



Importance Must be Salient for Heaviness to Increase Impressions of Importance



Jenna Manske, Isabel Saville, David Hauser, Phoebe Ellsworth

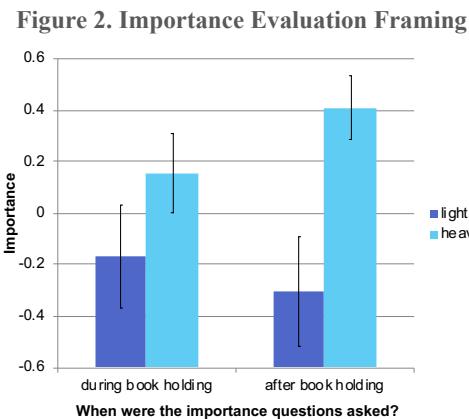
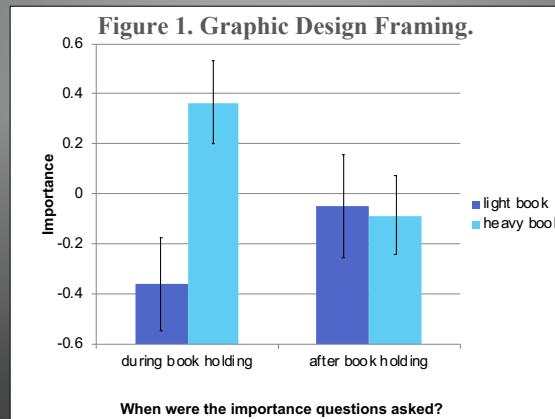


ABSTRACT

Recently, there has been an emphasis on the study of how the preconscious and subconscious embodiment of metaphors influence perception of various aspects of the world. Many of these studies have been conducted in order to understand how the metaphor affects perception, yet few have addressed the circumstances under which the metaphors influence has the greatest prevalence. Previous studies indicate that the incidental heaviness of an object affects people's impressions of its importance. As many metaphors imply, heaviness begets importance, yet the mechanisms driving these effects are not well known. In this study, the question under investigation is whether weight automatically affects importance, or if incidental heaviness requires the combination of contextual cues and physical perception to make salient its relevance to importance. Ninety participants, surveyed as part of either a visual evaluation task or an importance assessment task, evaluated the importance of either a heavy or control book while holding it or after returning it. When the task was framed as a visual assessment, only participants in possession of the book while evaluating were affected by the book's weight; however, when the task was framed as an importance evaluation, all participants judged the heavier book as more important than light book. Thus, contextual cues in combination with haptic cues elicit the weight effect.

INTRODUCTION

- Many metaphors imply that heavy things are important (e.g., "These are heavy issues we are dealing with").
- Participants feeling heaviness rank job candidates as better and see social issues as more important. (Ackerman et al., 2010; Jostmann et al., 2009).
- Yet the cognitive mechanisms driving these weight effects are not well known. While prior research assumes that weight automatically triggers thoughts of importance (via scaffolding; Williams, Huang, & Bargh 2009), these studies also make importance a salient aspect of the task either by introducing the task as an importance evaluation or by having participants evaluate importance while simultaneously feeling heaviness sensations.
- In this study, we question whether heaviness automatically signals importance or if heaviness only bears upon importance when contextual cues make salient its relevance to importance.
- In the current study, all participants evaluated the importance of a normal or heavy book either while holding it or after returning it. Prior research has shown that the salience of importance matters; participants judge heavy books as more important (than light books) only when they hold the book while judging it and not when they previously held and returned it before judging it.
- For some participants in the current study, the task was framed as a visual design evaluation, giving no context cues for importance. These participants should be affected by weight only when they evaluated the book's importance while holding the book and not after they returned it, replicating prior salience effects.
- For other participants, the task was framed as an importance evaluation task, making importance a salient aspect of the task from the beginning. If weight effects depend upon contextual cues that make salient its relevance to importance, then these participants should be affected by weight regardless of when they evaluated the book's importance.



DISCUSSION

- Our hypothesis was proven: contextual cues are necessary for haptic sensations of heaviness to increase perceptions of importance. If importance is not salient, heaviness does not beget importance.
- Future research could potentially sample children to see when whether these effects coincide with developmental milestones or could assess how applicable heaviness is within the marketing and valuation of products.
- In a more basic sense, the current research sheds light upon the foundations of human thought and perception. Heaviness does not automatically activate importance (as is often assumed), but human reasoning is highly sensitive to context and perceptions of situations, which factor into our judgments and behavior. Because of that, heaviness only affects importance if importance is relevant and cued within a situation.

