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Changing attitudes toward scientists by reducing intergroup biases: how a signage intervention focused on decategorization and recategorization improved trust

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Abstract

We experimentally examined how messaging strategies that prompted differences in how scientists are categorized as a group increased positive science attitudes among non-scientists. Results from the first study showed that messaging which personalizes science or highlights shared common identities with scientists diminishes outgroup effects through recategorization or decategorization, respectively. Study 2 largely replicated these results in an ecologically valid setting: a zoo. Collectively, these studies support the use of the recategorization strategy for improving trust and science attitudes, but produced less consistent effects for decategorization. The results emphasized the importance of contextualized messaging when creating effective appeals in science communication.

Keywords

Public perception of science and technology; Science centres and museums; Science communication: theory and models

DOI

https://doi.org/10.22323/2.21060203

Submitted: 7th March 2022
Accepted: 23rd June 2022
Published: 12th October 2022

Historically, there have been high levels of public ambivalence toward science [Losh, 2010; Pittinsky, 2015] and there has been some indication of a growing number of groups in the United States who hold negative science attitudes [Gauchat, 2015; Hart & Nisbet, 2012; Rutjens, Heine, Sutton & van Harreveld, 2018]. Contemporary anti-science messaging contributes to negative attitudes and skepticism by 'othering' scientists or reinforcing perceptions that scientists are biased toward specific interest groups [Hardy, Tallapragada, Besley & Yuan, 2019; Jaspal, Nerlich & van Vuuren, 2016]. These methods can — intentionally or otherwise — further undermine trust in science or people's perceptions of scientists' truthfulness by creating perceptions that scientists are a distinct group from the broader public [Hart & Nisbet, 2012; Fiske & Dupree, 2014]. One approach to building more positive perceptions of scientists is by using communication strategies that change perceptions of group identity [Uzelgun, Lewiński & Castro, 2016; Fielding & Hornsey, 2016].

We applied work on group identity dynamics to develop and test communication strategies for reducing intergroup prejudice and perceptions of scientists as an outgroup. Two studies examine if science messaging can improve attitudes between scientists and people who do not identify as scientists (from here: non-scientists) by using *decategorization*, which removes intergroup distinctions, and *recategorization*, which reclassifies individuals' social groups toward a shared identity.

The public's relationship with science

The majority of the public has little direct interaction with scientists [Brossard, 2013; Suleski & Ibaraki, 2010] and yet, scientists can be perceived to exert substantial authority over one's daily life, from making public health recommendations to developing new technology [Gauchat, 2011]. Given minimal direct interaction, messaging about scientists plays an important role in shaping public perceptions and trust in scientists [Fiske & Dupree, 2014; Jarreau et al., 2019; Dudo et al., 2011]. As trust impacts scientists' perceived credibility, it is valuable to determine how messaging can effectively promote trust in scientists [Fiske & Dupree, 2014].

'Scientists' as a group identity

Message framing refers to how a message is structured to convey information. Message framing that portrays scientists as a separate outgroup, i.e., a group separate from oneself, reinforces feelings of isolation [Jaspal et al., 2016; Hardy et al., 2019]. This type of 'us versus them' framing undermines the validity of science, suggesting scientists have an agenda that ultimately harms 'us' (i.e., the public) for the benefit of 'them' and can be seen in discussions of topics like climate change skepticism [Jaspal et al., 2016].

Science supporters also reinforce this perceived conflict through other types of message framing, such as the 'war on science.' Framing science as a part of the ingroup and under attack by the outgroup reinforces perceptions of science as exclusionary [Hardy et al., 2019; Fielding & Hornsey, 2016; Jaspal et al., 2016]. Agreement with science thus becomes an identity marker, providing cues about one's group membership, such as support for climate science cueing one's political orientation [e.g., McCright, 2016; Jaspal et al., 2016].

Message framing that otherizes scientists, combined with negative stereotypes about scientists as devoid of human characteristics, establishes scientists as an outgroup relative to non-scientists [Fiske & Dupree, 2014; Jaspal et al., 2016]. While categorizing others into groups is a common psychological phenomenon [Sherif, 1967; Tajfel, 1981], when applied to public perceptions of scientists, a person may feel more negatively about contact with scientists, especially if holding beliefs contrary to the scientific consensus [Barnes, Johnston, MacKenzie, Tobin & Taglang, 2018; Gierth & Bromme, 2020; Stephan, 2014]. Therefore, increasing public trust in science and scientists may begin with reducing beliefs that scientists are a singular group, separate from the rest of the public.

Changing the status of scientists as group members

To improve engagement with science, science communicators can do more than avoid using outgroup-related framing. They can create messaging to change scientists' outgroup status by highlighting commonalities and downplaying differences between scientists and non-scientists, prompting non-scientists to consider scientists as members of their community. This evidence-based approach has successfully improved intergroup relations with other stereotyped groups, such as immigrants [Kunst, Thomsen, Sam & Berry, 2015; Vezzali et al., 2015]. Weakening the salience of science-related group identities and promoting more inclusive ingroup identification may reduce prejudice and increase trust in both scientists and science [Gaertner et al., 2000; Riek, Mania, Gaertner, McDonald & Lamoreaux, 2010]. Two approaches for making intergroup perceptions more inclusive are decategorization and recategorization.

