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More Evidence, Greater Generalization? The Relation Between the Prevalence of Observed Action and the Strength of Generalization Depends on Action Properties

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Although group members may be diverse and have their own reasons for actions, people tend to generalize the actions of known members to unknown cases from the observer's perspective. Nevertheless, it is unclear whether action generalization is entirely determined by statistical evidence or is additionally constrained by prior knowledge or beliefs toward group members' actions. Given that people specifically believe that group members pursue common action goals, we hypothesized that action generalization is constrained by this belief. Accordingly, the extent of generalizing a goal underlying action does not always increase as the prevalence of the goal increases; instead, a strict monotonicity effect is observed for the action's movement. We found that the common goal is generalized to a new group member only when all sampled group members have this target property, revealing that the relation between the prevalence of goals and the strength of their generalization violates strict monotonicity (Studies 1a and 1b). In contrast, the more group members perform the same movement, the more likely this movement is to be generalized to an unknown group member, showing monotonic generalization of movements (Studies 3a, 3b, and 3c). Importantly, these dissociative generalizations are specific to entitative social groups (Studies 2, 4, and 6) and not due to differences in experimental tasks between studies. In shared experimental paradigms, when the goal status is available, the monotonic generalization of actions is not found; however, when the goal status is unavailable and the movement is still accessed, the monotonic generalization of actions is observed (Study 5). Thus, our findings highlight that the belief that group members pursue a common goal constrains action generalization to a greater extent than statistical evidence.

Public Significance Statement

This study strongly suggests that action goals are generalized to unknown group members only when all sampled group members have a common goal, whereas the more group members perform the same movement, the more likely this movement is to be generalized to an unknown group member. Hence, generalizing goals and movements within group members are differently influenced by the prevalence of the to-be-generalized property. Our findings indicate that knowledge of social groups, that is, pursuing a common goal, is utilized to support action generalization more than statistical evidence.

Keywords: social group, goal, movement, action generalization, belief

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Humans are profoundly dependent on social groups for affiliation and collective action. This living environment may shape our cognitive capacities regarding how to process and represent social groups (Hirschfeld, 2001). From the observer's perspective, social groups can automatically activate categorical thinking and guide interpretations and expectations of the actions of novel members (Hamilton & Sherman, 1996; Macrae & Bodenhausen, 2000; Prati et al., 2021). Under this guidance, although group members may be diverse and have their own reasons for behaving, people generally believe that individuals within a social group share behavioral properties, and adults and even infants generalize the actions of known individuals in a social group to unknown members (Bodenhausen et al., 2012; Liberman et al., 2017; Petersen & Blank, 2003; Powell & Spelke, 2013).

People make inductive generalizations based on accumulated samples of evidence (Hayes et al., 2019; Tentori et al., 2016). As a form of inductive reasoning, the extent of action generalization within social groups must be determined by the statistical prevalence of relevant actions of observed group members, for example, what proportion of group members act to approach the target banana instead of the target apple. Is action generalization driven predominantly by such statistical evidence? Namely, are people more likely to generalize action properties shared by many instances than those shared by few instances (i.e., does the extent of action generalization increase with the prevalence of observed action, that is, monotonic generalization[1])? In the broad domain of inductive reasoning, beyond statistical evidence, prior knowledge or beliefs about to-be-generalized properties also play an important role in inductive generalization in the form of top-down modulation (Hayes & Heit, 2018; Rehder, 2006, 2009). With respect to observed group members' actions, the relevant to-be-generalized properties could be either superficial movements (e.g., jumping) or underlying goals (e.g., external targets; Cavallo et al., 2013; Csibra, 2008), but we have different intuitive knowledge of these properties and hold a belief about group members' action goals–pursuing a common goal–even without accumulating observations (Brewer et al., 2004; Guala, 2016; Noyes & Keil, 2020). Nevertheless, whether action generalization is determined by one's belief that group members are pursuing a common goal to a greater extent than by the statistical evidence about the prevalence of observed actions has received relatively little research attention. In this article, we examine whether the generalization of observed action goals to new group members reflects a strict monotonic generalization solely based on statistical evidence or if it is constrained by the prior belief that group members pursue a common goal.

Beliefs of Shared Goals About Social Groups

Social groups are fundamental to the lives of humans. "Real" social groups are not treated merely as sets of individuals but as unified entities. Campbell (1958) introduced the term "entitativity" or "groupness" to describe the ontological status of social groups as units of perception. This conception has generated a stream of subsequent research on the consequences of entitativity; it has been suggested that real social groups afford reasons to explain group behaviors, as they mark fundamental similarities among the members of such groups (Agadullina & Lovakov, 2018; Brewer et al., 1995; Crawford et al., 2002; Hamilton et al., 2002, 2009; Hamilton & Sherman, 1996). This knowledge supports what perceivers believe about specific social groups and endows the groups with social meaning and predictive value (Bailey et al., 2021; McGarty et al., 1995; Murphy & Medin, 1985), and this is claimed to be an early-developing feature of human social cognition (Rhodes, 2012; Rhodes & Mandalaywala, 2017).

Entitativity also concerns common goals or intentions among group members (Abelson et al., 1998; O'Laughlin & Malle, 2002; Waytz & Young, 2012). Entitative social groups can be treated as actors that aim to achieve a desired end state and are ascribed a strong sense of agency (Bloom & Veres, 1999; Cooley et al., 2017; Sheikh & Hirschfeld, 2019). Coordination to approach a common goal, rather than similarity of behavior, is the hallmark of group agency. It has been claimed that perceivers look for variations in behavior and variability among group members to diagnose underlying common goals and responsiveness to changing situations and functional needs (Brewer et al., 2004). Hence, people have prior knowledge of group members' action goals and believe that group members have shared goals, even before accumulating statistical evidence.

The belief that group members have shared goals may be grounded in that group realizing its basic function. From the functional perspective, rather than similarity, social groups are organized in response to coordination problems and function by banding together for collective action to achieve common goals, at least for task groups, for example, a group of individuals playing football. The function of a social group determines its existence and persistence, and when a social group changes its realized function/goal, the sense of its continuity is challenged (Guala, 2016). Importantly, the function offers a deeper explanation of why groups exist, and substantial deviations in function can undermine a group's nature (Noyes & Keil, 2020). For example, if group A is created to play football, but afterward, it begins to play basketball, we may think that the new group is not the original group A. Hence, social groups are believed to continuously pursue certain common goals to realize their initial functions.

In summary, action goals have a special position in reasoning about group behaviors, and people tend to believe that social groups are formed of individuals who share a common goal. In this case, this available belief may contribute to action generalization, especially for goals, showing that action generalization is not as sensitive to statistical evidence. This prediction could be tested by how actions are generalized to new group members and how this generalization occurs with both action movements and goals.

Social Groups and Action Generalization

Social groups specify boundaries for individuals and can activate categorical thinking (Bodenhausen et al., 2012; Rhodes & Baron, 2019). It has been documented that when making predictions about unknown members of social groups, people tend to generalize the actions of known members to them, showing person-to-person generalization (Duan et al., 2021; Powell & Spelke, 2013; Xu et al., 2019; Yin et al., 2022). Such action generalization was found

[1] The term "monotonic generalization" refers to the extent to which action generalization increases with the prevalence of observed action. Here, the monotonic relation involves strong or strict monotonicity (i.e., always, if $x > y$, $f(x) > f(y)$) if other conditions are not considered. When the prevalence of observed action increases, if the extent of action generalization does not always increase and instead includes plateaus or decreases, then this response is described as not following the monotonic generalization.

to be held very early in development (Powell & Spelke, 2013) and, importantly, was not observed when social group cues were removed (Xu et al., 2019).

Nevertheless, an action can be perceived and represented as having the property of superficial movements and the property of underlying goals in a hierarchical manner (Cavallo et al., 2013; Csibra, 2008). Specifically, when an agent jumped instead of moving directly to grasp an apple, jumping was the movement, and approaching/getting the apple was the goal. How are these two types of action properties generalized? Duan et al. (2021) reported that when the observed group members perform the same inefficient movements toward an external goal, the movements are more likely to be generalized to other group members, as these inefficient movements may come to represent relevant norms and rituals shared by a social group (Kapitány & Nielsen, 2015; Legare & Souza, 2012). Moreover, when both movements and goals are available, action generalization is based on common goals, instead of shallow-level movements, among group members (Yin et al., 2022). That is, an unknown group member is expected to act consistently with the behavior of the majority in accordance with their goals instead of their movements.

Taken together, both goals and movements can be generalized among group members. Namely, people generalize the action properties shared by all known instances to a new group member. Previous studies have largely focused on situations in which all known cases have the same action property as positive evidence supporting generalization (Duan et al., 2021; Powell & Spelke, 2013; Yin et al., 2022), but action properties are sometimes shared by a proportion of the instances. Given that inductive generalization is based on accumulated samples of evidence, the extent of action generalization within social groups must be determined by the statistical prevalence of relevant action properties; it is possible that action generalization is driven primarily by statistical evidence, showing monotonicity. However, we not only treat social groups as the boundary for action generalization but also hold group-related knowledge or beliefs about these groups, one of which is that group members pursue a shared goal (Brewer et al., 2004; Noyes & Keil, 2020). Whether action generalization is also constrained by group-related beliefs has received relatively little research attention. The current research examined whether action generalization is a consequence of some statistical relationship (i.e., monotonicity) or whether the top-down belief about shared goals affects generalization differently for movements versus goals.

Overview of the Current Research

The research presented here explores whether action generalization is constrained by the belief about group members sharing goals. This question is pursued by examining how generalizing various types of action properties (i.e., goal and movement; see Figure 1a) to group members is influenced by the prevalence of the to-be-generalized property. If action generalization is primarily driven by statistical evidence, the extent of action generalization will increase with the degree of accumulated evidence, resulting in monotonic generalization. Specifically, as more individuals are observed to have an action property, the generalization of this property should be more likely; conversely, as more agents are observed to not have an action property, this property should be less generalized.

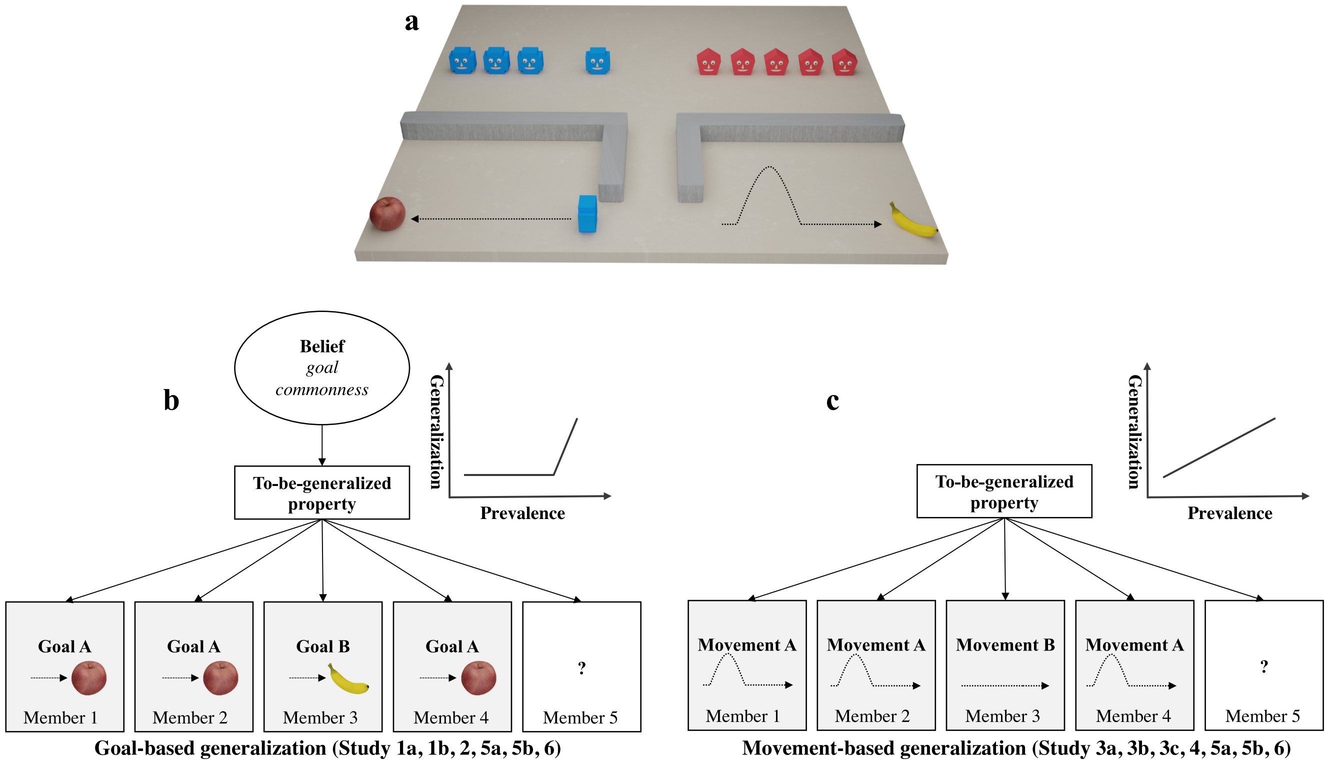
However, if action generalization is constrained by the belief about group members having a common goal, as previously suggested regarding the knowledge effect on inductive generalization (Cimpian et al., 2010; Hayes & Heit, 2018; Voorspoels et al., 2015), the standard monotonic generalization would be violated for the target property. Hence, this research investigates whether this phenomenon is present in generalizing goals to answer the question. Particularly, when all observed group members approach a common goal, this observation fits well with the belief of goal commonness, and this particular goal would be extended to other unknown group members. In contrast, when any group member deviates from pursuing a common goal, the belief of goal commonness is mismatched with the observed evidence, and accordingly, people become confused about to-be-generalized properties and are unsure which goal unknown group members will pursue. Hence, given the belief about group members sharing a goal, increasing the statistical prevalence of a goal would not always increase the extent of goal-based generalization, and only when all sampled group members act to reach a common goal should this goal be generalized (see Figure 1b). However, since no specific belief is held for movement, movement-based generalization should mainly rely on statistical evidence and still exhibit a strict monotonic relation with the prevalence of movement (see Figure 1c).