METHOD

- 90 participants (39 female, age range 18 – 28) were approached on at public areas on the University of Michigan college campus for a study about a book (*Dogboy* by Eva Hornung). Some were asked to participate in an assessment of the book's graphic design (i.e. the readability of the font) while others were asked to participate in an evaluation of the book's value and marketability (task framing randomly assigned).
- Researchers then handed the book to the participant. The book was either normal copy or one that contained concealed weights making it considerably heavier (book weight randomly assigned).
- Researchers asked participants four demographics questions and four book-related questions. Question order was manipulated; some participants received the book-related questions first (followed by demographics) while others received demographic questions first (followed by book-related questions; question order randomly assigned).
- Crucially, after the first four questions, researchers asked for the book back before asking the remainder of the questions. This established that participants either considered the importance of the book while feeling it's heft (*importance during book holding condition*) or considered it's importance after feeling it's heft (*importance after book holding condition*).
- The four demographics questions asked about participants' age, major, year at university, and political orientation. The four book-related questions asked participants how interested they were in reading the book (1 = not at all interested, 10 = very interested), how much they'd be willing to pay for a print copy of the book (free response), how likely the book was to appear on the New York Times' list of most influential and important books of the year (1 = not at all likely, 10 = extremely likely), and whether they'd read the book before (all said no).
- After answering all questions, participants were thanked, debriefed, and offered a piece of candy for their participation.

RESULTS

- Responses to the three importance-related questions were averaged together into importance index.
- Are weight effects dependent upon importance being salient? Yes – manipulating the salience of importance (via question order) moderated the effects. As shown in figure 1, when the task was framed as graphic design evaluation, the effect of weight depended upon question order, $F(1, 82) = 4.37, p = .040, r = .22$ for simple two way interaction. When participants were holding the book, those who held heavy books judged them to be more important than those who held light books, $t(82) = 2.83, p = .006, r = .30, 95\% CI [0.214, 1.243]$ for the simple simple effect. However, when participants returned the book before assessing its importance, they did not believe the heavy book to be more important than the light book, $t(82) = 0.14, p = .892$ for the simple simple effect.
- Furthermore, as shown in figure 2, when the task was framed as an importance evaluation, making importance salient at the beginning of the task, the effect of question order was eliminated, $F(1, 82) = 1.11, p = .296$ for the simple interaction. Participants judged heavy books as more important than light books, regardless of question order, $F(1, 40) = 9.37, p = .004, r = .44, 95\% CI [0.153, 0.745]$ for the simple main effect. This created an overall 3 way interaction of weight, question order, and task framing, $F(1, 82) = 4.91, p = .029, r^2 = .06, 95\% CI [0.026, 0.474]$.
- Thus, weight effects on judgments of importance depend upon importance being salient at the time heaviness is felt. If importance is not already on the mind, heaviness doesn't affect it.



ABC Brains: Linking Early Childhood Experience to Neural Activity and Obesity

Ruby G. Siada, Ashley N. Gearhardt, Erica M. Schulte, and Rachel Roberts
University of Michigan



INTRODUCTION

- Since the 1970s, obesity rates in children have more than tripled (Ogden & Carroll, 2014).
- Today, about one in five school-aged children (ages 6-19) has obesity (Ogden et al., 2016).
- Numerous studies have depicted the potentially irreversible damage caused by early-life exposure to obesity (Look et al., 2013; Moschen et al., 2013; Cancello et al., 2013)
- Studies utilizing fMRI have illustrated that differences in neural responses in reward and motivation brain regions are implicated in obesity (Rothenmund et al., 2007; Tang, Fellows, Small, & Dagher, 2012; Boswell & Kober, 2015).
- No previous research has examined these neural response differences in children from low socioeconomic statuses (SES), who are at elevated risk for obesity development (Rogers et al., 2015).
- The current study utilizes an fMRI food reward paradigm to examine differences in neural responses to food images for children living in poverty

HYPOTHESES

- Food images would be more effective at activating motivation and reward brain regions when compared to control fixation crosses.
- High-calorie foods (relative to low-calorie foods) would illicit even greater activation of reward and motivation brain regions
- Children with higher (relative to lower) BMI z-scores would exhibit greater activation of these neural systems in response to food images, especially high-calorie food images.

METHOD

Sample

Participant characteristic (<i>n</i> = 35)	Mean ± SD or percentage
Age (years)	10.4 ± 0.8
Sex (%)	
Male (<i>n</i> = 18)	51.4%
Female (<i>n</i> = 17)	48.6%
Race/Ethnicity (%)	
White, non-Hispanic	45.3%
Black, non-Hispanic	11.3%
Biracial, non-Hispanic	18.9%
Hispanic, any race	20.8%
Unreported	3.7%
Income-to-needs ratio	0.99 ± 0.67
BMI z-score	1.1 ± 1.1

fMRI Food Reward Task

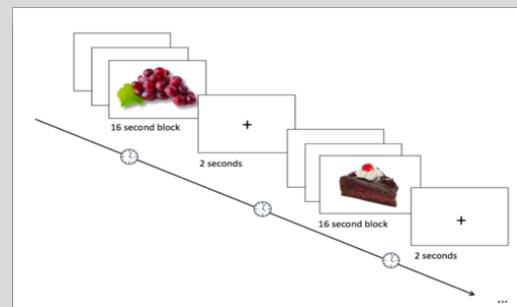


Figure 1. Food task fMRI block image design

• Instructions: "You are going to be having dinner after you leave here today. We are interested in what kinds of foods you most want to eat. In this task, you'll see pictures of foods. Please think about how much you WANT to eat each food that you see."