Decategorization

Decategorization attempts to remove intergroup boundaries so someone is evaluated as an individual rather than as a member of a specific group [Brewer & Miller, 1984]. Fostering greater exchanges of individuating information and creating situations with highly personalized information from a variety of outgroup members makes group status less salient [Gaertner et al., 1999; Gaertner et al., 2000]. This method is similar to educational strategies that show science's personal relevance for the broader public or illustrate science as a part of everyday life [e.g., Brown, Smith, Thoman, Allen & Muragishi, 2015; Kapon, Laherto & Levrini, 2018]. Promoting beliefs that science is something in which everyone participates may make the defining marker of scientists' group membership — whether one does science as part of their profession — less meaningful [Johnston, 2018; Dovidio, Gaertner & Kawakami, 2003].

Recategorization

Recategorization, in contrast, does not remove group membership, but reshapes it. Recategorization focuses on appealing to a shared, common identity or more inclusive ingroup identity [Riek et al., 2010]; for example, one's national identity as opposed to one's town identity. Transitioning outgroup members to ingroup members reduces bias through the same processes which originally produced preferential treatment for the ingroup [Riek et al., 2010].

Common ingroup identities can be elicited by increasing awareness of shared features [Gaertner et al., 2000]. When communicating about scientists, this approach could be effectively achieved through anti-prototypic depictions, showing scientists in non-stereotypical environments or engaged in non-stereotypical behaviors, such as smiling. While not necessarily examined within the context of recategorization, previous work has suggested these types of prosocial illustrations effectively improve attitudes toward scientists [e.g., Jarreau et al., 2019; Zambrano, Lee, Leal & Thoman, 2020; Lin-Siegler, Ahn, Chen, Fang & Luna-Lucero, 2016; Thomson, Zakaria & Radut-Taciu, 2019].

Objectives and overview of studies

Our studies address whether methods designed to change scientists' categorization can effectively reduce perceptions of scientists as an outgroup. In Study 1, we examined whether messaging containing appeals that personalize science and appeals demonstrating shared identities with scientists improved trust toward scientists, general attitudes toward scientists, and openness to cooperation with scientists. In Study 2 we tested whether the same strategies were effective in a real-world setting.

Study 1

Study 1 attempted to change ingroup categorization using messaging about how non-scientists use science to complete everyday tasks (i.e., personalizing science) in the 'Everyday Science' messaging or by illustrating similarities between scientists' and non-scientists' personalities, interests, and hobbies (i.e., appealing to a common, shared identity) in the 'Scientists Traits' messaging. By effectively addressing group identity beliefs, science communicators can improve the credibility of science by improving trust [Fiske & Dupree, 2014]. As negative beliefs about outgroups undermine trust, we expected that engaging with either form of messaging would improve trust and attitudes toward scientists by reducing outgroup effects [Gaertner et al., 2000].

Hypothesis 1a: Participants in either messaging condition will report higher evaluations of trust in science and trust in scientists compared to the control condition.

In addition to trust, we examined openness to cooperation with scientists to assess whether these interventions could prompt increased openness. This effect could be beneficial because mutual cooperation to achieve common goals is a known mechanism for improving intergroup relations and thus, increasing openness to this type of cooperation can benefit long-term attitude change [Gaertner et al., 1999]. As with trust, we expected the diminished perceptions of scientists' outgroup in both messaging conditions would produce greater interest in future cooperation [Riek, Mania & Gaertner, 2006; Riek et al., 2010].

Hypothesis 1b: Compared to the control, there will be greater openness to cooperation and more positive attitudes toward scientists for those in the messaging conditions.

Additionally, we examined whether the messages impacted perceived personalization of science and the degree scientists and non-scientists share common identities, consistent with how the signs were designed. Doing so supports the argument that the messages impacted outgroup beliefs through different strategies, e.g., decategorization and recategorization. We also examined if personalization of science and shared identities were related to the outcomes of interest, providing further support that these beliefs were meaningful aspects of why the messages altered trust and openness to cooperation.

Hypotheses 2a: Decategorization beliefs (i.e., personalization of science), will be higher in the 'Everyday Science' message condition compared to the 'Scientist Traits' message condition.

Hypotheses 2b: Recategorization beliefs (i.e., shared common identities), will be higher in the 'Scientist Traits' message condition compared to the 'Everyday Science' message condition.

Hypothesis 2c: Decategorization and recategorization will be positively related to trust in science, trust in scientists, and general attitudes toward scientists.

Participants

We collected data from 259 participants through Mechanical Turk, with participation limited to people in the United States who did not identify as scientists (i.e., did not identify scientists as an ingroup). Mechanical Turk provides an accessible pool of participants for online studies. The sample size ensured that, after exclusions, we retained enough participants to provide sufficient power to detect basic effects between groups at a medium effect size ($n = 159$).

Sixty-five participants were excluded for not being able to recall the correct messaging during an attention check or long response times, 2.5 standard deviations beyond the mean survey response time. These exclusionary criteria address concerns that some participants may have stopped partway through the survey and returned later, thus eliminating the effect of the manipulation. Of the 194 remaining participants, 41% were 34 years old or younger, 76% identified as White, non-Hispanic, and 61% identified as male (39% as female). 61% of participants had at least a Bachelor's degree and 7% had a Master's degree or higher. Half (51%) had close family or friends who were scientists, 51% identified as Democrats, 59% believed in God, and half (49%) identified as Christian or a Christian denomination (see supplementary material for a report of the full demographics).

