody was like, “you have to write this kind of story.” I knew that if I couldn’t create, get into their lives, and have the same kind of intimacy that I felt, that I could walk away from it. I always think, in the back of my mind, “I can get out of this.” To me, if you’re going to do it terribly, it’s better to move on and do something else. I feel that really strongly.

**CP:** So I’m really interested in, of course, the people. That’s the focus of the story. Can you talk a little about what made you decide to focus on these characters? Who are these people?

**KB:** I’m not interested in the “best story.” I’m interested in the story that reveals something about the structure of the society. So with Abdul, I was interested in him right in the beginning because he was looking at the world through garbage, and also because globalization and the Beijing Olympics had suddenly made his stigmatized work profitable. That economic linkage was



interesting to me. And I had no idea, of course, what was going to happen to him. But when it happened to him, that became a way to explore, obviously, the corruption in the police force, but also the situation in the public hospitals. Even though it's sort of a subtheme of the book, the things happening to people in public hospitals was appalling to me, and it was through the experience of Fatima and also, in a way, just little bits like Meena, when Meena was dying and they extracted all this money from her parents for imported injections. That just happened over and over again. I didn't meet a single person who went into the public hospital system in the whole entire time that I was reporting who wasn't asked for bribes or to buy their own medicine, and so that was an outrage to me. You're looking at stories that allow people to engage with those issues in a different way. If you just wrote a treatise on "the public hospital system in India," you might not feel it. But if you say, "Here's Fatima, or Meena, or Sanjay, the boy who committed suicide—and this is what they've got when they're in extremeness," then you feel it.

**CP:** That's something that really struck me, the approach to writing this as stories, and not necessarily as a "treatise" as you mentioned. How early on did you know that's what you wanted to do?

**KB:** I treat the form of narrative nonfiction with ambivalence, because I see what it's not, as well as what it is. All along I understood that I could write my critical evaluation of D.C. Parks and Recreation, or whatever thing I was obsessed about. When I wrote about social issues from the point of view of people—and people felt that I wasn't giving them cardboard cutouts, but real people that they would recognize—then people would be, like, doing anything they could, they would be getting involved, they would be angry, they would be wanting to right the injustices. It was just a dramatic level of reader involvement. I really started to feel that at the Washington Post. People, whether it was group homes for the developmentally disabled or welfare mothers during welfare reform, just completely engaged in their dilemmas, through people, through individuals. One of the things I always talk about when I discuss my work is that these are not representative people. It's not like I'm saying, this is a microcosm. I try not to use those words, because I think those are flimsy constructions. I don't posit that any of the people in this book are the story of India. But I do think it helps people to engage with these questions.

**CP:** Did you have an audience in mind? Is this for India or for America? For regular citizens or politicians?

**KB:** I had in mind two things: I wanted to do something that would, in its analysis, speak to the incredibly bril-

liant people in my husband's world. But I also wanted it to be a story that anyone could read. So the final read was my 12-year-old nephew, who is very bright. I just gave it to him, and I said, "tell me what don't you understand here." He went through it one weekend really carefully, and he didn't understand the part about Asha running off to the police van—which is fine, I'm glad he didn't understand that—but he helped me to find the places where it was unclear, and he said to me at some point, "oh, it's boring here," and he was so right!

The second thing that was really important to me is that I didn't want it to be a book published in America that then went sideways to India. So I worked really hard to make sure that it came out at the same time in America and India, because I thought if people are going to look at this and say it's not true, or it's wrong, or whatever—have at me, let's get it over now. I didn't own the world rights, so it was a real struggle to make sure that happened, but it was so important to me. Being in my husband's world let me see that there are some stories that are repackaged for the audience and things are made more exotic than they actually are; people make stuff up. I wanted it to be like, "okay, put it out there, you want to get to Annawadi, you can figure out how to get there." After the book, people came with their video cameras and their notebooks and were like, "Is this who you are? Did you know she was writing the book?" I think that's good, you know?

**CP:** I'm sure you did a lot of research before you even left, but was there anything once you were in Annawadi that surprised you? What were you least expecting?

**KB:** One of the things that surprised me was that the people who had permanent work were like rockstars, because there were only six of them. And when I say six, there were only three in the beginning, and then there were three others, and now there's four. But the number of people who had standing work was just so small. And the way that, like in the monsoon, if you were a daily wage worker, that means the whole monsoon you're going to be hungry. They were so sensitive to the smallest market fluctuations, for instance, or weather fluctuations. I didn't think that I knew that. I also didn't understand how, while their husbands had given up, the women were just not giving up. They were like, "whatever it takes to do this for my children." One of the reasons I think that I didn't understand that, is that so much nonfiction about India is written by men, and they focus on men. So very soon, I thought, "okay, this is a really important part of the story that's being left out." And, also, not just the women, but the young ones, because I thought what was happening was very interesting, because there were enough TVs

in Annawadi that people could see the contours of life for other women. Once they could see the sort of Tamil equivalent of “Sex and the City,” they could ask “what? Now I’m going to go for an arranged marriage in a village where they don’t even have television?”

**CP:** Did you find that the women, or the young women, were more likely to share things with you? Or maybe less so?

**KB:** Manju was the first young woman I really met, and through her I got to meet Meena. Kekashan I got to know after she returned home, after she left her husband. Manju wanted to know about the world. And she also, on a basic level, was trying to learn English. And so she was very interested to have somebody who spoke English around. Early on I had to say to her, “now Manju, I’m not going to help you with your school, I’m sorry, I’d love to, but this is a journalist writing about you, and you can choose not to do that, and if you don’t want to and then I can help you, but this is what I want to do.” And she’s like, “fine.”

**CP:** Could you talk more about that? How did you deal with your duties as a reporter and your more human instincts? You mentioned that you were either present or present immediately after almost all of the events that are described in the book. How did you deal with that tension?

**KB:** You never feel like you get it right. You’re always making decisions on the fly and second guessing yourself. I’m still second guessing myself about many things. But what you try to do, in the beginning, is to explain to people: “This is the ethics of my profession. I’m here to take your stories as accurately as possible, and then maybe bring them to a larger audience, so that things can be improved not just for you, but maybe for other people.” I’m always very honest about the fact that sometimes nobody cares, so nothing happens—but it’s worth a shot. And people get that. One of the things I try to emphasize—like when I was talking about Kalu’s friends, who so easily could have robbed me of all my reporting equipment when we were searching for witnesses to his murder—and it never even occurred to me that they would do that. Because they wanted somebody to put in a book that their friend was a cool kid, and he was murdered and it was covered up. That was more important to them than the money.

Things haunt me. Like when Fatima was in the public hospital, when she was burned. Her husband didn’t want her moved. And even the Husseins were trying to get her out, because they felt that Cooper was going to kill her. So, he didn’t want her moved. And I wonder, “gosh, if I had sort of forced him to do it, then maybe

he would’ve done it.” But I realized, I didn’t know any better. Cooper Hospital actually deals with more burns than the other hospitals. So you’re also wondering, “what is my reaction, and does that help them or does that hurt them?”

Then there’s easier ethical moments. When this woman is getting attacked—it’s the forcible eviction that Asha essentially supervises, and she’s getting attacked, and then there’s no question. Then you just get in there with your video camera and start yelling and screaming. I did that, and it managed to defuse the situation. People were just standing there watching her. I thought she was about to be raped. They were out of control. In those situations there’s no question that you act and hope for the best. But you never get it, like I said. Right now I have a friend who was in Iraq with soldiers and is now back and following them, and there’s a lot of PTSD and depression, and you can’t possibly know if your conversation has a chance to trigger it or prevent a suicide. It’s something that you feel in your stomach. Whenever I hear somebody saying I’ve got a clean, fast rule and I know exactly what to do, I think, “gosh, good for you. I don’t know.”

**CP:** As a final question, I really want to know, if you were to go back, which I assume probably you will, say, in 5 years or 10 years, looking further ahead, what would you hope to see changed, and what would you expect to see different?

**KB:** That’s such a hard question. I just don’t know at this point what is going to be changed. It’s finding people who will see past the dirt, will see past to the kids. I’ve gotten really good responses from people who are in the leadership of the country in Delhi, who are making everybody read the book, and so people are engaged in those problems. I don’t know how it’s going to trickle down to the lower level. When I was there just a couple weeks ago, people were saying, “well, the police aren’t beating us up as much, and they’re not as crazy.” Because I used the names of real officers, the police now know that they’re being watched. Recently, the Indian government decided to provide many more drugs to the public hospital system so that people wouldn’t be selling on the street. Does that have anything to do with being embarrassed by the account in the book? I don’t know. I hope so. You just hope that these small things are ultimately a force for good. But you can never predict. Often, I think, if I put down what happened to Kalil, it’s not going to happen to the next homeless boy, and whether or not it’s true doesn’t matter, but I tell myself it’s true, and that makes me keep doing what I do. 🍀

# Reliability and Validity of Three Physical Activity Measurements during Pregnancy and Postpartum

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## Abstract

We assessed reliability and validity of three physical activity (PA) measures during pregnancy and postpartum: SenseWear Armband (SA; kcal/kg/hr), Omron pedometer (PED; steps/day/hr), and Pregnancy Physical Activity Questionnaire (PPAQ; MET.hr/wk). Participants ( $n = 20$ ) wore SA and PED in free-living environments for two weeks at 20 weeks gestation, 32 weeks gestation, and 12 weeks postpartum, and completed the PPAQ to evaluate PA. Intraclass correlation coefficients (ICCs) and standard errors of measurement (SEM) were calculated to estimate reliability. Convergent validity among the modalities was assessed using Pearson correlations. PA was  $13.3 \pm 3.7$  kcal/kg/hr,  $497 \pm 192$  steps/day/hr, and  $15853 \pm 5702$  MET.hr/wk. Reliability (ICC:SEM) of SA was lower than PED and PPAQ at all time points (20 weeks = (0.55:1.3), 32 weeks = (0.42:1.2), postpartum = (0.19:2.8)). While PED reliability was (0.42:1.26), (0.89:53), and (0.86:93), PPAQ was more reliable across both pregnancy time points (0.88:3867) and (0.83:3820) than postpartum (0.57:5592). Validity estimates were low and variable ( $r = -0.37$ -0.30). Overall, results showed acceptable reliability but poor validity in our free-living environment study of PA during pregnancy and postpartum.

## Introduction

There are many known health benefits of performing physical activity (PA) during pregnancy for women and their offspring. These include decreased risk of gestational diabetes and preeclampsia for the mother, and a normalized birth weight and decreased adiposity for the baby (American College of Sports Medicine 2006). To continue to increase our knowledge about the effects of maternal PA, more detailed assessment of activity intensity across pregnancy trimesters is

warranted. However, most studies that examined the relationship between PA and health outcomes utilized self-reported measures, which are prone to bias. Additionally, studies examining reliability and validity of recently developed objective PA measurement devices throughout gestation are limited.

One PA measurement device that is gaining popularity is the SenseWear Armband (SA). It measures energy expenditure in kilocalories per kilogram per hour (kcal/kg/hr) via a proprietary equation that uses motion (or accelerometry), steps, skin temperature, electrical conductivity of the skin, and heat flux. In a study of pregnant women, the SA was validated (ICC = 0.85) against indirect calorimetry (Berntsen, Stafne, and Morkved 2011), but this research was conducted in a laboratory setting. Indirect calorimetry is used as the gold standard when estimating energy expenditure in laboratory settings and does so based on measurements of the volume of oxygen consumed and volume of carbon dioxide produced by the participant.

Another popular device among people wishing to track their physical activity is the Omron pedometer (PED). It measures physical activity in steps per day per hour (steps/day/hr). In a study where pregnant women walked on a treadmill, the PED was found to be the most accurate in detecting steps compared to three other pedometers and accelerometers (Connolly et al. 2011). However, as was the case with the armband, data were collected in a laboratory setting.

A third measurement device that was developed for use during pregnancy is the Pregnancy Physical Activity Questionnaire (PPAQ). It measures physical activity in metabolic equivalent . hours per week (MET.hr/wk). The PPAQ was validated in pregnant women in a free-living environment against ActiGraph accelerometers (ICC = 0.78 – 0.93, Spearman correlation

coefficient [SCC] =  $-0.08 - 0.49$ ) (Chasan-Taber et al. 2004). However, this was a cross-sectional investigation, as each woman was studied at only one time period during pregnancy.

Although these three measurement tools have been used in prior studies involving pregnant women, none have been compared against each other and in a free-living environment, and none have used the same women at different trimesters of pregnancy. Therefore, the purpose of this study was to assess the reliability and validity of the SA, PED, and PPAQ during pregnancy and postpartum in free-living environments.

## Methods

In this study, a convenience sample of twenty women participated, all of whom were recruited prior to 20 weeks gestation. Participants were between 18 and 35 years old, nonsmokers, and considered low risk by their physicians. Average age ( $\pm$  standard deviation) was  $28.9 \pm 2.9$  years, and average BMI at 20 weeks was  $25.8 \pm 4.5$  kg/m<sup>2</sup>. Upon enrollment, the women were informed of the procedures and potential study risks and benefits, and were required to have their physicians ensure that they had no existing medical conditions that could prevent their participation.

At 20 weeks gestation, 32 weeks gestation, and 12 weeks postpartum, women wore the SA on their left arm and the PED on their right hip for one week. They also recorded daily in a journal when the monitors were put on and taken off. At the end of this week, they came into the Department of Kinesiology's Human Energy Research Laboratory to complete the PPAQ, reflecting on the activity they had performed the previous week. The SA and PED were worn again the following week, and the women returned to the laboratory to complete the PPAQ once more.

In order to estimate the reliability of these measurement tools for the two consecutive weeks of wear, ICC and SEM were calculated at each of the three time points across the two weeks of wear for each device. ICC is derived from a repeated-measures analysis-of-variance model, where more than two measurement trials can be compared, as in the case here. Also, ICC is appropriate as it is sensitive to the magnitude, and not just direction, of measured PA values among participants. In addition to ICC, we calculated SEM in order to determine the degree to which the true PA scores are affected by measurement error. The higher

the SEM was, the higher the measurement error from the first week to the second week of data collection. The total energy expenditure values measured at each time point were used and provided by each device in their respective units: SA in kcal/kg/hr, PED in steps/day/hr, and PPAQ in MET.hr/wk.

No criterion measure was available in this study, so criterion validity could not be assessed. Therefore, we averaged consecutive week values at each time point, and then Pearson correlation coefficients were calculated among the three tools to assess interinstrument agreement, and therefore convergent validity.

## Results

At 20 weeks gestation, 32 weeks gestation, and 12 weeks postpartum, PA was  $12.9 \pm 3.5$  kcal/kg/hr,  $12.7 \pm 2.3$  kcal/kg/hr, and  $14.3 \pm 3.1$  kcal/kg/hr respectively. According to the pedometer, the women performed  $491 \pm 146$  steps/day/hr at 20 weeks gestation,  $428 \pm 157$  steps/day/hr at 32 weeks gestation, and  $581 \pm 221$  steps/day/hr at 12 weeks postpartum. As reported by the PPAQ, at 20 weeks gestation, 32 weeks gestation, and 12 weeks postpartum respectively, PA was  $15466 \pm 5320$  MET.hr/wk,  $13634 \pm 4721$  MET.hr/wk, and  $18533 \pm 5926$  MET.hr/wk, respectively. Overall, the women tended to be more physically active postpartum compared to the pregnancy time points.

The reliability of the PA measurement tools was moderate to good (range of ICC = 0.19–0.86). For the PED, reliability was highest at 32 weeks gestation and lowest at 20 weeks gestation (see table 1). For the SA and PPAQ, reliability was highest during 20 weeks gestation and lowest postpartum (see table 1). SEM values for the SA and PED were fairly low, approximately 1/3 of the standard deviation of the measure itself. However, SEM was higher for PPAQ, exceeding 50% of the standard deviation of the measure itself.