METHOD (cont.)

fMRI Analyses

- fMRI activation maps were generated for each participant and used to test group-level hypotheses. Hypotheses were tested within the general linear model of SPM12 (Wellcome Department of Imaging Neuroscience, 2014) using a whole brain analysis and with multiple comparisons corrected using the native FWE correction at $p < .05$

Association with BMIz

- Parameters for all significant group-level contrasts were extracted, and the association with BMIz was investigated using correlation matrixes in SPSS 24 (IBM Corp., 2016).

RESULTS

- Food images (compared to controls) did not result in greater activation of classic reward and motivation brain regions (i.e. dorsal striatum).
- High-calorie food images did not elicit greater activation of classic reward and motivation brain regions.
- BMIz was not correlated with greater activation in reward and motivation brain regions in response to food images (including high-calorie foods)

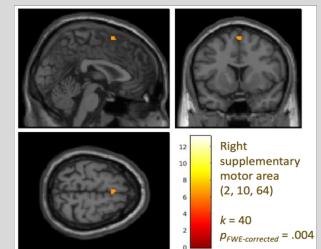


Figure 2. Brain activation map of the right supplementary motor area for food versus fixation

DISCUSSION

- Our hypotheses regarding food's effectiveness (especially high-calorie food's effectiveness) at engaging reward and motivation brain centers were not supported
- Our results did begin to inform the obesity research field about this at-risk and under-represented population of children who are living in poverty
- Future research is necessary to understand the neurobiological factors contributing to obesity risk in early childhood for low SES children

QUESTIONS?

Contact Ruby Siada at rubsiada@umich.edu

Development and Characterization of Gold Nanoparticles for Plant Genetic Engineering

Salwan Butrus¹, Natalie S. Goh², Gozde S. Demirer², Huan Zhang², Francis J. Cunningham², Markita P. Landry²

¹University of Michigan Department of Chemical Engineering, ²UC Berkeley Department of Chemical Engineering

Motivation

Plant genetic engineering is poised to fortify several key industries

Existing plant transformation methods lack practical applicability, have a narrow host range, are toxic, and inefficient

Research Objectives

- Design biocompatible vehicles capable of efficient transport into plant cells of mature leaves
- Tune physicochemical properties of carriers to screen for optimal formulations
- Integrate nanoplatforms into model plant systems to gauge gene silencing and expression efficiency

Nanoparticle Synthesis and Characterization

Approach 1: Electrostatic layer-by-layer siRNA and pDNA nanocarrier assembly

Carboxylation of AuNPs to obtain a stable negative surface for cationic polymer deposition

Successful loading of siRNA and pDNA onto engineered cationic nanoparticles

Approach 2: siRNA conjugation to AuNPs via complementary base pair hybridization

Thiolated Donor DNA attachment to AuNPs and hybridization to GFP siRNA

Methods and Results

Administration of Nanoparticles to Mature Leaves

siRNA Delivery for gene silencing

Preliminary results show GFP silencing in transgenic *Nicotiana benthamiana* leaves and conflicting results between mRNA and GFP levels

Approach 1: silencing at the protein level

Approach 2: silencing at the mRNA and protein levels

Approach 1: preliminary confocal imaging results show modest levels of GFP expression in wild-type *Nicotiana benthamiana* leaves

Conclusions and Future Work

We developed two nanoplatforms for the delivery of siRNA and pDNA to intact leaves. The following work must be conducted in the future:

- Repetition of all experiments with biological replicates to conclusively confirm or deny preliminary results
- Determination of critical AuNP toxicity concentrations to evaluate system scalability
- Evaluation of AuNP internalization into plant cells to gauge the platform's passive cell wall traversal capability
- Delivery of sgRNA to Cas9-expressing plants for precise plant genetic engineering

Acknowledgements

S.B. was supported by the Amgen Scholars Program and appreciates mentorship from all authors. We acknowledge helpful discussions with Abhishek Aditham and Dr. Sanghwa Jeong.

