witnessing harassment [8]. If marginalized people are less likely to engage in online discussions, online outrage disproportionately reflects privileged voices. Effective harnessing of the power of outrage while ensuring diverse participation remains an important challenge.

Concluding Remarks

Can moral outrage have an upside? We agree with Spring *et al.* that it can, but question whether motivating collective action on social media is the key process through which it will. The architecture of social media may instead amplify the downsides of outrage, limiting the effectiveness of collective action aimed toward social progress and the participation of marginalized groups. Like empathy [9], outrage can be harnessed for good, but is not *necessarily* a good moral compass in itself [7].

We propose that outrage with an 'upside' will ideally spark collective action that strategically pursues ingroup goals without excluding key stakeholders in the process. In practice, this may resemble what civil rights activist Audre Lorde described as the effective use of anger in social movements: 'Focused with precision, it can become a powerful source of energy serving progress and change' [10]. Future research should consider how new technologies can help or hinder the precise focusing of outrage for moral progress. This requires measuring whether online outrage is associated with offline actions focused on specific causes (e.g., tweeting about #March4OurLives and then actually attending the march). In addition, it is worth examining how long the motivational force of online outrage can last by measuring the temporal distance between online expression and offline action. It will also be important to examine the extent of oppressive outrage; for example, by measuring whether the frequency or intensity of online outrage depends on whether the target is a minority group member. Finally, researchers should investigate whether expressing outrage online – and getting socially reinforced for those expressions – can perpetuate intergroup conflicts by increasing hostility toward outgroup members (Box 1). By combining new computational tools for the analysis of naturalistic data with behavioral experiments informed by psychological theory, we can make progress on these questions.

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Letter

Asking Different Questions about Outrage: A Reply to Brady and Crockett

Victoria L. Spring,[1] C. Daryl Cameron,[1,2] and Mina Cikara[3,*]

Brady and Crockett [1] 'agree that moral outrage can have positive social consequences [2], but suggest that online outrage has more downsides than upsides'. At a high level, we take their commentary to ask: is online outrage on balance beneficial or harmful (i.e., for collective action)? And answer: harmful.

First, we submit that this is the wrong question. Brady and Crockett cite evidence that anger impairs decision-making and exacerbates intergroup conflict. It turns out anger also increases decision-makers' sense of control and agency [3]. Group efficacy, the belief that the group's goals can be achieved, is a key determinant of collective action (hence outrage's efficacy for promoting it [4]). Anger can also be productive, specifically in intergroup contexts (so long as it is not accompanied by hatred), because it makes people 'channel the anger into more constructive solutions such as education, negotiation, and even compromises' [5]. This suggests that hate, not anger, is the problem. Each of us could continue to highlight findings that nudge the evaluative needle toward 'beneficial' or 'harmful', but we believe this is a futile exercise. Our point is that we ought to

eschew the practice of determining whether any emotion is harmful on balance, for the purposes of any goal, and document instead the entire spectrum of behaviors that result from experiencing said emotion (see Box 1 for related discussion). This merits mention given the recent uptick in discussions of whether different emotions are effective or useful in everyday life, discussions that sometimes veer into non-falsifiable territory (e.g., 'outrage can be harnessed for good, but is not necessarily a good moral compass in itself.' [2]).

Second, even though our original comment focused specifically on the emotion outrage, Brady and Crockett dedicate most of their commentary to discussing the costs associated with 'online outrage', sharing expressions of outrage online. This exchange underscores how careful researchers must be to differentiate the experience of outrage from its expression and other downstream behaviors. Online outrage is only one possible behavioral response associated with experiencing outrage. As we note in our original article, there are several alternative behaviors that may result from experiencing outrage, including civil forms of collective action (e.g., peaceful protest, voting). Even when outrage drives people to log on to social media, it is not unilaterally destructive so long as constructive response options are available. This suggests one fruitful direction for future research (to which Brady and Crockett gesture in their concluding remarks): we should study how best to leverage choice architecture so that social media environments provide more constructive than destructive behavioral channels toward which users can target their outrage. For example, when Justine Sacco posted a racist 'joke' on Twitter about not wanting to contract AIDS on her trip to Africa, many took to social media to express (among many things) their outrage against her.[i] Sacco's tweet got her fired but also spurred a clever new fundraising opportunity: the URL justinesacco.com now directs visitors to a donation page for the nonprofit Aid for Africa.[ii] Similarly, outrage over the poaching of Cecil the Lion infused the Wildlife Research Conservation Unit with hundreds of thousands of dollars in donations, bringing the organization back from the brink of shuttering.[iii] Again, our broader point is that there is not a one-to-one mapping between a given emotion and the resulting behavior (or the pro or antisocial nature of that behavior).

Brady and Crockett highlight two specific costs associated with online outrage: the drowning out of the 'most important issues' with outrage-driven 'noise' and the oppression of marginalized voices. As to the first cost, they provide no evidence for this claim. Moreover, this line of reasoning immediately sparks the question most important for whom? Speaking directly contra their example, there was a massive surge in donation to RAICES, an organization focused on providing assistance to separated migrant families[iv], after their donation link went viral on social media (their website crashed from too many visits and donation attempts).[v] As to the second cost, the oppression of marginalized voices is well documented. What is less clear is how much variance in harassment is explained by outrage *per se*. Even if online outrage drives these effects, a full consideration should account for how social media also provides a relatively low-cost means of broadcasting and receiving common knowledge of a given injustice, while keeping communicators out of physical harm's way. However, this is all tangential to the point that these costs are associated with behavior on social media, not the experience of outrage itself.