Methodology

Participants completed a pre-manipulation survey on perceived similarity and using a between-groups design, were randomly assigned to one of three conditions: control, 'Everyday Science' messaging, or 'Scientist Traits' messaging. In the messaging conditions, participants read prepared messages, while the control group did not receive any messaging. Using the survey's internal timer, participants in the messaging conditions could not move forward from the messaging page for at least 30 seconds to ensure they did not auto-click through the manipulation. Participants then completed the post-manipulation survey, including questions of trust and general attitudes toward scientists.

Science messaging material development

For the science messaging conditions, we developed two sets of images in collaboration with an exhibit design team, so the images could also be used in Study 2 as zoo exhibit signage (Figure 1). The researchers and designers took a convergent science approach to develop the messages, applying multiple methods within a single condition to represent the intervention of interest. This integrative approach is commonly recognized as an effective method for reducing intergroup conflict [Hewstone, Rubin & Willis, 2002; Gaertner et al., 2000] and provides a more ecologically valid intervention. Both conditions' signs were contextualized for future placement in the Study 2 exhibit, including examples referring to snow leopards. There were efforts to maintain consistency in the physical features of the signs across conditions, including linguistic complexity, color, sentence length, and overall size.

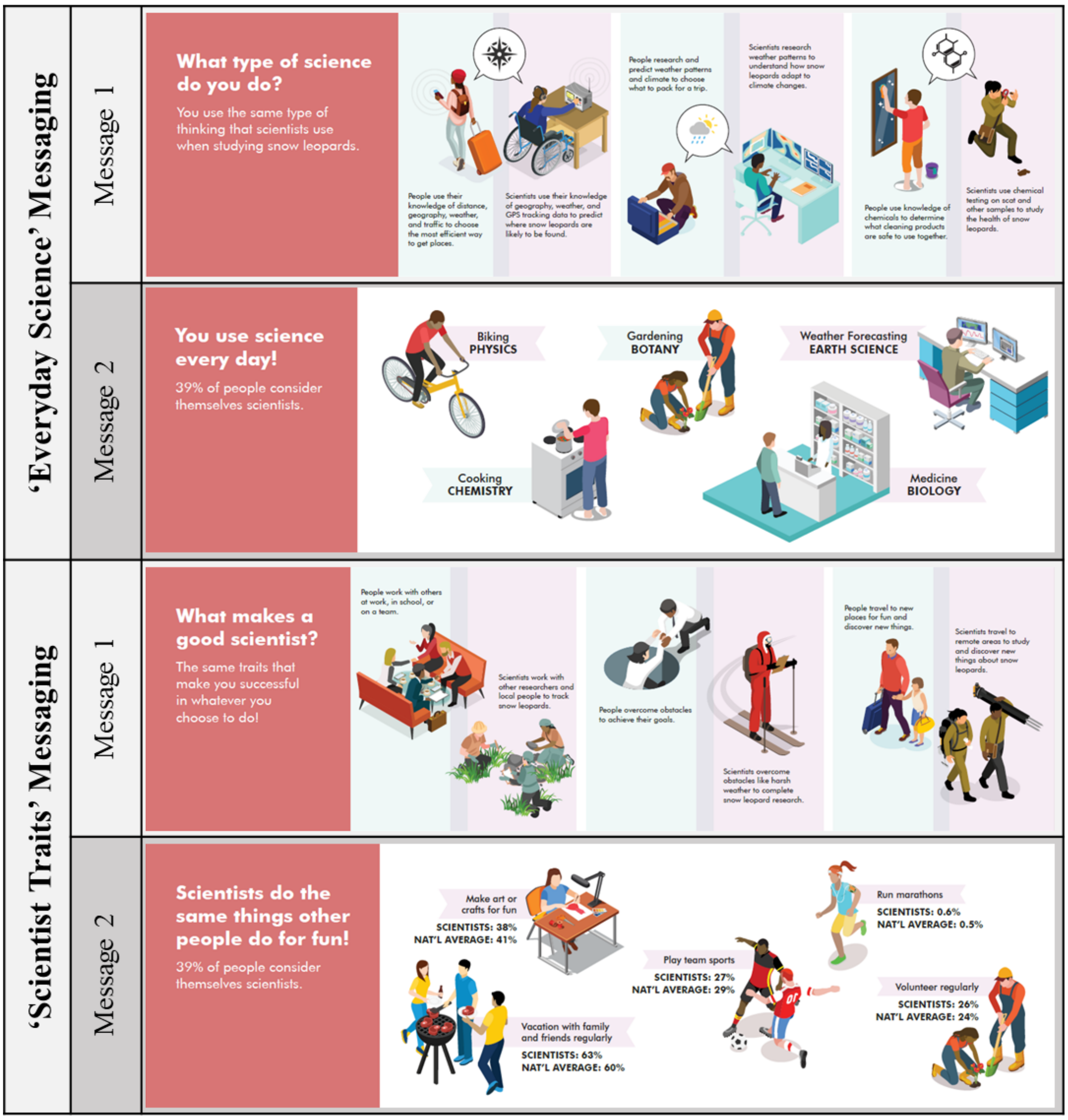

Figure 1. Science messaging conditions.

Everyday science messaging. This messaging applied decategorization strategies to reduce outgroup relevance and prompt participants to evaluate scientists as individuals rather than group members [Gaertner et al., 2000]. The 'Everyday Science' messaging emphasized the omnipresence of science to personalize science. Participants read examples of how they use scientific skills such as chemistry or earth science in tasks like cooking or weather forecasting. The message likened some of these scientific skills and knowledge to those used by field biologists. For example, a non-scientist uses GPS tools to determine travel routes and scientists use the same skill set to track snow leopards. Showing how society at large benefits from science, normalizing science as a process, and associating science with everyday activities makes the distinction between scientists and non-scientists less helpful for information processing and thus reduces the likelihood of viewing scientists as an outgroup [Gaertner et al., 1999; Gaertner et al., 2000; Matias, Dias, Gonçalves, Vicente & Mena, 2021].

