Conformity and Group Adaptability

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Abstract

This research provides evidence regarding the causal effect of group conformity on performance in stable and variable environments. Drawing on studies in cultural evolution, social learning, and social psychology, we experimentally tested the hypotheses that conformity improves group performance in a stable environment (H1), and decreases performance (by hindering adaptability) in a temporally variable environment (H2). We compared the performance of individuals, low-conformity (LC) groups, and high-conformity (HC) groups, within a four-arm randomized lab experiment (N = 240). The two group conditions were based on a novel treatment of group conformity applied in the HC condition. The findings support H2, that conformity reduces performance in a temporally variable environment. Although HC groups performed better than LC groups in the stable condition, the results did not provide statistically significant support for H1, that conformity increases group performance in stable conditions. Intra-group individual-level analyses provide insights into the mechanisms that account for the group-level results, indicating that lower conformity in groups facilitates efficient adaptability in the use of social information.

Keywords: conformity, cultural evolution, experience-based decision-making, adaptability

# Introduction

What is the causal effect of conformity on performance and adaptability of groups? Despite the huge number of studies devoted to conformity since Asch’s (1955) seminal work, its consequences for group performance are still contested (Kendel et al. 2018; Morgan and Laland 2012). Cultural evolution models suggest that the relationship between conformity and group performance varies between temporally stable and variable environments. Spatial variation and temporal stability of the environment promote conformity, while a temporally variable environment hinders it (Hoppitt, Kandler, Kendal, Laland, 2010; Nakahashi, Wakano, and Henrich, 2012).

Despite the centrality of this theory, existing empirical studies provide only tentative and partial support for its key propositions. Theoretically informed cultural evolution studies have advanced the conceptual understanding and empirical measurement of conformity (Boyd and Richerson 1998; Richerson and Boyd 2008). Building on these insights, other empirical studies suggest that conformity is an effective strategy in stable environments (Efferson et al. 2008; Morgan et al. 2012). The hypothesized ill-adaptive role of conformity in temporally variable environments is a key feature of some historical cases, e.g., the Pearl Harbor attack that inspired groupthink theory (Janis, 1972). However, these studies cannot directly assess causal relationships between conformity and group performance and adaptability, as they offer only correlational and qualitative historical evidence. To the best of our knowledge, no previous studies in this field have experimentally addressed group conformity.

Addressing the relative effectiveness of individual and group decisions, Lejarraga et al. (2014) presented an elegant experimental study that focused on simple decisions made during an experience task performed in a dynamic setting. Their results reveal that groups were more effective in identifying the best strategy in the stable stage of each task, but slower to adapt to changes. Lejarraga et al. (2014) attributed these findings to the superior memory of groups compared to individuals, a quality that benefits performance in a stable environment, but renders groups less adaptive to changes. We suggest that it is possible that group conformity may help explain their findings.

The current study expands upon the work of Lejarraga et al. (2014) by explicitly comparing two potential explanations for the performance of groups in stable and variable environments: memory and conformity. For this purpose, we conducted a four-arm randomized lab experiment (N = 240) that examined variants of the Lejarraga et al. (2014) study, with four conditions: Individual, Low-Conformity (LC) Group, High-Conformity (HC) Group, and Memory-Assisted Individual. All participants played a computer game consisting of 100 sequential choices between two alternatives, presented as two unlabeled buttons on a computer screen. Unknown to participants, the game included two stages. In stage one (the first 60 rounds), one option emerged as dominant. In the second stage (the last 40 rounds), the other option became dominant. Participants in the individual conditions received a monetary payoff based on their personal performance, and those in the group conditions received rewards based on their group’s performance. Group conformity was treated in the HC condition by partially deducting the payoff to group members who expressed the minority opinion, and distributing the deducted sum among members who expressed the majority opinion.

The experimental design controlled for asocial information that subjects process together with social information when arriving at their decisions (Morgan and Laland, 2012: 3). This enabled us to verify that the treatment indeed enhanced the impact of the majority opinion (social information), independently from the payoff (asocial information).

HC groups performed better than individuals and LC groups in the stable stage of the game, but only the latter difference is statistically significant. Thus, our findings do not support H1, that conformity increases group performance in stable conditions. Rather, the results suggest that the differences between groups and individuals in a stable environment found by Lejarraga et al. (2014) are partially attributable to group conformity. Our findings provide support for H2, that conformity decreases group performance in a temporally variable environment. No support was found for the claim that the superior memory of groups impedes their performance in such an environment.

Intra-group, individual-level analyses provided additional insights into the mechanisms that account for the group-level results. In the altered environment, social information became less influential among LC group members, while it retains a strong impact on HC group members. These results imply that LC within groups facilitates greater adaptability in the use of social information. When social information is useful (in a stable environment) LC groups attribute similar (although slightly lower) weight to social information as do HC groups. However, faced with indications of a change in the environment, LC group members tend to reduce the weight they allot to social information, whereas HC groups retain the same level of decision weight to this information, despite the poor quality of the information.

# Conformity and adaptability

Asch (1955) defined conformity as deference to one’s group norm in the hope of receiving social approval. This social phenomenon has been found in numerous studies conducted across various cultures and sociodemographic conditions (for a review, see Morgan and Laland 2012). Most studies in social psychology have concentrated on conformity as the dependent variable, namely addressing the many conditions that shape it. In contrast, the current research centers on the causal effect of conformity on groups’ performance and adaptability.

