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14. ABSTRACT This project examined a reinforcement learning model of conformity and social influence. Under this model, individuals value consensus—or agreement with groups—and conformity represents a strategy for maximizing consensus with a group. Under this project, we examined three predictions that emerge from a reinforcement model. First, people effects of social influence should generalize, such that people should agree with groups not only about particular exemplars (e.g., foods or paintings), but also about rules governing group behavior. Second, people should be most inclined to conform when they experience social “hunger” such as isolation or rejection.					
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## Report Title

Final Report: Social Influence as Reinforcement Learning

### ABSTRACT

This project examined a reinforcement learning model of conformity and social influence. Under this model, individuals value consensus—or agreement with groups—and conformity represents a strategy for maximizing consensus with a group. Under this project, we examined three predictions that emerge from a reinforcement model. First, people effects of social influence should generalize, such that people should agree with groups not only about particular exemplars (e.g., foods or paintings), but also about rules governing group behavior. Second, people should be most inclined to conform when they experience social “hunger,” such as isolation or rejection. Third, people should act more prosocially towards individuals who conformed with them (i.e., offer consensus). Predictions 1 and 3, but not 2, were borne out by our research.

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**Enter List of papers submitted or published that acknowledge ARO support from the start of the project to the date of this printing. List the papers, including journal references, in the following categories:**

**(a) Papers published in peer-reviewed journals (N/A for none)**

<u>Received</u>	<u>Paper</u>
01/13/2016 1.00	Erik C. Nook, Jamil Zaki. Social Norms Shift Behavioral and Neural Responses to Foods, Journal of Cognitive Neuroscience, (07 2015): 0. doi: 10.1162/jocn_a_00795
<b>TOTAL:</b>	<b>1</b>

**Number of Papers published in peer-reviewed journals:**

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**(b) Papers published in non-peer-reviewed journals (N/A for none)**

<u>Received</u>	<u>Paper</u>
<b>TOTAL:</b>	

**Number of Papers published in non peer-reviewed journals:**

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**(c) Presentations**

Number of Presentations: 0.00

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**Non Peer-Reviewed Conference Proceeding publications (other than abstracts):**

Received      Paper

**TOTAL:**

Number of Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

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**Peer-Reviewed Conference Proceeding publications (other than abstracts):**

Received      Paper

**TOTAL:**

Number of Peer-Reviewed Conference Proceeding publications (other than abstracts):

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**(d) Manuscripts**

Received      Paper

01/13/2016 2.00 Erik Nook, Desmond Ong, Sylvia Morelli, Jason Mitchell, Jamil Zaki. Prosocial conformity: Generalization across behavior and affect (invited revision submitted), Personality and Social Psychology Bulletin (06 2015)

01/13/2016 3.00 Emma Templeton, Michael Stanton, Jamil Zaki. Social norms shift food preferences, but not eating behavior (submitted), Health Psychology (01 2016)

**TOTAL:      2**

**Number of Manuscripts:**

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**Books**

Received      Book

**TOTAL:**

Received      Book Chapter

**TOTAL:**

**Patents Submitted**

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**Patents Awarded**

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**Awards**

2015 CAREER Award, National Science Foundation  
2015 Janet T. Spence Award for Transformative Early Career Contribution, Association for Psychological Science  
2014 Aldon and Winifred Brown Faculty Fellowship, Stanford University  
2013 "Rising Star" Award, Association for Psychological Science

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**Graduate Students**

<u>NAME</u>	<u>PERCENT SUPPORTED</u>
<b>FTE Equivalent:</b>	
<b>Total Number:</b>	

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**Names of Post Doctorates**

<u>NAME</u>	<u>PERCENT SUPPORTED</u>
<b>FTE Equivalent:</b>	
<b>Total Number:</b>	

### Names of Faculty Supported

<u>NAME</u>	<u>PERCENT SUPPORTED</u>	National Academy Member
Zaki, Jamil	0.12	No
<b>FTE Equivalent:</b>	<b>0.12</b>	
<b>Total Number:</b>	<b>1</b>	