We tested these predictions in 10 studies. In Studies 1a and 1b, we examined the impact of goal prevalence on action generalization with the implicit measurement using computer-animated events and explicit measurement using realistic human-generated scenes. To further examine whether action generalization is determined by social groups, we conducted Study 2, in which we removed some social group cues (e.g., synchronized motion) but retained the same visual agents as those used in Study 1a. Since the entitative social group defines the boundaries of social categorization, when a group of individuals is loose, goal-based generalization should become weaker or even absent. Given that the group-related belief is about sharing a goal, the generalization of other action properties should show different effects; otherwise, the findings in Study 1 would not be related to this belief. Therefore, Studies 3a, 3b, and 3c sought to explore whether the influence of movement prevalence on its generalization shows a monotonic relation, which was not present in goal-based generalization. Furthermore, the group boundary of movement-based generalization was addressed in Study 4 by removing social group cues. If the influences of property prevalence on action generalization vary between goals and movements in Studies 1 and 3, these effects may be due to different experimental tasks between subjects. To further test the generalizability of the findings, Studies 5a and 5b developed a new paradigm that is able to detect goal-based and movement-based generalization effects in the same task. Following previous studies, Study 6 removed social group cues to explore the role of the social group in action generalization.

General Method

We collected implicit and explicit measurements of action generalization. Concerning the implicit measurement for goal-based generalization, we used a method similar to that of Yin et al. (2022) with computer-animated events. This method allows possible confounding factors to be strictly controlled and to effectively inspect the rules of generalizing actions (Duan et al., 2021; Powell & Spelke, 2013; Yin et al., 2022) but still induces almost the same social meanings (e.g., social group, goal-directed action) as those induced by human-

Figure 1
The Framework for How to Set Scenes and Operationalize Different Variables



Note. (a) Depicts what constitutes goals and movements. The goal was defined as approaching the external target apple or banana, and the movement was defined as how to approach the target: jumping or going straight, shown by dashed lines. (b) Shows how the group-related belief alters the influence of the statistical observation on goal-based generalization. (c) Shows how the statistical observation of movement primarily contributes to movement-based generalization. For the group member with the gray rectangle, the action has been observed and is accumulated for statistical evidence, but for the group member with the blank rectangle, the action has not been observed and must therefore be inferred, which indicates the action generalization if the prevalent action is expected for the unknown group member. In both (b) and (c), the medium prevalence is displayed. Images were created with Blender 2.81a free software. See the online article for the color version of this figure.

generated stimuli (Chaminade et al., 2007; Hamlin, 2013; Mar et al., 2007). Specifically, we presented five cartoonized agents as group members performing goal-directed actions by manipulating the statistical prevalence of approaching a common goal among two possible targets. During testing, the locations of two possible targets were swapped; therefore, the old goal had to be reached through a new movement, and the old movement would achieve a new goal. Finally, a new group member performed the same movement to achieve an inconsistent goal or a different movement to achieve a consistent goal, which was previously presented as the prevalent property before testing. Implicit generalization of action goals across social groups was measured by asking the participants to identify the new agent's movement. If the participants implicitly generalize the target property of the action goal to the new agent, the new movement to reach the old goal, instead of the old movement to reach the new goal, should be expected to be judged more rapidly than the old action to reach the new goal because the former fits well with the generalized property.

Regarding the implicit measurement of movement-based generalization, we used a measure similar to that used by Duan et al. (2021), which followed almost the same logic as measuring goal-based generalization, except some group members implemented different movements (e.g., jumping) rather than going straight to the external goal, and the participants were asked to identify a new agent's action movement. If movement-based generalization occurs, the participants should identify the consistent movement faster than the inconsistent movement, as the consistent movement fits with the participants' generalized contents.

To test the generalizability of the findings, we presented more realistic scenes in which humans exhibited group behaviors at a party and asked the participants to explicitly report which goal a new group member would pursue after watching various scenes of persons approaching goals or whether a new group member would implement the same movements presented at various prevalence rates. The realistic scenes could also overcome the limits arising from presenting overly simplified "individuals" in computer-animated scenes.

Study 1a: Goal-Based Generalization with Group Cues

This study sought to test whether goal-based generalizations from known to unknown cases are made only when all sampled group agents have a common goal. Two/three/four members of the social group performed a consistent movement directed to the same object on one side of the screen, but the other members approached another object on the other side of the screen. The movement was presented as efficiently approaching the object (i.e., moving straight to the left or right object), which has been suggested to be interpreted as indicating a goal of reaching the target object (Jara-Ettinger et al., 2016; Jastorff et al., 2011; Schachner & Carey, 2013). Hence, the goal pursued by the majority was treated as the to-be-generalized property, and the goal's prevalence was operationalized by the proportion of group members who approached the to-be-generalized goal. Goal-based generalization predicts that when an identified agent undertakes an inconsistent movement to pursue an external goal that is consistent with that of the majority, the agent's action will be identified more quickly than when the identified agent undertakes a consistent movement to pursue an external goal that is inconsistent with the prevalent goal (i.e., goal-based generalization effect). If action generalization is constrained by the belief about group members pursing a common goal, the goal-based generalization effect should be found only when a specific goal prevails in all sampled exemplars but would not show the monotonic generalization property of increasing as the prevalence increases.

Method

Participants

Twenty-eight adult volunteers (12 men and 16 women, $M_{\text{age}} =$ 18.75 years, $SE = 0.12$) were paid approximately 35 RMB each to participate in this experiment. The sample size was determined for the following reasons. Considering that the main question of interest was whether the goal-based generalization effect depends on the prevalence, we conducted a power analysis using G*Power software (Version 3.1; Faul et al., 2009) to determine the minimum required sample size to detect a significant effect assuming a conventional medium effect size of $\eta_p{}^2 = 0.06$ with three repeated measures of prevalence (an α level of 0.05 and a power of 0.80). The minimum sample size was determined to be 28. Correll et al. (2020) pointed out that the conventional value is arbitrary based on nonscientific criteria. Hence, we conducted a pilot study that was similar to the current one, except for the order in which the exemplars were presented (please see Study S1 in the online supplemental materials for details). The pilot study was conducted to measure how goal prevalence (low vs. medium vs. high) influences action generalization and enrolled 28 participants as suggested by the conventional principle. The *F*-value of the interaction effect between prevalence and goal consistency was 14.59. We used BUCSS (Anderson et al., 2017) to perform the power analysis for a within-subject analysis of variance (ANOVA) in our study (https://designingexperiments.shinyapps.io/BUCSS_ss_power_wa/). Specifically, we set the observed *F*-value at 14.59 and focused on the 3×2 interaction effect. The target α level for the previous study was 0.05 and was retained for the planned study. The desired statistical power was set to 0.80, with a level of assurance of 0.80, which means we had an 80% chance of obtaining the desired statistical power or higher with the estimated sample size. With the above settings, the calculated value was 21. To be enough to detect a conventionally suggested effect size and an effect size in the pilot study, 28 valid individuals were finally included. Considering that Studies 2, 3a, 4, 5a, and 6 focused on the critical difference across prevalence rates despite having different comparisons, each study used the same effect size as Study 1a and recruited 28 valid participants.

All participants had a normal or corrected-to-normal vision and no history of neurological disorders. The study was approved by the Research Ethics Board of the Department of Psychology at the authors' university and was performed in accordance with the relevant guidelines and regulations. In all of the studies, we reported all measures, manipulations, and exclusions. No study designs were preregistered. All data, materials, and analysis codes have been made publicly available at the OSF and can be accessed at https://osf.io/qgzxb/?view_only=043efa44fea74ee8965864995099e1d9. Data were analyzed using Python, version 3.7.6, with the package Pingouin, Version 0.3.12 and the package Plotnine, Version 0.8.0.

Apparatus and Stimuli

All stimuli were presented on a gray background using a 15.6-in. LED monitor (1,920 × 1,080-pixel resolution; 120 Hz refresh rate) on a laptop computer at a 60-cm viewing distance and using custom software written in Python with the PsychoPy libraries.

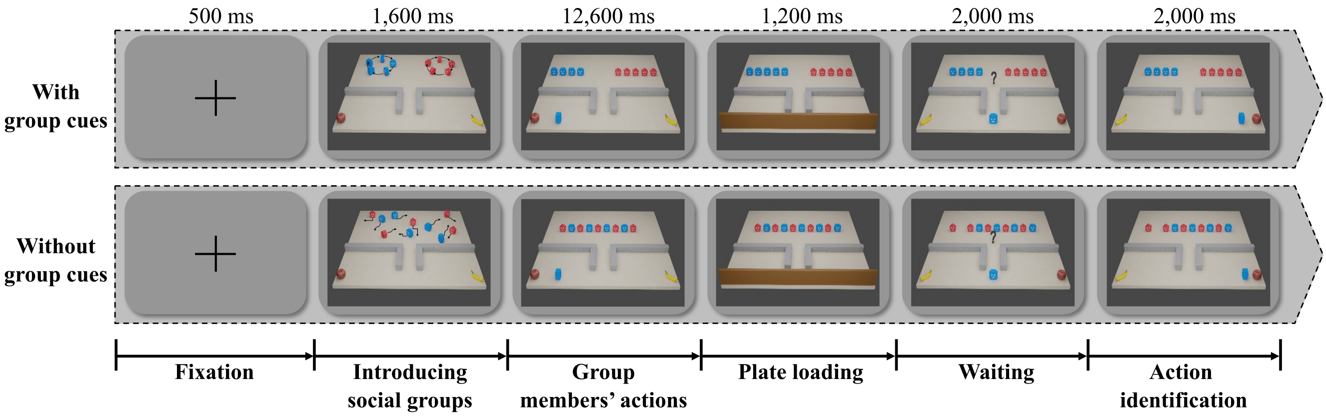
The visual stimuli were computer-animated events and were created with the open-free software Blender 2.81a. Each event included two groups of cartoonized agents with different appearances and two objects (i.e., an apple and a banana) constructed as targets. The agents were selected randomly from six animated figures with distinct colors and shapes. Each agent was rendered with two eyes as facial features and subtending 1.5° × 1.5°.