In conclusion, the goal of our original article was to bridge two literatures, moral psychology and intergroup relations, to emphasize the diversity of outcomes associated with experiencing outrage and to initiate a broader conversation regarding the (dis)utility of framing emotions as 'beneficial' or 'harmful' without detailed consideration of the relevant context. We hope this exchange inspires further research on several open questions about outrage and its consequences.

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Box 1. Emotion and Reason Are Not Mutually Exclusive

This conversation highlights another assumption implied in many theories of human behavior: that emotion and reason are mutually exclusive, or at least very strongly negatively correlated. Drawing an analogy to recent work demonstrating the dissociation of deontological and utilitarian inclinations in moral decision-making [6], we challenge the positioning of outrage as an absolute antagonist to reason. People may use emotions such as outrage to rationally inform their decision-making, directing their attention to important cues and leading them to draw clearer inferences about what they value (see [7] for related argument regarding empathic concern). As a thought experiment, do we imagine that Gandhi was not outraged by Britain's treatment of Indian citizens? Or do we grant that he experienced outrage but also recognize that his capacity for reason likely allowed him to channel that outrage toward civil resistance? In the latter case, it is not the absence of outrage that drove his behavior but rather the concomitant presence of deliberation and strategy. Future research should also account for the intensity of outrage; while extreme rage might predict destruction, moderated outrage coupled with well-articulated goals (and means of achieving them) may be especially effective for invigorating constructive behavior.

Resources

[i]www.nytimes.com/2015/02/15/magazine/how-one-stupid-tweet-ruined-justine-saccos-life.html
[ii]www.justinesacco.com
[iii]https://news.nationalgeographic.com/2015/08/150801-cecil-the-lion-death-spurred-donations-now-what/
[iv]www.usnews.com/news/articles/2018-06-21/raices-works-to-stay-afloat-in-a-flood-of-donations
[v]www.texastribune.org/2018/06/27/viral-facebook-fundraiser-has-generated-more-20-million-immigration-no/

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Spotlight

A New Look at Visual System Plasticity

Marcello Maniglia[1] and Aaron R. Seitz[1,*]

Reward-based learning is known to induce cortical plasticity in primary sensory areas. A new study by Goltstein, Meijer, and Pennartz [1] (*eLife*2018;7:e37683), adopting a dual-scale approach (single-unit and population level), shows how associative learning in mice tunes cortical processing, but unlike other primary sensory cortices it does not modify the retinotopic map.

The neural mechanisms of plasticity within the visual system have been a long-term target of research. Behavioral studies have found examples of learning that are specific to the orientation, retinotopic location, and even eye of training [2], all taken to be evidence that this learning could be the result of plasticity within primary visual cortex (V1). However, while there is evidence of substantial plasticity in primary auditory (A1) [3] and somatosensory cortex (S1) [4], findings of large-scale plasticity have been elusive in adult V1, especially regarding alterations to the primary feature map of visual retinotopy.

A new study [1] uses a dual-scale approach to understand plasticity at both the level of the retinotopic map and in local tuning properties of single units in V1. Goltstein *et al*. used a classical conditioning approach in mice, where rewards were paired with one of two oriented visual gratings presented on two contiguous retinotopic regions of the visual field. They evaluated the neural population level through intrinsic optical signal imaging and single neuron behavior with two-photon calcium imaging.

Results showed that this associative learning induced an increase in spatial separation between the adjacent rewarded and nonrewarded cortical representations as observed through optical imaging of the retinotopic map in V1, mediated by a decrease in response amplitude to the nonrewarded stimuli. This increased representation separation correlated with enhanced population coding for retinotopic location that was specific for the trained orientation and for the units codifying the portion of the visual field at the border between rewarded and nonrewarded stimulus representation. However, no change in the architecture, size, or extension of the retinotopic map of V1 was observed.

These data suggest that associative learning, rather than modifying the retinotopic map around the portion of the visual space associated with reward, acts to improve the response of neurons to the reward-paired stimulus location (increasing the differentiation between rewarded and nonrewarded stimulus locations), producing a more efficient cortical representation based on the improved response of fewer neurons.

The study builds upon previous findings in animal electrophysiology and human psychophysics. Seitz *et al*. [5] used a similar conditioning procedure in humans and found learning that was specific to the rewarded orientation and even the trained eye. Using a similar procedure in monkeys, Frankó *et al*. [6] found changes in local field potentials in V4, and suggested that a component of this might be the feed-forward effect of plasticity possibly originating from V1. Further Shuler and Bear [7], found neurons in rat V1 developed associative learning responses predicting the timing of a conditioned light stimulus. Together, these studies provide strong evidence that associative learning can give rise to behavioral changes and alter response properties in V1.

This is consistent with studies using training to drive plasticity in V1. Schoups *et al*. [8] trained macaque monkeys extensively on an orientation discrimination task. While they failed to find significant changes at the population level, orientation tuning was altered in neurons that were best suited for discriminating the training stimuli. van Kerkoerle *et al*. [9] trained macaques on contour integration