In contrast to reliability, validity was low and variable (see table 2). There does not seem to be a relationship between devices or time points. None of the devices appear to be in agreement during gestation or postpartum.

## Discussion

Overall, reliability was highest during pregnancy as opposed to postpartum. This may be due to women following a more strict daily routine during pregnancy compared to after the birth of their baby. However,

Devices	20 weeks gestation		32 weeks gestation		12 weeks postpartum	
	ICC	SEM	ICC	SEM	ICC	SEM
SA	0.55	1.3	0.42	1.2	0.19	2.8
PPAQ	0.88	3867	0.83	3820	0.57	5592
PED	0.42	126	0.89	53	0.86	93

**Table 1:** Reliability of each device at each time point, as measured by ICC and SEM. *Units for SEM for SA are measured in kcal/kg/hr, PPAQ in MET.hr/wk, and PED in steps/day/hr.*

Devices	20 weeks gestation	32 weeks gestation	12 weeks postpartum
SA vs. PED	-0.03	0.30	0.18
SA vs. PPAQ	0.13	0.00	-0.37
PED vs. PPAQ	-0.07	-0.02	0.26

**Table 2:** Validity for each device at each time point, as measured by PCC.

it is unclear whether these ICCs reflect the reliability of the PA measurement tools, or the women’s PA behavior changes across two consecutive weeks. In contrast, validity assessment did not show consistent agreement among any of the three devices, at any time point. This may be due to the devices measuring different PA constructs, as SA measured energy expenditure in kcal/kg/hr, PED measured steps, and PPAQ measured energy expenditure in MET.hr/wk. To obtain these results, different physiological and biomechanical responses and behaviors (e.g., heart rate, temperature, motion, recall) were also evaluated in the three modalities. However, based on these preliminary results, it is unclear which device, if any, is measuring PA during pregnancy accurately.

The study had limitations worth mentioning. First, since data were collected in free-living environments, possible inconsistencies of the women’s PA across two weeks of wear reduced internal validity of the study results. There was also no true criterion measure used to evaluate instrument validity, as no practical method currently exists for free-living environments. Lastly, a small sample size in this pilot project limits our statistical power. In contrast, study strengths also include the fact that we are evaluating the PA of pregnant women in a free-living environment, which is advantageous in terms of generalizability to real life. In addition, the study is ongoing, and more women continue to be recruited to increase statistical power. Finally, we are evaluating the same women across pregnancy at three time points, which, to the best of our knowledge, has not been done pre-

viously. Ultimately, our study results will have great benefit to anyone wishing to accurately evaluate maternal physical activity throughout pregnancy. 📌

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# Ways of (Not) Seeing: An Exploratory Study on the Influence of Genre on Memory Narratives

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## Abstract

This paper presents the research data from an oral history project conducted on members of the 1968–71 Kalamazoo Central High School yearbook staff, a project that focused on collecting these narrators' public memories of integration in the Kalamazoo Public School system. Their collected memories were then compared with the yearbooks they created and analyzed for content inclusion and exclusion. It was found that content relating to issues of race and discrimination in the schools was widely excluded from the yearbooks and that narrators consistently referenced the genre of yearbook as the factor leading to this exclusion. This limitation of public memory by the social construct of genre led to the forgetting of significant events and adoption of problematic cultural narratives by interview participants.

## Introduction

Every way of seeing is a way of not seeing.—Anne

With those words, my first oral history narrator summarized what would be my main thesis for the next four months. I was embarking on a research journey called *Integrated Memories*, which utilized the collective, public, and officialized memories of integration in the Kalamazoo Public School system from 1968 to 1971 as a means for exploring the ways in which genre influences what is remembered—and what is forgotten—in public memory works. I was particularly interested in yearbooks (and their creators) and the ways in which those remembrance genres had not been inclusive of alternative views of history. I wanted to hear their creators' stories, compare them to what I saw in the yearbooks, and ask questions about why the two were (so often) remarkably different.

## Literature Review

*Integrated Memories* is situated within three distinct scholarly conversations and areas of study, including the history of integration in Kalamazoo; the study of oral history's role within public memory studies; and the study of the genre of yearbooks. Within these areas, *Integrated Memories* seeks to complement and answer gaps and silences in the existing corpus of scholarly and historical literature. In this section, I will move quickly to sketch the existing scholarly framework and identify areas of new scholarship that the *Integrated Memories* research seeks to satisfy.

### Integration in Kalamazoo, Michigan

The history of integration in Kalamazoo, Michigan, is chronicled through both the 1969 Report of the Racial Balance Committee and the testimony and supplementary evidence submitted to Judge Noel P. Fox as part of *Oliver v. Kalamazoo Board of Education*. These documents outline the substantial amount of segregation that existed in Kalamazoo during the 1960s, both within the district's schools and within the Kalamazoo community as a whole. This division within the community resulted in increased racial violence and tension, particularly within the schools. A junior high school superintendent reported that, at one time, as many as 20 racial group fights were occurring per day. On multiple occasions, the schools were forced to close for extended periods of time in response to racial violence and death threats to students.

It was during these turbulent times that the school district began talking about taking steps to integrate the schools. In 1968, the Citizens' Committee on Integration submitted a plan for integrating the schools, with the scheduled integration date being the 1971 school year. Although originally approved, the plan was rescinded after massive public outcries denouncing inte-

gration took place during the summer of 1971. It was during this turn of events that Michelle Oliver—with the backing of the National Association for the Advancement of Colored People—filed a lawsuit against the Kalamazoo Board of Education, stating that they were unlawfully segregating the schools. Her petition asked the courts to legally enforce the original integration plan. After reviewing significant amounts of research and testimony, Federal District Court Judge Noel P. Fox Jr. issued a preliminary injunction ordering the Kalamazoo Board of Education to proceed with the original desegregation plan, officially integrating the schools in September 1971.

The yearbooks that recorded from 1968 to 1971 serve as one form of officialized historical narrative composed during that time. As memory works compiled during integration by students experiencing integration, the potential for these yearbooks to illuminate the realities of that process are vast. However, the historical value of these documents (and their authors) as case studies on public memory and officialized memory creation has been widely ignored in historical research and has not been commonly used as a lens by which to explore questions of memory, identity, and representation.

### Oral History and Public Memory

In addition to analyzing officialized forms of remembrance, there has also been a long history of scholars using the methodology of oral history as a means by which to discover alternative histories and public memories that may supplement, contradict, or complicate recognized historical narratives. The work of Alessandro Portelli in the early 1970s was particularly powerful in demonstrating how the subjectivity of oral history-based memory studies was just as valid in understanding reality as methods that prioritized “objective” historical data collection. Portelli’s (1998) seminal work “What Makes Oral History Different?” was instrumental in legitimatizing and expanding the use of oral history as a research methodology in historical studies. In the 1980s and 1990s, this oral history methodology was then applied to issues of social justice and seen as a vehicle by which to extract and validate alternative/countercultural memory narratives from people groups whose viewpoints had previously been marginalized (Thompson 2006). Since then, much work has focused on refining and theorizing various aspects of the practice and effect of oral history collection as it relates to public memory and collective history studies. However, little scholarship has explored the effects

that a memory narrative’s recording genre has on the type and scope of content captured.

### Genre Studies

Finally, *Integrated Memories* is situated within scholarly conversations on genre and high school studies. Although the definition of genre has been debated since the times of Aristotle, I based my research off of the definition proposed by Orlikowski and Yates, who argue that genre is “a distinctive type of communicative action, characterized by a socially recognized communicative purpose and common aspects of form” (1994, 543). My understanding of the genre of yearbook, specifically, was shaped by the Scholastic Yearbook Fundamentals’ definition of the purpose of yearbooks, which is “to tell the story of students at the school for one entire year” (Savage 1985). Lynn Hoffman’s work “Why High Schools Don’t Change: What Students and Their Yearbooks Tell Us” analyzes the genre of yearbook through the same lens, commenting on how the genre acts as both a historical artifact and a system of memory: “A high school yearbook is a piece of material culture, a physical object or artifact that can be used as data to interpret ‘past and present human activity.’ . . . The yearbook’s worth lies in its ability to increase our understanding of the society in which it was created” (2002-3, 25). While the genre of yearbook has, for the most part, been understudied, works such as these have demonstrated the historic purpose and value of yearbooks. *Integrated Memories*, as an analysis of these historic documents (and their creators) allows for new insights on the perceived and actual purpose, scope, and effects of the genre of yearbook.

### Methodology

Yearbook staff members from 1968 to 1971 were identified, contacted, and scheduled for voluntary interviews. Twenty-five former yearbook staff members were contacted. From these twenty-five contacts, four were able to give video-recorded, face-to-face interviews during the duration of the study. Each interview was recorded with both audio and visual recording tools and moved through five phases, beginning with general background information and moving to the participant’s role on the yearbook staff, the yearbook creation process, yearbooks and racial tension, and, finally, a reflection on the role of yearbooks. The average interview lasted for approximately 75 minutes. After the interviews were completed and transcribed, the narratives shared by the participants were analyzed

and compared with an evaluation of the yearbooks themselves in an attempt to answer the following research questions:

- What role do yearbooks play in the formation of public memory?
- How do yearbooks incorporate (or not) and appropriate (or not) official histories and collective memories (especially the collective memories of minority or unprivileged groups)?
- How does the genre of yearbook create public memories?

The remainder of this article will discuss the results of that analysis, as well as the implications this research has for a broader scholarly and public community.

## Results

After close analysis of the interview materials (both transcripts and video), the following trends were identified:

- Content dealing with racial tensions in the school was excluded from the yearbooks.
- The reason for this exclusion of content was attributed by the yearbook staff to an unknown authority.
- This unknown authority was consistently linked to statements about the genre and tradition of yearbooks.
- This concept of genre seemed to be the main factor in determining what content was included and what content was excluded.
- Having a yearbook that was not representative of narrators' memories led to a systematic forgetting of nonincluded incidents and adaptation of problematic dominant cultural narratives as a framework for re-remembering personal experiences.

For each of these results, I will summarize briefly how that data was demonstrated in the research materials, give contextualizing information, and discuss the broader implications these patterns suggest for memory studies and public history as a whole.

**Content dealing with racial tensions in the school was excluded from the yearbooks.**

Were strangers to browse Kalamazoo Central's yearbooks from 1968 to 1971, it is unlikely that they would be able to extrapolate a history of Kalamazoo Central that bears any similarity to those narrated in the oral history interviews collected as part of this study. One of the first questions asked of the narrators was, "If you were to write a history of Kalamazoo Central High School during your time there, what would be two or three events you would be sure to include?" Universally, narrators responded with at least one story of in-school violence that was predicated on issues of race or between members of opposite races. Two examples, given below, are typical of these types of responses.

Probably the most significant [memory], the one I can most clearly remember was when there was an altercation and a young lady was tossed out the second-story window. I'm not sure what precipitated that. But it was a white female student thrown out I think by several black female students. Tossed her out the second-story window. And racial tensions had been running sort of high anyway.

I can remember being in a study hall with probably 200–250 white male students, and finally one of them jumped up on a table and said that he was tired of it and that he was going to go out and kill somebody. And kill somebody of color. And you know it was a very ugly crowd that went out, and I think that someone would have gotten seriously hurt. I don't know if they would have killed anybody, but there was no student of color within two or three blocks. And they shut the school down for a week.

Although each narrator was able to articulate multiple incidents of racial violence and tension, analysis of the yearbooks themselves contained little corroboration for these memories. The yearbooks contain the usual pictures of sports teams, school dances, and clubs along with individual photographs of students, faculty, and school administrators. No direct mention is made of any particular incidents of violence or trauma or of the idea of integration. And the fact that the class of 1971 was the first officially integrated class in school history is not mentioned at all.

**The reasoning for this exclusion was attributed by the yearbook staff to an unknown authority.**

In the second phase of the interview, narrators were asked to describe the process by which content decisions were made by the yearbook staff and who was the ultimate authority that decided which stories got included and which stories were ignored. Surprisingly, instead of naming a specific person or organization



(e.g., the yearbook adviser, the school board, or the class editors) as the entity responsible for the rose-colored narrative of desegregation in the school system, the narrators were unable to articulate who was the final decision maker.

Rather, each narrator referenced an undefined authority as the force that prevented the yearbook creators from taking agency in the creation of the public memory work. Examples of this in the narrators' transcripts are demonstrated by frequent references to an unexplained "they" exemplified in the following excerpts:

So I don't know if we wanted to live in more of an ideal situation and didn't want to discuss that [racial tension]. Or, if we did, was it they said we couldn't put that in there? I don't know. It's kind of an interesting question as far who said we couldn't and who said we could (emphasis added). You asked me about what I remember and that [racial tension] is one of the things that came up then I think that it's less-than-accurate portrayal by the yearbook if you don't include things like that. Again, in our case—I don't know if it ever would have been allowed to be put in anyhow—but I don't think it was a deliberate thing.

This second quote is particularly compelling. The phrase "I don't know if it ever would have been allowed to be put in anyhow" follows another portion of the interview in which the participant specifically mentions not remembering there being anyone in the school crossing out content he had written and a statement that he wasn't sure who made decisions about what content got included in the yearbook. The quote ends with the narrator expressing his belief that these choices were not deliberate. Again, this comment would suggest that the narrator is not recalling a specific instance where the yearbook staff was expressly told, "You can't include this." Rather, something or someone had created an atmosphere in the school where it was inherently understood—although not explicitly stated—what sort of content was acceptable to be included in the yearbook.

**This unknown authority was consistently linked to statements about the genre and tradition of yearbooks.**

Narrators in this study had a recurring tendency to link statements about lack of agency in the yearbook creation process with generalized statements about the genre of yearbooks as a whole.

When I got your letter, I went down and looked at the yearbook, and I was also editor of the newsletter

my junior year, and, uhm, we didn't cover this. Partly because that's the world we lived in, you just didn't. I mean the school was, the yearbook was about . . . There was a format, and you followed the format.

Although this narrator never reflected on how content exclusion and yearbook format was related, this section of the interview reveals how the narrator clearly sees her yearbook as belonging to an identified genre, "yearbook." The narrator's lack of explanation of what type and/or style of content is characteristic of the genre of yearbook—along with consistent references throughout the interview to "the format"—evidenced the way in which the genre of yearbook had become self-evident to our narrator. The narrator never needed to be formally taught what should constitute yearbooks and (by referencing "the format" without explanation) assumed that the interviewer was equally aware of the boundaries of this genre.

Explanations for how the genre of yearbook has become self-evident in American society can be drawn from larger studies on American high schools and memory, particularly in the work of Lynn Hoffman. In her article "Why High Schools Don't Change: What Students and Their Yearbooks Tell Us," Hoffman (2002-3) talks briefly about the genre of yearbook and how that genre is directly related to coming-of-age rituals and narratives that are seen as essential components of the American high school experience. Borrowing the concept of *bildungsroman* as articulated by Lisa Lowe (1996) in her work "Immigrant Acts," yearbooks can be read as a genre for visualizing and memorializing the rites of passage that Western culture has deemed essential for the transition from childhood and puberty into adulthood.

It was into this highly solidified conception of what yearbooks should be that the narrators came into their roles as yearbook creators. Thus, their public memory creations are reflective of being written in response to this institutionalized genre.

And my guess is you could go to any yearbook in those three years [1968-1970] and you'll have the pictures of the clubs, and you'll have the sports pictures, and the picture of the king and queen at prom, and the name of the junior prom, and the name of the play.

Well you had all the old yearbooks there, and I think probably if you were to look at ten years of yearbooks from that period of time, they probably were pretty much cookie-cuttered in hindsight, yeah. You copied the format. You might have a team picture that was a

little bigger than another one, but, yeah, it was pretty much the team picture. I think the names of the people were under the team picture, a little article about how the season went, and then went to the next page and I would pretty much guarantee that all the previous years looked just like that too.