Procedure and Design

Each trial started with the presentation of a fixation cross (1.5° × 1.5°) at the center of the screen for 500 ms. Thereafter, two groups of agents were presented, and each group had five members. The agents composing each group initially appeared near one another in the top two corners of the screen; immediately thereafter, the agents in each group made a series of synchronized movements around a circular path for 1,600 ms (see Figure 2 and videos in the online supplemental materials; "introducing social groups"). Following this introductory sequence, all of the agents went to the top of the platforms, and four ingroup agents, as demonstrated exemplars, followed the order from the center to the periphery and successively performed the goal-directed actions; all of these steps lasted 12,600 ms (see Figure 2; "group members' actions"). Specifically, each exemplar initially moved to the lower side of the screen. Then, the agent turned to the left or right, balanced within each participant, to approach one of two objects as the target and then returned to the starting point. The two objects, a red apple and a yellow banana placed in the lower left-hand and right-hand corners of the screen, respectively, were counterbalanced across participants.

Next, a plate was presented to cover two objects, and the positions of the objects were swapped. This phase is shown in Figure 2 as "plate loading" and lasted 1,200 ms. Subsequently, a new agent at the outermost position moved. This agent imitated the initial actions of the exemplars. That is, the agent moved to the lower part of the screen and stopped, and a black question mark was presented above this agent for 2,000 ms (see Figure 2, "waiting"; here, there was no explicit requirement to tell the participants what to do). Finally, the last agent started to move again toward the left or right object on the screen with a constant velocity, and after 750 ms,

Figure 2
An Example Trial Sequence for Testing Goal-Based Generalization With Group Cues in Study 1a and Without Group Cues in Study 2.



Note. Images were created with Blender 2.81a free software. See the online article for the color version of this figure.

this agent reached the object. The participants were asked to identify whether this agent moved toward the left or right object as quickly as possible by pressing "F" or "J" on a standard keyboard (see Figure 2; "action identification"). If the participants did not respond within 2,000 ms, the program automatically proceeded to the next trial.

According to the proportion of the four exemplars that approached the same target, the action goals had three prevalence conditions: *low prevalence* when two exemplars approached a target and two exemplars approached the other target, *medium prevalence* when three exemplars approached a target but the other one approached the other target, and *high prevalence* when all exemplars approached the same target. Goal consistency was included as another factor and was defined by whether the approached target of the identified individual was consistent with that of the prevalent goal of the majority (but in the condition of low prevalence, the prevalent goal was randomly determined before experiments started). Due to swapping two targets before response, a consistent goal indicates an inconsistent movement, and an inconsistent goal indicates a consistent movement. Hence, the design of this experiment was a 3 (prevalence: low vs. medium vs. high) × 2 (goal consistency: consistent vs. inconsistent) repeated-measures design. The videos showing how each condition is designed in all studies can be accessed at https://osf.io/qgzxb/?view_only=d701bf06ca514cb680e671b008e54277.

Each condition had 20 trials, resulting in 120 trials for a 3 × 2 repeated-measures design. In each condition, whether the exemplar group was presented on the left or right and whether the position of the target approached by the majority was on the left or right were balanced. To strengthen the manipulation of social groups, 12 additional trials in which the identified agent was from an outgroup were included as filling trials to highlight the existence of social groups but were not analyzed. Hence, each participant completed 132 trials in total. To avoid the possible influence of the order in which the deviant was presented, that is, how the minority was presented, the exemplars who did not follow the majority were randomly determined. Before the formal experiment, the participants had 2 min to practice. Each participant took a break after completing 22 trials and finished the entire experiment within 55 min.

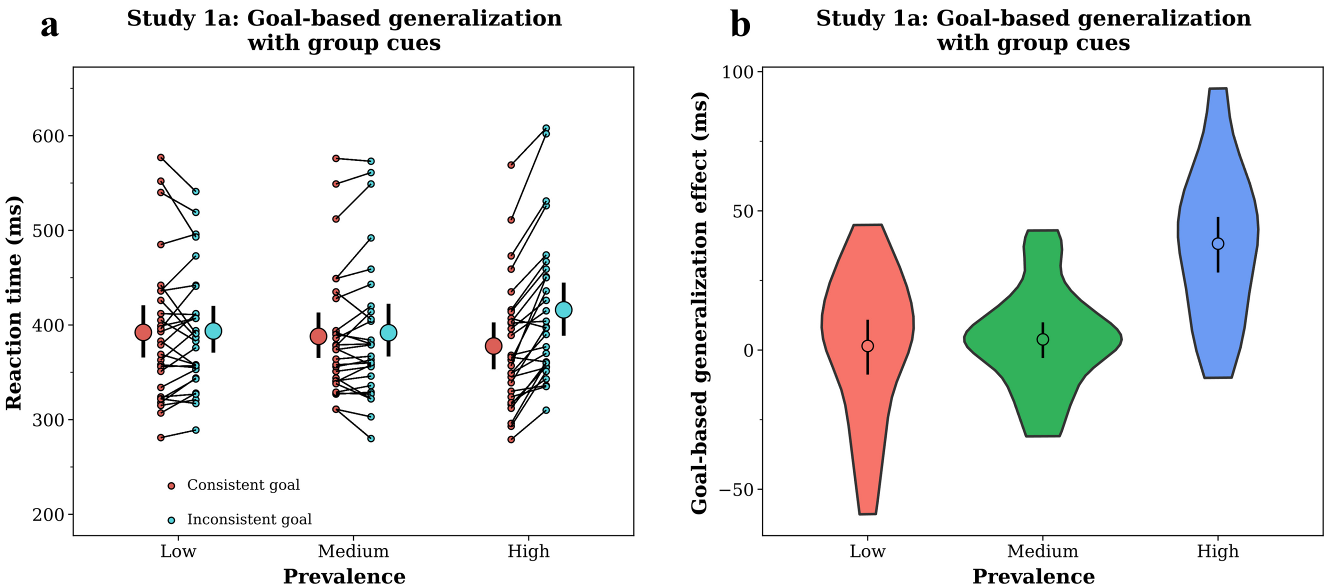
Results and Discussion

Because the reaction time was emphasized for the participants and was closely related to our hypothesis, the analyses mainly focused on the reaction time data; however, the accuracy data are also reported in the online supplemental materials. The mean reaction time of each participant for each condition (see Figure 3a) was computed after excluding trials with incorrect responses (exclusion rate = 5.33%). The reaction time data were subjected to a repeated-measures 3 (prevalence: low vs. medium vs. high) × 2 (goal consistency: consistent vs. inconsistent) ANOVA. The Greenhouse–Geisser Epsilon was used to adjust the degrees of freedom if needed (the uncorrected degrees of freedom were presented for simplicity), and post hoc contrasts were corrected with the false discovery rate method. To be consistent, $\eta_p{}^2$ was used to measure the effect size (please note that for the comparison between two conditions, Cohen's *d* can be converted by computing $\sqrt[2]{\eta_p^2}\Big/\sqrt{1-\eta_p^2}$). In addition to this traditional null hypothesis significance testing procedure, we conducted a Bayesian analysis (Cumming, 2014), which computes the ratio of the likelihoods of two competing hypotheses. We computed the Bayes factor (BF_{10}, H_1/H_0 as computed here) using the package Pingouin in Python, and a value less than one, especially a value less than 0.33, is interpreted as evidence for the null hypothesis (Andraszewicz et al., 2015).

The main effect of prevalence was not significant, $F(2, 54) = 2.97$, $p = .065$, $\eta_p{}^2 = 0.10$, $BF_{10} = 0.24$, and the main effect of goal consistency was significant, $F(1, 27) = 35.19$, $p < .001$, $\eta_p{}^2 = 0.57$, $BF_{10} = 6.37 \times 10^3$, showing that when the identified agent had the same goal as the majority, $M = 386$ ms, $SE = 13$, the participants responded more rapidly than when the identified agent approached a different goal from the majority, $M = 400$ ms, $SE = 14$. More importantly, the interaction effect was found to be significant, $F(2, 54) = 18.48$, $p < .001$, $\eta_p{}^2 = 0.41$, $BF_{10} = 2.35 \times 10^6$. The simple effects analysis determined that in the high prevalence condition, the participants responded faster when the identified agent approached the same goal as the majority, $M = 378$ ms, $SE = 13$, than when it approached the other goal,

Figure 3

Participants' Reaction Times Under Various Conditions in Study 1a



Note. (a) Represents the mean reaction time for correct responses as a function of prevalence and goal consistency and (b) represents goal-based generalization effects as a function of prevalence. The dots indicate the mean reaction time for each participant in each condition and are connected for the paired conditions. The large circles indicate the mean, and the black vertical lines indicate the bootstrapping confidence interval (CI) of the mean. See the online article for the color version of this figure.

$M = 416$ ms, $SE = 15$; 95% CI of difference = [−49, −28], $F(1, 27) = 55.50$, $p < .001$, $\eta_p^2 = 0.33$, $BF_{10} = 2.80 \times 10^5$, while in the medium (consistent goal: $M = 388$ ms, $SE = 13$; inconsistent goal: $M = 392$ ms, $SE = 14$; [−11, 3], $F(1, 27) = 1.21$, $p = .282$, $\eta_p^2 = 0.01$, $BF_{10} = 0.35$) and low prevalence conditions (consistent goal: $M = 392$ ms, $SE = 14$; inconsistent goal: $M = 394$ ms, $SE = 12$; [−12, 9], $F(1, 27) = 0.08$, $p = .773$, $\eta_p^2 < 0.01$, $BF_{10} = 0.21$), the reaction time between the goal consistency conditions did not reach significance.

To further examine how the prevalence of a goal influences goal-based generalization, we computed the effect by subtracting the mean reaction time of the consistent goal condition from that of the inconsistent goal condition. This index could clearly measure the extent to which the participants attributed the prevalent goal to a new group member, and the larger the goal-based generalization effect was, the higher the prevalence's influence on goal-based generalizations. The pairwise comparisons showed that the goal-based generalization effect at high prevalence, $M = 38$ ms, $SE = 5$, was larger than that at both medium, $M = 4$ ms, $SE = 3$; [22, 46], $F(1, 27) = 34.93$, $p < .001$, $\eta_p^2 = 0.24$, $BF_{10} = 7.19 \times 10^3$, and low, $M = 1$ ms, $SE = 5$; [21, 52], $F(1, 27) = 23.81$, $p < .001$, $\eta_p^2 = 0.17$, $BF_{10} = 5.70 \times 10^2$, prevalence, and no significant difference was found between medium prevalence and low prevalence, [−12, 16], $F(1, 27) = 0.12$, $p = .733$, $\eta_p^2 < 0.01$, $BF_{10} = 0.21$. Hence, the influence of the prevalence of goals on goal-based generalization does not follow strict monotonicity (Figure 3b), and this property is generalized to an unknown agent who shares group membership with the exemplars only when all sampled agents have a common goal, supporting the hypothesis that goal-based generalization is constrained by the group-related belief about sharing a goal.

Study 1b: Replicating Goal-Based Generalization With Explicit Reports

The experimental settings in Study 1a were computer animations with nonhuman agents. This method made it possible to strictly control for possible confounding factors, further allowing us to effectively inspect goal-based generalization. However, this method is not realistic and may limit the external generalizability of findings; in particular, the participants may have assumed that those agents were created to be programmed with common parameters. Study 1b tested whether the generalization of action goals would be extended to more realistic scenes with humans. We used a similar paradigm as in Study 1a, except that the participants were presented with recorded videos in which persons fetched target objects at a party and were asked to report explicitly and directly which goal the new individual had under various prevalence rates of approaching the same goal, that is, fetching a common object. Goal-based generalization should be manifested by the new individual rated as more likely to have the target property of approaching the prevalent goal.

Method

Participants

Seventy-four new participants participated in this study and received a gift after completing the investigation (25 men and 49 women, $M_{age} = 20.01$ years, $SE = 0.23$). To increase the diversity and inclusiveness of our samples in terms of participant demographics, we enrolled participants from multiple universities. Using

G*Power 3.1 (Faul et al., 2009), the sample size was determined by using a power analysis where the α level was set at 0.05, the power was set at 0.80 to detect a difference across three dependent groups, and the minimally suggested sample size to reach a small medium effect size ($f = 0.15$, since the explicit reports with questionnaire investigations usually have a small effect size) was 73 individuals. To have sufficient valid participants, 76 participants were tested. However, two of them were excluded because of incomplete investigations, and 74 valid participants were included.