Important contributions to this issue come from theoretical studies in evolutionary biology on culture and the social transmission of information. Conformity in this field is defined based on an observable pattern of behavior, namely, as a disproportionate propensity to adopt the majority opinion (Boyd and Richerson 1998; Richerson and Boyd 2008), which leads to consensual group behavior. Formal models in this field suggest that in a spatially variable environment with migration between subpopulations, conformity in adopting the locally adaptive behavior is an effective strategy (Boyd and Richerson 1988; Henrich and Boyd 1998; Nakahashi et al. 2012). Some experimental findings suggest that conformity is indeed an effective strategy for social learners in stable environments (Efferson et al. 2008, Morgan et al. 2012).[[3]](#footnote-3) However, a temporally variable environment predicts selection against conformity (Feldman et al. 1996, Hoppitt et al. 2010; Nakahashi et al. 2012). The extent to which conformity is considered adaptive is therefore subject to controversy (Morgan and Laland 2012; Kendel et al. 2018).

Another contribution of cultural evolution theory pertains to several important considerations in designing experimental studies of conformity. First, not all forms of social learning constitute conformity. Social learning is defined as the acquisition of behavior by observation of, or interaction with, other individuals (Alpin et al. 2017; Rendell et al. 2011). In contrast, asocial learning is based on personal experience (or trial and error). Conformity is an outcome of social learning that leads to the homogenization of group behavior through disproportionate adoption of popular traits (Efferson et al. 2008). Second, the use of social information increases as asocial information becomes more costly and the task more difficult (Morgan et al. 2012). Therefore, conformity is only expected in cases where a group member is unaware of how to cope with the task. Third, in order to distinguish between the effects of asocial and social information, the former must be controlled for (Morgan and Laland 2012).

Drawing on these studies, we suggest that conformity improves group performance in a stable environment (H1), and decreases performance in a temporally variable environment (H2). Specifically, our second hypothesis suggests that conformity reduces group adaptability. In the following we report on the experimental study conducted to test these hypotheses.

Additional indirect and tentative support for our hypotheses may be drawn from the findings of Lejarraga et al. (2014) whose study compared the performance of groups and individuals in decisions based on experience (Erev and Roth 2014; Hertwig et al. 2004) in stable and variable environments. In each trial, participants were asked to choose between two payoff distributions and received immediate feedback concerning the obtained and foregone payoffs. Each participant undertook six games, with 100 trials each. Games were performed under one of two conditions: individual or group. In the group condition, the participants sat in a triad in front a single computer screen, and had to reach a decision together. In line with previous findings, groups performed better, on average, than did individuals, under stable conditions. However, group performance was relatively slower to recover from a change in the environment in which decisions were made. Lejarraga et al. explained these findings by alluding to the superior memory of groups compared to individuals, a quality which renders groups less adaptive.

We posit that the experimental setting of Lejarraga et al. (2014) does not exclude the possibility that these results may be explained, alternatively, by the mechanism of conformity – a potential quality of groups but not of individuals. Individuals operated their own computer, while the groups of three sat together and jointly operated a single computer. The processes that led to the decisions within each group were not gauged or recorded. We therefore propose that conformity, rather than group memory, accounts for the results. Specifically, conformity provided an advantage to groups (over individuals) in the stable stage of the game, and undermined group’s adaptability after the change in the game.

In order to test our hypotheses, we utilized one of the experience-based decision tasks used by Rakow and Miler (2009) and Lejarraga et al. (2014). However, in order to obtain better control over group dynamics, and the causal processes involved our experimental design deviates from the designs of these previous studies. Notably, we employed a four-arm experimental design, with individuals, LC groups, HC groups, and memory-assisted individuals. Planned comparisons across the two group conditions were intended to test our hypotheses. The individual condition facilitated a comparison of our results with those of Lejarraga et al. (2014). The fourth condition (memory-assisted individual) allowed us to directly assess the role of memory, as suggested by Lejarraga et al. (2014).

# Experimental design

Two hundred and forty graduate students from [*an anonymized university*] participated in the study. Participants were randomly assigned to either the individual condition (n = 30), low-conformity (LC) group condition (n = 90, ngroups = 30), high-conformity (HC) group condition (n = 90, ngroups = 30), and memory-assisted individuals (n = 30). All the participants took part in a clicking paradigm experience-based decision task (Erev and Haruvy 2015; Erev and Roth 2014;) with 100 rounds. The specific task was based on game 5 in Lejarraga et al. (2014). In each round, participants clicked one of two buttons and received feedback consisting of their actually obtained payoff (from selecting the correct button) and the preset payoff that they would have received had they selected the other button. In all rounds, one button had a higher expected value than the other, and the aim was to maximize the number of points obtained over the 100 rounds of the game.