References

- Demirer et al. *J Nanosci Nanotechnol* (2018); DOI: 10.1166/jnn.2018.10564
- Gelvin, *Annu Rev Genet* (2017); DOI: 10.1146/annurev-genet-010616-064717
- Demirer et al. *PLoS One* (2018); DOI: 10.1371/journal.pone.0209612
- Chahal et al. *J Vis Exp* (2016); doi:10.3791/54872

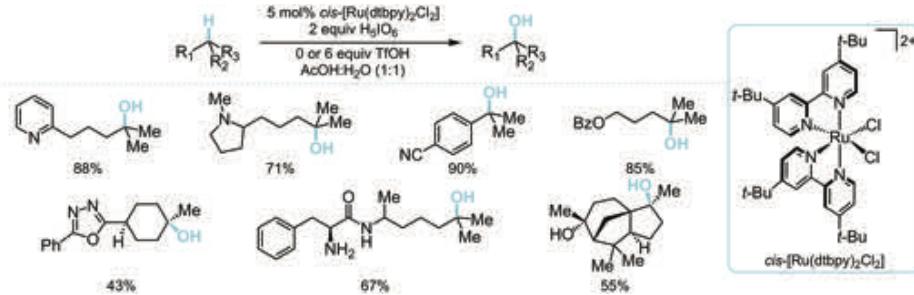
Electrocatalytic Bis(bipyridine)ruthenium Hydroxylation of Tertiary and Benzylic C–H Bonds

Sara N. Alektiar,[§] Sophia G. Robinson,[§] James B. C. Mack,[‡] J. Du Bois,[‡] Matthew S. Sigman[§]

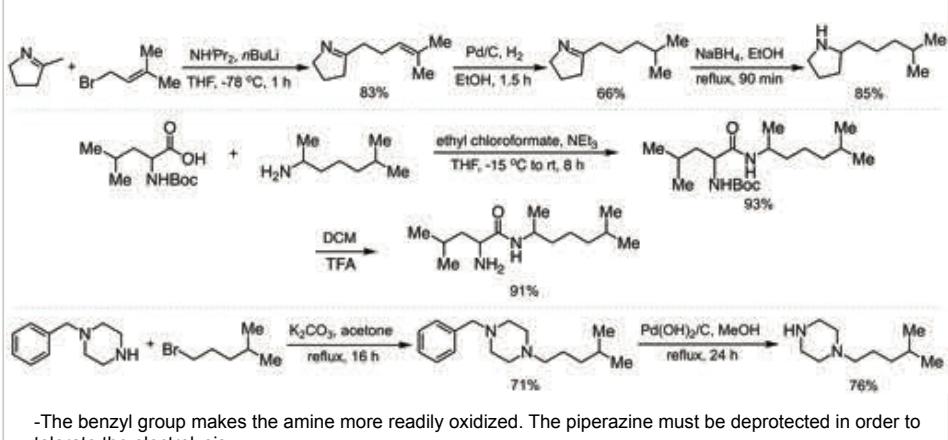
[‡]Stanford University, [§]University of Utah

Ruthenium Catalyzed C–H Hydroxylation of Amines

Abstract: The Sigman and Du Bois labs recently reported a methodology that employs a bis(bipyridine)Ru catalyst operating in acidic water to achieve oxidation of tertiary and benzylic C–H bonds in the presence of basic amines. The published method requires a stoichiometric amount of periodic acid to generate and turnover the active catalyst species. Efforts toward the development of an electrocatalytic method for generating the active catalyst in solution are disclosed. Performing the reaction electrocatalytically eliminates the need for periodic acid. Furthermore, the absence of periodic acid opens the possibility for broadening the functional group tolerance as well as reducing the amount of waste generated.



Substrate Syntheses



-The benzyl group makes the amine more readily oxidized. The piperazine must be deprotected in order to tolerate the electrolysis.

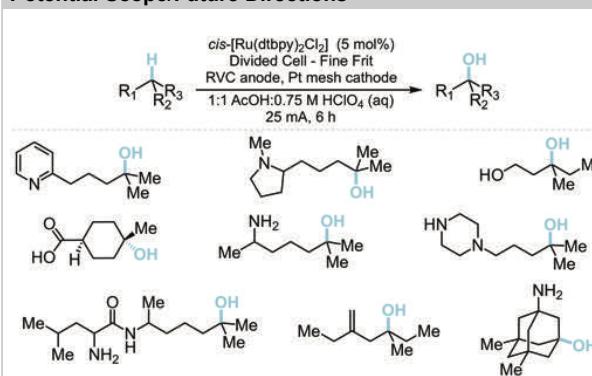
Bulk Electrolysis Screens

cis-[Ru(dtBpy)2Cl2] Divided Cell - Fine Frit RVC anode, Pt mesh cathode 1:1 solvent:0.75 M HClO4 (aq) Conditions				
Entry	Oxidant	Time	Variations ^a	NMR Yield ^b
1	H5IO6	4 h	—	75%
2	10 mA	14 h	0 mol%	—
3	10 mA	14 h	—	51%
4	20 mA	5 h	—	38%
5	25 mA	6 h	—	69%
6	25 mA	2 h	—	33%
7	30 mA	6 h	—	42%
8	40 mA	6 h	—	33%
9	25 mA	6 h	0.09 M	39%
10	25 mA	6 h	0.12 M	30%
11	25 mA	6 h	2.5 mol%	48%
12	25 mA	6 h	MeCN ^c	15%

^astandard conditions: c = 0.06 M, solvent = AcOH, cat = 5 mol%;

^bNMR standard = 4-nitrotoluene; ^celectrolyte = 0.1 M TBABF₄

Potential Scope/Future Directions



-This method should be able to tolerate both free amines and free alcohols, as well as terminal olefins.

