



Promoting the Middle East Peace Process by Changing Beliefs About Group Malleability

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bacterium exists. We conducted five experiments with initial inoculation numbers of 10^6 , 10^5 , 10^4 , 10^3 , and 10^2 wild-type *E. coli*. A mosaic of resistant bacteria emerged at all the different inoculation levels (Fig. 2), and even at inoculations of as few as 100 bacteria, resistance emerged; these results support the occurrence of de novo mutation. We developed a simple model (15) that predicted that as the initial number of wild-type bacteria inoculated (n_0) is decreased, the time for the emergence of de novo resistance increases but remains finite. A comparison of the data with the mean-field simulation of the model shows approximate agreement with the data (Fig. 3).

We examined whole genome sequences to understand what mutations occurred and spread within the population. Baseline sequences were obtained from the wild-type bacteria before introduction to the chip, and single-nucleotide polymorphisms (SNPs) were counted only if they did not appear in the wild-type base sequences. The experiment with 10^6 wild-type *E. coli* inoculations was repeated three times and whole genome sequences were obtained independently for each.

Four SNPs were found in each of the three experiments (DG-1, DG-2, DG-3) (Fig. 4). The four SNPs that fix are clearly functional SNPs that give rise to resistance: First, a T → C mutation in base 2,337,183 of the *E. coli* K12 genome causes an Asp⁸⁷ → Gly missense mutation in *gyrA*. Structural alignment of the protein sequences of the *E. coli* and *Staphylococcus aureus* gyrase A subunits revealed that *E. coli* Asp⁸⁷ aligned to *S. aureus* Glu⁸⁸. Asp and Glu differ by a single carbon, and these two residues are often substituted in similar proteins. Reconstructing this mutation in the known x-ray structure of *S. aureus* gyrase A (18) reveals that ciprofloxacin inhibits *gyrA* function by sitting in the active site of the enzyme, and the mutated amino acid (red in

Fig. 4) sits very close to ciprofloxacin. Thus, this SNP is likely to be functional.

Second, a missense A → T in base 3,933,247 in a region coding for the *rbsA* gene, which is a component of the ribose ABC transporter complex, has been previously reported to export other antibiotics (erythromycin, tylosin, and macrolides) (19). Thus, this SNP is also likely to be functional.

The third and fourth mutations constituted a pair of missense SNPs (C → G in base 1,617,460; A → C in base 1,617,461) in the coding sequence for *marR*. The normal function of *marR* is to repress the multiple antibiotic resistance (*mar*) operon (20). It is possible that these SNPs alter the ability of *E. coli* to regulate the expression of antibiotic resistance genes.

It is surprising that four apparently functional SNPs should fix in a population within 10 hours of exposure to antibiotic in our experiment. A detailed understanding of the order in which the SNPs occur is essential, but it is unlikely that the four SNPs emerged simultaneously; in all likelihood they are sequential (21–23). The device and data we have described here offer a template for exploring the rates at which antibiotic resistance arises in the complex fitness landscapes that prevail in the mammalian body. Furthermore, our study provides a framework for exploring rapid evolution in other contexts such as cancer (24).

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Supporting Online Material

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Materials and Methods
Figs. S1 to S3
References (25–29)
Movie S1

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Promoting the Middle East Peace Process by Changing Beliefs About Group Malleability

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Four studies showed that beliefs about whether groups have a malleable versus fixed nature affected intergroup attitudes and willingness to compromise for peace. Using a nationwide sample ($N = 500$) of Israeli Jews, the first study showed that a belief that groups were malleable predicted positive attitudes toward Palestinians, which in turn predicted willingness to compromise. In the remaining three studies, experimentally inducing malleable versus fixed beliefs about groups among Israeli Jews ($N = 76$), Palestinian citizens of Israel ($N = 59$), and Palestinians in the West Bank ($N = 53$)—without mentioning the adversary—led to more positive attitudes toward the outgroup and, in turn, increased willingness to compromise for peace.

Ending long-standing conflicts represents an urgent global challenge. One major barrier to successful conflict resolution is