The temporal change in the environment was simulated by implementing two stages in the clicking task, as described in Figure 1. In the first 60 rounds of the game, one button dominated the other (“stable environment”) and in rounds 61–100, the relationship between the two options was reversed (“altered environment”). Specifically, in the stable environment, the two keys were randomly assigned to two prospects: 7 with p = 0.9 and -5 otherwise (EV = 5.8), and 7 with p = 0.7 and -5 otherwise (EV = 3.4). After 60 rounds, the probability of gaining 7 by choosing the dominant key dropped to 0.5 (EV = 1). Thus, its expected value in rounds 61–100 was lower than the alternative key, which became dominant in this stage. In the stable environment, participants were able to learn which of the two keys obtained a higher payoff on average (expected value). However, the reduction in the expected utility of the dominant option key from round 61 onward rendered this learned information obsolete, requiring participants to identify the change, learn, and adapt in order to maximize their payoff.

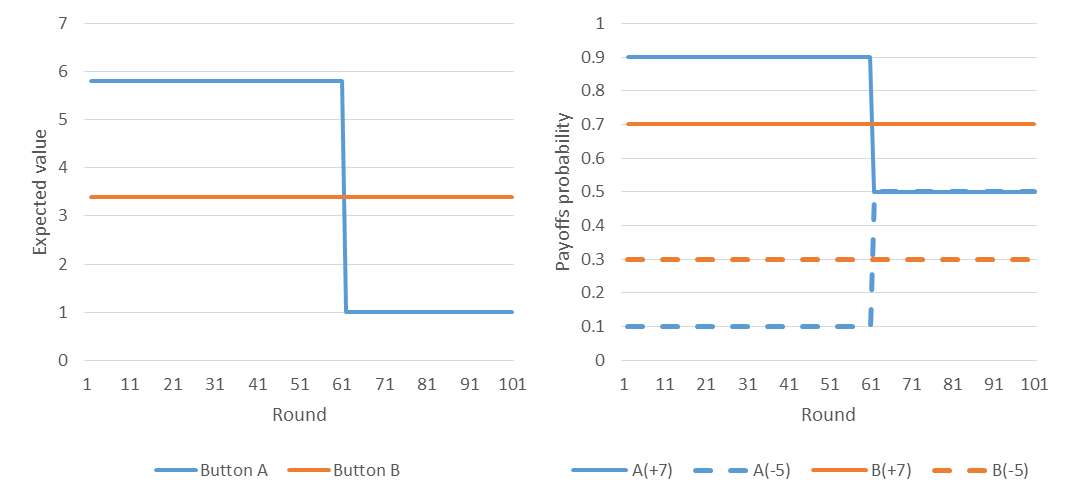


Figure 1: The experience-based task. The left panel presents the expected value of the two buttons throughout the game. Up to round 60 the higher paying button is A (blue), whereas from round 61 onward, the dominant button is B (orange). The right panel presents the probability of obtaining a positive (+7; solid lines) and a negative (-5; dashed lines) payoff in each of the two buttons across the 100 rounds.

**Procedure**

Participants assigned to the individual condition were provided with asocial information only – their payoff for each decision round. In the two group conditions, participants were provided with both asocial information (decision payoff) and social information – whether their individual choice was a minority opinion or aligned with the majority in each round. They inferred this information from the mismatch or match between their individual choice and the group choice, respectively.

In the individual condition, participants performed the experiment on their own computer terminal. They were given the following written instructions:

You will play a game of 100 rounds. In each round, you will be asked to choose one of two money machines. When you click on the machine, you will win or lose points. Your payoff at each round will be determined by your choice and to the probability of winning that may change during the game. At the end of each round, you will see your payoff and the foregone payoff had you chosen the other machine. If you have any question, please ask the experimenter. Please press start when you are ready.

In the two group conditions, we deviated from the design of Lejarraga et al. (2014), in which group participants sat together by a single computer terminal and only their collective choice in each round was recorded. To gain better control over intra-group mechanisms, specifically, the social information obtained by each group member in each round, each group member sat individually by their own computer terminal, and interacted with the two other group members only via the game interface. In each round, every participant was asked to make a choice and then wait for the other players’ choices. After all group members had completed their choices, each participant was informed of the group decision (based on majority rule) and their payoff given this choice. The software recorded the decisions made by individual group members and the group decisions. Participants were also informed of the foregone payoff each player would have received had the group chosen the other key.

The following instructions were given to participants in the LC group condition:

You are a part of a group of three players. You will play a game of 100 rounds. In each round, you will be asked to choose one of two money machines. When you click on the machine, you will win or lose points. Your payoff at each round will be determined according to your choice and the other players’ choices and to the probability of winning that may be changed during the game. At the end of each round, you will see your payoff and the foregone payoff had the group chosen the other machine. If you have any question, please ask the experimenter. Please press start when you are ready.

In the HC group condition, the procedure and the instructions were identical to the LC group condition, with one difference: the payoff for each player was affected by whether their individual choice aligned with the majority choice. In the case of a minority opinion, two points were deducted from the dissenting participant’s payoff, while each participant agreeing with the majority opinion received 1 additional point. This payoff structure kept the collective HC group payoff the same as in the LC group condition, and the differences pertain to its distribution among group members. Importantly, the payoff in the HC condition structure reproduced the social costs and benefits of dissenting and conforming, respectively, and contrasted with the socially-neutral payoff of the LC condition. In the terms of classic social influence theory (Deutsch and Gerard 1955) the HC group payoff treated the normative motivation, in comparison to the LC group payoff, while holding informational motivation constant. This novel treatment of conformity was structured so that the rational choice in both group conditions was to opt for the correct button, regardless of a minority position.