References

- Mack, J. B.; Gipson, J. D.; Du Bois, J.; Sigman, M. S. *J. Am. Chem. Soc.* **2017**, *139*, 9503–9506.
- Lee, M.; Sanford, M. S. *J. Am. Chem. Soc.* **2015**, *137*, 12796.
- Howell, J. M.; Feng, K.; Clark, J. R.; Trzepkowski, L. J.; White, M. C. *J. Am. Chem. Soc.* **2015**, *137*, 14590.
- Adams, A. M.; Du Bois, J.; Malik, H. A. *Org. Lett.* **2015**, *17*, 6066.
- McNeill, E. M.; Du Bois, J. *Chem. Sci.* **2012**, *3*, 1810.
- McNeill, E. M.; Du Bois, J. *J. Am. Chem. Soc.* **2011**, *132*, 10202.
- Che, C. M.; Leung, W. H. *J. Chem. Soc. Chem. Commun.* **1987**, 1376.

Acknowledgements



This work was supported by the NSF under the CCI Center for Selective C–H Functionalization, CHE-1700982

Any opinions, findings or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the NSF

Computational Catalysis with Density Functional Theory

Kevin P. Greenman¹, Peilin Liao²

¹Department of Chemical Engineering, University of Michigan

²Department of Materials Engineering, Purdue University

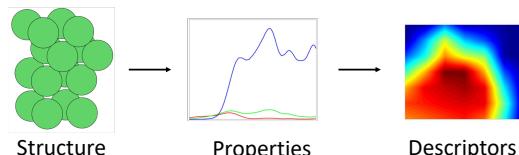
Background & Motivation

Importance of Catalysis



- 90% of all chemical and fuel production¹
- 30% of U.S. Gross National Income^{1,2}
- \$4.5 trillion/year in U.S. products²
- \$1 spent is \$1000 earned²

Studying Catalysis with Computational Methods



- Ideal catalysts are highly active, selective, and stable
- Predictions from computation drastically reduce the number of possibilities that must be tried experimentally
- Even with computation, the sample space is too large to examine by brute-force methods
- Using descriptors allows us to screen new catalyst candidates efficiently

Problem Statement

Computational methods currently used to study catalysis require specialized software packages and high-performance computing resources, making them less accessible for students and beginning researchers.

Objectives

1. Create a tool on nanoHUB that can calculate properties of interest to catalysis.
2. Make the tool versatile for use in both research and education.

Methods & Approach

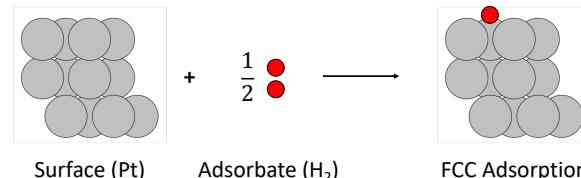
Generating Structures



Density Functional Theory

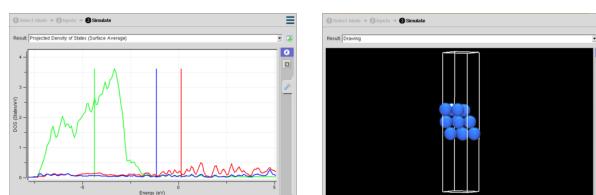


Calculating Adsorption Energy

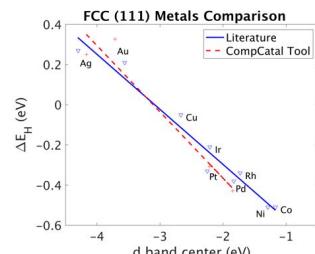


Results & Analysis

Projected Density of States



Calculating Catalytic Properties



- d band center is important for predicting catalytic properties
- Results from nanoHUB tool match closely with literature values^{3,4}

Results & Analysis (cont.)

Usability in Education and Research

Basic Inputs (Education):

- Surface
- Adsorbate
- Adsorbate position
- Distance from surface
- Energy of surface
- Energy of adsorbate

Advanced Inputs (Research):

- All basic inputs
- Lattice parameter
- Miller indices
- Supercell dimensions
- Number of layers
- Vacuum thickness

Conclusions

- Tool is able to calculate adsorption energy and d band center with comparable accuracy to literature values
- Basic and Advanced modes of operation enable use of the tool in both research and educational settings
- Tool removes the barriers to studying catalysis (specialized software and high-performance computing resources no longer required)

Try out the tool for yourself!
<https://nanohub.org/tools/compatal>



Future Work

- Perform additional benchmarking to test accuracy with other adsorbates and metals
- Access Rappture tool through Jupyter notebook for improved visualization capabilities