Scientist traits messaging. This messaging applied recategorization strategies to group scientists and non-scientists into a more inclusive category [Dovidio, Gaertner, Shnabel, Saguy & Johnson, 2010]. Given that prosocial traits are traditionally seen as less common in scientists [Rutjens & Heine, 2016], the messages attempted to humanize scientists by providing illustrations of how non-scientists collaborate in school or work, just as scientists collaborate to track animals for study. They also show scientists in non-science contexts, such as making crafts, volunteering, or playing team sports. To emphasize a common identity, the 'Scientist Traits' message highlighted these shared traits between scientists and non-scientists to prompt participants to see scientists as part of the broader community [Dovidio et al., 2010].

Study 1 materials

Only measures relevant to the analysis are presented here. For a full list of all measures and questions, please refer to the supplementary material.

Measures

Perceived similarity. To measure pre-manipulation beliefs about self-scientist similarity ($\alpha = .85$), three semantic differential questions asked participants to assess similarities in their 'goals,' 'values' and 'daily life' relative to non-scientists versus scientists (1 = *non-scientists*; 5 = *neutral*; 9 = *scientists*).

Manipulation effectiveness. For those who viewed either messaging condition, we asked eight questions focused on beliefs consistent with showing the personalization of science (decategorization) or awareness of shared common identities (recategorization; 1 = *strongly disagree*; 7 = *strongly agree*). Examples of questions include how the messages made the participant think about, "how science is useful in everyday life", and "how scientists and non-scientists share many of the same traits".

Feeling thermometer. Using a single-item feeling thermometer, we assessed how individuals felt about scientists using a 100-point scale (0 = *cold*; 100 = *warm*). Previous research has demonstrated this measure's effectiveness for predicting general intergroup attitudes [e.g., Inbar, Pizarro & Bloom, 2012; Turner, Hewstone, Voci & Vonofakou, 2008].

Trust in science. Science trust was examined using an average of an eight-item scale (1 = *strongly disagree*, 5 = *strongly agree* [Bauer, Durant & Evans, 1994]). Items included, "the benefits of science are greater than any harmful effects", and "science and technology are making our lives healthier, easier, and more comfortable".

Trust in scientists. We used a 21-item scale to measure trust in scientists (1 = *strongly disagree*, 5 = *strongly agree* [Nadelson et al., 2014]) and calculated an average composite score. Items included, "we should trust the work of scientists", and "scientists ignore evidence that contradicts their work" (R).

Openness to cooperation with scientists. Based on work by Gómez and associates [2013], we used six items to measure the extent to which participants would be open to cooperating with scientists (1 = *strongly disagree*, 5 = *strongly agree*) and calculated an average score ($\alpha = .87$). Items included, "I would cooperate with scientists to solve problems that affect the world's population", and "I would be happy to personally get to know more scientists".

Results

Intergroup categorization interventions on intergroup beliefs

Effects of condition on trust in science and scientists. To test Hypothesis 1a, the effect of message condition on trust in science and scientists, we used ANOVAs, examining whether there were differences between messaging conditions across trust. There was a significant effect of condition on trust in science, $F(2,191) = 3.62$, $p = .03$, ${\eta_p}^2 = .04$ (see Figure 2). Trust in science was significantly lower in the control condition ($M = 5.00$, $SE = 0.10$) compared to the 'Scientists Traits' messaging ($M = 5.41$, $SE = 0.12$), $p = .01$, 95% CI $[-0.73, -0.09]$, but not significantly different from the 'Everyday Science' messaging ($M = 5.32$, $SE = 0.13$), $p = .06$, 95% CI $[-0.64, .01]$. There was no significant difference between the two messaging conditions, $p = .60$, 95% CI $[-0.26, 0.44]$.

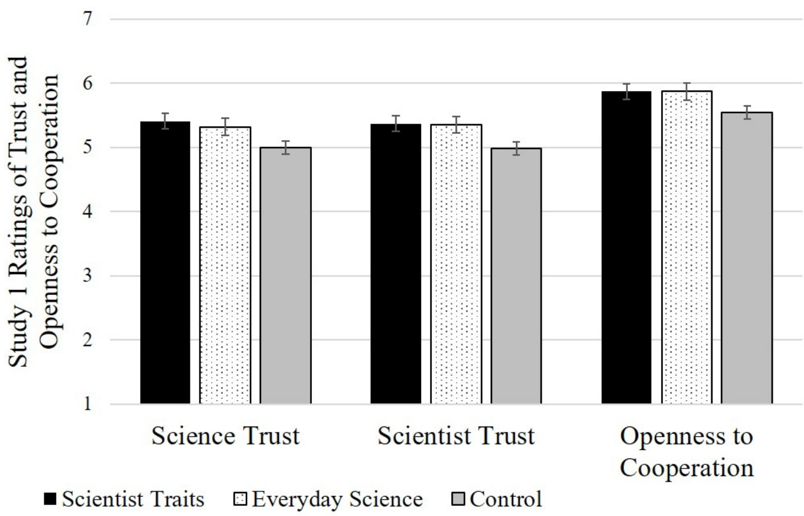

Figure 2. Study 1 trust in science, scientist trust and openness to cooperation depending on message condition.