Additionally, we empirically assessed whether the treatment affected the individual-level propensity to adopt the majority choice, as opposed to the monetary payoff. Finally, to assess the efficacy of the conformity treatment at the group-level, we estimated the propensity for minority opinions within group decisions across the two group conditions. These analyses are reported in the Results section.

This design addresses the critique of the social psychological literature on conformity presented in Morgan and Laland (2012: p. 3). First, given that conformity leads to the homogenization of group behavior, we evaluated the efficacy of our conformity treatment by comparing the proportion of minority decisions [i.e., ]. Second, participants were naïve regarding the task, and received both social (majority/minority opinion) and asocial (noisy payoff) information, which are recorded for each group decision (participants in the individual condition received only asocial information). Third, our design created an equally difficult task in these three conditions, thus creating the same propensity to rely on social information in the two group conditions (see Kendal et al. 2018: 652–653).

The two group conditions provided the comparisons required to test our hypotheses in both the stable and variable stages of the game. The individual condition was added in order to provide an additional performance benchmark and to facilitate a comparison to the results of Lejarraga et al. (2014).

To address the alternative claim made by Lejarraga et al. (2014), according to which the differences found between individuals and groups resulted from the enhanced memory of groups, we included a fourth condition – “memory-assisted individual.” In this condition, participants played the same game as in the individual condition, with one difference: the results of all the previous trials were shown in two lists on the screen. Each list included the payoffs received when choosing each button, providing participants with a “perfect memory” of the payoff history.

The instructions given to participants in all the conditions informed them that a change in the probability of gaining the positive payoff was possible, but did not indicate how prevalent the change would be, nor when in the sequence of trials it would occur. Our goal was that participants would not assume a stable environment. In all three conditions, payoffs in points were converted to monetary sums. In the group conditions, all three members received full compensation; thus group members had the same economic incentives as individual participants. The mean total individual compensation was equivalent to US$ 9.7.

## Statistical analysis

To identify the effect of conformity on performance in a temporally variable environment, we estimated the interaction effect of change and conformity on performance. Equation 1 presents this relationship as follows:

(1)

where is a binomial variable that represents a choice of the higher expected value option (Maximization) [] or not [], by group or individual in round , conditional on game round (1-100), the stage of the game [stable (1-60) or altered (61-100)], and experimental condition (individual, LC group or HC group). The two coefficients of interest are and , which represent the difference in performance between HC and LC groups in the stable stage (rounds 1–60), and the difference in the effect of change on performance between HC groups and LC groups (the latter being the reference condition), respectively. Given that choices are clustered within groups/individuals, Equation 1 was estimated using generalized estimating equations (GEE) (Liang and Zeger 1986) with a logit-link function, and standard errors were clustered within groups. Statistical analyses were performed using the Stata 17 software.[[4]](#footnote-4)

# Results

## Assessing the validity and efficacy of the conformity treatment

We began by assessing the validity and efficacy of our conformity treatment – that is, the propensity to adopt the majority choice – rather than simply a response to the monetary payoff. Since this treatment operated at the individual level (group payoff structure was the same for the two group conditions), we estimated the joint effects of payoff (asocial information) and of being in a minority opinion (social information) on group members’ subsequent choices – specifically, the propensity to change their most recent choice. Table A1 presents this analysis in the appendix. The results show that the two sources of information influenced choices in the expected way, namely that the payoff negatively affected the propensity to change one’s subsequent choices, and holding a minority opinion positively affected the propensity to change subsequent choices. However, while the effects of asocial information in the two conditions were similar in size, the effect of social information was stronger among group members in the HC condition, controlling for asocial information. These results attest to the validity of the conformity treatment, as it increased the effect of majority opinion on participants’ choices, independently from the effect of the payoff.

Additionally, to assess the efficacy of the conformity treatment at the group-level, we compared the propensity for minority opinions within group decisions in the LC group and HC group conditions. The proportion of group decisions involving minority opinions was overall higher among the LC group condition (61.5%) compared to the HC group condition (37.72%; N = 8980; Χ2 = 2600; p < .001). Moreover, in line with the definition of conformity, decisions in the HC condition group grew increasingly homogeneous, as reflected by the decreasing proportion of minority opinions (see Figure A1 in the appendix).

## Descriptive results

Figure 2 presents the probability of choosing the maximizing option across individuals (blue), LC groups (red) and HC groups (green) over the course of 100 rounds. It is apparent that in the initial stage of the game, participants in both group conditions were quicker to identify the maximizing choice. HC groups continued to improve in making the correct choices, beyond the level of individuals and LC groups. However, after round 60, this pattern reversed, and HC groups were slowest to adapt to the change in the game. In fact, even at the 100th round (40 rounds after the change) they reached only about a 50% probability of correct choices.



Figure 2: Rolling probability of choosing the maximizing choice before and after the change (round=61) and across conditions (blue=individual; red=LC group; green=HC group). The vertical dashed red line indicates the point of change in the game.

Table 1 presents the average probabilities of a maximizing choice in the stable stage (rounds 1–60) and altered stage (61–100) of the game. While HC groups obtained the highest average probability of correct choices in the stable stage (0.79), their performance was the lowest of all four conditions in the altered stage (0.37). Notably, the change in the parameters of the game resulted in a decline in the performance of both individuals and groups across conditions, with the largest decline evident in the performance of the HC groups.