Procedure and Design

Each participant was asked to watch six videos sequentially, in which two groups of five people at a party fetched food (or drink), and the participants answered two questions after watching each video. For diversity, two tested scenes were included. In one scene, a party scenario was created in a room, with 10 persons sitting at the top two corners of the room, and five apples and five bananas were presented in front of the persons at a short distance and on different tables. The 10 persons formed two social groups of five persons who sat together and wore the same waistcoat. At the start, the group members talked to each other to make social group information salient, and similar to Study 1a, four persons from the same group walked individually to the front of the room and turned to the left or right to fetch food from a table. According to the prevalence, four persons took the same food (i.e., *high prevalence*); three persons took the same food, but one person took the other food (i.e., *medium prevalence*); or two of them took the same food, and two of them fetched the other food (i.e., *low prevalence*). After obtaining the food, the demonstrating person returned to his or her original seat. Finally, the fifth person (i.e., a new group member) walked to the side of the table, faced the participant, and paused. The participants were asked to answer two questions–"How likely is this person to fetch an apple?" and "How likely is this person to fetch a banana?" (rated from 1 = *completely unlikely* to 7 = *completely likely*)–to avoid measuring only a specific kind of individual goal and recognizing that the other goal may be generalized as well. In another scene, the food was replaced by a drink (Cola or Sprite). Hence, each participant watched six videos, and each prevalence was presented in two videos.

The videos and rated items were presented with PsychoPy software. To help the participants understand how to complete the tasks, each participant was shown a picture of a weather report and asked "How likely is the temperature to rise?" (rated from 1 = *completely unlikely* to 7 = *completely likely*); they answered by using a mouse to mark the corresponding scale on the screen. The sequence of the videos was randomized, and the food and drink fetched was counterbalanced across participants. The entire investigation lasted approximately 6 min.

The index in which the participants expected the fifth person to follow the prevalent goal (but in the low prevalence condition, it was randomly determined before investigations) was constructed and was referred to as the goal-based generalization index. The value of items investigating the likelihood of fetching the minority's food or drink was reversed, and the correlation between the two items was found to be high (Pearson $rs \geq .41$, $ps < .001$); accordingly, the average rating for each item was computed. Then, we averaged the mean ratings of the two scenes to attain a goal-based generalization index for each prevalence (Pearson $rs \geq .24$, $ps < .05$).

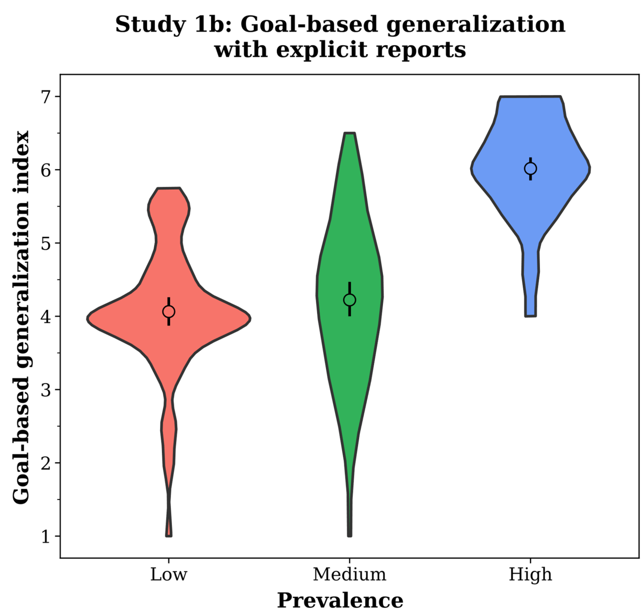
Results and Discussion

A repeated-measures ANOVA with prevalence (low vs. medium vs. high) was conducted on the goal-based generalization index (see Figure 4). The prevalence had a significant effect, $F(2, 146) = 116.54$, $p < .001$, $\eta_p^2 = 0.62$, $BF_{10} = 2.69 \times 10^{32}$. Post hoc comparisons showed that the goal-based generalization index in the high prevalence condition, $M = 6.02$, $SE = 0.08$, was larger than that in the medium prevalence condition, $M = 4.22$, $SE = 0.13$; 95% CI of difference = [1.52, 2.07], $F(1, 73) = 170.04$, $p < .001$, $\eta_p^2 = 0.37$, $BF_{10} = 5.00 \times 10^{17}$, and that in the low prevalence condition, $M = 4.06$, $SE = 0.10$; [1.68, 2.23], $F(1, 73) = 201.36$, $p < .001$, $\eta_p^2 = 0.40$, $BF_{10} = 3.87 \times 10^{19}$, but there was no significant difference between medium prevalence and low prevalence, [−0.14, 0.46], $F(1, 73) = 1.12$, $p = .295$, $\eta_p^2 < 0.01$, $BF_{10} = 0.22$. Importantly, in the low prevalence condition compared with baseline, in which each goal could be treated as the to-be-generalized property, its rating value was not significantly different from the mid-value (i.e., 4), which partly indicates the absence of generalization, [3.86, 4.26], $F(1, 73) = 0.41$, $p = .525$, $\eta_p^2 < 0.01$, $BF_{10} = 0.16$. This, similar to the goal-based generalization effect under different prevalence rates in Study 1a, suggests that the extent of goal-based generalization does not always increase with the prevalence of a specific goal.

The results of this study show that the target property is generalized to a new group member only when all sampled group individuals have a common goal, with explicit reports of group behaviors

Figure 4

Participants' Likelihood Ratings of Goal-Based Generalization as a Function of Prevalence in Study 1b



Note. The large circles indicate the mean, and the black vertical lines indicate the bootstrapping confidence interval (CI) of the mean. See the online article for the color version of this figure.

demonstrated by humans. Hence, the relation between the prevalence of a goal and the strength of its generalization is not strictly monotonic, supporting the conclusion that to a greater extent than statistical observations, action generalization is also constrained by the belief that group members pursue a common goal.

Study 2: Goal-Based Generalization Without Group Cues

To investigate whether social groups underlie the generalization effects of goals, in Study 2, we introduced a manipulation wherein individuals were spatially separated and independent in terms of actions during the phase of forming social groups. This operation has been widely documented to be sufficient to reduce social group information (Duan et al., 2021; Yin et al., 2022). If the social group is the determinative factor for generalization, no or a weak difference should be observed between conditions at each prevalence when the social group information is reduced; that is, the goal-based generalization effect should be absent or weak.

Method

Twenty-eight new participants (13 men and 15 women, $M_{age} =$ 20.89 years, $SE = 0.36$) were paid approximately 35 RMB each to participate in this experiment. The stimuli and procedures applied were the same as those used in Study 1a, except regarding how the 10 agents moved during the phase of introducing social groups. Specifically, the synchronized motion cues were removed, and 10 cartoonized agents were set in an ABABABABAB arrangement instead of the AAAAABBBBB arrangement used in Study 1a, and these agents moved independently with different trajectories rather than synchronously. In the phase of presenting group members' actions, the agent at the leftmost moved first, and then, the agents with the same appearance as the first agent moved successively in sequence from left to right. Consequently, there were no real social groups, but two assemblies could be defined based on their distinct appearance (i.e., five agents had the same appearance).

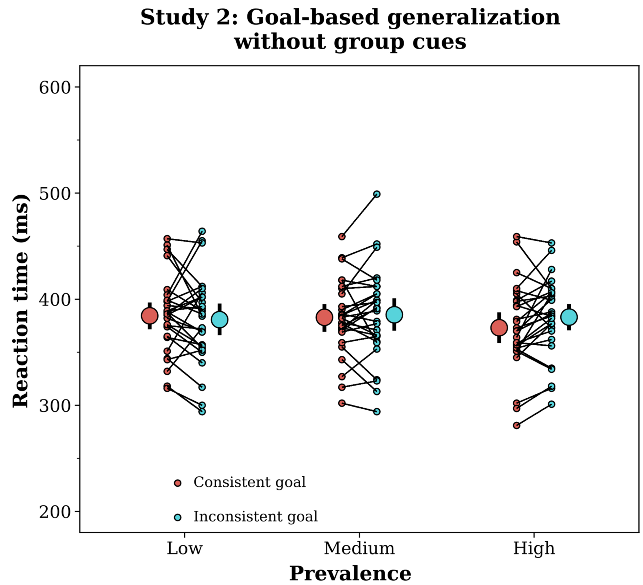
Results and Discussion

The mean reaction time of each participant for each condition (see Figure 5) was computed after excluding trials with incorrect responses (exclusion rate = 5.24%). We conducted a repeated-measures 3 (prevalence: low vs. medium vs. high) × 2 (goal consistency: consistent vs. inconsistent) ANOVA, as in Study 1a, and revealed that the main effect of prevalence, $F(2, 54) = 1.48$, $p = .238$, $\eta_p^2 = 0.05$, $BF_{10} =$ 0.22, the main effect of goal consistency, $F(1, 27) = 1.82$, $p = .188$, $\eta_p^2 = 0.06$, $BF_{10} = 0.26$, and the interaction effect, $F(2, 54) = 1.62$, $p = .208$, $\eta_p^2 = 0.06$, $BF_{10} = 0.47$, were not significant. Hence, for each prevalence, the goal as an action property did not generalize to a physically similar agent.

The methods in this study were almost the same as those in Study 1a, except that the social group cues were eliminated at the beginning of the goal-directed actions. Hence, the generalization of goals relies on the existence of a social group, which is consistent with the proposed account of the goal's commonness among group members. These findings may be explained by an immediately learned rule that group members tend to perform differently based on social group introductions, such as nonsynchronous and independent movements. This would suggest that the new individual should have a different goal from that of the prevalent agents to fit with the learned rule that individuals act differently, but this is not consistent with our findings, in which no different performance was found between consistent goal and inconsistent goal conditions for the high prevalence. Hence, the reason to generate the goal-based generalization effect should largely depend on the available group-related belief.

Figure 5

Mean Reaction Time for Correct Responses as a Function of Prevalence and Goal Consistency in Study 2



Note. The dots indicate the mean reaction time for each participant in each condition and are connected for the paired conditions. The large circles indicate the mean, and the black vertical lines indicate the bootstrapping confidence interval (CI) of the mean. See the online article for the color version of this figure.

Study 3a: Movement-Based Generalization With Group Cues

The above three studies demonstrate that the action goal generalizes to another group member only when all sampled group individuals have a common goal, supporting that more than the statistical prevalence, action generalization is constrained by the belief about social groups. This generalization pattern may hold for all action properties, for example, movement, but is not specific to the belief of group members sharing goals. Study 3a was designed to test the generalization of a movement. Specifically, after introducing the social groups as in Study 1a, group members from a social group then performed a jump or straight movement directed toward the same object on one side of the screen. Hence, the movement performed by the majority was treated as the to-be-generalized property, and its prevalence was the proportion of group members who performed the to-be-generalized movement. Later, the remaining agent, an ingroup member, performed a movement consistent or inconsistent with the to-be-generalized movement. The participants were asked to judge whether the agent was going straight or jumping. Movement-based generalization can be reflected by the fact that when the last agent performs a movement consistent with the majority movement, the movement will be judged more quickly than when it is inconsistent with the majority movement; that is, there is a movement-based generalization effect. Given that we have no specific belief about action movements, their generalization should follow a typical monotonic relation with the influence of its prevalence.

Method

Twenty-eight new participants (11 men and 17 women, $M_{\text{age}} =$ 20.14 years, $SE = 0.36$) were paid approximately 35 RMB each to participate in this experiment. The stimuli and procedures applied were the same as in Study 1a, with the exceptions noted below. During the "group members' actions" phase, each exemplar initially moved to the bottom of the screen, turned to the left or right (balanced within subjects) to approach one of two objects with an inefficient movement (i.e., jumping) or an efficient movement (i.e., going straight) and then returned to its starting point by going straight. The movement of jumping started after approximately 45 ms and reached the climax at approximately 210 ms after turning to the left or right. The velocity of jumping in the horizontal direction remained the same as going straight and reached the target after 750 ms for both types of movements. Hence, the RTs in this study should be longer than those reported in Study 1a, as it would not be possible to discriminate movements until later in the animations.

According to how four exemplars selected movements, three movement-based prevalence conditions were formed: *low prevalence* when two exemplars jumped and two exemplars went straight, *medium prevalence* when three exemplars jumped but the other one went straight, and *high prevalence* when all exemplars jumped. The participants were asked to judge whether the identified agent was going straight or jumping by pressing the "F" or "J" buttons, respectively, on a standard keyboard. This identified agent performed the movement, which was consistent with that of the majority (but in the condition of low prevalence, the movement was randomly selected) or not. Hence, this experiment had a 3 (prevalence: low vs. medium vs. high) × 2 (movement consistency: consistent vs. inconsistent) repeated-measures design.