**This concept of genre seemed to be the main factor in determining what content was included and what content was excluded.**

As Hoffman demonstrates, yearbooks are consistently associated with high school coming-of-age and rites-of-passage narratives. These stories focus on the ways in which American youth mature from adolescence into adulthood and narrate the particular moments where this maturity is believed to demonstrate itself (i.e., school dances, sporting events, school-sanctioned clubs, etc.). Because the Kalamazoo Central yearbook, as part of this genre, was so focused on crafting positive, progressive narratives, content that contradicted those ideals was excluded. This exclusion, however, was not explicit in the form of an authority figure physically not permitting the stories to be printed in the yearbook. Rather, the exclusion took place as a subconscious process in the mind of the narrator. Since the idea of what yearbooks should look like had become so engrained in American culture, yearbook creators self-censored content that they knew did not fit the stereotypical narrative.

Eviatar Zerubavel has done extensive research work focusing on how memory is “regulated by unmistakably social rules of remembrance that tell us quite specifically what we should remember and what we can or must forget” (2011). The genre of yearbook acts as an enforcer of the socially constructed rules of remembrance for what high school should and should not be, and—in the instance of the 1968–1971 classes of Kalamazoo Central—that genre led to the systematic exclusion of content on the racially polarized realities of what was happening in the Kalamazoo Public School system.

This censorship of content was automatic, self-initiated, and unnoticed in the narrators’ memories, which resulted in narrators reporting that the idea to cover content related to racial tension “never occurred” to them or that “you just didn’t do that.”

**Having a yearbook that was not representative of narrators’ memories led to a systematic forgetting of nonincluded incidents and adaptation of**

**problematic dominant cultural narratives as a framework for re-remembering personal experiences.**

A lack of narrative attention by the yearbooks to the racial issues that were occurring in Kalamazoo Central has led to a general inability of participants to now recall the details of why certain events occurred. Although they can recall with clarity certain instances of racial violence, they are not as able to remember what sparked those actions or why students participated in the activities they did—even if they themselves were involved in those activities.

For example, one narrator also shared a narrative at the beginning of his interview that discussed a walk-out by white students during his senior year. Although he remembered walking out (and later mentioned being personally involved in the incident), he struggled to remember the date of the event and what motivated the student demonstration, saying, “Uhm, I not so sure, but for the majority of us it meant that we were getting out of school too. Can’t really—I’m not that clear on them anymore.”

While this may be partly to blame on the long span of time that had passed between the events and the narrators’ accounts of those events in 2012, the passage of time is not an entirely sufficient explanation. The same participant who struggled to remember the motivations behind walking out of school his senior year recalled with great clarity a momentous Kalamazoo Central football victory over long-time rivals Battle Creek Central, even to the point of remembering the final score. The difference in his ability to recall is directly correlated to the lack of any mention of the walkout in the 1968 yearbook and the rather extensive yearbook coverage of the Kalamazoo Central vs. Battle Creek Central football win.

The exclusion of traumatic content has also affected the way narrators remembered incidents of racial violence. Most of the examples of racial tension given by the narrators portrayed black students as the perpetrators of the violence and white students as victims or bystanders. This positioning of blacks as aggressors and whites as victims is highly problematic and is drawn from the local news media of that time, which often scapegoated a few individuals as the cause for social problems (and usually individuals of color).

Further, none of the instances of violence remembered were associated with specific individuals. While narrators could remember whether the victim was “a white

student” or the riot centered around “a group of black students,” these memories had become detached from specific individuals. The following narrative illustrates this most clearly and demonstrates how the lack of narrative attention given by the yearbooks to these issues has reduced individuals with biographies into racial symbols.

The students [who were rioting]—and I guess they were primarily black students, though I don’t really recall knowing any of them or knowing individual persons in this group. It was just—I just remember it as a group of black students. But I don’t know them.

## Discussion

Understanding the capacity of genre to influence what types of memories are remembered—as well as how they are remembered—has significant implications for the fields of memory studies and public history. First, it demonstrates the significant effects the genre of a memory narrative can have on the shape and scope of the recollection and asks memory scholars to consider the genre of the memory narrative itself as a factor that influences and constrains recollection.

Second, it calls for a new method of public history collection within high schools that exists separate from the traditional yearbook genre. Because this genre bears with it heavy social connotations of ongoing progress and Westernized concepts of maturity, the yearbook genre as it now stands has little capacity to include alternative and/or countercritical perspectives. Further research is needed to determine alternate modes for the collection, preservation, and dissemination of the public memory of high schools in the United States. This work is important, not only to begin documenting a more robust history of the past for future generations but also for allowing high school students of today to find outlets for different “ways of seeing” and for the sharing, validating, and discussing of their high school experiences. ♡

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## Availability of Recordings

All interviews used in this study were recorded in both audio and visual format and are in the possession of the interviewer. Although she is in the process of making these recordings available online, access to the recordings or transcripts can be given upon request submitted to rzantjer@gmail.com. All interviewees have given signed consent for the content of these interviews to be made available for any noncommercial, educational use.

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# Embedded Control System of a Tail-Assisted Running and Jumping Robot

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## Introduction

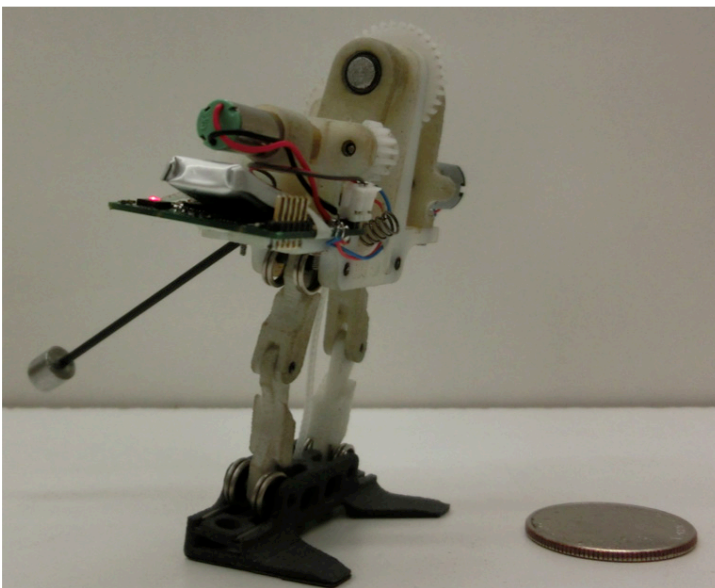
Recently, Spartan Jumper, a bioinspired miniature running and jumping tailbot (Figure 1), has been developed (Zhao, Zhao, et al. 2013). This robot can be deployed into rugged terrain to create a mobile sensor network for environmental monitoring, military surveillance, search-and-rescue applications, and so forth. For example, after a severe earthquake, these tailbots can peer into the ruins first to search for survivors and inspect whether the buildings are stable enough to send in rescuers. Spartan Jumper performs not only wheeled locomotion on the ground but also jumping locomotion when it encounters large obstacles. Both low energy consumption and multimodal locomotion of this tailbot cannot be achieved by existing wheeled and aerial robots. The Spartan Jumper consists of four mechanisms (Zhao, Zhao, et al. 2013). The running mechanism can ensure that the robot runs and steers using its wheels. The tail mechanism can move the robot's body to a standing position to

prepare for jumping. The energy and jumping mechanisms allow the robot to store energy and jump up to 89 cm high (Zhao, Xu, et al. 2013). With the maximum size of 7.5 cm, this robot has the ability to overcome obstacles that are much larger than itself (Zhao, Xu, et al. 2013). When it leaps into the air, the tail mechanism is actuated to change the body's pitch to a proper landing posture to minimize impact damage from the ground. In order to implement these functionalities, a miniature embedded control system is needed, as well as a specific controller for aerial maneuvering. This article addresses the design and experimentation for an embedded control system of Spartan Jumper.

## Design and Approach

An embedded control system was designed for Spartan Jumper. The electrical hardware of the control system includes a central processor, motion sensors, actuators, and wireless communication. The circuit board is only 22.8 mm by 24.8 mm in size and 3 g in weight. An Atmega128RFA1 microcontroller integrated with a 2.4 GHz RF transceiver was used as the central processor. The microcontroller operates quickly and accepts two-way wireless transmission using ZigBee protocol, which avoids an extra board for wireless communication. The software used to program the microcontroller was AVR Studio 6, supporting embedded C programming language. In addition, an MPU6050 sensor, containing both a three-axis accelerometer and a three-axis gyroscope, and an HMC5883L digital compass were built into the system. Furthermore, the actuation unit was an MC34933, a dual H-bridge motor driver, controlling both the jump motor and the tail motor using pulse-width modulation. The entire embedded system is powered by a 50 mAh LiPo battery.

Two controllers were designed to implement the control of the aerial maneuvering, a proportional-



**Figure 1:** Prototype of the running and jumping tailbot (Size referenced by a U.S. quarter).

derivative (PD) controller and a sliding-mode (SM) controller (Khalil 2002). The expressions for the PD and the SM controllers are shown in equation (1) and (2), respectively.  $U$  represents the voltage output of the tail motor in Pulse-Width-Modulation signal form.  $K_p$ ,  $K_d$ ,  $k_l$ ,  $\alpha$ , and  $\mu$  are constant parameters for the controllers.  $\theta_{\text{desired}}$  and  $\dot{\theta}_{\text{desired}}$  are the desired pitch angle and angular velocity,  $\theta_{\text{body}}$  and  $\dot{\theta}_{\text{body}}$  are the pitch angle and angular velocity of the robot's body.  $\text{sat}()$  stands for saturation function ( $\text{sat}(x) = 1$  for  $x \geq 1$ ,  $\text{sat}(x) = -1$  for  $x \leq -1$ , and  $\text{sat}(x) = x$  for  $-1 < x < 1$ ). The control process of aerial maneuver is explained as follows: The accelerometer obtains the initial pitch angle of the robot and detects the free-fall motion if the robot jumps up. Once the robot jumps into the air, the gyroscope measures the body's angle and angular velocity and sends feedback to the microcontroller. The microcontroller calculates the error between the body's angle and the desired angle, as well as the angular velocity error. These errors are then sent to the controller. The controller will give the corresponding voltage output  $U$  to the tail motor to adjust the robot's body angle. The plant of the tail-body dynamic system was derived in Zhao, Zhao, et al. (2013). However, the moment of inertia of the body was hard to estimate because of the complexity of the geometry of the robot prototype. Thus, parameters  $K_p$  and  $K_d$  in the PD controller were tuned manually based on experiments and MATLAB simulations. Similarly, a simplified SM controller with  $k_l$  reduced to a constant was used. The values of  $\alpha$  and  $\mu$  were tuned in the same manner as the PD controller.

$$U = K_p(\theta_{\text{desired}} - \theta_{\text{body}}) + K_d(\dot{\theta}_{\text{desired}} - \dot{\theta}_{\text{body}}) \quad (1)$$

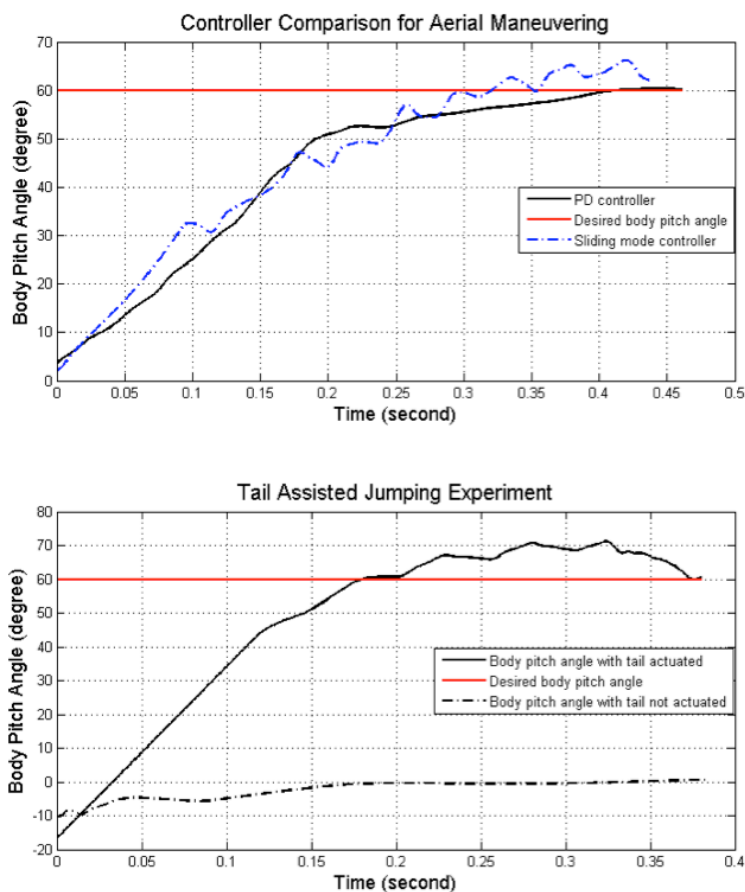
$$U = -k_l \text{sat}\left(\frac{\alpha(\theta_{\text{body}} - \theta_{\text{desired}}) + (\dot{\theta}_{\text{body}} - \dot{\theta}_{\text{desired}})}{\mu}\right) \quad (2)$$

Several experiments were conducted to test the functionalities of the robot. For an assessment of multimodal locomotion, running, steering, jumping, and self-righting behaviors were examined. The performance of the robot was recorded by a camera. The linear and angular velocities of the wheeled locomotion were measured from the videos. To determine the choice of controller for aerial maneuvering, free-fall experiments were conducted. The robot coded with a  $60^\circ$  desired angle was hung from a beam placed 1.5 m above the ground. Once the robot was released, the accelerometer would detect the free fall and actuate the tail. The microcontroller would record the instan-

taneous angle of the robot. Based on the results, the better controller could be selected for the tail-assisted jumping experiment. The robot would jump onto a desk from the ground and control its midair orientation to a desired value. The entire motion was recorded by a high-speed camera. An experiment with the tail disabled was also conducted for comparison. Lastly, indoor and outdoor multimodal locomotion experiments were conducted to demonstrate the transitions from multiple modes: running, steering, self-righting, jumping, and aerial maneuver. The robot was controlled wirelessly throughout the experiments.

## Results and Discussion

The result of the experiments revealed that the robot could successfully run and steer on a flat surface using its spur gears. The average linear and angular velocities were 3.66 cm/s and 0.185 rad/s, respectively. In addition, the robot was able to self-right from both sides using its tail as a support (Zhao 2013). Figure 2 includes the results for free-fall and tail-assisted jumping experiments. The first plot shows the performance of the PD and SM controllers during free fall. The result from the SM controller had a relatively large oscillation. Additionally, after 0.35 s, the body's angle started to settle down and vibrate about  $65^\circ$ , which was  $5^\circ$  larger than the desired angle, known as steady-state error. The PD controller, however, gave good control of the orientation with only slight steady-state error. Thus, the PD controller was selected over the SM controller and used for the jumping experiment. The second plot shows the robot's body angle in the jumping experiment with the tail disabled and enabled. With the tail disabled, it was clear that the body's angle only changed slightly. This change was due to the unexpected initial angular momentum (unavoidable rotational input caused by jumping). From the video, the landing posture was bad and the robot bounced a lot on the desk such that damage might occur from the impact. However, with the tail enabled, the body's angle was regulated to the desired angle in 0.175 s. Even though there was an overshoot in the movement as the body pitch changed to  $70^\circ$ , the controller still changed the body's angle back to the correct value of  $60^\circ$ , so that the robot landed safely on its wheels. More examples of the robot's performance in these experiments are shown in Zhao (2013). The outdoor multimodal locomotion can be seen in Robotics and Automation Lab (2013).



**Figure 2:** Pitch plots for free-fall and tail-assisted jumping experiments.

From the videos, the robot easily transitioned from running mode to jumping mode to overcome the barriers, showing the advantages of multimodal motion.