References

1. Touhoat, H. Heterogeneous Catalysis: Use of Density Functional Theory. *Encycl. Mater. Sci. Technol.* 2010, 1–7.
2. Bravo-Suárez, J. J.; Chaudhari, R. V.; Subramaniam, B. Design of Heterogeneous Catalysts for Fuels and Chemicals Processing: An Overview. In *Novel Materials for Catalysis and Fuels Processing*; ACS Symposium Series; American Chemical Society, 2013; Vol. 1132, pp 1–3.
3. Nørskov, J. K.; Bligaard, T.; Logadóttir, A.; Kitchin, J. R.; Chen, J. G.; Pandelov, S.; Stimming, U. Trends in the Exchange Current for Hydrogen Evolution. *J. Electrochem. Soc.* 2005, 152 (3), J23.
4. Ruban, A.; Hammer, B.; Stoltze, P.; Skriver, H.; Nørskov, J. . Surface Electronic Structure and Reactivity of Transition and Noble Metals. *J. Mol. Catal. A Chem.* 1997, 115 (3), 421–429.

SYNTHETIC HYDROGEL CULTURE SEQUESTERS EXTRACELLULAR MATRIX PROTEINS AND PROMOTES FIBROBLAST PROLIFERATION AND OVARIAN FOLLICLE GROWTH

Irina Kopyeva¹, Claire E. Tomaszewski², Ariella Shikanov^{2,3}

1. Department of Chemical Engineering; 2. Department of Biomedical Engineering; 3. Department of Macromolecular Science and Engineering, University of Michigan, Ann Arbor

ABSTRACT

The extracellular matrix (ECM) significantly contributes to the microenvironment of cells and tissues by acting as a physical scaffolding, offering adhesion sites and initiating crucial biochemical and biomechanical cues required for tissue differentiation, morphogenesis, and homeostasis. The ECM is made up of many cell-secreted proteoglycans, polysaccharides, and proteins such as collagens, fibronectin, and laminins that self-assemble to form dense networks. Three-dimensional culture provides a biomimetic platform for studying the role of ECM in cellular processes in a facile manner, but current synthetic hydrogels are unable to facilitate ECM deposition and remodeling. In this study, we designed a poly(ethylene glycol) vinyl sulfone (PEG-VS) system and functionalized with ECM-sequestering peptides to promote ECM retention. Preliminary studies used fibroblasts, as they are robust cells which secrete a variety of ECM proteins, to investigate proliferation, ECM deposition, and spreading.

We further investigated the effects of this matrix on ovarian follicle survival and growth for preserving fertility in women facing gonadotoxic anti-cancer treatments. The ovarian follicle is composed of an oocyte surrounded by layers of hormone-secreting granulosa and theca cells that are separated by a basement membrane that mediates the diffusion of intermediates. The basement membrane consists of multiple cell-secreted molecules, including the aforementioned ECM components. Allowing for the follicle to secrete and assemble its basement membrane results in higher survival, growth, and maturation rates.

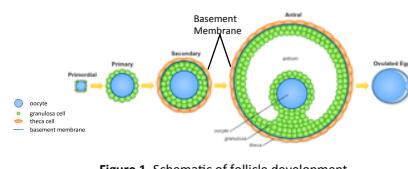


Figure 1. Schematic of follicle development.

MATERIALS AND METHODS

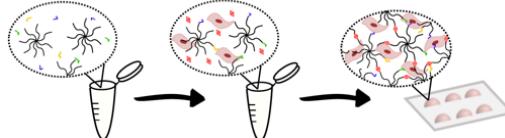


Figure 2. Peptide is reacted with PEG-VS via Michael-type addition. Mouse Embryonic Fibroblasts (MEFs) are suspended in PEG-peptide precursors mixed with a MMP-sensitive peptide crosslinker at a concentration of 10^6 cells/mL. $10\mu\text{L}$ PEG beads are formed on a glass slide and undergo gelation at 37°C for 7 minutes.

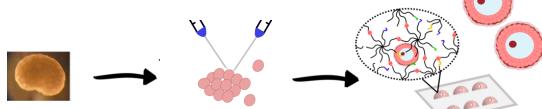


Figure 3. Mouse ovaries were removed from pre-pubertal pups, 12–14 days old. Secondary ovarian follicles are mechanically isolated and individually encapsulated in PEG with peptides.

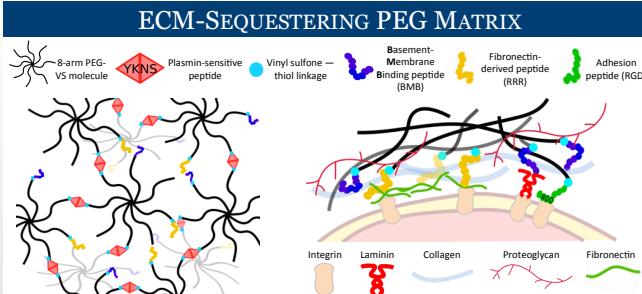


Figure 4. 8-arm poly(ethylene glycol)-vinyl sulfone (PEG-VS) molecules are functionalized with ECM-sequestering peptides and crosslinked via Michael-type addition chemistry of cysteine-terminated peptides containing plasmin-sensitive moieties. RGD is a common cell adhesion motif, RRR has been shown to bind fibronectin, and BMB binds laminin and collagen IV.