### Names of Under Graduate students supported

<u>NAME</u>	<u>PERCENT SUPPORTED</u>
<b>FTE Equivalent:</b>	
<b>Total Number:</b>	

### Student Metrics

This section only applies to graduating undergraduates supported by this agreement in this reporting period

The number of undergraduates funded by this agreement who graduated during this period: ..... 0.00

The number of undergraduates funded by this agreement who graduated during this period with a degree in science, mathematics, engineering, or technology fields:..... 0.00

The number of undergraduates funded by your agreement who graduated during this period and will continue to pursue a graduate or Ph.D. degree in science, mathematics, engineering, or technology fields:..... 0.00

Number of graduating undergraduates who achieved a 3.5 GPA to 4.0 (4.0 max scale):..... 0.00

Number of graduating undergraduates funded by a DoD funded Center of Excellence grant for Education, Research and Engineering:..... 0.00

The number of undergraduates funded by your agreement who graduated during this period and intend to work for the Department of Defense ..... 0.00

The number of undergraduates funded by your agreement who graduated during this period and will receive scholarships or fellowships for further studies in science, mathematics, engineering or technology fields:..... 0.00

### Names of Personnel receiving masters degrees

<u>NAME</u>
<b>Total Number:</b>

### Names of personnel receiving PHDs

<u>NAME</u>
<b>Total Number:</b>

### Names of other research staff

<u>NAME</u>	<u>PERCENT SUPPORTED</u>
Kleiman-Tapley, Zoe	1.00
Nook, Erik	0.50
Templeton, Emma	0.82
<b>FTE Equivalent:</b>	<b>2.32</b>
<b>Total Number:</b>	<b>3</b>

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**Sub Contractors (DD882)**

**Inventions (DD882)**

**Scientific Progress**

SEE ATTACHMENT

**Technology Transfer**

N/A

Final progress report  
DARPA Project 110894  
Title: *Social influence as reinforcement learning*  
PI: Jamil Zaki

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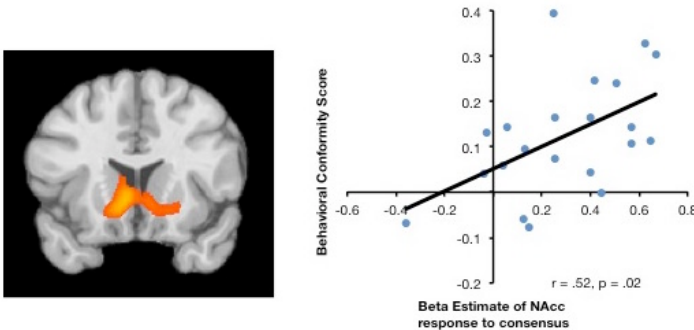
## **List of Tables and Figures**

Figure 1: Neural signal in response to consensus tracks later conformity

Figure 2: Learning over rules, rather than exemplars.

## Statement of the problem studied

Market bubbles, fashion trends, and political polarization all constitute forms of *social influence*, whereby individuals in a group shift their beliefs, preferences, or perceptions to match those of other group members [1-4]. Despite decades of research on social influence, the mechanisms governing this crucial behavior remain unclear. In this project, we tested a model of social influence as reinforcement learning. This model holds that individuals value *consensus*, or agreement with other group members, as it provides a signal to affiliation and acceptance into a group [5]. As a result, individuals conform to group members' opinions as a way of maximizing consensus, in much the same way that they adjust their behavior to efficiently harvest other valuable outcomes from the environment. Further, this learning should track activity in targets of the brain's mesolimbic dopaminergic system, associated with reinforcement learning more generally [6-8]. This model accords with neuroscientific evidence from our own group. For instance, we found that individuals who learn that their opinions are shared—as opposed to unshared—with other group members exhibit activity in ventral striatum, a brain region associated with motivation and reward learning. Further, individuals' level of striatal activity in response to consensus tracks their subsequent conformity [9 and Figure 1], suggesting that the reward value of consensus indeed drives conformity.