## Conclusion

The embedded control system successfully implemented the full function of the tail-assisted running and jumping robot: to wirelessly direct the tailbot to run, steer, self-right, and perform aerial maneuvering. The experiments' results demonstrate the application of the bioinspiration and multimodal locomotion in robotics. The future improvement for this control system will focus on improving the performance of the controllers. The overshoot in the jumping experiment suggests that the controller had a long settling time. Obtaining the optimal values of parameters in PD and SM controllers can minimize the overshoot and settling time, giving an accurate and fast orientation control. 🍀

## Acknowledgments

The author would like to thank Profs. Ning Xi and Jianguo Zhao from the Robotics and Automation Laboratory at the Department of Electrical and Computer Engineering for their support and suggestions. This project is supported by the National Science Foundation under the grant CNS-0721441.

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# 2013 National and International Fellowship and Scholarship Recipients

Each year, MSU undergraduates and alumni are awarded highly competitive national and international fellowships and scholarships. In this issue of ReCUR, recent recipients of these prestigious awards are profiled.

Lauren Link | Department of Writing, Rhetoric, and American Culture

## Erik Bates



Getting his start as a Professorial Assistant under Dr. Jeffrey Schenker in the Department of Mathematics, Erik Bates has spent a large portion of his time at Michigan State University immersed in math-related pursuits. His research and his participation in events such as the annual Lyman Briggs College Summer Undergraduate Research

Institute in Experimental Mathematics (SURIEM) and Research Experience for Undergraduates (REU), helped lead Bates to his 2013 Goldwater Scholarship.

Erik's current work is in the area of image processing. Since the summer of 2011, he has been developing and testing algorithms to improve the clarity and accuracy of MR images and to refine the mathematical schemes used by MRI machines in converting radiation to images—to generate higher quality of images with the same quality of measurement.

In addition to his research, Erik is a supervisor at the Brody Mathematics Learning Center. He tutors students in mathematics courses and runs review sessions for calculus classes. Erik is currently in the process of applying to PhD programs in both pure and applied mathematics. After earning a doctorate, he intends to conduct research while teaching at the college level.

When asked what his biggest inspiration has been, Erik relayed the story of how he first got into MRI machinery: at a research program at Arizona State University. He and other students were told what they were going to do that summer in a mere ten minutes. "I had known before those ten minutes why I originally entered mathematics, but only after them did I realize why I wanted to stay: a small group, with nothing but a bit of mathematical knowledge and a lot of creativity, could improve a million-dollar machine without ever seeing it."

## Kayla Felger



A native of Fort Wayne, Indiana, Kayla Felger was named a 2013 Goldwater Scholarship recipient, one of 271 in the nation. Felger is a chemistry and human biology major, with significant research projects under her belt. "I've worked in several labs, but the project that I am currently working on is my favorite," Kayla says. She is currently working

on a device that can be inserted into an injury site to help nerves regenerate. Ideally, regenerating the nerves would allow for regain of feeling and function, and her lab has had some success with regeneration in rat models.

In addition to her research, Kayla strives to give back to the world. She is the public relations officer for International Justice Mission, a group raising awareness and support for victims of human trafficking. She is also a student leader for Bridges International. Finally, she is a member of Science Theater, a fun, interactive group that inspires elementary children to study science. Kayla's future plans include pursuing a PhD in biomedical engineering and ultimately building biomaterials for the purpose of tissue regeneration and drug delivery. When asked what advice she had for fellowship and scholarship applicants, she responded, "Really stop and think about what you love to do and why it matters to you."

She, along with Erik, joins the ranks of 34 MSU students to have received this award.

## Elena Herfi



Elena Herfi, a senior at MSU, is a dual major in comparative cultures and politics in James Madison College and Arabic in the College of Arts and Letters. She is also the recipient of a 2013 Boren Undergraduate Scholarship. This scholarship, established by the National Security Education Program and awarded to only 161 students out of nearly 1,000 applicants, is allowing her to study Arabic in Amman, Jordan for the 2013-2014 academic year. As a Boren Scholarship recipient, Elena joins a program that provides up to \$20,000 to U.S. undergraduate students wishing to study abroad in underrepresented, yet extremely important, regions, which include Africa, Asia, and the Middle East.

Elena, a graduate of Grosse Ile Township High School, plans to continue her studies by pursuing cultural anthropology in graduate school and to pursue a career in the foreign service. This accomplished student has had many unique experiences, which include studying abroad in Morocco and participating in the Arabic Flagship Programs at MSU and the University of Texas at Austin.

## Highlights of Undergraduate Research

Schroder, J., Feelin' Blue About the Ol' Switcheroo: Depression Exacerbates Performance Decrements After S-R Reveals, 24th Annual Convention of the Association for Psychological Science, 24-27 May 2012.

DeLand, K., Potential use of specific milk fatty acids to predict enteric methane emissions from lactating dairy cows, American Dairy Science Association Annual Meeting, 15-19 July 2012.

Peruski, A. and VanDyke, M., ArtSmarts: Arts & Crafts Participation Correlates with Entrepreneurial Innovation among Scientists and Engineers, The Arts, New Growth Tehroy, And Economic Development Symposium, 9-11 May 2012.

Schmidt, S., Incorporation of Palmitic and Stearic Acids into Plasma Lipid fractions of lactating dairy cows, ADSA-AMPA-ASAS-CSAS-WSASAS Joint Annual Meeting, 15-19 July 2012.

Nave, K., Discrimination of Slow Rhythms Mimics Beat Perception Impairments Observed in Parkinson's Disease, International Conference for Music Perception and Cognition (ICMPC), 23-28 July 2012.

Lulloff, J., Music performance, World Saxophone Congress XVI, 12 July 2012.

Dawood, S., Interpersonal Subtypes in Depression: Alcohol Use Differences Among College Students, The Society for Research in Psychopathology, 4-7 October 2012.

Williams, T., The Aversive Interpersonal Impacts of Personality Pathology, Society for Personality Assessment, 20-24 March 2013.

Bond, T. and Shannon, H., The Dancing Body – A Site of the Everyday and the Sacred, Humanities Education and Research Association, 21-24 March 2013.

Kray, S., Juvenile Gang Involvement: Contextualizing Offending with Risk Assessment, Academy of Criminal Justice Sciences Annual Meetings, 20-23 March 2013.

Caron, Z., Child Abuse and Family Outcomes in Juvenile Court: The Main and Moderating Effects of Parental Stress Levels, Academy of Criminal Justice Sciences Annual Meetings, 20-23 March 2013.

Gross, P., Design and Characterization of Thermotoga Maritime Glycerol Dehydrogenase to Reduce Inactivation by Dihydroxyacetone, Experimental Biology 2013, 20-24 April 2013.

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*Continued on Page 39*



# The Supplementary Motor Area as a Potential Neural Substrate of Beat Perception

## An Investigation Using Transcranial Magnetic Stimulation

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Department of Psychology<sup>1</sup>, Lyman Briggs College<sup>2</sup>, and Department of Kinesiology<sup>3</sup>

### Abstract

Previous studies using functional magnetic resonance imaging (fMRI) have shown that musical beat perception engages a network of cortical motor regions of the brain (Grahn and Brett 2007). Individual differences in the strength of beat perception have further been shown to be correlated with functional activation of the supplementary motor area (SMA) (Grahn and McAuley 2009). These findings suggest an important role for the SMA in internal beat generation. The present study used transcranial magnetic stimulation (TMS) to stimulate the SMA during an ambiguous tempo task that has been used to assess strength of beat perception. If the SMA is involved in internal beat generation, we hypothesized that TMS over the SMA would alter performance on the ambiguous tempo task. Results show that TMS over the SMA enhanced decision times on the task, providing some support for our hypothesis.

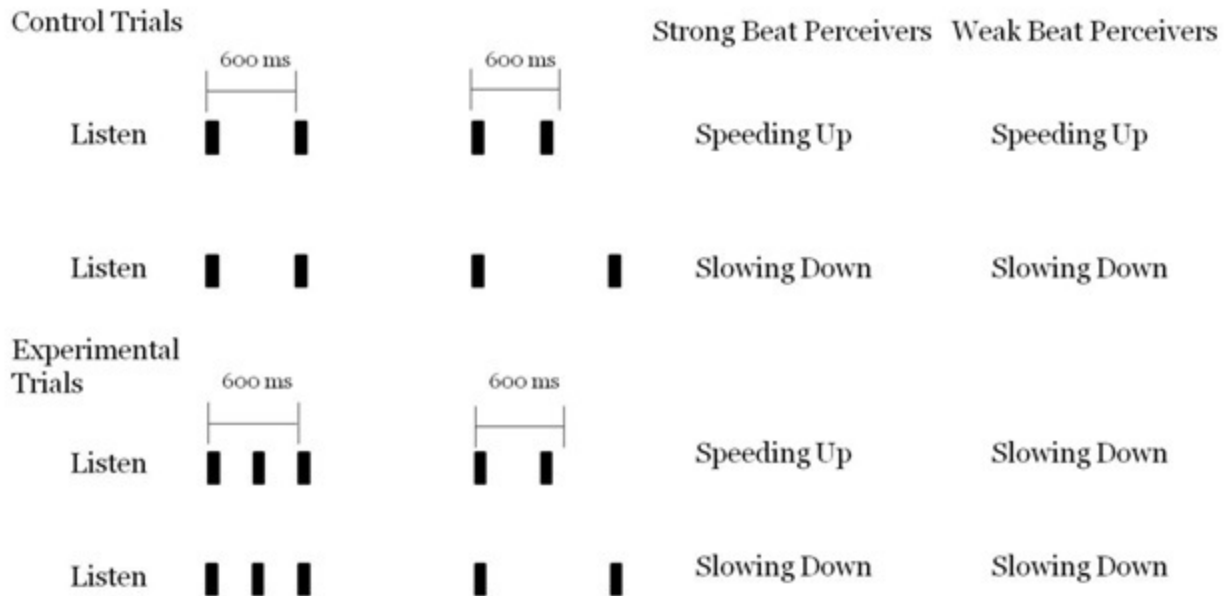
### Introduction

Synchronized movement of the body to music is a universal and readily observable behavior, whether it is swaying to a classical symphony or clapping to the beat at a rock concert. The beat, or tactus, is defined as a pulse that occurs at periodic intervals, which often, but not necessarily, coincides with the onset of musical notes or events (McAuley 2010). Additionally, beats are often marked by acoustic nontemporal accents such as pitch, volume, and timbre. However, a beat can still be perceived without these cues, indicating that just the temporal properties of an over-

arching rhythm, such as duration of an element itself or the duration of intervals between elements, play a large role (McAuley 2010).

The connection between beat perception and movement proves to be an interesting one. One study on beat perception, using fMRI, has found that listening to and making same-different judgments of rhythms with an easily perceivable beat elicited a higher level of activation of certain motor areas such as the basal ganglia, SMA, and premotor cortex than when performing similar tasks involving irregular rhythms (Grahn and Brett 2007). Activation in these regions of the brain was observed despite the fact that there was no movement involved when making the actual judgment, indicating a close relationship between the neural mechanisms involved in perceiving musical rhythms and those that produce rhythmic motor outputs.

Another fMRI study has investigated the same beat-based timing mechanism using rhythms with implied beats and found individual differences in activation of the areas found in previous studies, namely the basal ganglia and SMA (Grahn and McAuley 2009). The authors used an “ambiguous tempo” paradigm from McAuley et al. (2006). In this paradigm, as depicted in Figure 1, participants listen to two types of tone sequences and are asked to judge whether they are “speeding up” or “slowing down.” The first type is the four-tone control sequence, which consists of two tones with an interonset-interval (IOI) of 600 ms, followed by a 1200 ms silence, ending with two tones with a variable final interval of 600 ± 4, 12, and 20 ms. The



**Figure 1.** Ambiguous tempo paradigm. An illustration of control (four-tone) and test (five-tone) rhythms along with task and expected response.

second type is the five-tone experimental sequence, which is almost identical to the control except for the fact that there are three tones (with 300 ms intervals between each) followed by the variable interval tones. In the behavioral study, McAuley et al. (2006) found that for the control sequences, all participants responded with a similar pattern, using the initial 600 ms interval as a referent when comparing the final variable interval. In the experimental sequences, however, there were large individual differences: some participants responded using a 300 ms referent for the comparison, while others seemed to pick up on the implied 600 ms beat (the interval between the onsets of the first and third tones of the test sequence). Despite the fact that identical experimental stimuli were presented, participants, in some instances, showed two different patterns of perception that resulted in opposite responses (i.e., “speeding up” vs. “slowing down”) depending on the referents used. These differences were mapped onto varying activation in the aforementioned brain areas. Strong beat perceivers, those that picked up on the 600 ms implied beat, showed greater activity in the SMA, left premotor cortex, and left insula than did weak beat perceivers, those that used the explicit 300 ms referent.

Converging evidence for the neural underpinnings of the beat circuitry was found in a study using a cross-modal design where similar areas (particularly the basal ganglia and superior temporal gyri) are impli-

cated in beat perception (Grahn, Henry, and McAuley 2011). Specifically, these areas showed greater activation for auditory than for visual sequences, and for when visual sequences followed exposure to the auditory sequences, as opposed to the opposite order. This result converges with previous findings, suggesting that the auditory system is more sensitive to beat-based encoding than the visual system. Moreover, auditory exposure can facilitate a beat-based encoding of visual rhythms but not the reverse.

Furthermore, if cortical and subcortical areas in the motor circuit of the brain are linked to the perception of beats, a dysfunction in this circuit should lead to impairment in beat processing. In fact, this was observed in Parkinson’s disease patients who suffer from basal ganglia dysfunction due to the deterioration of dopaminergic neurons in the substantia nigra (Grahn and Brett 2009). In this study, Parkinson’s patients performed worse on a discrimination task with simple metric rhythms than did healthy controls. Interestingly, they performed the same as controls in the discrimination of complex rhythms without a strong beat structure. The deficit was exclusive to those rhythms that had a regular beat, suggesting that the basal ganglia play a direct role in beat processing.

Moreover, many previous studies on this topic, which used fMRI, are only correlational. While fMRI shows changes in activation of particular brain regions associated with the performance of specific tasks, it is not

possible to establish a causal relationship between activation and task performance. One way to better establish causal links between brain and behavior is using TMS (Ziemann 2011).

TMS is a noninvasive tool that uses principles of electromagnetic induction to cause depolarization or hyperpolarization of neurons. It allows us to investigate excitability of brain regions and even artificially induce a temporary “virtual lesion” by interfering with cortical activity in order to discern components of neural networks (Ziemann 2011). Whereas Parkinson’s disease provides a natural instance of modifications of brain activity (i.e., of the substantia nigra) from which we draw neuropsychological conclusions, TMS allows us to harmlessly do the same even with healthy participants. By showing that an impairment of functioning in a specific area leads to an observable and systematic change in behavior, one can provide better evidence for a causal relationship. One study in a related field has shown that by inhibiting the left ventral premotor cortex, using 0.9 Hz repetitive TMS, the strength of the subject’s individual tempo, or beat rate, preference can be reduced (Kornysheva, von Anshelm-Schiffer, and Schubotz 2011).

The present study extended previous research on beat perception by using TMS to temporarily interfere with the electric activity of the SMA while participants performed the aforementioned ambiguous tempo paradigm, which has been shown to reliably involve the SMA. For instance, Grahn and McAuley (2009) found that the most significant differences in brain activity between strong and weak beat perceivers in the paradigm were in the supplementary motor area. Furthermore, it is a great candidate because SMA is a cortical structure and TMS is most effectively used on more superficial parts of the brain, thereby ruling out deeper regions such as the basal ganglia. If the SMA does indeed play a critical role in beat perception, one would expect TMS over the SMA to affect performance on the ambiguous tempo task (Grahn and McAuley 2009). Whether single-pulse TMS would have an excitatory or inhibitory effect remains uncertain. For instance, there are at least two main possibilities. One is that the stimulation provided by the TMS happens to align with the normal pattern of firing (i.e., is close enough temporally to its electrical rhythm) that it yields an amplification of activity, causing enhanced performance. On the other hand, the electrical activity induced by the TMS could also have caused neurons of the SMA to depolarize

and fire off-phase, interfering with its rhythmicity and thereby leading to a deficit in performance (e.g., slower response times or more inaccurate responses).