[1] Martino, M. M. *Science*. 2014; 343(6173): 885–888. [2] Cook, C. D. *Integrative Biology*. 2017; 9(4): 271–289.

FIBRONECTIN-SEQUESTRING MATRIX PROMOTES NETWORK FORMATION

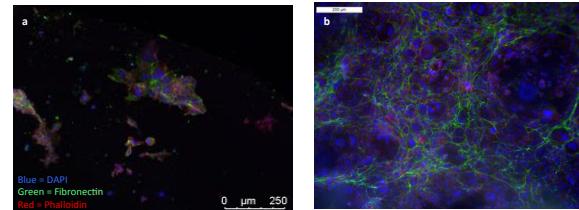


Figure 5. MEFs encapsulated in PEG with (a) cysteine (control), scale bar = $250\ \mu\text{m}$ and (b) RRR, MEFS in PEG-RRR exhibited increased network formation and fibronectin deposition.

DUAL PEPTIDE PEG INCREASES ECM DEPOSITION

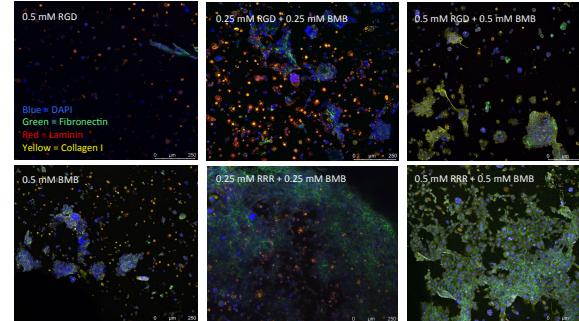
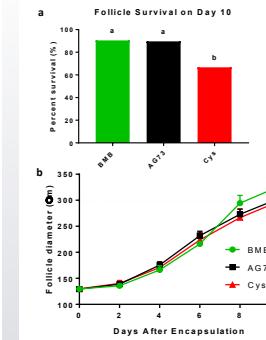


Figure 6. Confocal imaging shows that increasing total concentration of modification, particularly the combination of BMB and RRR, increases ECM protein deposition and retention when compared to RGD and BMB individually, leading to increased network formation. Scale bars = $250\ \mu\text{m}$.

ECM-SEQUESTRING PEPTIDES IN FOLLICLE CULTURE



a Follicle Survival on Day 10

Percent survival (%)

* * b

BMB AG73 Cys

n = 14 n = 17 n = 6

Days After Encapsulation

100 200 300 400

500

600

700

800

900

1000

1100

1200

1300

1400

1500

1600

1700

1800

1900

2000

2100

2200

2300

2400

2500

2600

2700

2800

2900

3000

3100

3200

3300

3400

3500

3600

3700

3800

3900

4000

4100

4200

4300

4400

4500

4600

4700

4800

4900

5000

5100

5200

5300

5400

5500

5600

5700

5800

5900

6000

6100

6200

6300

6400

6500

6600

6700

6800

6900

7000

7100

7200

7300

7400

7500

7600

7700

7800

7900

8000

8100

8200

8300

8400

8500

8600

8700

8800

8900

9000

9100

9200

9300

9400

9500

9600

9700

9800

9900

10000

10100

10200

10300

10400

10500

10600

10700

10800

10900

11000

11100

11200

11300

11400

11500

11600

11700

11800

11900

12000

12100

12200

12300

12400

12500

12600

12700

12800

12900

13000

13100

13200

13300

13400

13500

13600

13700

13800

13900

14000

14100

14200

14300

14400

14500

14600

14700

14800

14900

15000

15100

15200

15300

15400

15500

15600

15700

15800

15900

16000

16100

16200

16300

16400

16500

16600

16700

16800

16900

17000

17100

17200

17300

17400

17500

17600

17700

17800

17900

18000

18100

18200

18300

18400

18500

18600

18700

18800

18900

19000

19100

19200

19300

19400

19500

19600

19700

19800

19900

20000

20100

20200

20300

20400

20500

20600

20700

20800

20900

21000

21100

21200

21300

21400

21500

21600

21700

21800

21900

22000

22100

22200

22300

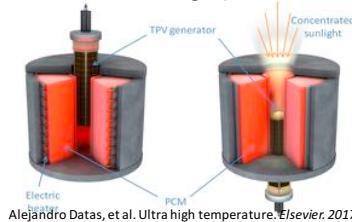
2240

Impact of heterogeneous surface absorption on thin-film thermophotovoltaic performance

Vinod Raman, Tobias Burger, Andrej Lenert
 Department of Chemical Engineering, University of Michigan, Ann Arbor

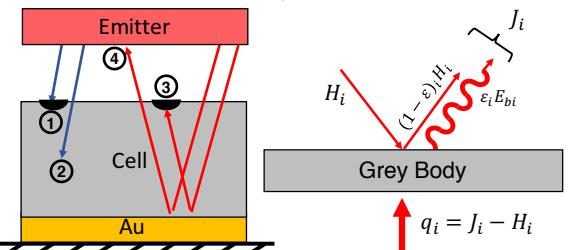
Background

- Thermophotovoltaic (TPV) generators are a promising technology for applications in solar thermal energy conversion and grid-scale electrical storage systems.
- Large efficiency gaps are observed between cell-based laboratory experiments and practical TPV modules.
- The extent of this performance drop-off is an important consideration when designing realistic TPV cells that are both highly-efficient and robust.

