

or relatives of the altruistic performer) could maximize genetic frequencies at the group level. The reciprocal motivation and social exchange theory suggests that an altruistic performer could

Prosocial Trait

We used the Social Value Orientation Questionnaire (Van Lange et al., 1997) to measure prosocial traits. This questionnaire contains nine multiple-choice situations. In each situation, a participant needed to choose one of three options to decide the outcomes for himself/herself and for another player. The three options in each situation corresponded to three social value orientations: competitive (seeking a larger difference between one's own and other's outcomes), individualistic (seeking a larger outcome for oneself), and prosocial (seeking a larger joint outcome). If the choices of six or more out of the nine situations were consistent with one of these social value orientations, participants were classified accordingly. Otherwise, the participant was designated as unclassified.

Results and Discussion

The manipulation check of altruistic behavior was successful. Participants in the altruistic condition shared more packs of bread ($M D 3.11$, $SD D 0.98$) with the help-seeker than those in the non-altruistic condition ($M D 2.55$, $SD D 1.13$), $t(78) D 2.36$, **$p < .001$**

Method

Participants

The computation of the sample size was identical to that of Study 1, resulting in a sample size of 72. Study 3a took place in a university in Beijing, China and participants were college students recruited from the campus online forum. The final sample contained 64 participants (33 males; $M_{\text{age}} \text{ } \text{D } 22.66$ years, $SD \text{ } \text{D } 2.47$). Thirty-two participants who engaged in the altruistic task were labeled the altruistic group and the rest were labeled the non-altruistic group.

Materials and Procedure

The temperature of the experiment room was maintained constantly at 15 C. Seventy-one college students were recruited and completed a 10-min irrelevant decision-making questionnaire for a reward of 10 yuan RMB (approximately \$1.5). After participants were paid, they were invited to participate in an additional activity organized by the Student Union of the Department of Psychology, but for no extra reward. Seven participants refused to participate and were excluded from the final analysis. Thus, the final sample contained 64 participants.

The additional activity involved two tasks for children from low-income migrant workers' families. These children are usually regarded as a disadvantaged group in China. The first task was time-consuming and required considerable attention. Participants needed approximately 10 min to read and revise some educational materials for these children. The second task required participants to just complete a 1-min questionnaire about their understandings on these children. In this questionnaire, a 1-item measure of perceived social distance toward these children was presented along a 7-point scale (1 $\text{D } \textit{extremely close}$, 7 $\text{D } \textit{extremely distant}$) with some filling items. Participants could decide whether to participate in both tasks or in the second task only. Based on their decisions, participants were labeled as altruistic or non-altruistic.

Lastly, participants were asked to finish another small survey entitled "A survey on the Laboratory Environment." In the survey, participants were required to report their perception of the warmth of the experiment room on an 11-point scale (0 $\text{D } \textit{extremely cold}$, 10 $\text{D } \textit{extremely warm}$). They were also asked to estimate the room temperature in degrees Celsius. As a control, we measured the body temperature of the participants using a non-contact infrared thermometer. Finally, participants were debriefed and thanked for their participation.

Results and Discussion

As expected, participants in the altruistic group felt the room was warmer ($M \text{ } \text{D } 6.06$, $SD \text{ } \text{D } 2.18$) than those in the non-altruistic group ($M \text{ } \text{D } 4.53$, $SD \text{ } \text{D } 2.09$), $t(62) \text{ } \text{D } 2.86$, $p \text{ } \text{D } 0.006$, $d \text{ } \text{D } 0.72$. This effect remained significant when body temperature was included as a covariate, $F(1,61) \text{ } \text{D } 9.31$, $p \text{ } \text{D } 0.003$, $\eta^2 \text{ } \text{D } 0.13$. Participants in the altruistic group also reported higher estimates of the room temperature ($M \text{ } \text{D } 16.91$, $SD \text{ } \text{D } 5.21$) than those in the non-altruistic group ($M \text{ } \text{D } 12.58$, $SD \text{ } \text{D } 4.48$), $t(62) \text{ } \text{D } 3.57$, $p \text{ } \text{D } 0.001$, $d \text{ } \text{D } 0.89$. This effect also remained significant when

Method

Participants

Because Study 4 was a field study, a power of 0.8 and an effect size d of 0.5 (which was smaller than previous studies) were used to compute the expected sample size, resulting in a sample size of 102. A total of 108 people participated in this experiment (47 males; $M_{\text{age}} = 22.27$ years, $SD = 5.50$). Of these, 55 made a donation.