## Methods

### Participants

Twelve college students (M = 18.9 yrs., SD = 1.27, Range = 18–21, 9 female) were recruited for the study from the participant pool at Michigan State University. They received compensation in the form of either course credit or cash (\$10/hour). Before commencing the study, participants confirmed that they had no metal implants, history of stroke, history of seizures, or heart complications and that they were not taking neuroleptic drugs at the time.

### Design

Each participant completed nine blocks of the ambiguous tempo task (Figure 1): one block at baseline (without any involvement of the TMS machine), four blocks of TMS over the SMA, and four blocks of TMS over the calcarine sulcus of the occipital lobe, which served as our control condition. It is important to note that, often, the control condition of a TMS study is called sham and involves placing the coil on its vertical edge on the participant’s scalp. We opted to stimulate a control location (i.e., an area that would have no effect on this task) as our sham stimulation, thereby maintaining as many facets of the stimulation as constant as possible across conditions. The TMS coil was oriented such that it would stimulate predominantly the left SMA, but since the structure is so small and medial, bilateral activation cannot be ruled out entirely. Blocks alternated between activation of the SMA and the occipital lobe (i.e., the sham condition), with the order counterbalanced between subjects such that half started with SMA stimulation and the other half started with occipital stimulation. Each block consisted of 40 trials: 20 control (10 at 20%, 10 at -20%) and 20 experimental (10 at 20%, 10 at -20%). Additionally, TMS was administered at two different onset times: 50 ms or 100 ms prior to the penultimate tone. In summary, the SMA and occipital conditions had 160 trials each, consisting of 80 with the 100 ms onset and 80 with the 50 ms onset. Combining baseline, SMA, and occipital conditions, each participant completed a total of 372 trials in the experiment. Overall, the within-subject variables of the design can be summarized as 2 (site of stimulation: SMA or occipital lobe) x 2 (TMS onset: 50 or

100 ms) x 2 (final interval: -20%, +20%) x 2 (sequence type: control or experimental). The between-subjects variable was the order of stimulation, whether the SMA or the occipital lobe was stimulated first.

### Stimuli and Apparatus

The stimuli used in this study were those used in Grahn and McAuley (2009) as described earlier (Figure 1). Sequences were composed of 50 ms sine tones at a frequency of 440 Hz and were generated using Audacity. However, in this study, only  $\pm 20\%$  trials were used since they resulted in the most obvious “speeding up” or “slowing down” of the sequence. If participants perceived the experimental sequences to have an implied beat with a 600 ms interbeat interval marked by the onset of the first and third tones, then this would be carried over to a missing beat halfway between the 1200 ms interval before the fourth tone. In this way, the fifth tone will always be “early” or “late” according to the beat that the participant perceived. Therefore, this implied beat was then used to judge whether the sequence as a whole was speeding up or slowing down. On the other hand, the experimental sequence could also be perceived as having had a beat at 300 ms intervals if the participant used the IOI between the first and second tones as a referent. If the latter possibility was the case, then the participant would generally respond that the final interval was slowing down because very few variable final intervals were shorter than 300 ms.

In the current study we used single-pulse TMS (Magstim) with a figure-8 coil. The SMA was localized by using reliable landmarks and known distances relative to the center line of the skull (i.e., Cz) according to the international 10-20 EEG system, a standardized method of describing and locating the places on the scalp that correspond to underlying areas of the cerebral cortex. These were marked on a tightly fitting skullcap. The TMS butterfly (i.e., figure-8) coil has a spatial resolution of approximately 1 sq cm and is placed tangential to the location being stimulated.

For each individual, the resting motor threshold (RMT), defined as the minimum intensity needed to induce a motor-evoked potential (MEP) of greater than 50 mV in 5 out of 10 trials, was determined in the extensor digitorum communis muscle of the right forearm. The stimulation intensity for the course of the experiment was set at 120% of the individual's RMT.

### Task

Participants listened to tone sequences over headphones, initiating them on each trial by pressing and holding down the spacebar with their right index finger. They were instructed to let go only once they had decided whether the sequence was speeding up or slowing down. After having decided, they removed their finger and made a button-press response, selecting one of the two choices. Additionally, they were asked to respond as quickly and as accurately as possible. Splitting their response in this way allowed the decomposition of response time into two components: decision time (from end of sequence to spacebar release) and motor time (from release to button press).

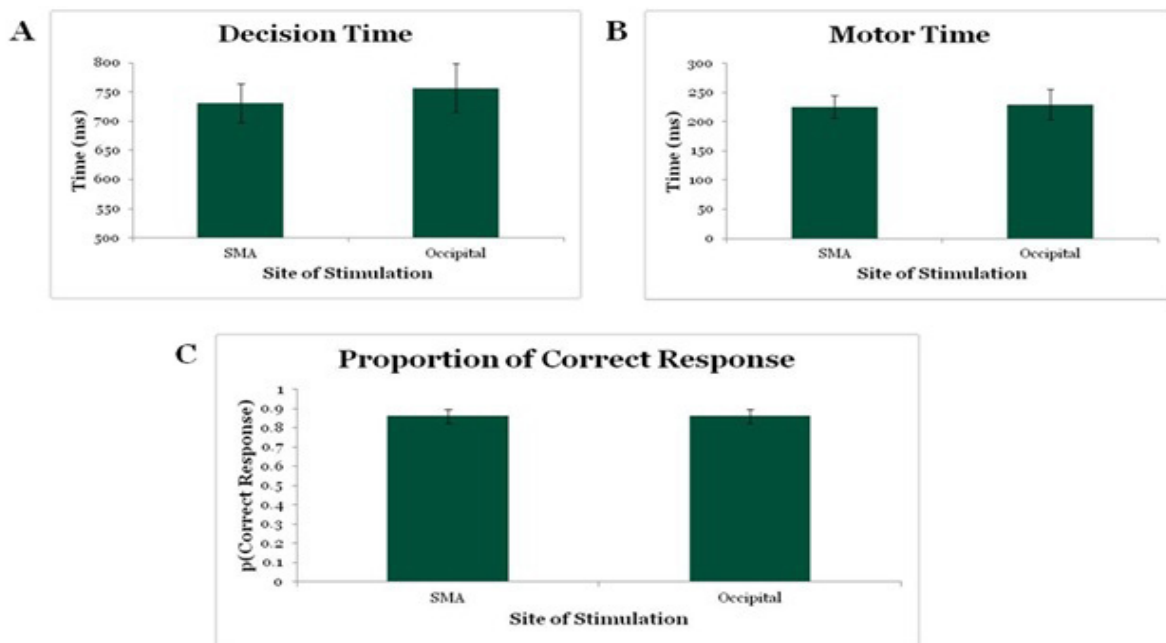
### Data Analysis

The dependent variables used in the analyses are proportion correct, proportion of speeding up response, decision time, and motor time. Responses were coded as correct if the participant responded “speeding up” if the sequence was -20% or “slowing down” if the sequence was 20%. We identified and subsequently removed outliers in the response times by using Tukey's (1977) criterion for outliers. The criterion, given that interquartile range (IQR) =  $Q3 - Q1$ , basically defines outliers as those values outside of the fences set by  $Q1 - 1.5 \text{ IQR}$  and  $Q3 + 1.5 \text{ IQR}$ . Decision time, motor time, and proportion correct were analyzed using 2 (order of stimulation: SMA first or occipital first) x 2 (site of stimulation: SMA or occipital) x 2 (final interval: -20%, +20%) x 2 (trial type: control or experimental) repeated-measures analyses of variance (ANOVA). The order of activation (SMA first or occipital first) was included as a between-subjects factor. It is important to note that performance did not differ in the 100 ms TMS onset condition; therefore, the analyses discussed here focus only on those trials in the 50 ms onset condition. Additionally, the SMA stimulation did not result in MEPs in the extensor muscles of either arm, as verified through the absence of any MEPs in the recorded electromyogram.

## Results

### Decision Time

Figure 2A shows that SMA stimulation had a marginally significant effect on decision time, defined as the time from the end of the stimulus to spacebar release, such that it was faster than occipital stimula-



**Figure 2.** Summary of performance in each stimulation site condition in terms of (A) decision time, (B) motor time, and (C) proportion of correct response.

tion,  $F(1, 22) = 3.416$ ,  $p = 0.094$ . There was no effect of order of activation on timing,  $F(1, 22) = 0.818$ ,  $p = 0.387$ , or interaction between order of activation and activation type,  $F(1, 22) = 0.259$ ,  $p = 0.622$ . On average, participants were around 30 ms faster when the SMA was stimulated ( $M = 731.4$  ms,  $SD = 104.8$ ) as opposed to when the occipital lobe was stimulated ( $M = 756.7$  ms,  $SD = 136.6$ ).

In order to rule out order or practice effects, just the decision times from the first and last blocks were analyzed. There were no main effects of stimulation site on decision time in neither the first block,  $F(1, 10) = 0.439$ ,  $p = 0.523$ , nor the last block,  $F(1, 10) = 0.541$ ,  $p = 0.483$ . However, the same trend, where decision time in SMA stimulation is lower than in occipital stimulation, was still observed.

### Motor Time

There was no overall effect of stimulation site on motor time, or the time it took from spacebar release, after having decided on the tempo judgment, to the button press,  $F(1, 22) = 0.100$ ,  $p = 0.758$  (fig. 2B). Similarly, there was no effect of order of stimulation on timing,  $F(1, 22) = 2.976$ ,  $p = 0.115$ , or interaction with activation type,  $F(1, 22) = 0.000$ ,  $p = 1.000$ .

### Accuracy

Figure 2C shows that SMA stimulation did not affect accuracy, measured as proportion correct in this

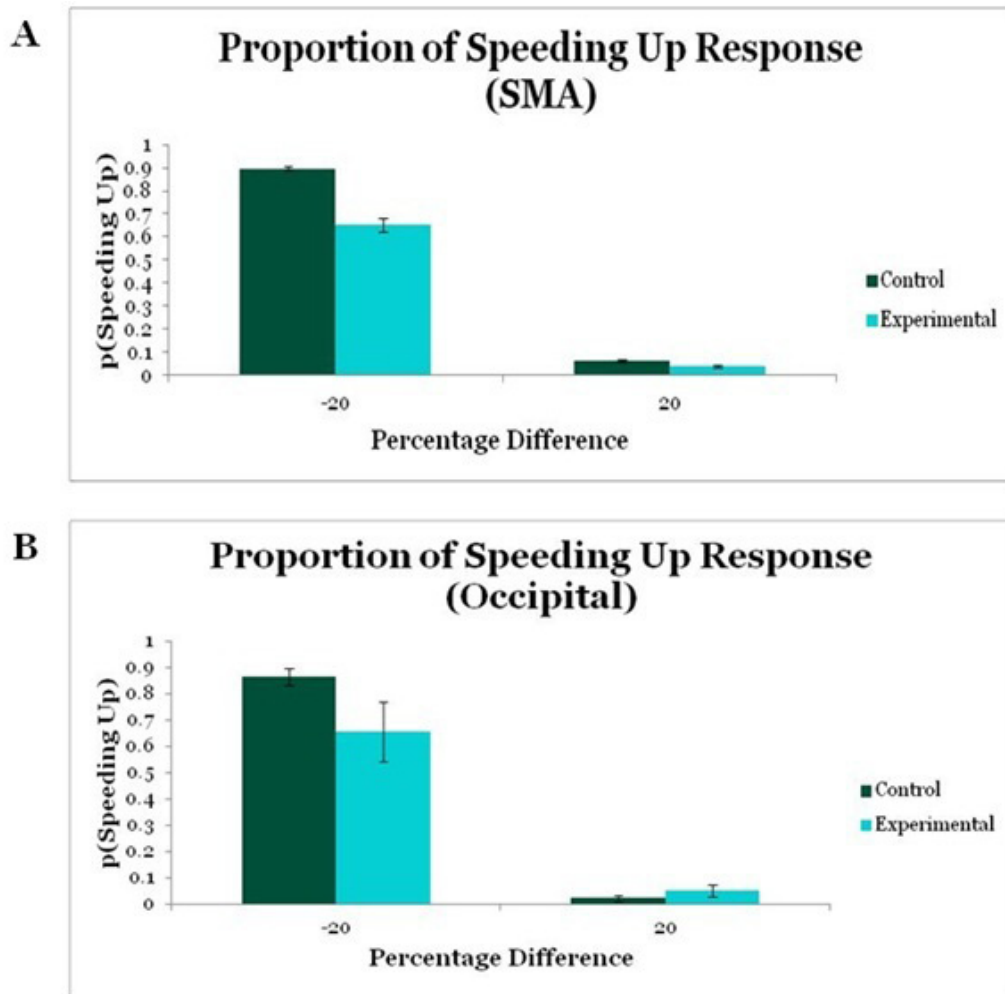
study,  $F(1, 22) = 0.009$ ,  $p = 0.926$ . There was no overall effect of stimulation order on timing,  $F(1, 22) = 0.006$ ,  $p = 0.939$ , or interaction between order of stimulation and site of stimulation,  $F(1, 22) = 0.009$ ,  $p = 0.926$ .

### Proportion of Speeding Up Responses

There was no main effect of stimulation site on proportion of speeding up responses,  $F(1, 22) = 1.100$ ,  $p = 0.319$ . Additionally, there was no interaction among stimulation site, trial type, and final interval,  $F(1, 22) = 0.044$ ,  $p = 0.839$ . This would have been interesting because the ambiguous case (where participants hear either “speeding up” or “slowing down” depending on their referent) is possible only in experimental trials when the final interval is -20% of 600 ms. As Figure 3 shows, there was barely any difference in performance in this critical case when comparing SMA stimulation to the control occipital stimulation.

## Discussion

This study investigated whether disruption of SMA function, accomplished with the TMS, affected performance on an ambiguous tempo task where they made tempo judgments upon listening to tone sequences. Previous neuroimaging studies have correlated activation of the SMA with performance on several tasks involving beat perception, namely the one used in the present study. If the SMA is indeed critically involved in the beat perception process, then we should see



**Figure 3.** Summary of proportion of speeding up response data split by final interval (-20%, +20%) and trial type (control, experimental) for both sites of stimulation.

either impairment or a boost in performance on the task when the normal activity of the area is interfered with. Recall that either enhanced or impaired performance could result from temporal alignment with the normal firing pattern of the brain region.

Results from this study show some evidence that TMS over the SMA results in a speeding up of decision time when compared to the stimulation of the occipital lobe. Currently, this finding seems to be in alignment with the first possibility: enhancement or facilitation of the process governing beat perception. It is interesting that the TMS does not bring about changes in correct responses or “speeding up” response (i.e., the “what”) but rather only in decision time (i.e., the “how”). This implies that it is a cognitive process that the TMS is influencing, perhaps involved with internal beat generation. Another explanation could be that the TMS sped up the motor planning, thought to be carried out by the SMA, upon having established the beat (Goldberg 1985). This would explain why

the motor time remains unaffected: much of the work could be done by the SMA prior to the initiation of movement.

As for the lack of behavioral differences in the 100 ms onset condition, this could be evidence for an optimal window of stimulation. Many factors are involved with effective transcranial magnetic stimulation, such as density of brain tissue, strength of the magnetic field varying according to the inverse square law, duration of effects induced by stimulation, and more. Therefore, it could be that the pulse 50 ms prior to the penultimate tone is more temporally salient in terms of maintaining the effect of stimulation until the decision point in the paradigm.