Likewise, there was a significant effect of condition on trust in scientists, $F(2,190) = 3.32$, $p = .04$, ${\eta_p}^2 = .03$ (see Figure 3). Those in the control condition ($M = 4.98$, $SE = 0.11$) reported significantly less trust in scientists than either the 'Scientists Traits' messaging ($M = 5.37$, $SE = 0.13$), $p = .03$, 95% CI $[-0.74, -0.04]$, or the 'Everyday Science' messaging ($M = 5.35$, $SE = 0.14$), $p = .04$, 95% CI $[-0.72, -0.23]$. There was no difference between the 'Scientists Traits' and the 'Everyday Science' messages, $p = .92$, 95% CI $[-0.36, -0.40]$. Hypotheses 1a was only partially supported, with trust in science evaluated similarly in the 'Everyday Science' message and the control, but the 'Scientist Trust' message being different from the control on both measures of trust.

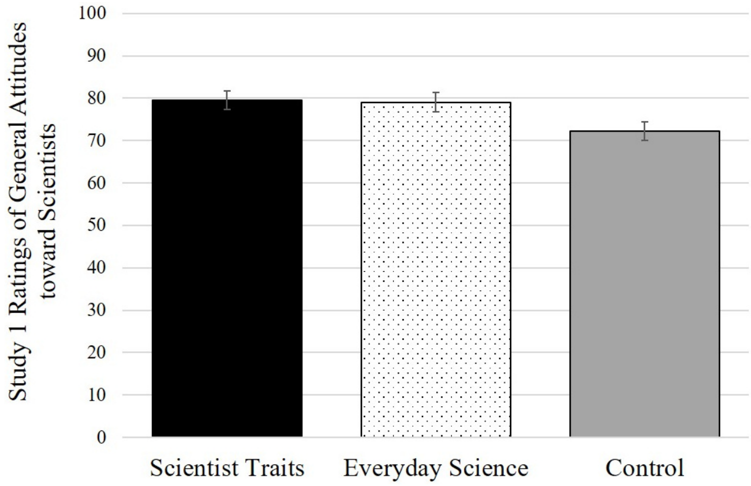

Figure 3. Study 1 general attitudes toward scientists depending on message condition.

Effects of condition on openness to cooperation. We conducted two ANOVAs to test Hypothesis 1b, the effect of condition on openness to cooperation and general attitudes toward scientists. We found a significant effect of condition on openness to cooperation, $F(2, 190) = 3.69$, $p = .03$, ${\eta_p}^2 = .04$ (see Figure 3). Those in the control condition ($M = 5.54$, $SE = 0.09$) reported less openness to cooperation with scientists compared to those in the 'Scientist Traits' messaging ($M = 5.87$, $SE = 0.11$), $p = .02$, 95% CI $[-0.62, -0.04]$, and the 'Everyday Science' messaging ($M = 5.87$, $SE = 0.11$), $p = .02$, 95% CI $[-0.62, -0.05]$. The messaging conditions were not significantly different, $p = .98$, 95% CI $[-0.32, 0.31]$.

Similarly to the previous analysis, a significant effect of condition was found on general attitudes toward scientists, $F(2, 188) = 3.61$, $p = .03$, ${\eta_p}^2 = .04$ (see Figure 3). Those in the control condition ($M = 72.21$, $SE = 2.02$) reported a significantly lower rating, indicating less positive attitudes compared to the 'Scientist Traits' messaging ($M = 79.51$, $SE = 2.37$), $p = .02$, 95% CI $[-13.44, -1.16]$, and the 'Everyday Science' messaging ($M = 79.00$, $SE = 2.39$), $p = .03$, 95% CI $[-12.97, -0.62]$. There was no significant difference between the messaging conditions, $p = .88$, 95% CI $[-6.12, 7.14]$. The result supports Hypothesis 1b, indicating that the messages effectively improved general attitudes toward scientists and openness to cooperation.

Effects of condition on common shared identity and personalization of science and implications for outcomes of interest. To address Hypotheses 2a and 2b, we conducted a series of independent samples t-tests examining whether there were significant differences in the extent the two messaging conditions produced differences consistent with decategorization or recategorization. Significant effects between the two conditions were found on six of the eight variables examined.

Those seeing the 'Everyday Science' message reported higher agreement with statements that daily activities can be both scientific and non-scientific (see Table 1 for means and standard deviations), $t(111) = 4.97$, $p < .001$, $d = 0.94$, 95% CI $[0.69, 1.60]$, science is useful in everyday life, $t(111) = 6.28$, $p < .001$, $d = 1.18$, 95% CI $[1.03, 1.97]$, science is a part of everyone's lives, $t(111) = 4.63$, $p < .001$,

Table 1. Study 1 means and standard deviations on message manipulation effectiveness questions.