Table 1: Average probabilities of correct choice

|  |  |  |  |
| --- | --- | --- | --- |
| *Condition* | *Average maximizing choice* | *Average maximizing choice* | *Difference* |
| Individual | 0.627 | 0.543 | -0.09 |
| LC group | 0.694 | 0.535 | -0.16 |
| HC group | 0.792 | 0.372 | -0.42 |
| Memory-assist. Individual | 0.701 | 0.598 | -0.10 |
|  |  |  |  |
| *Χ2* | 118.83 | 134.89 |  |
| p-value | < 0.001 | < 0.001 |  |

## Results of Generalized Estimating Equation Analyses

To formally estimate the varying effect of a change of environment on performance across group conformity levels, we conducted a set of Generalized Estimating Equation (GEE) analyses, reported in Table 2. The dependent variable in all models is a binomial variable that takes the value 1 if the dominant option was chosen (maximizing choice), and zero otherwise. Model 1 is a simple preliminary model that estimates the overall effects of the change in the game and the number of rounds played. The effect of the number of rounds played was positive and statistically significant, providing support for a learning process. The effect of the change in the game was negative and statistically significant, reflecting a sharp decrease in performance after the change.

Models 2–4 fit Equation 1 to the data, including the stable stage and the full rounds 20, 30, and 40 following the change, respectively. These separate analyses enabled us to address the fact that as time elapsed after the change, the game reverted to a new stable state. The coefficients of the interaction between change and conformity level are presented first (in bold). All three estimates were negative and statistically significant, suggesting that the negative effect of change on performance was greater for HC groups, compared to LC groups (the reference category). In contrast, the coefficients of the interaction between individuals and LC group (Change × Individual) were small and statistically insignificant, suggesting that the effect of change on the performance of individuals and LC groups was not significantly different.

Note that the GEE results indicate no significant differences between the performance of LC and HC groups in the stable stage of the game (rounds 1–61), given the insignificant coefficients of individual and HC group conditions. These results do not provide support for H1. Replacing the reference group with “individual” permits a comparison of HC and individuals in the stable and altered stages, as shown in Table A2 in the appendix. This analysis shows that HC groups performed better than individuals in the stable stage (*p* = 0.013) and worse in the altered stage (*p* = .005). These results seem to replicate those of Lejarraga et al. (2014). However, our findings suggest that the different performance levels of individuals and groups in stable and variable environments should be attributed to group conformity, since such differences were not found when comparing individuals to LC groups. Moreover, as seen in Table A2, there were no significant differences between individuals and memory-assisted individuals. Thus, there was no support for the proposition that enhanced memory accounts for the different performance levels of individuals and groups in stable and variable environments.[[5]](#footnote-5)

Table 2: Generalized Estimation Equation (GEE) estimation of group performance.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Model 1 | | Model 2 | | Model 3 | | Model 4 | |
| *Variables* | *Learning & change* | | *Conformity & change (1-80)* | | *Conformity & change (1-90)* | | *Conformity & change (1-100)* | |
|  |  | |  | |  | |  | |
| **Change x HC group** | |  | | **-1.344\*** | | **-1.321\*** | | **-1.199\*** |
|  | |  | | **(0.628)** | | **(0.603)** | | **(0.599)** |
| Change x Individual | |  | | 0.234 | | 0.287 | | 0.343 |
|  | |  | | (0.579) | | (0.556) | | (0.547) |
| Change | | -1.984\*\*\* | | -1.697\*\*\* | | -1.699\*\*\* | | -1.752\*\*\* |
|  | | (0.324) | | (0.506) | | (0.495) | | (0.489) |
| Round | | 0.021\*\*\* | | 0.020\*\*\* | | 0.021\*\*\* | | 0.021\*\*\* |
|  | | (0.003) | | (0.003) | | (0.003) | | (0.003) |
| Individual | |  | | -0.308 | | -0.309 | | -0.309 |
|  | |  | | (0.349) | | (0.350) | | (0.350) |
| HC group | |  | | 0.528 | | 0.529 | | 0.529 |
|  | |  | | (0.363) | | (0.364) | | (0.364) |
| Constant | | 0.265\* | | 0.243 | | 0.206 | | 0.203 |
|  | | (0.123) | | (0.253) | | (0.249) | | (0.250) |
|  |  | |  | |  | |  | |
| Observations | 8,980 | | 7,200 | | 8,091 | | 8,980 | |
| Number of groups | 90 | | 90 | | 90 | | 90 | |

Coefficients represent logit estimates. Group clustered standard errors in parentheses; \*\*\* p<0.001, \*\* p<0.01, \* p<0.05.

Figure 3 graphically presents the GEE estimates of performance over each set of 10 rounds and across conditions. Point estimates are accompanied by 1 SE confidence interval. The performance of HC groups was higher than that of LC groups and individuals, but only the latter differences are statistically insignificant. However, the decline in performance due to the change in the game was more pronounced in the case of HC groups for each of the three sets of 10 rounds after the change. Only in the final 10 rounds of the game did this difference diminish to a statistically insignificant level. Note that individuals and LC groups similarly adapted to the altered environment. A similar graph that also includes the memory-assisted individual condition is shown in Figure A2 in the appendix.