Additionally, we had to consider the sensation of the TMS firing itself and the influence it may have on performance. The noise of the machine is mostly attenuated by the ear headphones through which participants heard the stimuli. Nonetheless, the tactile sensation of the pulse remained. This presumably would not affect our results, in terms of the pulse being used as a metronome of sorts, because it is present in all trials, whether it was SMA, occipital, four-tone (control), or five-tone (experimental). That is, we used an active control and would expect the same effect in both conditions if this metronome was being used. Furthermore, since stimuli durations vary over the course of the experiment (based on permutations of number of tones and final interval length) and the stimulation itself occurred at two different time points (50 or 100 ms prior to the penultimate tone), it would be very difficult to establish and maintain a consistent metronome as a strategy for task performance.

## Future Directions

The present study is limited by the relatively small number of participants, preventing the ability to more confidently establish the effects of SMA interruption on performance. Regardless, the trend that the results currently demonstrate, particularly that interfering with cortical activity leads to an observable change in a behavioral measure, are promising and warrant further attention. This facilitation effect could be interpreted as evidence that the SMA is crucial for performance on this task. The immediate next step is to recruit more participants for the study. Moreover, neuronavigated TMS would allow for more reliable activation of the SMA, as opposed to relying on the external estimations of the 10-20 system. In this technique, each individual's SMA is localized using neuroimaging, and these coordinates are subsequently used to guide the TMS to more accurately stimulate the site in question.

Furthermore, other brain areas thought to play a role in the beat perception circuitry, such as the medial premotor cortex need to be targeted by the TMS as well (Grahn and McAuley 2009). Analysis of individual components of a circuit is extremely important to discern the nature and complexity of the connections and to arrive at a potential mechanism of functioning (Grahn and Brett 2009). Any findings in this line of study could help elucidate the workings of the neural circuitry underlying beat generation and the interface between beat perception and the production of rhythmic movements. This has pathological implications for understanding mechanisms behind movement- or motor planning-related disorders such as Parkinson's disease (Grahn and Brett 2009). ♣

## Acknowledgments

We would like to thank the Department of Psychology and the Dean's Assistantship Award provided by the College of Social Science for funding this research. We would also like to thank David McFarlane for his technical support with programming and the members of the Timing, Attention, and Perception Lab for their guidance and suggestions.

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# Aromatic Hydrocarbons from Biomass Fast Pyrolysis and Catalysis

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## Abstract

Lab-scale experiments were conducted using catalytic fast pyrolysis in a microscale analytical pyrolysis reactor (chromatography pyroprobe unit). The catalysts—red mud, microporous and mesoporous sulfated zirconia, and mesoporous Al-MSU-S (foam) and (worm)—were evaluated and compared with ZSM-5 for their potential to produce aromatic hydrocarbons. Catalyst properties of surface area, pore volume and acidity were measured. Catalysts for upgrading poplar (DN-34) were examined using analytical pyrolysis and gas chromatography–mass spectrometry (GCMS). The product yield, the carbon selectivity, and the yield of hydrocarbon products were evaluated. The char and coke yields of these catalysts were estimated using a thermogravimetric analysis, and the yields of aromatic hydrocarbons were compared for each catalyst. It was found that none of the prepared catalysts produced as high a percentage of aromatics as ZSM-5.

## Introduction

Plant biomass-based energy can provide local heat and power, use existing infrastructure, give impetus to the local economy, and increase energy independence of communities, while being carbon neutral. Fast pyrolysis technologies offer a potentially less expensive route to hydrocarbon liquid fuels (Zhang et al. 2007; Demirbaş 2001). Biomass fast pyrolysis involves the rapid heating of biomass in an inert atmosphere to intermediate temperatures. The products include a solid char, noncondensable gases, and a condensable product (bio-oil). The quality and selectivity of pyrolysis products can be altered and improved by using heterogeneous catalysts. Catalytic upgrading of pyrolysis products removes oxygen in the form of noncondensable gases and gives a product richer in

hydrocarbons. Catalytic fast pyrolysis produces higher quality bio-oil and reduces the cost and intensity of downstream refining processes.

A hydrocarbon is an organic compound consisting mostly of hydrogen and carbon. An aromatic hydrocarbon is a hydrocarbon exhibiting delocalized pi bonds. Aromatics such as benzene, toluene, ethylbenzene, and xylenes (BTEX) are important petrochemicals used in the chemical industry for the production of polymers or as fuel additives. Aromatics may be obtained from renewable resources, as an alternative to fossil fuels, by using thermochemical methods such as pyrolysis with catalysis (Carlson et al. 2009).

In a single step, fast pyrolysis converts low-value, low-density biomass to a denser liquid product, bio-oil, at yields in excess of 70% by weight (Zhang et al. 2007). Biomass fast pyrolysis involves the rapid heating of biomass ( $\sim 500^\circ\text{C}/\text{sec.}$ ) in an inert atmosphere to intermediate temperatures ( $\sim 500^\circ\text{C}$ ).

Low selectivity limits the applications of pyrolysis, as hundreds of compounds are produced from pyrolysis of biomass (Adam et al. 2006). Negligible amounts of aromatics are observed. Aromatics can be produced by reacting biomass pyrolysis products with heterogeneous (solid) catalysts (Carlson et al. 2009).

The objective of this research was to identify which, if any, of the selected catalysts could match the aromatic production of ZSM-5.

## Methods

The selection of appropriate catalysts is crucial for high aromatic yields from biomass pyrolysis. In this study, microporous sulfated zirconia and red mud were evaluated and compared with the widely used petroleum industry-standard catalyst ZSM-5 for their potential to produce aromatic hydrocarbons



(Horne and Williams 1996). A novel variant of sulfated zirconia on an MCM-41 (an industry-synthesized mesoporous silica nanoparticle) support was prepared, which increased its surface area. Mesoporous Al-MSU-S foam and worm catalysts were also tested.

**Pyrolysis GCMS:** Catalysts for upgrading hybrid poplar DN-34, previously shown to be a strong candidate for this pyrolysis and catalysis, were examined using analytical pyrolysis connected to gas chromatography-mass spectrometry (Sutton, Kelleher and Ross 2001). Approximately 0.5 mg of ground biomass sample was packed between quartz wool and layers of catalyst in a quartz tube with a filler rod. The catalyst-to-biomass ratio was 1:1. Six replicates of each sample were run. The pyroprobe operated at 650°C (550°C pyrolysis temperature) with helium as the carrier gas. Pyrolysis GCMS provided data on total product composition and for identification of products.

**Catalyst properties:** Surface area measurements and pore size distribution analysis were done by nitrogen adsorption at 78 K in a Micromeritics ASAP 2010 instrument. Acid site measurements were performed using NH<sub>3</sub>-TPD (temperature-programmed desorption) by volumetric adsorption in a Micromeritics AutoChem 2910 instrument.

## Results

Production of aromatics from biomass using fast pyrolysis with catalysis was demonstrated (fig. 1). The catalysts removed unstable oxygenated compounds found in biomass pyrolysis vapors and generated aromatic hydrocarbons, along with gases such as CO, CO<sub>2</sub>, and H<sub>2</sub>O. Of the five catalysts evaluated, ZSM-5 gave the highest yield of aromatics.

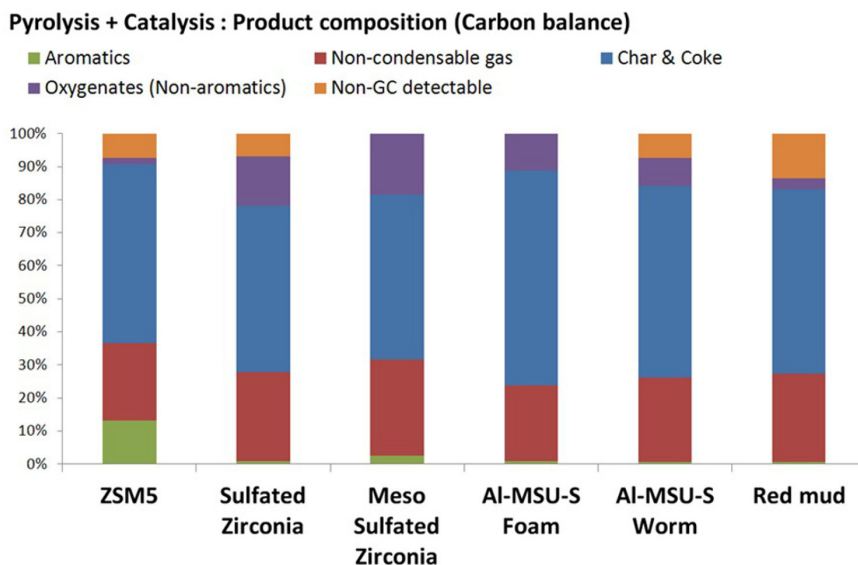
Aromatics and coke production are functions of catalyst acidity, shape selectivity, and pore size. With change in the catalyst shape selectivity and pore size, an effect on yields of aromatics was expected. Mesoporous catalysts with large pores (meso sulfated zirconia and MSU-S) produced more coke (carbon product of petroleum processing) and less aromatics than microporous catalysts with smaller pores (ZSM-5 and sulfated zirconia).

## Discussion

ZSM-5 is a crystalline aluminosilicate zeolite with a high silica and lower aluminum content. Zeolite catalysts have been shown to be effective at modest temperature, low pressure, and in the absence of molecular hydrogen as a cofeed (Pindoria et al. 1998). Our experiments show that microporous ZSM-5 catalysts have the desired shape selectivity to produce high aromatic yields from biomass pyrolysis. However, the mesoporous catalysts have large bottlenecks and cages that promote coke generation and are not shape selective for aromatics production. It was concluded that these catalysts were not as effective in producing high yields of aromatics as the mesoporous catalysts, particularly the industry-standard ZSM-5. 📌

## Acknowledgments

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**Figure 1:** The product composition results of biomass fast pyrolysis are presented here for each of the six catalysts used. The products of the six replicates for each catalyst were identified, aggregated, and classified into the categories listed in the key, represented in graphical form as a percentage of the total products of each catalyst. The green aromatics bars are of the greatest interest, and none of the other catalysts produced as great a percentage of aromatics as the industry-standard ZSM-5.

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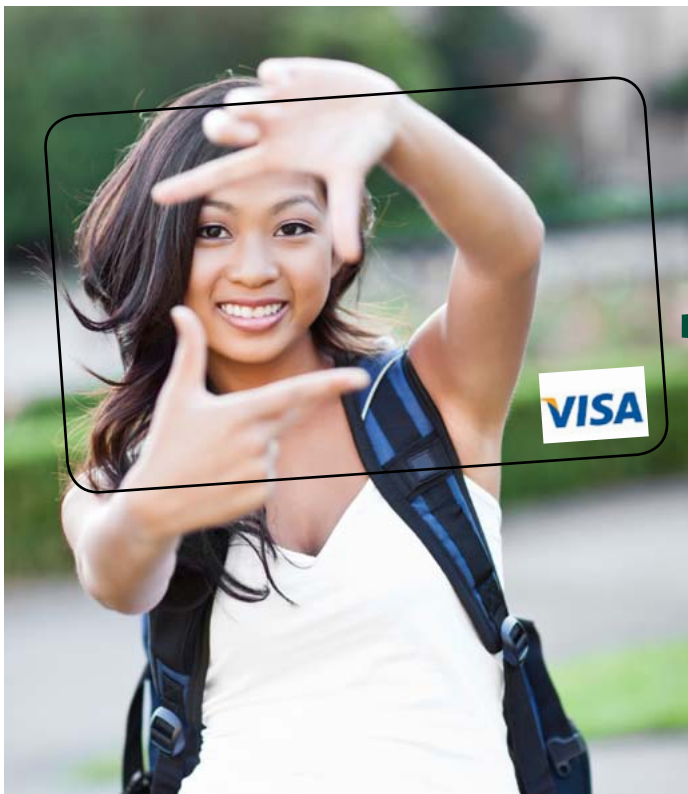
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## Reason #14

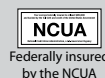
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# The Effect of Language Background on Auditory Perception

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## Abstract

When listening to tone sequences, individuals naturally hear the tones as occurring in groups. Iversen, Patel, and Ohgushi (2008) proposed that the “weak-strong” (iambic) perceptual bias for sequences of long and short tones may be related to the phrasal structure of English whereby (weak) function words often precede (strong) content words (e.g., “a bus”). The current work addresses the principal question of whether biases in auditory perceptual grouping patterns are universal or are influenced by language background. This study investigates the proposed hypothesis by testing native speakers of English and Indonesian whose languages have contrasting phrasal structures. If language background influences grouping biases in accordance with phrasal structure and prominence patterns, speakers of Indonesian should show a “strong-weak” (trochaic) bias. Results show that an iambic grouping bias in native English speakers is much weaker than previously found. Preliminary results provide relatively little support for a trochaic bias in Indonesian speakers.

## Introduction

Understanding speech and music requires listeners to segment a continuous acoustic signal into meaningful units. When listeners perceive speech and music, they tend to organize the acoustical signal into groups based on auditory cues such as pitch, duration, and amplitude (Patel 2006). Grouping of elements into rhythmic patterns helps encode the auditory signal into comprehensible units. Patel (2006) suggests that there are many similarities between grouping principles in music and grouping principles in speech. Music has metrical hierarchy based on beats, whereas speech has metrical hierarchy based on stress prominence. Previous literature has studied whether there

is a perceivable relationship between grouping patterns across different languages (Hay and Diehl 2007; Iversen, Patel, and Ohgushi 2008). However, there are open questions as to whether a perceptual grouping bias is based on universal principles or could be influenced by language background.

Individual tendencies to perceptually group elements are evident when listening to sequences comprised of physically identical tones, as, for example, when an isochronous metronome is heard as a “tick tock” pattern (Bolton 1894). Bolton (1894) and Woodrow (1909) were the first to establish several perceptual grouping principles of simple tone sequences that are widely studied today. Several studies have looked into the universality of perceptual grouping preferences for speech and nonspeech sequences based on the iambic/trochaic law (Hayes 1995). The iambic/trochaic law states that when successive tones contrast in intensity, listeners tend to form binary groupings with initial prominence, eliciting a “strong-weak” (trochaic) perceptual pattern. Similarly, when successive tones contrast in duration, listeners tend to form binary groupings with final prominence, eliciting a “weak-strong” (iambic) perceptual pattern. For many years, these principles were considered to be innate and not dependent on language experience.

Hay and Diehl (2007) support the argument that perceptual grouping preferences rely on general auditory mechanisms and are not influenced by language background. They tested native English and native French speakers on their perception of simple tone sequences. Cross-linguistic comparison between French and English was driven by the differences in stress patterns of the two languages, as well as previous findings indicating that stress patterns affect speech segmentation (e.g., Cutler et al. 1986). Results from Hay and Diehl (2007) show no significant differences be-

tween English and French speakers in their grouping responses for simple tone sequences. In addition, Hay and Diehl (2008) confirmed the principles governing the iambic/trochaic law in native English speakers; variation in duration resulted in iambic grouping preference, whereas variation in intensity resulted in trochaic grouping preference.

However, recent studies investigating these biases have suggested that perceptual grouping preferences may be influenced by language background. Iversen, Patel, and Ohgushi (2008) tested native English speakers and native Japanese speakers on their perception of simple tone sequences consisting of alternating tones, some varying in duration and some varying in intensity. A striking difference was found between the two language groups when perceiving duration-varying sequences. Native English speakers showed a strong bias for perceiving a repeated iambic (“weak-strong”) grouping pattern while Japanese speakers showed no preference toward any specific grouping pattern. A follow-up study by Yoshida et al. (2010) found that these grouping preferences develop very early in life. Looking at Japanese- and English-learning infants of five to seven and seven to eight months of age, infants developed nonlinguistic grouping preferences consistent with their language’s structure (and the grouping biases found in adulthood) at seven to eight months of age but not at five to six months of age. Yoshida et al. (2010) argue that the seven-to-eight-month range is generally the same age as when linguistic phrasal grouping develops. These results provide strong evidence for differences in perceptual grouping patterns, supporting the idea that grouping preferences in auditory sequences may not just rely on general auditory mechanisms, but might be influenced by language background.