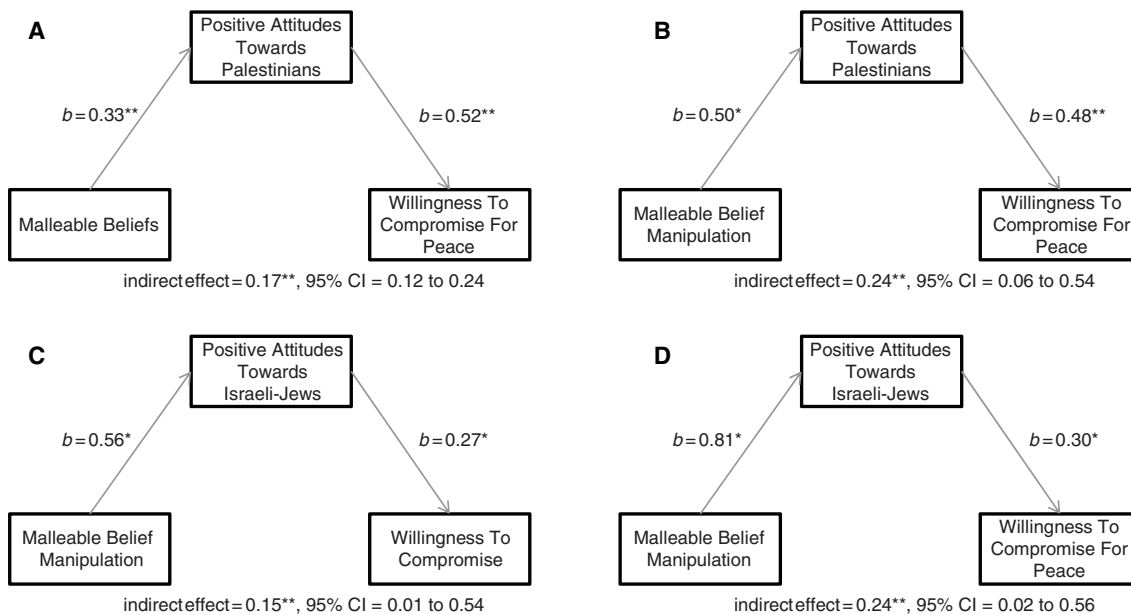
each group's intensely negative attitudes toward the other group in the conflict (1). Because direct attempts to alter attitudes toward an adversary

can backfire by bringing about defensive reactions (2), we tested the value of a more indirect route: focusing on beliefs about whether groups in general can change.

This focus was suggested by prior research showing that those who believe that people are malleable (versus fixed) are less likely to attribute wrongdoing to a person's fixed qualities, less likely to recommend punishment for a wrongdoer, and more likely to recommend negotiation (3, 4). More specifically, past research has demonstrated that when faced with negative behavior, people who believe that human qualities are malleable are more likely to understand

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* $P < 0.05$, ** $P < 0.01$

the behavior as stemming from people's current motivations and situations, rather than from their permanent traits (3). In line with this, their proposed solutions to the negative behavior involve steps that would alter motivations or situations, such as education or negotiation (4). For those who understand wrongdoing as emanating from fixed traits, however, punishment and retaliation are the favored responses (4). These belief-related differences, especially with regard to groups (5), would be particularly important in intergroup conflicts in which harmful behaviors are frequently enacted on both sides.

One such conflict is currently taking place in the Middle East. Beginning with a sample of Israeli-Jewish participants, we hypothesized that a general belief in the malleability (versus fixedness) of groups would be associated with (study 1) and causally related to (study 2) more positive attitudes toward Palestinians, and that these more positive attitudes would, in turn, predict greater willingness to make compromises for peace. But what about Palestinian citizens of Israel, historically the weaker side of the conflict, who have often been denied the full rights due to citizens (study 3)? And, even more so, what about Palestinians in the West Bank, who are not citizens of Israel, who have been fighting for self-determination and sovereignty since the 1960s, have no stake in the continued existence of Israel, and many of whom belong to political and militant political groups (study 4)? Would members of these groups be influenced by our manipulation, which induces malleable versus fixed beliefs about groups? And if so, would they show changes in their attitudes toward Israeli Jews and in their willingness to make important compromises for peace?

In study 1, a nationally representative sample of 500 Israeli Jews was interviewed. We

assessed their general beliefs about groups (whether or not they believed that groups had a fixed inherent nature) through their level of agreement with statements such as "Groups can't change their basic characteristics." We also assessed their attitudes toward Palestinians and their willingness to compromise with Palestinians (e.g., to evacuate settlements or compromise over the status of Jerusalem) (6). As expected, malleable beliefs about groups predicted significantly more positive attitudes toward Palestinians ($r = 0.30$, $P < 0.001$), which predicted greater willingness to compromise ($r = 0.50$, $P < 0.001$). [See Fig. 1A for a formal test of mediation (7).] The effect held after controlling for gender and malleable beliefs about individuals (as opposed to groups) in this and the other three studies presented below, and also for political beliefs measured in studies 1, 2, and 4.