Results and Discussion

The mean reaction time of each participant for each condition (see Figure 6a) was computed after excluding trials with incorrect responses (exclusion rate = 6.55%). Similar to Study 1a, a repeated-measures 3 (prevalence: low vs. medium vs. high) × 2 (movement consistency: consistent vs. inconsistent) ANOVA was conducted on reaction times. The main effect of prevalence was not significant, $F(2, 54) = 0.68$, $p = .508$, $\eta_p^2 = 0.02$, $\text{BF}_{10} =$ 0.08, but the main effect of movement consistency was significant, $F(1, 27) = 35.27$, $p < .001$, $\eta_p^2 = 0.57$, $\text{BF}_{10} = 1.61 \times 10^{10}$, showing that when the identified agent performed the same movement as the majority, $M = 456$ ms, $SE = 16$, the participants responded more rapidly than when the identified agent performed a movement different from that of the majority, $M = 487$ ms, $SE = 14$. More importantly, the interaction effect was found to be significant, $F(2, 54) = 8.12$, $p = .002$, $\eta_p^2 = 0.23$, $\text{BF}_{10} = 10.11$. The simple effects analysis determined that in the high prevalence condition, the participants responded faster when the identified agent performed the same movement as the majority, $M = 451$ ms, $SE = 16$, than when performing a different movement, $M = 497$ ms, $SE = 15$; 95% CI of difference = [−58, −34], $F(1, 27) = 57.91$, $p < .001$, $\eta_p^2 =$ 0.34, $\text{BF}_{10} = 4.07 \times 10^5$, and this effect was found in the medium prevalence condition as well (consistent movement: $M = 454$ ms, $SE = 16$; inconsistent movement: $M = 487$ ms, $SE = 14$; [−42, −23], $F(1, 27) = 45.97$, $p < .001$, $\eta_p^2 = 0.29$, $\text{BF}_{10} = 5.78 \times 10^4$). However, at the low prevalence, the reaction times between movement consistency conditions did not reach significance (consistent movement: $M = 462$ ms, $SE = 18$; inconsistent movement: $M =$ 477 ms, $SE = 14$; [−34, 4], $F(1, 27) = 2.72$, $p = .110$, $\eta_p^2 = 0.02$, $\text{BF}_{10} = 0.67$).

To further examine how the prevalence of an action movement influences movement-based generalization, similar to Study 1a, the movement-based generalization effect (see Figure 6b) was computed by subtracting the mean reaction time of the consistent movement condition from that of the inconsistent movement condition. The pairwise comparisons showed that the movement-based generalization effect at the high prevalence, $M = 46$ ms, $SE = 6$, was larger than those at both the medium, $M = 32$ ms, $SE = 5$; 95% CI of difference = [1, 26], $F(1, 27) = 4.75$, $p = .038$, $\eta_p^2 = 0.04$, $\text{BF}_{10} = 1.53$, and low, $M = 15$ ms, $SE = 9$; [12, 50], $F(1, 27) = 11.29$, $p = .007$, $\eta_p^2 = 0.09$, $\text{BF}_{10} = 16.16$, prevalence, and the movement-based generalization effect at the medium prevalence was larger than that at the low prevalence, [2, 33], $F(1, 27) = 5.52$, $p = .038$, $\eta_p^2 =$ 0.05, $\text{BF}_{10} = 2.07$. These results showed that the movement-based generalization effect at the medium prevalence was between that at the high prevalence and that at the low prevalence, suggesting that when the movement's prevalence increases, the movement-based generalization increases.

Different from goal-based generalization, we found that the more group members performed the same movement, the more likely this movement was generalized to an unknown group member, showing the strict monotonic generalization of movements. Hence, different action properties generalize differently, and the finding of the generalization of goals has specificity.

Study 3b: Replicating Movement-Based Generalization With Explicit Reports

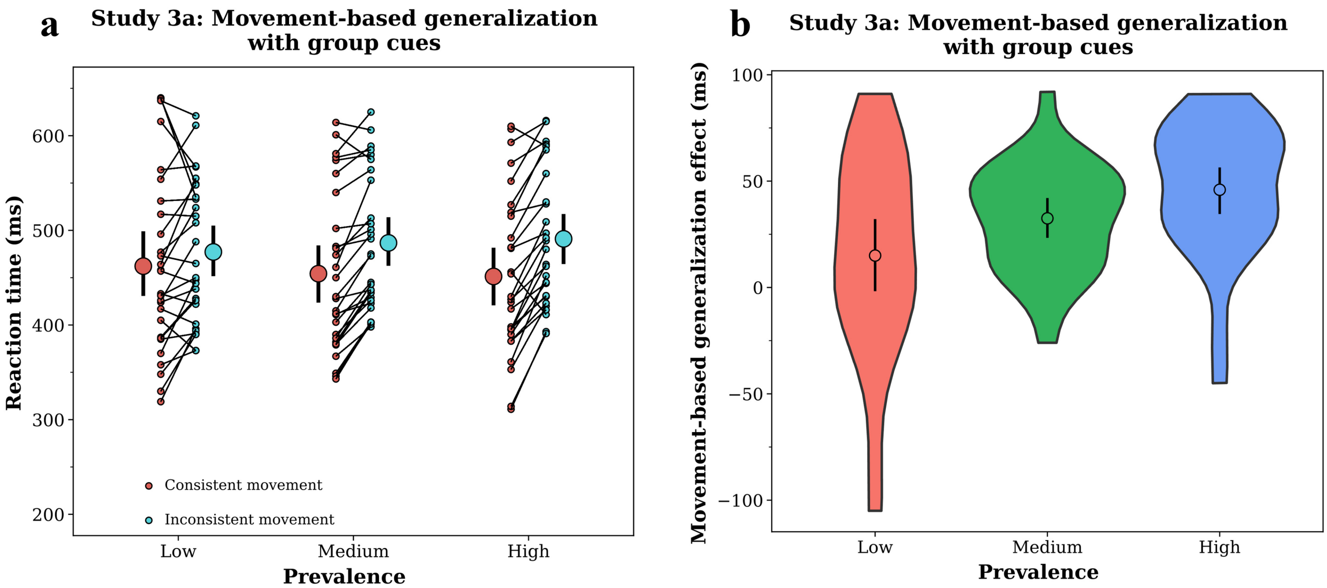
Similar to Study 1b, this study sought to replicate the monotonic generalization of action movements with explicit reports using more realistic scenes. The paradigm in Study 3b was similar to that in Study 1b, except that two groups of five persons at a party went straight or with irrelevant movement (e.g., touching a shoulder) to acquire something. The monotonic generalization of movements predicts that as more persons in a social group perform the same movement, a new group member should be rated as more likely to perform this movement.

Method

Seventy-four new participants participated in this study and received a gift after completing the investigation (24 men and 50 women, $M_{\text{age}} = 20.45$ years, $SE = 0.27$). The sample size in this study was determined by using the same rules as in Study 1b, as the studies had similar designs, except as noted below. Before the demonstrating person took the food (always fetching the apple) or drink (always fetching the cola), this person performed an apparently ritualized action movement: touching his or her left shoulder then his

Figure 6

Participants' Reaction Times Under Various Conditions in Study 3a



Note. (a) Represents the mean reaction time for correct responses as a function of prevalence and movement consistency and (b) represents movement-based generalization effects as a function of prevalence. The dots indicate the mean reaction time for each participant in each condition and are connected for the paired conditions. The large circles indicate the mean, and the black vertical lines indicate the bootstrapping confidence interval (CI) of the mean. See the online article for the color version of this figure.

or her right shoulder in one scene and putting his or her palms together in another scene. The participants were asked to rate "How likely it is that this person will touch his or her shoulder before fetching an apple?" and "How likely is it that this person will go straight to fetch an apple?" (rated from 1 = *completely unlikely* to 7 = *completely likely*) in one scene and rate "How likely is it that this person will put his or her palms together before fetching the Cola?" and "How likely is it that this person will go straight to fetch the cola?" (rated from 1 = *completely unlikely* to 7 = *completely likely*) in one scene.

The composite movement-based generalization index was computed. Specifically, the value of items investigating the likelihood of going straight to fetch the food or drink was reversed, and the correlation between the two items was found to be high (Pearson $rs \geq .50$, $ps < .001$); accordingly, the average rating for each item was computed. Then, we averaged the mean ratings of the two scenes to attain a movement-based generalization index for each prevalence (Pearson $rs \geq .47$, $ps < .001$).

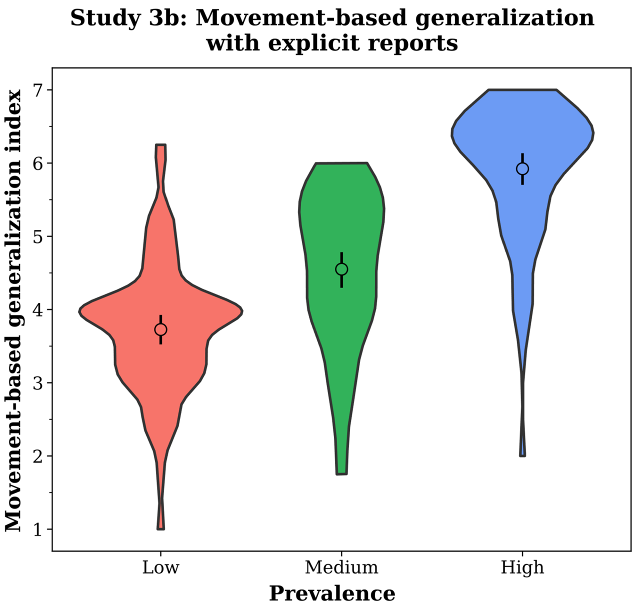
Results and Discussion

A repeated-measures ANOVA with the factor of prevalence (low vs. medium vs. high) was conducted on the movement-based generalization index (see Figure 7). The prevalence had a significant effect, $F(2, 146) = 104.19$, $p < .001$, $\eta_p^2 = 0.59$, $BF_{10} = 1.50 \times 10^{30}$. Post hoc comparisons showed that the movement-based generalization index at the high prevalence, $M = 5.92$, $SE = 0.11$, was larger than those at the medium prevalence (95% CI of difference = [1.10, 1.64], $M = 4.55$, $SE = 0.12$; $F(1, 73) = 101.00$, $p < .001$, $\eta_p^2 = 0.25$, $BF_{10} = 3.32 \times 10^{12}$) and at the low prevalence, $M = 3.73$, $SE = 0.10$; [1.85, 2.54], $F(1, 73) = 161.80$, $p < .001$, $\eta_p^2 = 0.35$, $BF_{10} = 1.47 \times 10^{17}$, and the movement-based generalization index at the medium prevalence was greater than that at the low prevalence [0.53, 1.12], $F(1, 73) = 30.36$, $p < .001$, $\eta_p^2 = 0.09$, $BF_{10} = 2.78 \times 10^4$. Similar to the implicit measurement, the extent of movement generalization increases with its prevalence. Hence, the findings from explicit reports about realistic scenes replicate the monotonic influence of movement prevalence on movement-based generalization.

Study 3c: Further Replicating Movement-Based Generalization With Explicit Reports

The two options for movements in the above studies were touching shoulders and going straight. Regarding goal-directed actions, touching a shoulder is treated as an inefficient movement for acquiring a target, but going straight is an efficient way to achieve a goal. In this case, these actions are interpreted as having different statuses, and the touching action may draw more attention. Hence, the more persons implement touching movements, the more attention the participants pay to this movement, accordingly increasing the movement-based generalization. Moreover, there is an additional confounding factor of rationality: one of the actions performed is an inefficient movement (touching shoulders), while the other is an efficient movement (going straight). Different from efficient movement, which is treated as a means to achieve a goal, inefficient movement can be explained by a shared group norm. For instance, a blue agent touches a shoulder because that is how these blue agents do it. In this case, the generalization of movements in Study 3b could be driven primarily by this inefficiency. Although these interpretations are not in contrast with inductive generalization, as more

Figure 7
Participants' Ratings of Likelihood of Movement-Based Generalization as a Function of Prevalence in Study 3b



Note. The large circles indicate the mean, and the black vertical lines indicate the bootstrapping confidence interval (CI) of the mean. See the online article for the color version of this figure.

evidence is also collected, this result made the findings specific to the comparison between efficient and inefficient movements. This study aimed to test the generalizability of the monotonic generalization of movements by comparing two seemingly inefficient movements. Namely, one of two possible redundant action movements was performed by an exemplar before acquiring a target, and the participants were asked to rate which one is likely to be chosen by a new group member. The monotonic relation between movement prevalence and its generalization would still be found in this case if what we found is true for inductive generalization regarding movements.