Figure 3: Predicted performance across conditions throughout the game. GEE estimates for 10 sets of 10 rounds (CI = 1SE). Significance levels refer to the diff-in-diff in the effect of change on HC group and LC group. In each of the four post-change 10-round stages (performance in the last 10 rounds before change (51–60) as reference).

## Individual Level, Within-Group Mechanism

In order to obtain a better understanding of the group-level results, we conducted a set of individual-level within-group analyses. This was done to estimate the role of social information (expressing the minority opinion) in determining the decisions of group members – namely, whether they changed their choice in the subsequent round. Following Morgan and Laland (2012), the analysis also included asocial information (the payoff received) in the respective round. These analyses estimate the effect of the two types of information on the propensity that a group member would change her/his choice, with respect to the choice in the previous round.

Table 3 presents GEE estimations of the propensity to change one’s subsequent choice. Model 5 includes decisions in the stable stage of the game (rounds 1–60). The results show that both social and asocial information predicted the likelihood of an individual’s subsequent choice. Holding a minority opinion increased the likelihood of changing one’s subsequent choices, and receiving a positive payoff decreased this likelihood. At this stage of the game, social information was more influential in the HC group condition, but this difference was statistically insignificant (*p* = .119), as reflected by the coefficient for the Social info. × HC group interaction. However, after the change in the game, social information became less influential on group members’ decisions in the LC group (and statistically insignificant). Its influence increased in the HC group, and this difference between the two group conditions was statistically significant (*p* < .001). Note that the effect of asocial information was stable across the stages of the game and across group conditions (as shown in Figure 4).

Table 3: GEE estimation of group members’ choice change.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Model 5 | | Model 6 | |
| *Variables* | *Stable stage* | | *After change* | |
|  |  | |  | |
| Social info. (minority opinion) | | 0.680\*\* | | 0.324 |
|  | | (0.226) | | (0.178) |
| Asocial info. (positive payoff) | | -0.693\*\*\* | | -0.625\*\*\* |
|  | | (0.134) | | (0.122) |
| HC group | | -0.188 | | -0.494 |
|  | | (0.314) | | (0.261) |
| Social info. × HC Group | | 0.663 | | 1.220\*\*\* |
|  | | (0.426) | | (0.343) |
| Round | | -0.00535\* | | -0.000177 |
|  | | (0.00250) | | (0.00327) |
| Constant | | -0.596\*\*\* | | -0.724\* |
|  | | (0.160) | | (0.313) |
|  | |  | |  |
| Observations | | 10,502 | | 7,097 |

Coefficients represent logit estimates. Group clustered standard errors in parentheses; \*\*\* p < 0.001, \*\* p < 0.01, \* p < 0.05.

Figure 4 graphically presents these results, while adding estimates for the effects of asocial information in the individual condition, for reference. The upper-left and upper-right panels present the effects of social and asocial information at the early (rounds 1–20) and late (21–60) rounds of the stable stage of the game, respectively. Both sources of information were predictive of the players’ choices. Asocial information (positive payoff) was predictive of a reduce propensity to change one’s choice in the subsequent round, and social information (holding a minority opinion) was predictive of an increased propensity to change one’s subsequent choice. Note that the effects of asocial information were similar in the three experimental conditions, throughout the game. However, social information played a different role in the two group conditions. In the stable part of the game, social information appeared to be more influential in the HC condition, yet this difference was not statistically significant. However, after the change in the game was implemented (round > 60) the effect of social information within LC groups slightly diminished (and became statistically insignificant), while it retained its effect within HC groups, resulting in a significant difference in the effect of social information between the two group conditions.



Figure 4: The propensity of a player to change her/his choice in the subsequent round, given the asocial (receiving a positive payoff) and social (expressing a minority opinion) information in the current round, across experimental conditions and stages of the game. Estimates represent logit coefficients with 95% CIs.

These findings provide an individual-level account for the varying group-level adaptability under conditions of high- and low-conformity. Whereas asocial information in our setting was a noisy yet unbiased signal that facilitated learning and adaptation, social information was based on accumulated learning, and therefore reflected collective, lagged, asocial-based knowledge. Once players had a chance to experience the game and learned to evaluate the options, social information became beneficial, as the majority was less likely to err. However, this advantage of social information became a drawback in an altered environment, where lagged information was rendered obsolete. This can be empirically demonstrated by the estimated likelihood that a minority opinion would be correct (a maximizing choice) over the course of the two stages of the game, as shown in Figure A2 in the appendix. In the stable stage, as the game proceeded, the players gained experience, and the probability that a minority opinion was correct became significantly lower than 0.5; thus, the majority was more likely to be correct. However, immediately following the change in the game, a minority opinion was more than 60% likely to be correct, since the majority opinion reflected the outdated knowledge of the environment, and thus at that stage, social information was non-adaptive.

Given this varying utility of social information across stable and altered environments, the finding that social information became less influential among members of LC groups when the environment changes, while it retained its influence among members of HC groups (bottom panels of Figure 4), accounts for the reduced adaptability of HC groups.