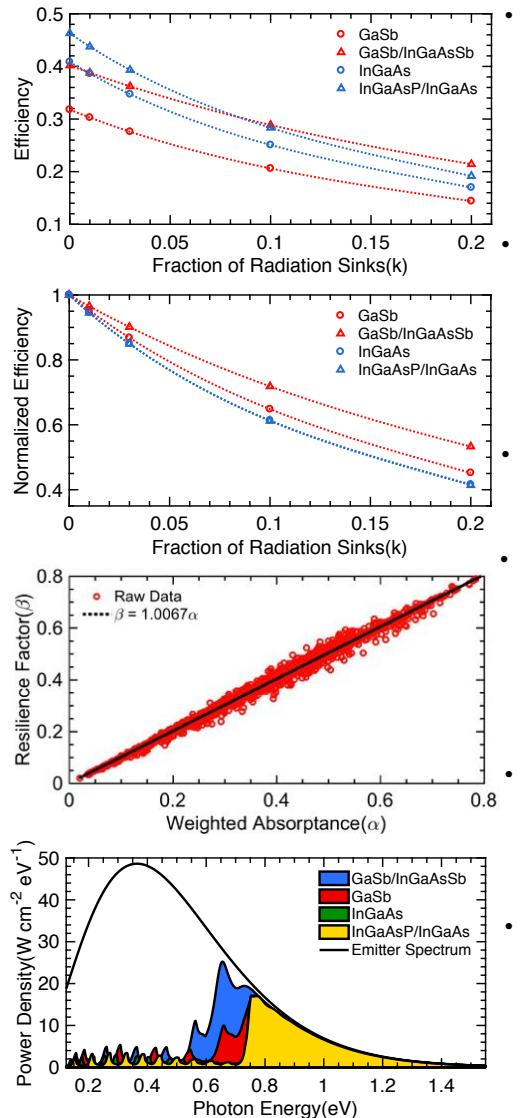


Methods

- Single- and dual-junction TPV cells are modeled at fraction of radiation sinks (k) ranging from 0 to 20%.
- The PV materials considered include: GaSb, GaSb/InGaAsSb, InGaAs, InGaAsP/InGaAs
- Heat transfer between the cell, emitter, and radiation sinks is captured by a spectral network of three diffuse surfaces.
- Spectral properties are modeled using the Transfer Matrix Method for multilayered structures.



Results and Discussion



- Absolute efficiencies for GaSb-based and InGaAs-based systems are determined at an emitter temperature of 1500K and a view factor of .9 across the k range.
- Normalization allows for consistent comparison of performance drop across devices and can be approximated by:
$$\eta^* = \frac{(1-k)\beta}{(1-k)\beta + k}$$
- The GaSb-system is more robust to radiation sinks.
- Performance-drop can be quantified by Resilience Factor β which is shown to be strongly correlated to the weighted absorptance of the device (α).
- α can be interpreted as the spectral overlap between the blackbody emission spectrum of the emitter and the absorptance of the cell.
- While the addition of low band-gap InGaAsSb increases α , high-band gap InGaAsP has negligible impact on α or β of InGaAs

Conclusion

- Quantifying the impact of radiation sinks using simple descriptors can help predict the performance of TPV modules using readily-accessible, yet idealized, lab measurements.
- The key descriptor of device robustness, quantified by Resilience Factor β , is the weighted absorptance of the cell (by the emitted spectrum).
- InGaAs-based devices achieve greater efficiencies at ideal conditions ($k = 0$), but are less robust than GaSb-based devices.
- Lowering the effective band-gap of the device, by the addition of low-band gap active layers (< .7 eV) is optimal for maximizing above band-gap absorption and robustness, while maintaining or improving efficiency.

Future Directions

- Growth and performance analysis of GaSb/InGaAsSb and InGaAsP/InGaAs thin-film devices via epitaxial lift-off.
- Techno-economic analysis of realistic single- and dual-junction thin-film TPV devices.

References

- Tobias Burger, et al. Thin-Film Architectures with High Spectral Selectivity for Thermophotovoltaic Cells. *ACS Photonics*. 2018.
- Vinod Raman, et al. Performance drop-off due to Heterogeneous Surface Absorption in Thermophotovoltaic Devices. *In preparation*. 2018.