Method

Eighty-one new participants participated in this study and received a gift after completing the investigation (29 men and 52 women, $M_{age} = 20.37$ years, $SE = 0.19$). The minimum sample size in this study was the same as in Study 3b, as both studies focused on the critical difference across prevalence rates despite having different conditions. To be conservative, this study finally recruited 81 participants.

The procedure was almost the same as in Study 3b, except that the redundant and ritualized-like action movements performed by the demonstrating person were either touching the left shoulder and then the right shoulder or putting one's palms together. According to how many demonstrating persons performed the movement of putting their palms together, five prevalence conditions were obtained: *0% prevalence* (i.e., none of the demonstrating persons performed putting their palms together but all performed the touching movement), *25% prevalence* (i.e., only one demonstrating persons put his or her palms together but three of the four performed the touching movement), *50% prevalence* (i.e., two of the four demonstrating persons put their palms together but two of the four performed the touching movement), *75% prevalence* (i.e., three of the four demonstrating persons put their palms together and only one performed the touching movement), and *100% prevalence* (i.e., all demonstrating persons performed put their palms together but no one performed the touching movement). In fact, the 0% and 25% prevalence meant that the majority performed the touching movement, although it was treated as a case of the minority putting their palms together. In one scene, a food item (i.e., an apple or a banana) was presented as the target, and in another scene, a drink (i.e., a cola or a Sprite) was presented as the target. The participants were asked to rate "How likely is this person to put his or her palms together to fetch an apple?" and "How likely is this person to touch his or her shoulder before fetching an apple?" (rated from 1 = *completely unlikely* to 7 = *completely likely*) in one scene and rate "How likely is this person to put his or her palms together to fetch the cola?" and "How likely is this person to touch his or her shoulder before fetching the cola?" (rated from 1 = *completely unlikely* to 7 = *completely likely*) in another scene.

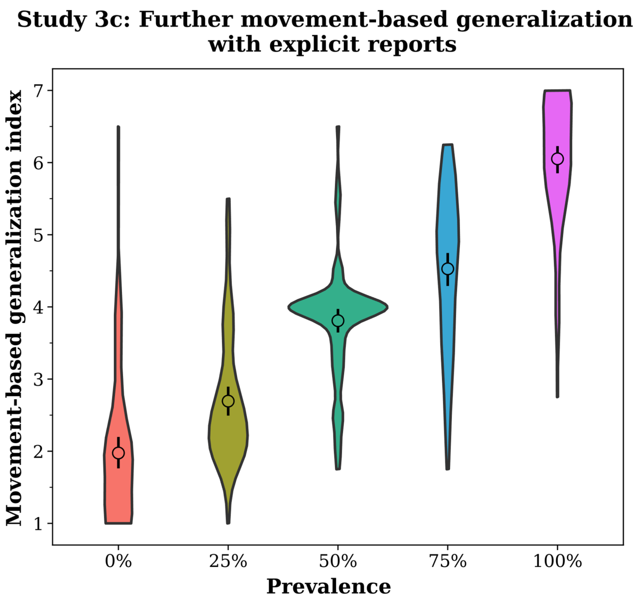
The composite movement-based generalization index was also computed. At first, the value of items investigating the likelihood of an individual touching his or her shoulder before fetching food or drink was reversed. Second, the correlation between the two items was found to be high (Pearson $rs \geq .38$, $ps < .001$), and accordingly, the average rating for each item was computed. Finally, we averaged the mean ratings of the two scenes to attain a movement-based generalization index for each prevalence (Pearson $rs \geq .39$, $ps < .001$). Hence, the higher the movement-based generalization index is, the greater the participants generalize the movement of putting palms together (touching their shoulders).

Results and Discussion

A repeated-measures ANOVA with the factor of prevalence (0% vs. 25% vs. 50% vs. 75% vs. 100%) was conducted on the movement-based generalization index (see Figure 8). The prevalence had a significant effect, $F(4, 320) = 230.93$, $p < .001$, $\eta_p^2 = 0.74$, $BF_{10} = 1.87 \times 10^{102}$. Post hoc comparisons showed that the movement-based generalization index in the 100% prevalence condition, $M = 6.05$, $SE = 0.10$, was larger than those in all other prevalence conditions ($Fs > 160.78$, $ps < .001$, $\eta_p^2s > 0.33$, $BF_{10} > 6.36 \times 10^{17}$); the movement-based generalization index in the 75% prevalence condition, $M = 4.53$, $SE = 0.12$, was the second largest and was larger than those in the 0%/25%/50% prevalence conditions ($Fs > 22.00$, $ps < .001$, $\eta_p^2s > 0.06$, $BF_{10} > 1.54 \times 10^3$); the movement-based generalization index in the 50% prevalence condition, $M = 3.81$, $SE = 0.09$, was greater than those in the 25%/0% prevalence conditions ($Fs > 96.43$, $ps < .001$, $\eta_p^2 > 0.23$, $BF_{10} > 3.10 \times 10^{12}$); and the movement-based generalization index in the 25% prevalence condition, $M = 2.69$, $SE = 0.10$, was greater than only that in the 0% prevalence condition (i.e., none of the demonstrating persons put their palms together, but all performed the touching movement; $M = 1.98$, $SE = 0.11$; 95% CI of difference = [0.47, 0.97], $F(1, 80) = 33.52$, $p < .001$, $\eta_p^2 = 0.09$, $BF_{10} = 9.82 \times 10^4$). The results clearly show that when the prevalence of the target movement increases, this property is more likely to be generalized to new group members.

Figure 8

Participants' Ratings of the Likelihood of Movement-Based Generalization as a Function of Prevalence in Study 3c



Note. The large circles indicate the mean, and the black vertical lines indicate the bootstrapping confidence interval (CI) of the mean. See the online article for the color version of this figure.

Taken together, the results of this study provide evidence that the monotonic effect of movement prevalence on generalizing this property extends to the contexts of generalized properties that are both inefficient and redundant to achieve an external goal. Furthermore, this study presented more prevalence rates of a movement, including only the minority exhibiting such movement, and revealed that as more individuals with a property are observed, generalizations are more likely. Hence, the monotonic generalization of movements is robust.

Study 4: Movement-Based Generalization Without Group Cues

Similar to Study 2, this study was designed to investigate whether social groups underlie the monotonic generalization of movements. Study 4 presented individuals with spatially separated and independent actions during the introduction of social groups. If movement-based generalization relies on social groups, no difference between conditions in each prevalence should be observed.

Method

Twenty-eight new participants (16 men and 12 women, $M_{age} =$ 20.14 years, $SE = 0.46$) were paid approximately 35 RMB each to participate in this experiment. The stimuli and procedures applied were the same as those in Study 3a, except that the social group cues were removed. Similar to Study 2, 10 cartoonized agents had an ABABABABAB arrangement instead of the AAAAABBBBB arrangement used in Study 3a, and the agents moved independently rather than synchronously.

Results and Discussion

The mean reaction time of each participant for each condition (see Figure 9) was computed after excluding trials with incorrect responses (exclusion rate = 3.36%). A repeated-measures 3 (prevalence: low vs. medium vs. high) × 2 (movement consistency: consistent vs. inconsistent) ANOVA was conducted, as in Study 2a, and revealed that the main effect of prevalence, $F(2, 54) = 0.08$, $p = .922$, $\eta_p^2 < 0.01$, $BF_{10} = 0.06$, the main effect of movement consistency, $F(1, 27) = 2.06$, $p = .163$, $\eta_p^2 = 0.07$, $BF_{10} = 1.86$, and the interaction effect, $F(2, 54) < 0.01$, $p = .984$, $\eta_p^2 < 0.01$, $BF_{10} = 0.11$ were not significant.

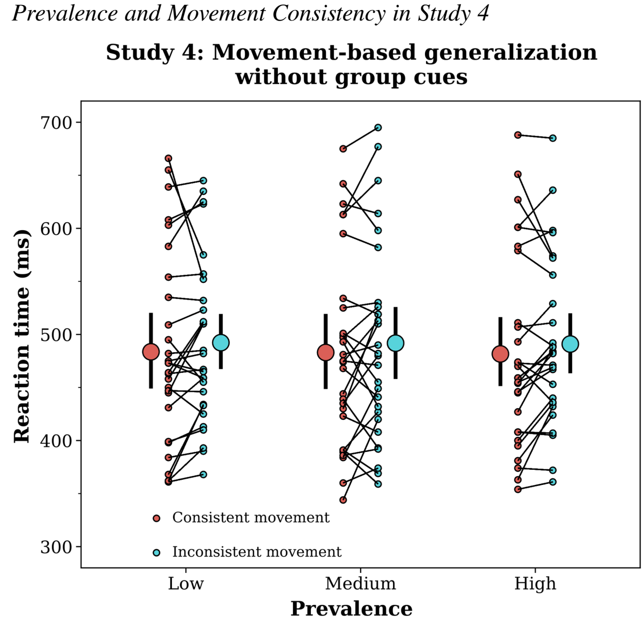
Taken together, these results support that the boundary for inductive generalization about movements is based on social groups. Both Study 2 and Study 4 indicate that visual similarity defined by physical appearance is not sufficient to drive inductive reasoning, and at least, behavioral cues should be included. This may reflect our knowledge of behaviorally formed groups, at least task-oriented groups.

Study 5a: Various Kinds of Action Generalizations With Group Cues

The above studies demonstrated that goal prevalence and movement prevalence have distinct influences on action generalization; the responses do not show monotonic generalization for goals but do show monotonic generalization for movements. Importantly, these influential relations must be based on group-related beliefs, as no action generalization was found when the social group cues

Figure 9

Mean Reaction Time for Correct Responses as a Function of Prevalence and Movement Consistency in Study 4



Note. The dots indicate the mean reaction time for each participant in each condition and are connected for the paired conditions. The large circles indicate the mean, and the black vertical lines indicate the bootstrapping confidence interval (CI) of the mean. See the online article for the color version of this figure.

were weakened. However, the different roles of property prevalence in goal-based and movement-based generalizations may be due to differences in the experimental tasks between studies. Specifically, the task for measuring goal-based generalization was set to identify the direction an agent moved, but the task for measuring movement generalization aimed to identify which movement (e.g., going straight or jumping) an agent performed. Such different tasks regarding understanding actions may have caused the previous findings.

To further test the generalizability of the findings, Study 5a slightly modified the paradigm of Study 1a by presenting only a single target on the screen; that is, a target was removed. In this case, when agents are directed to a position without a target, only the action movement can be learned for generalization; however, when agents move to a position with an external goal, even when the movement remains identical, the goal is attributed and accordingly provides a property candidate for generalization. Therefore, whether the target is presented on the approaching side could change which property is learned, and both the goal prevalence and movement prevalence can be manipulated. Importantly, although the participants were required to identify which direction the agents moved, the extent of generalizing different properties can be tested by measuring whether goal-consistent action or movement-consistent action as the corresponding prevalent property is identified rapidly. If the different generalization effects between goals and movements are universal, when the prevalent property is a goal, only the goals pursued by all sampled individuals should generalize to other group individuals, and when the prevalent (or the majority's) property is a movement, the increase in movement prevalence should increase its generalization.

Method

Participants

Twenty-eight new participants (12 men and 16 women, $M_{age} =$ 18.96 years, $SE = 0.26$) were paid approximately 40 RMB each to participate in this experiment. The sample size in this study was kept the same as in Study 1a, as both studies focused on the critical difference across prevalence conditions.

Procedure and Design

This study had almost the same procedure as Study 1a, except that only one target (i.e., an apple or a banana) was presented on one side of the screen, and the position of this target was kept constant during the presentation of group members' actions but changed during testing, similar to Study 1a. In this case, the agent could approach only a target goal or an empty location, and when the majority of exemplars approached this target, the prevalent property was a goal; in contrast, when the majority of exemplars moved to an empty location, the prevalent property was a movement. Different from Study 1a, only one external goal was included; hence, even when the position of this target was not changed, to some extent, the expectation of action toward the old direction with a target could be treated as a goal-based generalization, and the expectation of action toward the old direction without an object (i.e., an empty location) could be treated as a movement-based generalization. We ran a study without changing the position of the approached target during testing and found almost identical results to those of the present study (please see Study S2 in the online supplemental materials).