Iversen, Patel, and Ohgushi (2008) proposed the idea that the iambic bias for sequences contrasting in duration may be related to the phrasal structure of English whereby function words (weak) tend to precede more prominent (strong) content words (e.g., “a bus”). In Japanese, content words precede function words. However, in expecting differences in language background to affect auditory perception, it is important to consider the differing role of duration in English and Japanese. Duration is a cue to prominence pattern in the English language, where longer duration syllables tend to mark stress patterns (Cutler and Carter 1987). In Japanese, there are no lexical stress patterns, and longer duration syllables

can occur in variable positions throughout a word (Kubozono 2003, 2004). As a result, duration is not a reliable cue to phrasal structure in Japanese and could contribute to the lack of a strong preference for either “weak-strong” or “strong-weak” grouping pattern in Iversen, Patel, and Ohgushi (2008).

A pronounced perceptual grouping bias which contrasts with that of English may be more likely to emerge if the contrasting language exhibits the opposite phrasal structure from English, while utilizing similar acoustic cues to prominence. Thus, the Indonesian language is of interest. In Indonesian, the phrasal structure contrasts with English in that (strong) content words tend to precede (weak) function words (e.g., *palu itu* [hammer the]). Iversen, Patel, and Ohgushi (2008) suggest that the function-content word order could have acoustic consequences that predict grouping preferences of nonlinguistic sounds. Because duration is used as a cue to prominence in the Indonesian language (Goedemans and Van Zanten 2007), looking at contrasting differences between English and Indonesian speakers could provide additional support to the hypothesis in question. If language background influences grouping biases in accordance with the phrasal structure, then despite use of duration and intensity in both languages (English and Indonesian) as cues to prominence, speakers of the Indonesian language should show a trochaic rather than an iambic bias for tone sequences.

The current study will address the overarching question of whether biases in auditory perceptual grouping patterns are based on universal principles or are influenced by language background. The goal of the study is to investigate the hypothesis proposed by Iversen, Patel, and Ohgushi (2008) that perception of tonal sequences varying in duration may be influenced by the phrasal structure and prominence pattern of the listener’s native language. First, we aim to replicate previous findings of Iversen, Patel, and Ohgushi (2008) to confirm an iambic grouping bias in native English speakers. Second, we aim to test native Indonesian speakers using the same paradigm to investigate whether grouping biases are influenced by the structure of the Indonesian language.

## Methods

### Participants

Participants were a pool of 30 native English speakers and 9 native Indonesian speakers who did not

formally learn English until their preteen years (mean age of acquisition = 11 years). Native English speaking participants were recruited from the Human Participation in Research pool at Michigan State University and were given credit toward participation, fulfilling a course requirement. Indonesian participants were recruited from the East Lansing community and were compensated \$10.00 per hour for participation. All participants had self-reported normal hearing. An additional 4 individuals (2 native English speakers and 2 native Indonesian speakers) completed the experiment but were not included in the final sample due to misunderstanding of the instructions and the task. Rules and regulations were met regarding research with humans as addressed by Michigan State University's Institutional Review Board policies and procedures.

Native English speaking participants were monolingual undergraduates (24 female, 18–23 years,  $M = 19.4$ ,  $SD = 1.8$ ), and native Indonesian speaking participants were international undergraduate and graduate students (6 female, 23–36 years,  $M = 29.44$ ,  $SD = 5.2$ ). Participants varied in number of years of formal music training ( $M = 2.5$ ,  $SD = 3.2$ ). Although all Indonesian participants had been born in Indonesia and lived there for most of their lives (13–31 years,  $M = 23$ ), participants were highly proficient in English. However, all Indonesian participants reported that they read, write, and converse (via text message, email, or in person) in their native language every day.

### Stimuli and Equipment

Stimuli were 21 different tone sequences in which tones alternated in short-long or long-short interonset interval (IOI) duration as shown in figure 1. IOI is the time interval between the onset of a tone and the onset of the following tone. Hence, the IOI includes the duration of the tone and the duration of the silent period in between the tones. Shorter IOI duration was set to 150 ms, 200 ms, and 250 ms long at 440 Hz frequency. The alternating longer IOI durations were created by multiplying the shorter IOI duration by a factor of 1, 1.67, 2.33, and 3. For example, the shorter IOI duration of 150 ms consisted of a 130 ms tone and 20 ms of silence following the tone. The alternating longer IOI durations were 150 ms (1:1), 250.5 ms (1.67:1), 349.5 ms (2.33:1), and 450 ms (3:1). All other duration ratios were constructed using the same method. For the remainder of the descriptions, we will refer to the long IOI-to-short IOI comparison

as Long:Short ratio. Duration ratios for the current study were picked to best match the duration ratios used in Iversen, Patel, and Ohgushi (2008) but were not identical.

Each sequence was 11 s long with a fixed 20 ms silence between each tone. Sequences were generated in MATLAB software (The Mathworks, Inc.) and were presented at a comfortable listening level over Sennheiser HD 280 Pro headphones (Old Lyme, CT). Each sequence was presented ten times, half of the sequences starting with the short IOI duration and half of the sequences starting with the long IOI duration. In addition, sequences were masked with white noise and an amplitude ramp for the first 5 s of the sequence to eliminate possible effects of starting order. Stimuli presentation and response collection was controlled by E-Prime 2.0 software (Psychology Software Tools, Inc.) running on a Dell OptiPlex 760 series computer with a Creative Sound Blaster Audigy sound card installed. Participants made responses using a serial button response box.

### Procedure

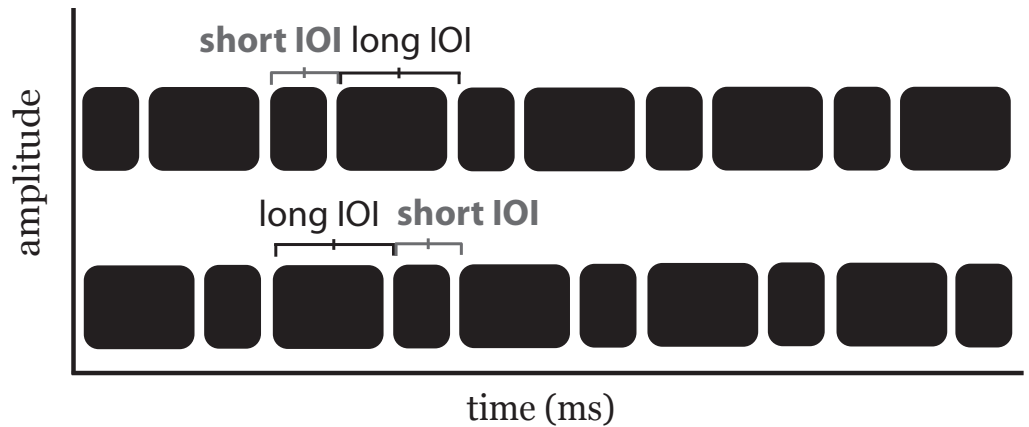
On each trial, participants heard one sequence of tones in which the tones alternated in duration (long-short, short-long, or alternating tones of the same duration). Participants judged whether they heard the sequence organized as a “strong-weak” alternating pattern or a “weak-strong” alternating pattern by pressing the corresponding button on the response box. Each participant completed one practice block and two experimental blocks. The practice block consisted of four sequences randomly chosen from the set of stimuli sequences. The sequences used in the practice block were still included later in the experimental blocks. Each participant's practice sequences were randomly chosen; however, the practice block did not include any of the isochronous (Long:Short ratio of 1:1) tone sequences used in the experimental blocks. Exposure to stimulus sequences during the practice block allowed participants to get an idea of what the experiment was like and to help them better understand the task.

Each experimental block consisted of 105 sequences presented in a random order for a total of 214 sequences (4 practice sequences, 210 experimental sequences). Participants were encouraged to ask questions in between the practice and experimental blocks if they did not understand the instructions or felt unclear about the task. All instructions, verbal and written,

were given in English. Vocal instructions reviewed that there was no correct answer to each perceptual judgment, and participants were encouraged to read the on-screen instructions carefully before beginning the experimental blocks. Participants also listened to recorded instructions over headphones. At the end of the experimental portion, a questionnaire about participant background demographics and any strategies used during the experiment was administered. Indonesian participants completed an additional background questionnaire which included questions about how often they speak, read, or write in their native language. The entire experiment took approximately sixty minutes.

### Data Analysis

The dependent variable used in the analysis is proportion of “weak-strong” (iambic) responses. Participants’ button-press responses were coded as 1 for every “weak-strong” response and coded as 0 for every “strong-weak” response. Proportion means were compared between the two language groups using an independent-samples t-test. For each language



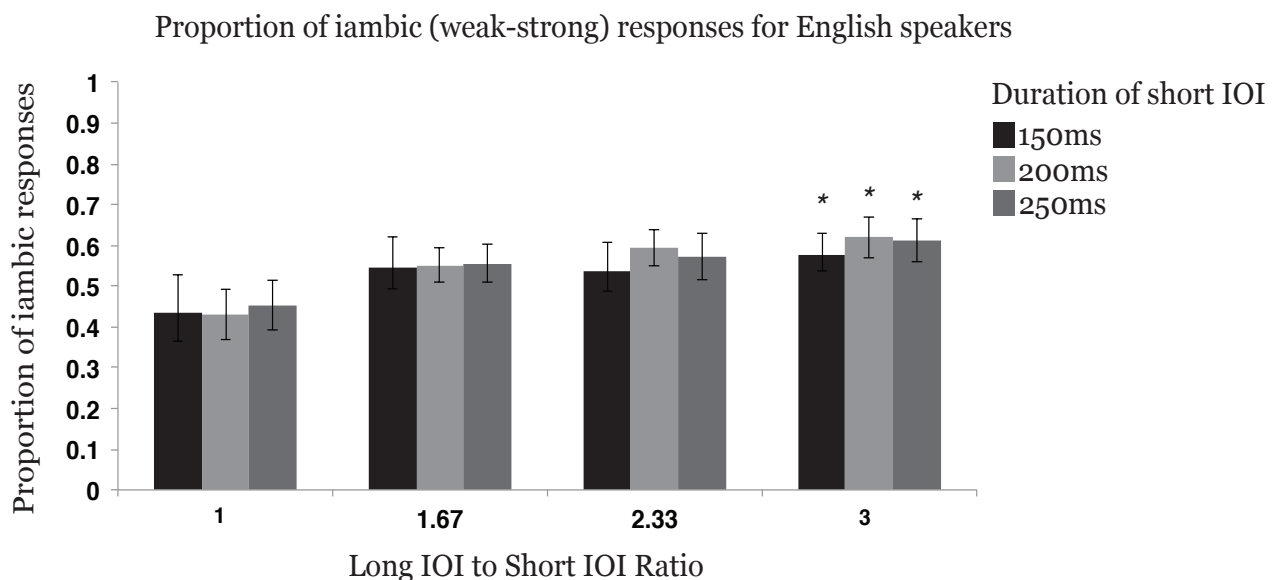
**Figure 1:** Depiction of the stimuli sequence in which tones alternated in short-long or long-short pattern. Participants were presented with sequences with both starting orders. Stimuli sequences were also masked with an amplitude ramp and white noise for the first 5 s to eliminate starting-order effects. See text for more stimuli details.

group, a one-sample t-test against chance (0.5) was also performed. It is important to note that population size of the two language groups greatly differed.

### Results

Results from the practice block and experimental blocks were measured in proportion of “weak-strong” (iambic) responses. Practice block results for each language group are as follows—native English speakers:  $M = 0.69$ ,  $SD = 0.46$ ; native Indonesian speakers:  $M = 0.89$ ,  $SD = 0.18$ .

Figure 2 shows average proportions of “weak-strong” (iambic) responses for native English speaking



**Figure 2:** Average proportion of “weak-strong” (iambic) responses for native English speakers. Asterisks indicate a significant difference from chance ( $p < .05$ ). Error bars indicate standard error of the mean.

participants for each Long:Short ratio. Means (pooled across the three IOIs) are as follows—1.0 Ratio:  $M = 0.47$ ,  $SD = 0.36$ ; 1.67 Ratio:  $M = 0.56$ ,  $SD = 0.24$ ; 2.33 Ratio:  $M = 0.57$ ,  $SD = 0.27$ ; 3.0 Ratio:  $M = 0.61$ ,  $SD = 0.25$ . As expected, a one-sample  $t$ -test against chance showed a significant iambic bias in native English speakers, but only for tone sequences with a Long:Short ratio of 3 (150 ms short IOI:  $t(29) = 3.64$ ,  $p < 0.05$ ; 200 ms short IOI:  $t(29) = 2.5$ ,  $p < 0.05$ ; 250 ms short IOI:  $t(29) = 2.2$ ,  $p < 0.05$ ).

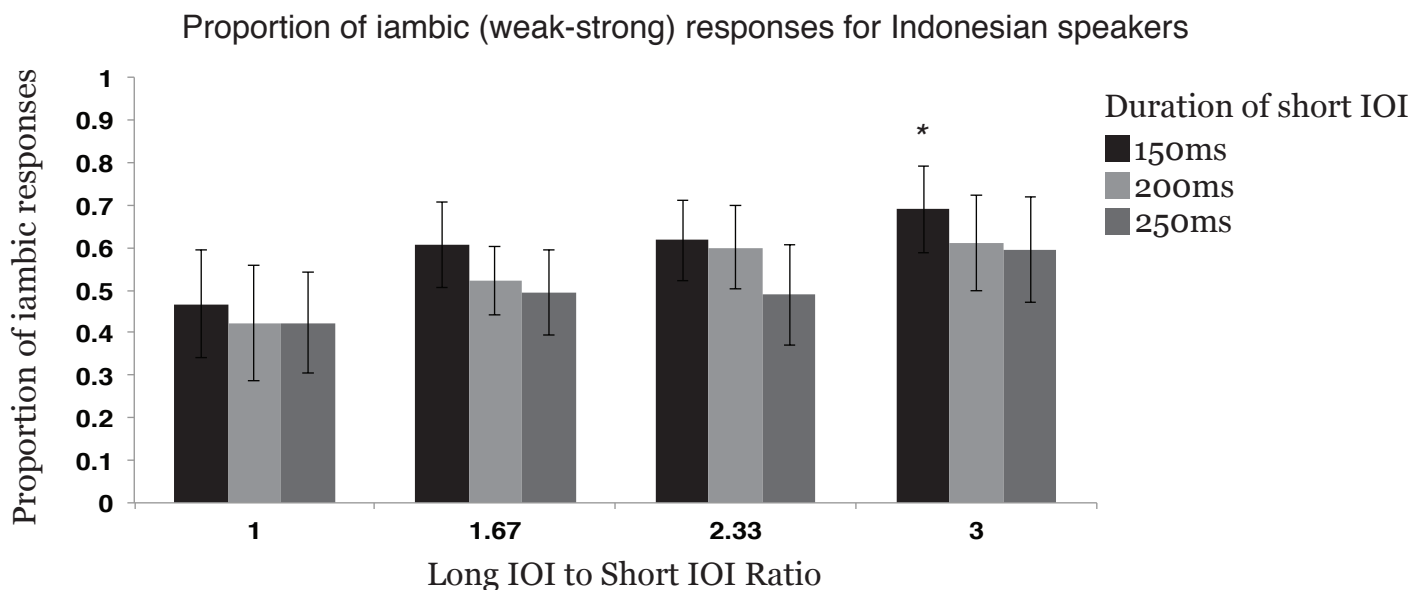
Figure 3 shows average proportions of “weak-strong” (iambic) responses for native Indonesian speaking participants for each IOI ratio. Means (pooled across the three IOIs) are as follows—1.0 Ratio:  $M = 0.42$ ,  $SD = 0.37$ ; 1.67 Ratio:  $M = 0.54$ ,  $SD = 0.27$ ; 2.33 Ratio:  $M = 0.57$ ,  $SD = 0.32$ ; 3.0 Ratio:  $M = 0.61$ ,  $SD = 0.25$ . In native Indonesian speakers, a one-sample  $t$ -test against chance showed a significant iambic bias (not expected) for sequences with 150 ms short IOI in the 3.0 ratio condition ( $M = 0.67$ ,  $SD = 0.11$ ;  $t(8) = 4.7$ ,  $p < 0.05$ ).