	'Everyday Science' *Mean (SD)*	*'Scientist Traits'* *Mean (SD)*
Personalization of science		
Daily activities can have both scientific and non-scientific features.	6.20 (*0.75*)	5.05 (*1.56*)
Science is part of everyone's life, even people who are not scientists.	6.27 (*0.80*)	5.16 (*1.61*)
Science and scientific skills can be used in many situations.	6.32 (*0.72*)	5.28 (*1.56*)
Shared common identities with scientists		
Scientists and laypeople share many of the same traits.	5.52 (*1.28*)	5.93 (*0.82*)
Scientist have likes, interests, and hobbies outside of their work as a scientist.	4.63 (*1.91*)	5.95 (*0.97*)
Scientists have similar goals and values to me.	5.16 (*1.57*)	5.63 (*1.11*)
Science equates to personal success		
Science is useful to my everyday life.	6.39 (*0.62*)	4.89 (*1.68*)
Many of the skills or traits that make me successful are also traits that make a good scientist.	5.36 (*1.52*)	5.30 (*1.48*)

$d = 0.87$, 95% CI $[0.63, 1.59]$, and science is useful in many situations, $t(111) = 4.55$, $p < .001$, $d = 0.86$, 95 CI $[0.59, 1.49]$. Conversely, those seeing the 'Scientist Traits' messaging reported higher values that scientists and non-scientists share traits, $t(111) = -2.04$, $p = .04$, $d = 0.38$, 95% CI $[-0.81, -0.01]$, and that scientists hold interests and hobbies outside their work, $t(111) = -4.65$, $p < .001$, $d = 0.87$, 95% CI $[-1.89, -0.76]$. There was not a statistically significant difference between the two conditions when evaluating that scientists have similar goals and values, $t(111) = -1.84$, $p = .07$, $d = 0.35$, 95% CI $[-0.98, 0.04]$. There were no differences between conditions in perceptions that success is determined by similar traits for scientists and non-scientists, $p = .84$, 95% CI $[-0.50, 0.62]$. Hypotheses 2a and 2b were supported, suggesting the message conditions produced meaningful differences in perceptions of scientists' intergroup status consistent with the original designs of the signs.

To address whether these message attributes were related to our outcomes of interest as suggested in Hypothesis 2c, we conducted partial correlations with trust in science, trust in scientists, and openness to cooperation, controlling for message condition (dummy-coded). We created an aggregate score of the three main variables for science personalization ($\alpha = .91$) and the three main variables for common identities ($\alpha = .77$). Despite non-significance, we retained the question on common goals to compute the common identities variable, as it was conceptually similar to the other items. We excluded the variables about shared success traits and science's use in everyday life because these variables did not address changes in categorization of scientists, but pertained to the association of science with personal success. Results indicated that personalization of science was positively related to trust in scientists, $r(110) = .25$, $p = .01$, trust in science, $r(110) = .21$, $p = .03$, general attitudes toward scientists, $r(110) = .23$, $p = .01$, and openness to cooperation, $r(110) = .29$, $p = .002$. Common shared identity scores were positively related to trust in scientists, $r(110) = .27$, $p = .004$, trust in science,

$r(110) = .27$, $p = .004$, and openness to cooperation, $r(110) = .36$, $p < .001$. Common identity was not related to general attitudes toward scientists, $r(110) = .18$, $p = .06$. Overall, Hypothesis 2c was supported, with the exception of the correlation of common identities and general attitudes, suggesting these mechanisms were related to evaluations of trust and used in evaluations of intergroup beliefs.

Study 1 discussion

The results of Study 1 largely supported the hypotheses and demonstrated the messaging conditions were performing as intended, except for a non-significant result for the 'Everyday Science' messaging for trust in science. Participants reported experiencing higher levels of personalization of science with the 'Everyday Science' messaging, and higher levels of shared, common identity awareness with the 'Scientist Traits' messaging. These findings give some support that the 'Everyday Science' messaging decategorizes scientists by personalizing science and reduces the distinction between scientists and non-scientists' use of science. It also supports the establishment of shared, common identities through recategorization in the 'Scientist Traits' messaging by humanizing scientists and establishing similarities to non-scientists.

Both message conditions positively impacted trust in scientists, general attitudes toward scientists and openness to cooperation with scientists. As both forms of messaging reduced perceptions of scientist as an outgroup, this study provides initial evidence that decategorization and recategorization science messaging can be effective strategies for improving intergroup relations. However, as the effects of the 'Everyday Science' message were not consistent, further study can examine whether decategorization is an equally effective strategy or if refinement to the intervention is necessary.

Study 2

Building on the results of Study 1, Study 2 examined whether the same messaging can produce similar effects in an ecologically valid, in-person setting. Using exhibit signage at a zoo simulated how the public might encounter scientific messaging in their daily lives, testing whether the intervention could be successful in a naturalistic setting. We reduced the length of the survey to make it more appropriate for a zoo setting, where participants are often eager to continue their visit. Thus, analyses were restricted to testing only *Hypotheses 1a* and *1b*, exploring the effects of the conditions on trust in science, scientists, and openness to cooperation.

Participants

We collected data from 147 adult visitors to New York City's Central Park Zoo, with three participants excluded for not being able to recall the correct signage. We removed an additional 30 participants who reported strongly identifying as a scientist, as we sought to examine the impacts of science messaging on people who did not readily identify scientists as an ingroup.

Of the remaining 114 participants, 63% identified as female, 71% as White, non-Hispanic, and 59% had at least a Bachelor's degree (18% had a Master's degree or above). The majority (75%) lived in the United States and were 34 years old or younger (66%). (See supplementary material for full demographic breakdowns.)

Most participants (75%) attended the exhibit alone or with one other person (25% attended with 2 or more) and most attended with children (87%). Exhibit crowding was fairly evenly split across low crowding (25%; zero to four others in the exhibit), mid-level crowding (41%; six to nine others), and crowded conditions (33%; 10 or more others).