Since the prevalence could be defined by either a goal or a movement, to be comparable with Study 1a and Study 3a, the action prevalence was referred to as follows: *high goal prevalence*, in which all exemplars approached the common target; *high movement prevalence*, in which none of the exemplars performed goal-directed actions and all approached the empty location; *medium goal prevalence*, in which three exemplars approached the target, but the other one moved to the empty location*; medium movement prevalence*, in which only one exemplar approached the target, but the other three moved to the empty location; *low prevalence*, in which two exemplars approached the target, but the other two moved to the empty location. The low prevalence can be seen as the baseline for both types of prevalent action properties. Another factor was action consistency, which was defined by whether the approaching action of the identified individual was consistent with that of the prevalent action of the majority (but in the condition of low prevalence, the prevalent action was randomly determined). Namely, when the majority approached the common target, a consistent (inconsistent) action indicated a consistent (inconsistent) goal, but when the majority moved to the empty location without an external goal, a consistent (inconsistent) action indicated a consistent (inconsistent) movement. Hence, the design of this experiment was a 5 (action prevalence: high in goal vs. medium in goal vs. low vs. medium in movement vs. high in movement) × 2 (action consistency: consistent vs. inconsistent) repeated-measures design.

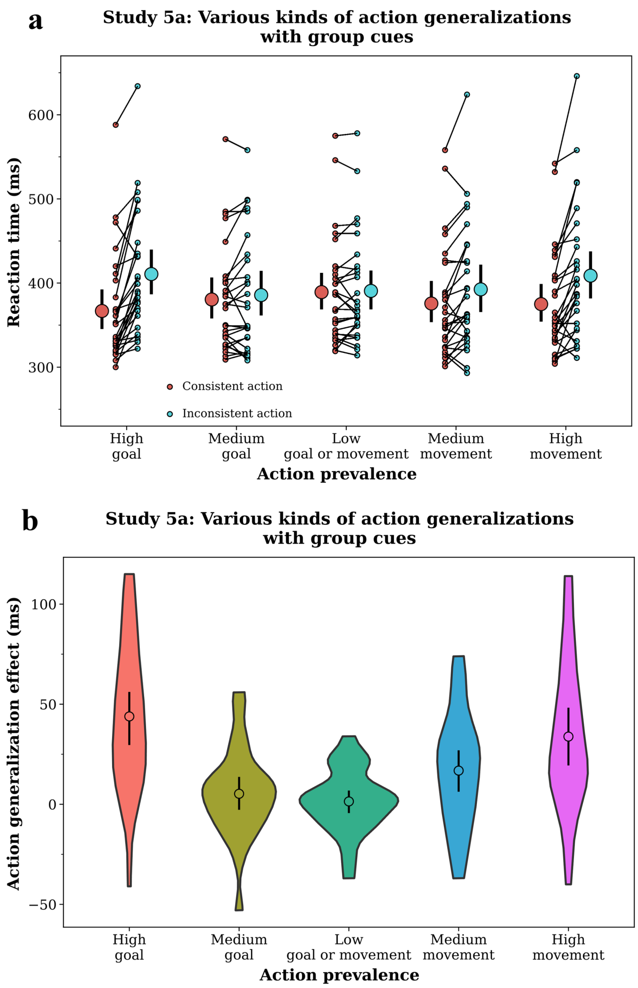
Each condition had 20 trials, and whether the exemplars' group was presented on the left or right and whether the prevalent target was approached on was left or right were balanced in these 20 trials. To make social groups salient, 20 trials in which the identified agent was from the outgroup were included as filling trials but were not analyzed. In total, each participant completed 220 trials, and in each trial, the exemplars who did not follow the majority were randomly determined. The apple and banana targets were counterbalanced across participants.

Results and Discussion

The mean reaction time of each participant for each condition (see Figure 10a) was computed after excluding trials with incorrect responses (exclusion rate = 3.59%). A repeated-measures 5 (action prevalence: high in goal vs. medium in goal vs. low vs. medium in movement vs. high in movement) × 2 (action consistency: consistent vs. inconsistent) ANOVA was conducted on reaction times. The main effect of action prevalence was not significant, $F(4, 108) =$ 2.15, $p = .092$, $\eta_p^2 = 0.07$, $BF_{10} = 0.08$, but the main effect of action consistency was significant, $F(1, 27) = 38.42$, $p < .001$, $\eta_p^2 = 0.59$, $BF_{10} = 2.46 \times 10^{10}$, showing that when the identified agent performed the same action as the majority, $M = 377$ ms, $SE = 5$, the participants responded more rapidly than when the identified agent performed an action different from that of the majority, $M = 398$ ms, $SE = 6$; the interaction effect was found to be significant, $F(4, 108) = 13.50$, $p < .001$, $\eta_p^2 = 0.33$, $BF_{10} = 1.17 \times 10^6$. The simple effects analysis revealed that when the prevalence was high in goal, the participants responded faster when the identified agent approached the same goal as the sampled individuals, $M =$ 367 ms, $SE = 12$, than when the agent approached the empty location, $M = 411$ ms, $SE = 14$; 95% CI of difference = [−58, −30], $F(1, 27) = 40.96$, $p < .001$, $\eta_p^2 = 0.27$, $BF_{10} = 2.31 \times 10^3$, but this effect was not found when the prevalence was medium in

Figure 10

Participants' Reaction Times Under Various Conditions in Study 5a



Note. (a) Represents the mean reaction time for correct responses as a function of the action prevalence and action consistency and (b) represents action generalization effects as a function of the action prevalence. The dots indicate the mean reaction time for each participant in each condition and are connected for the paired conditions. The large circles indicate the mean, and the black vertical lines indicate the bootstrapping confidence interval (CI) of the mean. See the online article for the color version of this figure.

goal (consistent action: $M = 380$ ms, $SE = 12$; inconsistent action: $M = 386$ ms, $SE = 13$; [−14, 3], $F(1, 27) = 1.56$, $p = .221$, $\eta_p^2 = 0.01$, $BF_{10} = 0.41$) or when the prevalence was low in goal (consistent action: $M = 389$ ms, $SE = 12$; inconsistent action: $M = 391$ ms, $SE = 12$; [−8, 5], $F(1, 27) = 0.22$, $p = .640$, $\eta_p^2 < 0.01$, $BF_{10} = 0.22$). In both the medium movement prevalence condition (consistent action: $M = 376$ ms, $SE = 13$; inconsistent action: $M = 392$ ms, $SE = 14$; [−28, −6], $F(1, 27) = 9.86$, $p = .004$, $\eta_p^2 = 0.08$, $BF_{10} = 9.87$) and the high movement prevalence condition (consistent action: $M = 375$ ms, $SE = 12$; inconsistent action: $M = 409$ ms, $SE = 15$; [−48, −19], $F(1, 27) = 23.04$, $p < .001$, $\eta_p^2 = 0.17$, $BF_{10} = 4.78 \times 10^2$), the participants responded faster when the identified agent moved to the empty location, consistent with the majority, than when the agent approached an external target. Namely, when the group members converged on a movement with a directed goal, the participants responded faster when the identified agent performed this same movement than when the agent performed a different movement.

To further examine how the goal or movement prevalence influences action generalization, similar to Study 1a, the goal-based or movement-based generalization effect (see Figure 10b) was computed by subtracting the mean reaction time of the consistent action condition from that of the inconsistent action condition. This index could clearly measure the extent to which the participants generalize the target property. The pairwise comparisons showed that when the prevalent property was a goal, the goal-based generalization effect in the high goal prevalence condition, $M = 44$ ms, $SE = 7$, was larger than that in the medium, $M = 5$ ms, $SE = 4$; 95% CI of difference = [22, 55], $F(1, 27) = 24.11$, $p < .001$, $\eta_p^2 = 0.18$, $BF_{10} = 6.15 \times 10^2$, and low, $M = 1$ ms, $SE = 3$; [26, 59], $F(1, 27) = 29.16$, $p < .001$, $\eta_p^2 = 0.21$, $BF_{10} = 2.07 \times 10^3$, goal prevalence conditions, but the difference between the latter two conditions did not reach significance [−5, 12], $F(1, 27) = 0.86$, $p = .361$, $\eta_p^2 < 0.01$, $BF_{10} = 0.30$. When the prevalent property was a movement, the movement-based generalization effect in the high movement prevalence condition, $M = 34$ ms, $SE = 7$, was larger than that in the medium, $M = 17$ ms, $SE = 5$; [3, 31], $F(1, 27) = 6.20$, $p = .027$, $\eta_p^2 = 0.05$, $BF_{10} = 2.67$, and low, $M = 1$ ms, $SE = 3$; [18, 52], $F(1, 27) = 18.06$, $p < .001$, $\eta_p^2 = 0.14$, $BF_{10} = 1.25 \times 10^2$, movement prevalence conditions, and the movement-based generalization effect in the medium movement prevalence condition were also greater than that in the low movement prevalence condition [5, 32], $F(1, 27) = 7.71$, $p = .016$, $\eta_p^2 = 0.06$, $BF_{10} = 4.66$. In other words, the extent of movement-based generalization was the largest in the high movement prevalence condition, that in the medium movement prevalence condition was in the middle, and that in the low medium prevalence condition was the smallest.

This study found that whether an identical movement was directed to an empty location or an external target altered the effect of its prevalence on action generalization. Importantly, in measuring both goal-based and movement-based generalizations, the participants were arranged in the same paradigm, and the only difference between them involved the availability of goal status. Hence, this study further confirms that goal-based generalization does not always increase with the prevalence of this goal, but movement-based generalization does. The reason underlying this observation is that object-directed action is attributed to a goal, and therefore, the belief that goals are shared among group members constrains inductive generalization.

Study 5b: Replicating Various Kinds of Action Generalizations With Explicit Reports

Based on the settings of Study 5a, this study was conducted to replicate various generalization effects for goals and movements with more realistic scenes. We expected that when the action goal is prevalent, a relation without following strict monotonicity should be observed between its prevalence and generalization scope, as found in Study 5a, whereas when the movement is prevalent, we should observe a monotonic relation between its prevalence and generalization extent, as revealed in Study 5a.

Method

Seventy-six new participants participated in this study and received a gift after completing the investigation (26 men and 50 women, $M_{age} = 20.39$ years, $SE = 0.18$). The minimum sample size in this study was kept the same as in Study 1b, as both studies focused on the critical difference across prevalence conditions. To be conservative, this study finally recruited 76 participants.

The procedure was almost the same as in Study 1b, except that only one target (an apple or a cola) was placed on a table, and the other table was empty. The demonstrating person either turned to the table with a target and directly fetched this object or turned to the table without a target and remained still for a while. In this case, the goal prevalence was defined as the proportion of persons fetching the target, and the movement prevalence was defined as the proportion of persons going to the empty table. Importantly, an increase in one kind of prevalence meant a decline in the other kind of prevalence. To be concise, we mainly referred to the prevalence of the goal, as in Study 1b.

There were five action prevalence conditions: *high goal prevalence* when all demonstrating persons approached the target; *high movement prevalence* when none of the demonstrating persons performed goal-directed actions but went to the empty table; *medium goal prevalence* when three demonstrating persons approached the target but the other one moved to the empty table; *medium movement prevalence* when only one demonstrating person approached the target and the other three moved to the empty table; *low prevalence* when two demonstrating persons approached the target, but the other two moved to the empty table. Each participant was presented with these five conditions in a scene with either an apple as the target or a banana as the target, which was counterbalanced across participants. The participants were asked "How likely is this person to go to the side of the table with the food/drink and fetch an apple/a cola?" and "How likely is this person to go to the side of the table without the food/drink and stand for a while?" (rated from 1 = *completely unlikely* to 7 = *completely likely*).