# Discussion

This research provides evidence regarding the causal effect of group conformity on performance in stable and variable environments. Drawing on studies in evolutionary biology on culture and the social transmission of information (Boyd and Richerson 1988; Henrich and Boyd 1998; Kendel et al. 2018; Nakahashi et al. 2012) we experimentally tested the hypotheses that conformity improves group performance in a stable environment, and decreases performance (adaptability) in a temporally variant environment.

Our experimental design built on the experimental designs of Rakow and Miler (2009) and Lejarraga et al. (2014), and expanded upon their studies by introducing a conformity treatment that increased the cost of dissenting (randomly assigned to only half of the groups, that is, HC but not LC), and by fully controlling and recording intra-group choices and interactions. In line with Morgan and Laland (2012), we assessed the efficacy of the conformity treatment by comparing the proportion of minority decisions; assigning participants to an experience-based decision making task of which they were unaware; and exposing them to both social and asocial information, which were recorded for each group and individual decision. Lastly, the equal difficulty of the task across experimental conditions created an equal baseline propensity to rely on social information in the two group conditions.

The results do not provide support for the hypothesis that conformity increases group performance in stable conditions (H1). It should be noted that HC groups did perform better in the stable stage, but the current analysis does not permit rejecting the null (*p* = 0.146). Our findings provide support for the hypothesis that conformity negatively affects group performance in a temporally variable environment (H2). This statistically significant result was retained for ~30 rounds following the change in the environment, before diminishing in the final 10 rounds, as the game effectively reverted to a new stable environment.

Individual-level analyses within groups provided further insights into the mechanisms that account for the group-level results. In a stable environment, both asocial information (payoff) and social information (minority/majority opinion) appear to influence behavior. Notably, both appear to exert a similar influence on the choices of individuals in the two group conditions. Social information was more influential on members of HC groups, but this difference was statistically insignificant at this stage of the game (*p* = .197).

However, in the altered environment, social information became less influential among LC group members, while it retained a strong impact on HC group members. This difference likely accounts for the reduced adaptability of HC groups. Asocial information in our setting was a noisy yet unbiased signal that equally facilitates learning in both stable and temporally variable environments. Social information integrates noisy asocial information, and therefore reflects collective, lagged, asocial-based knowledge. Given the opportunity to experience a stable environment over time, social information thus becomes increasingly beneficial, as the majority is less likely to err compared with individuals. Yet, as our empirical results show, in this particular case, the cumulative and lagged quality of the social information became a drawback in the altered environment. Therefore, the minority opinion enjoyed a greater likelihood of being correct than the majority – limiting the adaptability of the social information.

Specifically, the individual-level analyses suggest that low conformity within groups facilitated greater adaptability in the use of social information. When social information was useful (in a stable environment) LC groups allotted similar (although slightly lower) weight to social information as did the HC groups. However, when faced with indications of a change in the environment, LC group members tended to allocate less weight to social information, whereas HC groups retained the same level of weight to this information when making a decision.

To the best of our knowledge, these findings are the first to provide human behavioral evidence for the causal effect of conformity on the performance and adaptability of groups. These findings support evolutionary models of social transmission of information (Boyd and Richerson 1988; Henrich and Boyd 1998; Nakahashi et al. 2012), particularly the claim regarding the limited adaptability of conformity in a temporally variable environment, thus contributing to the debate over the adaptability of conformity (Morgan and Laland 2012; Kendal et al. 2018).

The results of this research correspond to the findings of Lejarraga et al. (2014), but demonstrate that the different patterns of performance of individuals and groups in stable and temporally variable environments are the result of group conformity rather than memory. HC groups performed better than individuals in stable environments, but relatively worse than individuals after the change in the game. However, these differences were not found when comparing individuals to LC groups – especially in the altered game, in which the performance of individuals and LC groups was roughly identical. Additionally, these differences were not found when comparing the performance of individuals with and without the memory-assisted feature.

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**Appendix**

To assess the validity of the conformity treatment, the following analysis estimates the propensity of group members to change their choice, given their asocial (payoff) and social (minority opinion) information from the previous round. Importantly, this analysis was intended to assess whether social information is more influential in the HC condition, controlling for asocial information. Model 1 and 2 present the effects of the two sources of information on group members in the LC and HC conditions, respectively. It is evident that the two sources of information influenced choices in the expected way, as payoff negatively affected the propensity to change one’s choice, and being in a minority opinion positively affected this propensity. However, while the effects of asocial information in the two conditions were similar in size, the effects of social information were stronger among group members in the HC condition.

Model 3 provides formal comparisons of the effects of asocial and social information in the two conditions by including observations from the two conditions and estimating the interactions between each of the information sources and experimental condition (HC). These results show that the difference in the effects of asocial information in the two conditions was not statistically significant (*p* = .558), while the difference in the effects of social information is (*p* = .029).