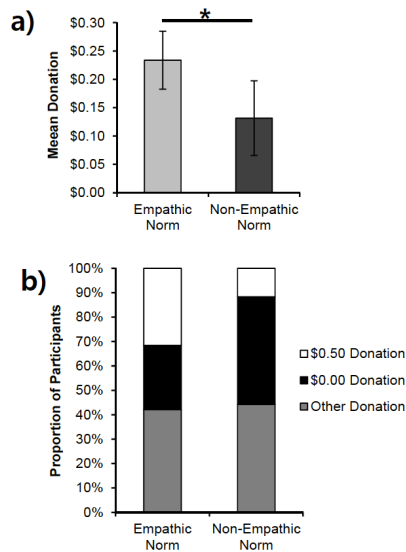


**Figure 1:** A cluster in ventral striatum responds more to consensus, as compared to lack of consensus, with a group concerning food preferences (left panel). Activity in this region on a per subject basis further tracked individuals' tendency to later conform to group norms.

Under this project, we tested three further predictions emerging from our model. First, like other forms of reinforcement learning, individuals should not only shift their behavior to maximize consensus over particular items (e.g., agreeing with others about a single political candidate), but should rather internalize broader *rules* governing group behavior (e.g., preference for candidates in a particular political party) and conform to those rules. Second, individuals should most value consensus—and subsequently conform most—when they are induced to need connection with others (for instance, following a feeling of isolation). Third, people should act prosocially towards people who conform to their opinions, and thus act as reliable sources of consensus.

## Summary of most important results

*Generalizing over social norms and rules.* Our data supported the claim that people not only conform to others' opinions about particular exemplars, but rather internalize deeper rules governing group behavior. We documented this effect in two domains: prosociality and food preferences. With respect to prosociality, in a set of 5 studies we found that individuals who learned others had donated generously (or stingily) to one set of charities later donated more themselves, not only to those charities, but to novel ones as well. Further, participants who simply learned about others' prosocial *intention* (e.g., their empathy towards others in need) later donated more to relevant causes [10 and Figure 2]. This suggests that even in the absence of direct behavior to which to conform, people



**Figure 2:** Participants who learned that others felt empathically, as opposed to less empathically, towards a cause later donated more to those cause themselves.

internalize group-based behavioral rules. In the domain of food, we found that students induced to believe that their classmates valued healthy, versus unhealthy foods conformed not only to others' opinions about specific foods, but to the general healthfulness of their preferences even for novel items.

*Social “hunger” and susceptibility to influence.* In two studies, we examined the effect of social “hunger” on people's tendency to conform. In each study, participants were induced to believe that they had been evaluated either positively or negatively by a group of their peers. Negative evaluation in paradigms like this induces loneliness and efforts to repair social relationships [11, 12]. Following these inductions, we examined participants' willingness to conform to a separate peer group's music preferences. Results from these studies did not confirm our hypotheses: people conformed to an equal degree following social rejection versus acceptance.

*Prosocial consequences of conformity.* Finally, we examined the hypothesis that people might value others who conform to them, and later act prosocially towards conformists. In a first study, participants rated their own music preferences and learned about another participant's preferences. In some cases, participants learned that the other participant had conformed to their preferences (agreeing with the original participant on ~80% of choices), and in other cases they learned the other participant had not conformed to them (agreeing with them on ~20% of choices). Later, participants played a public goods game, providing a behavioral economic assay of cooperation [13, 14]. People cooperated more with others who had initially conformed, as opposed to not conformed, with them. In a second study, we examined whether this effect might be explained by people preferring cooperation with similar, as opposed to conformity, others. We replicated the overall design of the first study, but in this case all participants learned their partner shared their musical tastes. In some cases, participants believed that their partner had not seen the participant's own responses, and thus coincidentally agreed with

them (similarity), whereas in others cases participants believed that their partner had seen the participant's own rating and purposefully agreed with it (conformity). As in the prior study, participants then played a public goods game. We found that people acted more cooperatively with partners who had conformed to them, as opposed to merely agreeing with them. This supports our third prediction that conformity—although often thought of as a form of weakness—can in some cases spur positive behavior.

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