Figure 4 shows the difference between English and Indonesian means of proportions of “weak-strong” (iambic) responses. For Indonesian speakers, negative values indicate a greater iambic preference than among English speakers, whereas positive values indicate a greater trochaic preference. The two language groups’ means for all duration ratios were not significantly different from each other as determined by an independent samples  $t$ -test (minimum  $p > 0.2$ ). Differences between the two language groups show a

slight trochaic preference in Indonesian speakers for the 200 ms short IOI and 250 ms short IOI sequences. However, the magnitude of these differences is quite small and not statistically significant.

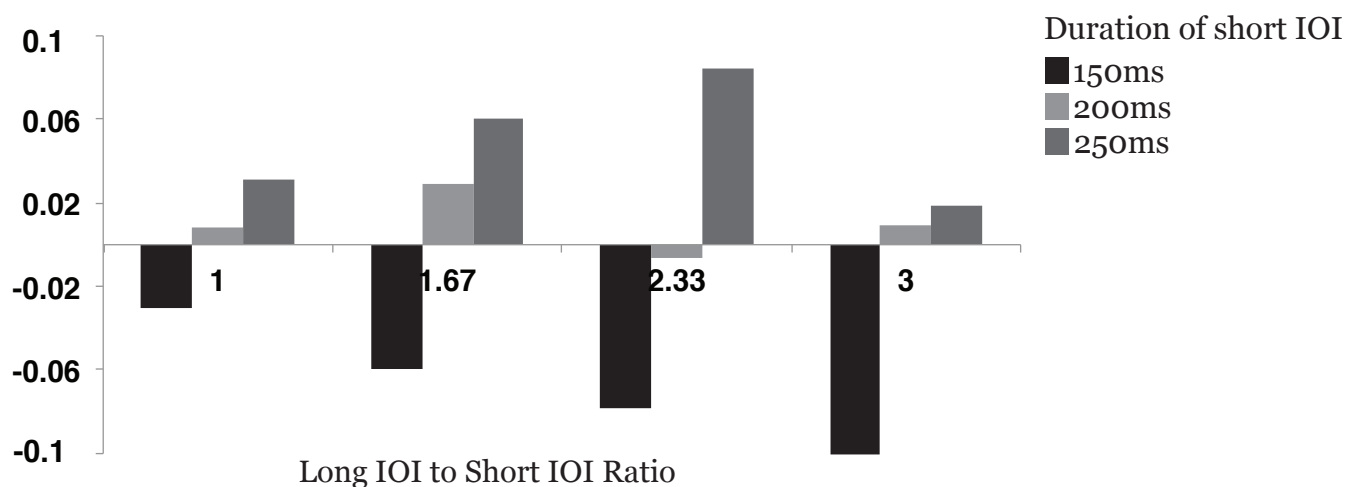
## Discussion

This study investigated the effects of language background on the perception of tonal groupings in native English and native Indonesian speakers. We aimed to replicate previous findings of Iversen, Patel, and Ohgushi (2008) in which native English speakers showed a strong preference for a “weak-strong” (iambic) grouping in duration-varying tone sequences. Additionally, we aimed to test native speakers of Indonesian using the same paradigm to investigate whether grouping biases are influenced by the structure of the Indonesian language. Some previous studies investigating iambic/trochaic law in perceived grouping of elements in tone sequences (Hayes 1995) had suggested that these preferences may rely on general auditory mechanisms (Hay and Diehl 2007). However, Iversen, Patel, and Ohgushi (2008) and Yoshida et al. (2010) show clear evidence for differences in perceptual grouping patterns in English and Japanese speakers, thus supporting the idea that grouping preferences in auditory sequences may be influenced by language background. Iversen, Patel, and Ohgushi (2008) propose that the iambic bias for sequences contrasting in duration may be related to the function-content word order in English, whereby (weak) function words tend to precede (strong) con-



**Figure 3:** Average proportion of “weak-strong” (iambic) responses for native Indonesian speakers. The asterisk indicate a significant difference from chance ( $p < .05$ ). Error bars indicate standard error of the mean.

## Difference between English and Indonesian means of proportion of iambic responses



**Figure 4:** Difference between English and Indonesian means of proportions of “weak-strong” (iambic) responses for each Long:Short ratio.

tent words. The present study investigated this proposal using the Indonesian language, which contrasts with English in that more prominent content words tend to precede function words. In addition, duration is a cue to prominence in Indonesian, as in English (Goedemans and Van Zanten 2007), suggesting that duration differences may bias perceptual grouping patterns for Indonesian speakers, whereas there was no strong evidence of a bias for Japanese speakers (Iverson, Patel, and Ohgushi 2008). If language background influences grouping biases in accordance with the phrasal structure, as suggested by Iverson, Patel, and Ohgushi (2008), speakers of the Indonesian language should show a trochaic rather than an iambic bias for tone sequence groupings.

In the current study, participants listened to a series of tone sequences in which alternating tones varied in duration and then judged whether they heard the sequence organized as a “strong-weak” alternating pattern or a “weak-strong” alternating pattern. Results show that the effect of an iambic grouping bias in native English speakers was much weaker than previously found. The expected iambic bias emerged for native English speakers at the largest IOI ratio (3), but not at the other IOI ratios. Duration ratios used in the present study replicated similar duration ratios used by Iverson, Patel, and Ohgushi (2008). However, Iverson, Patel, and Ohgushi (2008) report that English listeners showed a strong preference for an iambic grouping pattern (89% of all responses;  $p < 0.0001$ ). In the present study, proportions of iambic responses

in English speakers were close to 50%. The results of our study do not converge with the previous findings in showing a strong iambic grouping preference in native English speakers. Because the stimuli and paradigm were nearly identical, a proposed explanation for the differences between our results and the previous study’s might involve the differences in the task used. Participants in Iverson, Patel, and Ohgushi (2008) circled their grouping preferences on a visual schematic depicting the tone sequences they heard, while we employed a button box response method.

Results provide relatively little support for a trochaic bias in Indonesian speakers. That is, proportion of “weak-strong” (iambic) responses in Indonesian speakers was greater than originally predicted. This was especially evident in Long:Short duration ratios of 1.67, 2.33, and 3. A possible explanation could be that even though all Indonesian participants had been born in Indonesia and lived there for most of their lives, they were highly proficient in English and all formally studied in English at the university level. Participants’ exposure to English could have influenced their responses. To gain additional insight into the patterns of responses, we analyzed each participant’s data individually. Again, looking at mean proportion of iambic responses, we found that individual results greatly varied in terms of the presence of a bias. For example, some participants exhibited more of a bias than other participants. The strength of individual biases also varied for each Long:Short ratio. However, we do not yet know the cause of the variations.



## Future Directions

The current study was limited by the relatively small number of Indonesian participants as compared to the number of native English speaking participants. In addition, participants were bilingual in Indonesian and English, which could affect the strength of a native language bias. One immediate goal is to recruit more Indonesian participants. In doing so, it will also be important to look further at individual participant differences in grouping preferences with respect to dialect differences across the different regions of the Indonesian islands. Although similar, some dialects of the Indonesian language vary in their linguistic structure and could potentially influence the results of the present study (Goedemans and Van Zanten 2007). Further investigations will also address the question of possible differences with prior studies, such as the visual response paradigm used by Iversen, Patel, and Ohgushi (2008). 📍

## Acknowledgments

We would like to thank the Department of Psychology and the Dean's Assistantship Award provided by the College of Social Science for funding this research. We would also like to thank members of the Timing, Attention, and Perception Lab for their support throughout this project.

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# Highlights of Undergraduate Research

*MSU undergraduates publish and present their work in a wide range of scholarly venues. Below are summaries of their work.*

Buschman, J., Leitkam, S., Bush, T. Relative Rotations of Pelvis and Ribcage in Seated and Standing Postures, American Society of Biomechanics, 4-7 September 2013

Jessica Buschman was part of a team that investigated how the movement of the pelvis and ribcage affects the curvature of the spine when people are either sitting or standing, in order to better understand the forces that determine spinal curvature. Using motion capture to analyze twenty healthy subjects, they recorded four postures (arched, erect, comfort, and slouched) for both sitting and standing. These data were used to obtain angles relative to the spinal cord. It was concluded that both the pelvis and the ribcage have a significant influence on spinal curvature, with the position of the ribcage showing the most influence. These results can be applied to future experiments on digital human modeling.

Drost, J., Manorama, A., Bush, T., Blood Flow Characterization in Multiple Anatomical Locations during Normal and Shear Loading, American Society of Biomechanics, 4-7 September 2013

Joshua Drost was part of a team that evaluated the effects of external forces on blood flow in several anatomical locations. Skin tissue requires blood flow to remain healthy, and many common conditions such as decubitus ulcers (bed sores) arise when external pressure occludes blood flow to certain parts of the body. The researchers evaluated the blood flow of twelve healthy participants in four locations: heel, calf, sacrum, and forearm. Each location was tested under three conditions: baseline (no load), normal loading, and combined normal and shear loading over one-minute intervals. Their results showed that blood flow in the heel and forearm decreased as a normal load was applied and even further as a shear load was added, while the calf and sacrum did not display this trend. It was concluded that this result was likely due to a similar load being applied even though a different pressure was applied and different typical loads are applied in daily life.



*Continued from Page 21*

Sonnenschein, S., Sex Differences in Pubertally Added Cells in the Rat Prefrontal Cortex, Society for Behavioral Neuroendocrinology, 23-26 June 2013.

Ueberroth, J., Possible Parthood and Modal-Mereological Composition, Pacific University Undergraduate Philosophy Conference, 19-20 April 2013.

Morton, A., A Flavonoid-Rich Apple Extract Inhibits Growth of HCT116 Human Colon Cancer Cells, Experimental Biology 2013, 20-24 April 2013.

Dawood, S., Assessing Normal and Abnormal Parental Personality Traits from Observations of Family Interactions, Association for Psychological Science Convention, 23-26 May 2013.

Townson, C., Toward an Understanding of the CSI Effect and Forensic Sciences: Communication and the Law, American Society of Trial Consultants Conference, 30 May – 1 June 2013.

Fitzsimmons, K., Exploring the Experience of Undergraduate Research: A Case Study Using Facebook, 120th American Society for Engineering Education (ASEE), 23-26 June 2013.

Nave, K., Symposium: Good Data Practices and Prepliability in Music Perception and Cognition, Society for Music Perception and Cognition (SMPC), 7-11 August 2013.

Lakey, B., A comparison of the Chloroplast Genomes From Two Strains of *Lepocinclis* Tripteris, International Phycology Conference, 2-8 August 2013.

# About the Contributors

Lauren Link | Department of Writing, Rhetoric, and American Culture

## Kevin Andreassi



Kevin Andreassi graduated from Michigan State University in May 2013 with a BS in Mechanical Engineering and a BA in Spanish. He spent all four of his years at MSU working with Dr. Christopher Saffron in Biosystems and Agricultural Engineering, the first two

of those years as a Professorial Assistant through the Honors College. Kevin's laboratory projects focused on biomass pyrolysis, which sparked his interest in energy-related engineering research. His research experiences as an undergraduate at Michigan State led this Rochester, New York native to his decision to continue his education in graduate school: Kevin is currently a graduate student at the University of Notre Dame, where he is pursuing a PhD in Mechanical Engineering, and is part of Dr. David Go's laboratory group conducting research on microplasmas with energy implications.

## Prashanth Rajarajan



Prashanth Rajarajan, originally from Troy, Michigan, is a 2013 graduate and currently an MD/PhD student at the Icahn School of Medicine at Mt. Sinai, pursuing a doctorate in Neuroscience. He first started research at MSU his freshman year through the Honors College Pro-

fessorial Assistantship Program, joining the labs of Dr. Devin McAuley and Dr. Laura Dilley to investigate the effects of musical elements (e.g., timing, pitch, rhythm) on speech perception. The article included in this issue of ReCUR is an extension of the collaborative thesis project he completed. Prashanth presented findings from this study and several follow-up experi-

ments at the Society for Neuroscience conference in San Diego in November. Prashanth has not forgotten about his cognitive roots, but is also interested in exploring more in the fields of electrophysiology, stem cell modeling of neuropsychiatric disorders, and neurodegeneration.

## Neelima Wagley



Neelima Wagley is a 2013 graduate from Michigan State University with a BS in Psychology, a minor in German, and a specialization in Cognitive Science. She was born in Kathmandu, Nepal, but has been a Michigan resident for the last fifteen years. At MSU, Neelima worked in Dr. Devin McAuley's

Timing, Attention, and Perception (TAP) Lab on various research projects. Her main interests are language acquisition, bilingualism, and the underlying mechanisms of language processing in the brain. She is interested in using neuroimaging methods such as fMRI and MEG as research tools. During her undergraduate career, Neelima participated in two summer programs: the Summer Research Opportunity Program (SROP 2011) at the University of Michigan and the Summer Research Initiative (SRI 2012) at the University of Maryland. Her involvement and interactions with peers and faculty mentors at these various institutions, along with the skills and knowledge she gained working in the TAP lab, influenced her to go onto graduate school. She is currently a PhD student in Developmental Psychology at the University of Michigan.

## Deanna Phelan



Deanna Phelan, an Elburn, Illinois native, is the author of “Reliability and Validity of Three Physical Activity Measurement Devices During Pregnancy and Postpartum.” She graduated from Michigan State University in 2013 with a Bachelor’s of Science degree from the Department of Kinesiology.

During her time at MSU, Deanna assisted with several exercise physiology studies in the Human Energy Research Laboratory. Deanna’s research topics included physical activity during pregnancy, the intensity of collegiate ice hockey practices, and the relationship between academic success and the use of recreational facilities. Deanna was a member of the Michigan State Synchronized Skating team, and held leadership positions in the professional kinesiology fraternity, Phi Epsilon Kappa.

## Rebecca Sue Zantjer



Rebecca Zantjer hails from Delton, Michigan, and is a 2013 graduate of the Residential College in the Arts and Humanities and the Professional Writing program. She is now a graduate student seeking her MA in Digital Rhetoric and Professional Writing at Michigan State University, where she teaches

first-year writing and is continuing her research at the intersections of memory, rhetoric, and physical/digital spaces. Rebecca has recently partnered with the Kalamazoo Valley Museum to conduct interviews for an upcoming exhibit that explores the future of race relations and social justice in Kalamazoo. Rebecca also co-produced “For the 25,” a documentary film exploring the experiences of four young veterans of the war in Afghanistan. Reviews of the film have appeared in the New York Times, USA Today, NPR, and other news sources. The crew of “For the 25” is also continuing work on a sequel to the film that follows the journeys, both emotional and physical, of wounded veterans participating in the Ride 2 Recovery.

## Tianyu Zhao



Tianyu Zhao is a recent Michigan State University graduate, originally from Jinan, China. During his time at MSU, he studied Mechanical Engineering. During his senior year, Tianyu was an undergraduate research assistant in the Robotics and Automation Laboratory at the Department of

Electrical and Computer Engineering; he is currently a first-year masters student in Mechanical Engineering at Carnegie Mellon University. “My advisers, Professor Ning Xi and PhD student Jianguo Zhao, introduced me to the world of robotics,” says Tianyu. “This undergraduate research experience at MSU prepared me with hand-on design and analytical skills for my future research in robotics, as well as my future career development.”

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