Methodology

We collected data at the Central Park Zoo because informal science institutions attract visitors with a diverse understanding and interest in science [McCallie et al., 2009; Beauchamp & Roberts, 2022]. All data were collected at the zoo's upper snow leopard exhibit, with participants moving unidirectionally through the space. The exhibit houses one snow leopard and contains factual signage and interactive elements describing snow leopard ecology and conservation efforts.

Participants were recruited into the study as they approached the exhibit. Upon accepting, they completed the pre-exhibit survey and entered the exhibit, where they experienced one of three randomly assigned conditions, a control condition and two conditions using the same science messaging as Study 1. In the 'Control' condition, the exhibit remained unchanged from typical operations. In the other two conditions, two additional pieces of signage containing the science messaging were mounted on a blank exhibit wall. Upon exiting the exhibit, participants completed the post-exhibit survey.

Study 2 materials

Due to the time restraints of collecting data on-site, we limited the number of main variables to trust in science, scientists, and openness to cooperation, and limited scaling to 1–5 (*strongly disagree to strongly agree*). We added measures about the exhibit experience, reflecting the in-person nature of the study.

Need for cognition

Need for cognition, or the interest in solving complex problems, was measured with a validated measure of need for cognition [Cacioppo, Petty & Kao, 1984] containing six questions (1 = *extremely uncharacteristic of me*, 5 = *extremely characteristic of me*). Examples of items include, "I would prefer complex to simple problems", and "Thinking is not my idea of fun" (R).

Participant measures

As participants entered the exhibit, researchers recorded the number of people in the participant's group (≤ 2, 3–5, ≥ 6 people), if the group included children (Yes, No), the exhibit crowdedness, or number of other people in the exhibit (≤ 3, 4–9, ≥ 10 people), and whether the animal was readily visible (Yes, No).

Science identification

Science identification was determined using four questions on a 7-point scale (1 = *strongly disagree*, 7 = *strongly agree*) examining the extent a person identified themselves as a scientist ($\alpha = .93$). Items included, "I see myself as a scientist", and, "I feel that being a scientist is an important reflection of who I am.

Other measures. Trust in science, scientists, and openness to cooperation with scientists were the same measures as Study 1 (one item on the openness to cooperation instrument was reworded, ($\alpha = .86$). Demographic information was collected, but limited to core variables of age, gender, race and ethnicity, and whether the participant worked in a science career (Yes, No).

Results

Impacts of intergroup categorization interventions

To test Hypothesis 1a and 1b, we conducted a series of ANCOVAs on trust in science, scientists, and openness to cooperation with scientists. We included exhibit crowdedness as a potential moderator and need for cognition as a covariate as they may impact participants' stay time and ability or willingness to maintain attention within the exhibit [Kirchgessner & Sewall, 2015; Enge, Fleischhauer, Brocke & Strobel, 2008].

Effects of condition on trust in science and scientists. We tested Hypothesis 1a by conducting two ANCOVAs addressing the impact of condition on trust in science and trust in scientists. Covariates were exhibit crowdedness and need for cognition.

For trust in science, there was a significant effect of condition on trust, $F(2, 104) = 7.61$, $p = .001$, ${\eta_p}^2 = .13$ (see Figure 4). Those in the control condition ($M = 3.55$, $SE = 0.09$) reported significantly lower trust in science compared to both the 'Everyday Science' ($M = 3.90$, $SE = 0.08$), $p = .004$, 95% CI $[-0.59, -0.11]$, and 'Scientist Traits' messages ($M = 4.02$, $SE = 0.09$), $p < .001$, 95% CI $[-0.73, -0.22]$.

Examining trust in scientists, there was also a significant effect of condition, $F(2, 104) = 3.27$, $p = .04$, ${\eta_p}^2 = .06$ (see Figure 4). Those seeing the 'Scientist Traits' messaging ($M = 3.95$, $SE = 0.10$) had significantly higher trust in scientists compared to the control condition ($M = 3.60$, $SE = 0.09$), $p = .01$, 95% CI $[0.07, 0.61]$, but wasn't significantly different compared to the 'Everyday Scientist' condition ($M = 3.72$, $SE = 0.09$), $p = .09$, CI 95% $[-0.03, 0.49]$. There were no differences between the control condition and the 'Everyday Science' message, $p = .38$.

Results suggest that while both conditions have the potential to impact trust in science generally, Hypothesis 1a was not entirely supported, as the 'Everyday Science' signage did not produce a significant effect on trust in scientists.

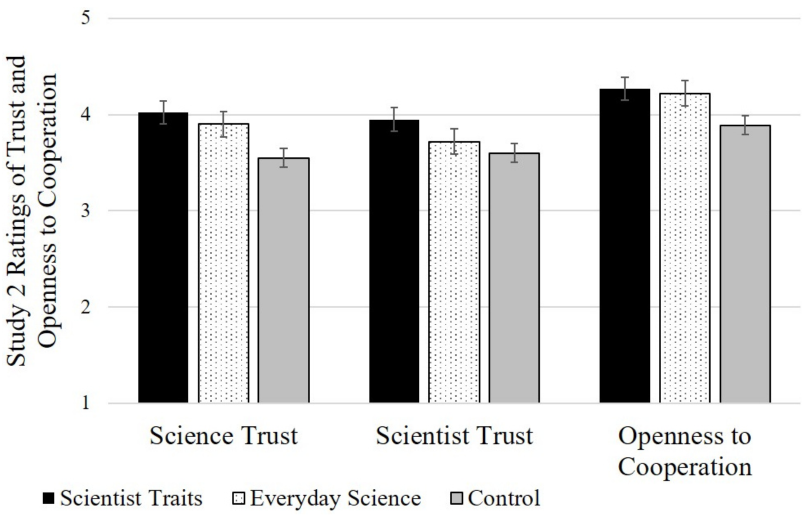

Figure 4. Study 2 trust in science, scientist trust and openness to cooperation depending on signage condition.