Table A1: Generalized estimation equation (GEE) of individuals’ change of choice.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Model 1:  *Low-conformity condition* | Model 2:  *High-conformity condition* | Model 3:  *Joint analysis* |
|  |  |  |  |
| Lagged asocial info. (payoff) | -.045 (.012)\*\*\* | -.063 (.016)\*\*\* | -.047 (.012)\*\*\* |
| **Lagged social info. (minority opinion)** | **.535 (.178)\*\*** | **1.292 (.305)\*\*\*** | .535 (.177)\*\* |
| Lagged asocial info. × HC |  |  | -.011 (.019) |
| **Lagged social info. × HC** |  |  | **.769 (.352)\*** |
| HC |  |  | -.262 (.243) |
| Round | -.0002 (.001) | -.006 (.002)\* | -.003 (.001)\* |
|  |  |  |  |
| Constant | -1.057 (.152)\*\*\* | -1.026 (.208)\*\*\* | -.927 (.152)\*\*\* |
|  |  |  |  |
| Observations | 8,910 | 8,689 | 17,599 |
| Number of groups | 30 | 30 | 60 |

Coefficients represent logit estimates. Group clustered standard errors in parentheses; \*\*\* p < 0.001, \*\* p < 0.01, \* p < 0.05.

Figure A1 presents the proportion of group decisions that included minority opinions throughout the game and across the two group conditions. This probability was expected to be 0.75 under random individual choices. However, given asocial learning, this probability was considered likely to decline. While the mean proportion of minority opinions in the LC condition remained around 0.6 throughout the game, this proportion in the HC condition steadily decreased during the stable stage of the game until it reached a nadir of 0.25, just before the change in the game. This proportion rose to about 0.4 after the game change, but remained lower than in the LC condition.



Figure A1: GEE estimate of group decisions with minority opinion throughout the game and across the two group conditions (Cis = 95%). The vertical dashed red line indicates the point of change in the game.

Table A2: Generalized estimation equation (GEE) estimation of performance across all four conditions, with “individual” as the reference category.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Model 1 | | Model 2 | | Model 3 | | Model 4 | |
| *Variables* | *Learning & change* | | *Conformity & change (1*–*80)* | | *Conformity & change (1*–*90)* | | *Conformity & change (1*–*100)* | |
|  | |  | |  | |  | |  |
| Change × HC group | |  | | -1.580\*\* | | -1.609\*\* | | -1.545\*\* |
|  | |  | | (0.562) | | (0.546) | | (0.545) |
| Change × LC group | |  | | -0.235 | | -0.287 | | -0.344 |
|  | |  | | (0.579) | | (0.555) | | (0.547) |
| Change × (Individual +memory) | |  | | -0.143 | | -0.205 | | -0.121 |
|  | |  | | (0.464) | | (0.448) | | (0.435) |
| LC group | |  | | 0.309 | | 0.310 | | 0.310 |
|  | |  | | (0.349) | | (0.350) | | (0.351) |
| HC group | |  | | 0.837\* | | 0.839\* | | 0.841\* |
|  | |  | | (0.338) | | (0.339) | | (0.339) |
| Individual + memory | |  | | 0.344 | | 0.345 | | 0.346 |
|  | |  | | (0.302) | | (0.303) | | (0.303) |
| Change | | -1.930\*\*\* | | -1.490\*\*\* | | -1.436\*\*\* | | -1.470\*\*\* |
|  | | (0.266) | | (0.404) | | (0.399) | | (0.396) |
| Round | | 0.0218\*\*\* | | 0.0202\*\*\* | | 0.0214\*\*\* | | 0.0222\*\*\* |
|  | | (0.00261) | | (0.00269) | | (0.00267) | | (0.00262) |
| Constant | | 0.227\* | | -0.0836 | | -0.118 | | -0.141 |
|  | | (0.101) | | (0.213) | | (0.213) | | (0.214) |
|  | |  | |  | |  | |  |
| Observations | | 11,980 | | 9,600 | | 10,791 | | 11,980 |
| Number of groups | | 120 | | 120 | | 120 | | 120 |

Coefficients represent logit estimates. Group clustered standard errors in parentheses; \*\*\* p < 0.001, \*\* p < 0.01, \* p < 0.05.



Figure A2: Predicted performance across conditions throughout the game. GEE estimates for 10 sets of 10 rounds (CI = 1SE).



Figure A3: The probability that a minority opinion is correct (a maximizing choice) throughout the game, across the two group conditions (CI = 1SE). Estimates are based on a logit regression with group clustered SEs. The vertical dashed red line indicates the point of change in the game.

1. Technion – Israel Institute of Technology. [↑](#footnote-ref-1)
2. The Hebrew University of Jerusalem. We are grateful to Reut Blaywais, Yuval Berger, Itamar Faran, Micha Mandel, Sarah Roost, and Omer Yair for helpful suggestions and comments on previous versions of this article. [↑](#footnote-ref-2)
3. Experimental studies with human subjects that relied on these cultural evolution models have concentrated on identifying conditions that facilitate conformist behavior (Efferson et al. 2008; McElreath et al. 2005; Toelch et al. 2010, Morgan et al. 2012), which are less relevant to the current research. [↑](#footnote-ref-3)
4. The main question addressed in this study pertains to the role of conformity in the performance and adaptability of groups. Thus most of the analyses presented here focus on this issue, and in some places the memory-assisted individual condition is excluded, for purposes of clarity. The memory-assisted condition was included in order to address an alternative explanation for the different performance of individuals and groups, and thus is of secondary importance. This condition is fully included in the analysis later in the Results section, and in the appendix. [↑](#footnote-ref-4)
5. Participants in the memory-assisted individual condition, however, generally performed better than other individuals throughout the game, in both the stable and variable stages, but this difference was not statistically significant (*p* = .114). [↑](#footnote-ref-5)