To determine whether people's beliefs actually play a causal role, in study 2 we randomly assigned 76 Israeli-born Jewish participants to read an article that portrayed aggressive groups as having a fixed nature or a malleable nature. Neither article referred to Palestinians or the Israeli-Palestinian conflict. Later, as part of what was ostensibly another study, attitudes toward Palestinians and support for compromise with Palestinians were assessed (6). Although no mention was made of Palestinians in the articles, participants in the malleable condition had significantly more positive attitudes toward Palestinians ($M = 3.32$, $SD = 1.01$) than did those in the fixed condition [$M = 2.83$, $SD = 0.75$; $t(74) = 2.43$, $d = 0.56$, $P < 0.05$]. These more positive attitudes, in turn, predicted greater support for major compromises ($r = 0.45$, $P < 0.001$). (See Fig. 1B for a formal test of mediation.)

Would these results hold only for the "strong" group in a conflict, one that possesses most of the power? In study 3, we tested the same psychological mechanism among 59 Palestinian citizens of Israel (PCIs), a minority group in Israel constituting 19% of the population (6). PCIs are citizens of Israel, but they are perceived by many Israeli Jews to be a hostile minority with intimate connections to the enemies of Israel who must be kept in check (8). We adjusted the materials to make them appropriate to the group and its context, focusing on the compromises most relevant to their situation today. Although no mention was made of Israeli Jews in the articles, participants in the malleable condition had significantly more positive attitudes toward Jews ($M = 3.82$, $SD = 0.82$) than did those in the fixed condition [$M = 3.26$, $SD = 1.10$; $t(57) = 2.19$, $d = 0.58$, $P < 0.05$]. These more positive attitudes, in turn, predicted greater support for major compromises ($r = 0.37$, $P < 0.01$). (See Fig. 1C for a formal test of mediation.)

Would these results hold only for Palestinians who had a stake in compromising with Israel, or would they also hold for Palestinians who were not citizens of Israel, many of whom were sworn enemies of Israel? Study 4 was conducted with 53 Palestinian adults in Ramallah, the capital of the Palestinian National Authority, more than half of whom were members of political and militant organizations such as Fatah or Hamas (6). We repeated the procedure from studies 2 and 3, again making appropriate changes to match the context. Once more, participants in the malleable condition had significantly more positive attitudes toward Israeli Jews ($M = 3.64$, $SD = 1.49$) than did those in the fixed condition [$M = 2.83$, $SD = 1.21$; $t(51) = 2.19$, $d = 0.60$, $P < 0.05$]. These more positive attitudes, in turn, predicted greater support for major compromises

Fig. 1. (A to D) Effect of malleable beliefs [(A); study 1] and the malleable belief manipulation [(B) to (D); studies 2 to 4, respectively] on willingness to compromise for peace, through its effect on positive attitudes toward the other group (b values are unstandardized β values).

($r = 0.43$, $P < 0.01$). (See Fig. 1D for a formal test of mediation.)

One noteworthy feature of study 4 is that we assessed participants' willingness to meet with Israeli Jews and hear their point of view on the conflict. Research has shown that this type of measure significantly predicts actual involvement in intergroup contact (9). Moreover, willingness to meet typically mediates the relation between attitudes toward another group and contact with members of that group (9). Indeed, much longstanding psychological research shows that willingness or desire to act or interact is one of the most robust predictors of behavior (10). A review of this literature reveals that the prediction of behavior runs from 0.35 to 0.67 (10), and a meta-analysis of relevant studies yields an overall correlation of 0.54 (11). In the current study, participants in the malleable condition were significantly more likely to express interest in meeting with Israelis ($M = 4.08$, $SD = 1.62$) than were those in the fixed condition [$M = 2.41$, $SD = 1.65$; $t(51) = 3.72$, $d = 1.02$, $P < 0.01$]. Interestingly, this measure was highly correlated with willingness to compromise ($r = 0.88$), supporting the validity of our compromise measures. Moreover, the indirect effect of the manipulation on this measure through improved attitudes was significant (indirect effect = 0.56, 95% confidence interval = 0.07 to 1.14, $P < 0.05$).

Thus, in three key groups involved in a major conflict—groups varying in history, power, and aspirations—a manipulation that changed people's beliefs about the malleability of groups also altered their attitudes toward each other, as well as their desire to make central compromises in the interest of peace. These findings suggest the potential value of a new approach to intervening in longstanding conflicts, and one important next step would be a longitudinal intervention investigating the lasting effects of changing people's beliefs. It would also be interesting to determine whether adding a "beliefs about groups" component to existing conflict resolution programs would boost their efficacy in both the short and long term.

Our research shows that even in the face of prolonged conflict, deeply rooted beliefs may be malleable, and mechanisms may exist for bringing more constructive attitudes to the fore. In thinking that groups have the potential to become better, adversaries may be more likely to bypass fixed, global, negative judgments (12)—judgments that delegitimize or dehumanize each other (13)—even when they have a long history of mutual animosity.

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