Materials and Procedure

Data were collected from 9:00 a.m. to 1:00 p.m. during the day. The environment temperature during the experiment ranged from -7 C to 0 C. Participants filled in a short questionnaire called "Perception of Weather Conditions in Beijing," which included items assessing warm feelings about the environment along an 11-point scale (0 = *extremely cold*, 10 = *extremely warm*) and an estimation of the environment temperature in Celsius degrees. To control for hourly temperature variations, we paired a passer-by who did not donate within 2 min after a donor completed the questionnaire.

Results and Discussion

Consistent with our prediction, results showed that the passers-by who made a donation (altruists) perceived the ambient environment as warmer ($M = 3.07$, $SD = 2.01$) than those who did not ($M = 2.40$, $SD = 1.86$). The difference was marginally significant, $t(106) = 1.81$, $p = 0.073$, $d = 0.35$. The donors also reported significantly higher temperature estimations ($M = 0.51$ C, $SD = 3.40$) compared to the non-donors ($M = -2.34$ C, $SD = 3.33$), $t(106) = 2.83$, $p = .006$, $d = 0.54$.

A META-ANALYSIS

So far, we have consistently revealed the effects of altruistic behavior on physical warmth. For further verification, we conducted a meta-analysis to test the statistical replication of the experiments. The present experiments provided a good condition for such an analysis for two reasons. First, the altruistic behaviors varied in category, including sharing food with others, charitable helping, and monetary donations. Second, both college students in China and residents in America were included in the experiments, offering a significant diversity of participant populations.

Because Study 2a did not involve grouping participants, data from all other five studies were included. We used warmth perception of the ambient environment as the main dependent variable. Using Comprehensive Meta Analysis software, we entered the means, standard deviations, and sample sizes of the altruistic group and the non-altruistic group to calculate effect sizes. As shown in **Table 1**, the combined z -value was 5.94 ($p < 0.001$), which confirmed that altruistic behaviors increased physical warmth. Moreover, the heterogeneity test showed that the q -value was 6.24 ($\beta(1) = 4.32$).

(Dunn et al., 2008), self-efficacy (Midlarsky and Kahana, 1994), and positive self-evaluation (Post, 2005). Moreover, Dawans et al. (2012) found that exposure to acute social stress could increase prosocial responses, which implied an immediate protective function of altruism in coping with acute stress. In the current research, the immediate reward was found to extend to concrete physical feelings through a psychological process.

We proposed three characteristics of the immediate reward system of altruism that were different from those of its long-term benefits. First, an immediate reward is a much more certain and spontaneous effect compared with long-term benefits. An altruistic performer may end up with no real benefits in the long run but could always obtain positive feedbacks through the immediate reward system. Second, the immediate reward could operate on the psychological or even perceptual level. Compared with the external benefits from genetic propagation and reciprocity, the internal immediate reward could serve as a direct incentive to engage in altruistic behaviors. Third, receiving an immediate reward could be a self-feedback process. For long-term benefits, altruistic performers usually need to rely on the behaviors or the survival possibilities of others. In contrast, altruistic behaviors could directly activate the performer's psychological and physical processes on the individual level. To summarize, an immediate reward from altruism could be certain, internally perceived, and self-activated, compared to long-term benefits.

The immediate reward for altruistic performers could be very valuable. The observed results of altruistic behaviors in previous research included positive emotions and positive self-cognitions, all of which were found to be positively related with people's subjective well-being (e.g., Bandura, 1986; Brunstein, 1993). A meta-analysis found that volunteers had lower risks of mortality (Jenkinson et al., 2013). In the current research, we observed a consistent and direct connection between physical warmth and altruism. Physical warmth may be an important source of psychological energy or at least a strong comfort for individuals who were exposed to a cold environment. Specifically, individuals could perceive the environment as more secure and predictable (Ijzerman et al., 2015a), and thus gain more confidence in coping with the environment. Thus, if the immediate reward from altruism could be valuable for the altruistic performers, they can be trusted because the reward would be more direct and certain.

In all, it suggests that altruism can be a valuable and direct reward. The genetic p411[0 -141(more)]TJ 0411[11.457 -11.457 Td [411[an

The interaction between physical and psychological systems

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