Effects of condition on openness to cooperation. Similar to the Study 1 analysis for Hypothesis 1b, we conducted an ANCOVA to examine the effects of condition on openness to cooperation with scientists. Exhibit crowdedness and need for cognition again served as covariates.

A significant effect of condition was found on openness to cooperation, $F(2, 104) = 3.34$, $p = .04$, $\eta_p{}^2 = .06$ (see Figure 4). Compared to the 'Everyday Science' messaging ($M = 4.22$, $SE = 0.11$), $p = .04$, 95% CI $[-0.65, -0.03]$, and the 'Scientist Traits' messaging ($M = 4.27$, $SE = 0.12$), $p = .02$, 95% CI $[-0.72, -0.06]$, the control condition ($M = 3.89$, $SE = 0.11$) was significantly lower. The 'Everyday Science' and 'Scientist Traits' messages were not significantly different, $p = .76$. Consistent with Hypothesis 1b, both forms of science messaging were found to positively impact openness to cooperation with scientists.

Study 2 discussion

Results for the 'Scientist Traits' messaging within the naturalistic setting of zoo signage were consistent with Study 1, showing improvements in trust and openness to cooperation compared to the control. Less consistent, the 'Everyday Science' messaging was related to higher trust in science and openness to cooperation compared to the control, but contrary to Hypothesis 1a, was not related to trust in scientists. This was also different from Study 1, where 'Everyday Science' showed significant effects on trust in scientists and no effect for trust in science. The reduced consistency for the 'Everyday Science' messaging may indicate more limited, or at least less consistent, effects compared to the 'Scientist Trait' messaging.

General discussion

Identifying scientists as a distinct outgroup compared to non-scientists can increase negative beliefs about scientists [Hewstone et al., 2002]. Results from both studies indicated that recategorization was an effective and impactful strategy for improving trust and future engagement with science, which suggests potential for reducing intergroup differences between scientists and non-scientists by diminishing perceived discrepancies. Decategorization messaging produced some significant effects, but they were less consistent within and between Studies 1 and 2. Further research is needed to ascertain if this inconsistency is true for any intervention using decategorization or if this effect was due to the messages or setting of this study.

For the recategorization present with the 'Scientist Trait' messaging, and less consistently for the decategorization strategy within the 'Everyday Science' messaging, results showed that negative beliefs associated with scientists' outgroup status can be reduced. Science messaging that applies these strategies should resonate with a broad audience and increase positive science attitudes [Gaertner et al., 2000; Paolini, Harwood, Hewstone & Neumann, 2018; Fiske & Dupree, 2014]. Diminishing the perceived differences between science and the public should make the current science messaging more accessible and open avenues for future engagement [Gaertner et al., 1999; Tang, Abbazio, Hew & Hara, 2021; Paolini et al., 2018].

The positive effects on openness to cooperation presents an important step for science communicators seeking a long-term engagement strategy. Science communication is not a singular event, but a series of interactions where the public can choose whether to engage and process or ignore information. Decreasing the relevance of intergroup differences means the public should be more willing to engage and cooperate with scientists in the future, evidenced by the significant effects of messaging in both studies [Gaertner et al., 1999; Dovidio et al., 2003; Paolini et al., 2018]. Increasing future cooperation can benefit not only direct outcomes, but increase the potential for future benefits, such as increasing the willingness to interact with scientists directly to solve problems.

Limitations of the current work include the small sample size and the restricted survey length in Study 2, which prevented us from assessing whether all effects observed in Study 1 can be replicated in a real-world environment. The highly contextualized nature of the intervention could also be considered a limitation of the study, however, we would argue this maximizes the ecological validity of the results and is also a strength.

The potential for appeals to be context-dependent

Although both strategies show promising benefits in online and in-person zoo settings, implementation in additional real-world settings and across audiences requires careful consideration. To draw effective comparisons, these messages were highly contextualized, presenting examples of snow leopard research within a zoo's snow leopard exhibit. While the online nature of Study 1 shows the possibility for effects to occur across platforms, further study is necessary to determine how effectively messages designed for one context can translate to others.

Science denialism should also be considered, as science denialism could become a foundation of group identity for individuals who are skeptical of science [Losh, 2010; Pittinsky, 2015; Hardy et al., 2019; Jaspal et al., 2016]. For these groups, strategies that do not require relinquishing their ingroup identity, such as decategorization, could potentially be a more effective approach for communication, despite showing more mixed effects in this study [Crisp, Stone & Hall, 2006].

This work provides initial evidence that research on social identities can have a significant, meaningful impact on science communication. Science communicators can benefit from messaging which incorporates strategies to reduce the public's feelings about scientists as an outgroup, thereby maximizing potential message engagement and acceptance.

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How to cite

Beauchamp, A. L., Roberts, S.-J. and Piper, C. (2022). 'Changing attitudes toward scientists by reducing intergroup biases: how a signage intervention focused on decategorization and recategorization improved trust'. *JCOM* 21 (06), A03. https://doi.org/10.22323/2.21060203.

Supplementary material

Available at https://doi.org/10.22323/2.21060203

ISSN 1824-2049. Published by SISSA Medialab. jcom.sissa.it