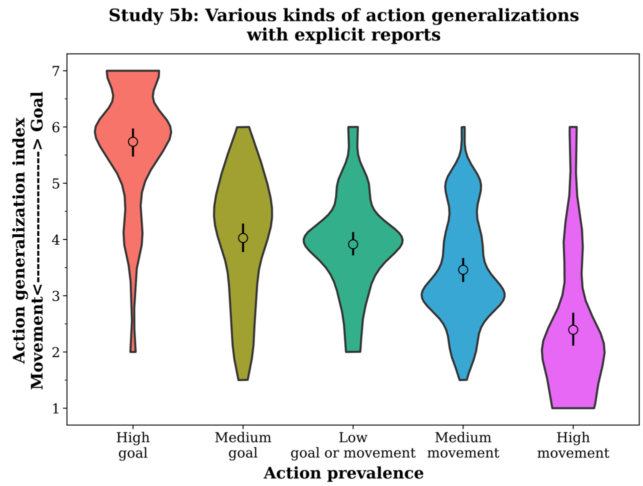
Regarding the dependent measurement, the items investigating the likelihood of standing for a while were reverse-scored. The correlation between the two items was found to be high (Pearson $rs \geq .31$, $ps < .001$), and accordingly, the average rating for each item was computed to obtain a composite action generalization index. Hence, the higher the action generalization index, the greater the participants generalized the property of action goal to group members, and the lower the index, the greater the participants generalized the property of action movement to group members.

Results and Discussion

A repeated-measures ANOVA with the factor of action prevalence (high in goal vs. medium in goal vs. low vs. medium in movement vs. high in movement) was conducted on the action generalization index (see Figure 11). The action prevalence had a significant effect, $F(4, 300) = 92.46$, $p < .001$, $\eta_p^2 = 0.55$, $BF_{10} = 5.36 \times 10^{53}$. Post hoc comparisons showed that when the majority had a common action goal, the action generalization index at the high goal prevalence, $M = 5.74$, $SE = 0.13$, was larger than those at the medium goal prevalence, $M = 4.03$, $SE = 0.13$; 95% CI of difference = [1.37, 2.05], $F(1, 75) = 102.21$, $p < .001$, $\eta_p^2 = 0.25$, $BF_{10} = 5.56 \times 10^{12}$, and at the low goal prevalence, $M = 3.91$, $SE = 0.10$;

Figure 11

Participants' Ratings of Likelihood of Action Generalization as a Function of Action Prevalence in Study 5b



Note. The large circles indicate the mean, and the black vertical lines indicate the bootstrapping confidence interval (CI) of the mean. See the online article for the color version of this figure.

[1.48, 2.16], $F(1, 75) = 112.36$, $p < .001$, $\eta_p^2 = 0.27$, $BF_{10} = 4.35 \times 10^{13}$, but there was no significant difference between the latter two conditions [−0.22, 0.44], $F(1, 75) = 0.45$, $p = .504$, $\eta_p^2 < 0.01$, $BF_{10} = 0.16$. Importantly, with the low prevalence condition as the compared baseline, in which either the goal or the movement could be treated as the to-be-generalized property, its rating value was not significantly different from the mid-value (i.e., 4; [3.71, 4.12], $F(1, 75) = 0.71$, $p = .404$, $\eta_p^2 < 0.01$, $BF_{10} = 0.18$). Hence, only when all known group members approach the common goal is the unknown member in this social group more likely to be generalized to reach the same action goal.

When the majority exhibited the same movement without an external target, the action generalization index at the high movement prevalence, $M = 2.39$, $SE = 0.15$, was smaller than that at the medium movement prevalence, $M = 3.46$, $SE = 0.11$; 95% CI of difference = [−1.42, −0.72], $F(1, 75) = 36.60$, $p < .001$, $\eta_p^2 = 0.11$, $BF_{10} = 2.46 \times 10^5$, and that at the low prevalence, $M = 3.91$, $SE = 0.10$; [−1.83, −1.21], $F(1, 75) = 93.32$, $p < .001$, $\eta_p^2 = 0.24$, $BF_{10} = 8.18 \times 10^{11}$, while that at the medium movement prevalence was smaller than that at the low prevalence [−0.77, −0.14], $F(1, 75) = 8.47$, $p = .005$, $\eta_p^2 = 0.03$, $BF_{10} = 6.06$. Namely, when the movement's prevalence increases, this movement is more likely to be generalized to a new group member.

Similar to the implicit measurement, the explicit reports about realistic scenes again confirmed that the increase in the prevalence of movement increases the extent of its generalization, but this goal is generalized to other group members only when all sampled group individuals approach a common goal.

Study 6: Various Kinds of Action Generalizations Without Group Cues

Similar to Study 2, this study presented individuals with spatially separated and independent action when introducing social groups to explore whether the different action generalization effects in Study 5 depend on group-relevant information. The positive answer to this question predicted no difference between conditions at each prevalence.

Method

Twenty-eight new participants (14 men and 14 women, $M_{\text{age}} = 18.47$ years, $SE = 0.24$) were paid approximately 35 RMB each to participate in this experiment. The stimuli and procedures were the same as those used in Study 5a, except that the social group cues were removed. Similar to Study 2, 10 cartoon agents spread out into an ABABABABAB arrangement instead of the AAAAABBBBB arrangement, and the agents moved independently rather than synchronously.

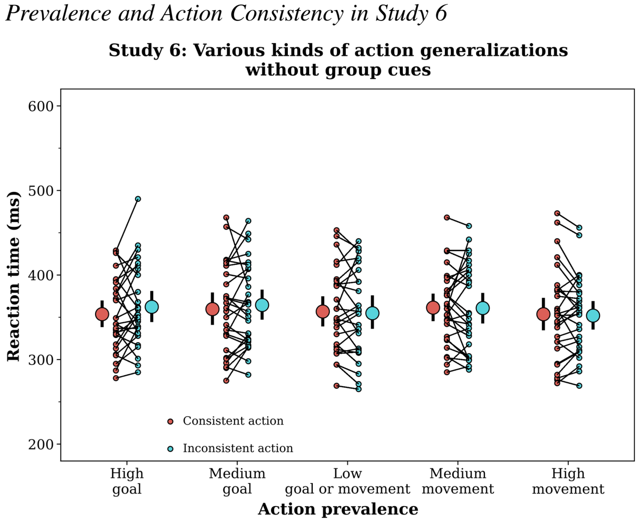
Results and Discussion

The mean reaction time of each participant for each condition (see Figure 12) was computed after excluding trials with incorrect responses (exclusion rate = 4.64%). We conducted a repeated-measures 5 (action prevalence: high in goal vs. medium in goal vs. low vs. medium in movement vs. high in movement) × 2 (action consistency: consistent vs. inconsistent) ANOVA. The results showed that the main effect of action prevalence, $F(4, 108) = 2.12$, $p = .088$, $\eta_p^2 = 0.07$, $BF_{10} = 0.27$, the main effect of action consistency, $F(1, 27) = 0.77$, $p = .388$, $\eta_p^2 = 0.03$, $BF_{10} = 0.18$, and the interaction effect, $F(4, 108) = 0.78$, $p = .519$, $\eta_p^2 = 0.03$, $BF_{10} = 0.07$, were not significant.

This study tested goal-based generalization and movement-based generalization effects by weakening group cues and found null effects for both, further confirming the role of a social group in action generalization. Hence, the inductive generalization of action properties largely rests on entitative social groups, and the group-specific belief plays a crucial role in generalizing goals.

Figure 12

Mean Reaction Time for Correct Responses as a Function of Action Prevalence and Action Consistency in Study 6



Note. The dots indicate the mean reaction time for each participant in each condition and are connected for the paired conditions. The large circles indicate the mean, and the black vertical lines indicate the bootstrapping confidence interval (CI) of the mean. See the online article for the color version of this figure.

General Discussion

Due to social categorization, group members' actions are generalized. Nevertheless, it is unclear whether action generalization is primarily driven by statistical evidence or is additionally constrained by the knowledge or belief of group members having a common goal. In line with our predictions, we found consistent evidence that the prevalence of the to-be-generalized property has dissociable influences on generalizing goals and movements to new cases. Specifically, for both the implicit measurement with computer-animated events and the explicit measurement with realistic human-generated scenes, the target property is generalized to a new group member only when all sampled group individuals have a common goal, not showing the typical monotonic relation between the prevalence of a goal and the strength of its generalization. In contrast, the more group members perform the same movement, the more likely this movement is to be generalized to an unknown group member, showing strict monotonic generalization of the movement. Importantly, these effects are absent when the social group information is eliminated; hence, generalizing different action properties relies on the group-related belief. Moreover, the different roles of property prevalence in goal-based and movement-based generalizations are not due to differences in the experimental tasks of the studies, as in the same experimental paradigm. When the goal status is available, action generalization does not always increase with the prevalence of this goal, whereas when the goal status is unavailable and the movement is still accessed, the monotonic generalization of actions is observed. Again, such findings are specific to entitative social groups. Hence, more than the statistical evidence about the prevalence of the to-be-generalized action property, action generalization is constrained by the specific belief about group members' goals–pursuing a common goal; otherwise, generalizing goals would show a monotonic effect as well.

Possible Alternatives

In our experimental methods, when the social group context was present, the displayed agents performed similar actions in the "social group manipulation" phase (see Figure 2). It can be argued that the perceivers established only an associative rule that the agents behave similarly in the manipulation phase and thereby act consistently in the response phase, showing an action generalization effect rather than appealing to group membership. Nevertheless, this explanation can be ruled out for the following reasons. First, in realistic scenes, group members sat together and talked to each other but with different action movements to show group membership. In this case, the associative rule of similarity, at least about movements, is difficult to establish, but movement-based generalization was still observed. Second, if the participants utilized the associative rule of similarity, instead of being based on understanding social groups, the prevalence of the target property should exert the same influences on inductive generalizations for both a goal and a movement, as identical manipulations were adopted, and the same associative rules can be applied. In summary, goal-based generalizations and movement-based generalizations are mainly due to reasoning about social groups instead of learned associative rules.

Moreover, it may be argued that the findings in Study 3a are driven primarily by inefficiency; in contrast to the efficient movement (going straight) that is treated as a means to achieve a goal, inefficient movement (jumping) can be explained by a shared group norm, and there is no need to generalize an efficient movement. If only Study 3a is considered, this interpretation is plausible. Nevertheless, in Study 3c, two kinds of inefficient movements were present, and in Study 5a, the action movement was displayed as moving to an empty location. Despite different movements, these studies showed similar results, indicating that the monotonic generalization for movements is not specific to the comparison between inefficient and efficient actions. Therefore, the monotonic generalization for movements is conclusive.

The effects of goal-based generalization may be argued that individuals may attribute a kind of superordinate or coordinative goal but with different individual-level goals to predict a new group member's in-the-moment goals when known group members have different goals. In this case, the new group member could be predicted to collect both apples/cola and bananas/Sprite. This argument would predict that the likelihood of collecting any target would not be correlational, as either of the individual-level goals could be treated as achieving a superordinate goal in the current paradigm. However, this is not the case. Study 1b asked the participants to answer two questions: "How likely is this person to fetch an apple?" and "How likely is this person to fetch a banana?" The answers to both questions were rated from $1 =$ *completely unlikely* to $7 =$ *completely likely*. One of the questions measured the likelihood of expecting the fifth person to follow the prevalent (i.e., to-be-generalized) goal, and the other measured the likelihood of expecting the fifth person to follow the minority's goal. In the low prevalence condition, if not reversed, the correlation between these two ratings was −0.68 and −0.69 in the two scenes, respectively. This finding suggests that the more a specific kind of shared goal is generalized to a new group member, the less the other kind of goal is generalized to this new group member. Importantly, if these two items are not merged but are analyzed separately, the ratings for the item measuring the likelihood of expecting the fifth person to follow the to-be-generalized goal show similar results, $M_{\text{high}} = 6.16$, $M_{\text{Medium}} = 4.37$, $M_{\text{low}} = 4.24$, as reported in the main text, whereas the opposite results were found as the ratings for the item measuring the likelihood of expecting the fifth person to follow the other kind of goal, $M_{\text{high}} = 2.13$, $M_{\text{Medium}} = 3.93$, $M_{\text{low}} = 4.11$. Importantly, in Study 5b, when only one goal was available, the same results as in Study 1b were found, and the implicit measures also revealed that the relation between the tendency of goal-based generalization and the prevalence of this goal does not follow strict monotonicity as the statistical evidence would suggest. Hence, this alternative is largely impossible. Nevertheless, the result does not exclude that two possible goals could be attributed (not generalized) to the new group member, especially in the low and medium prevalence condition, as the participants were not sure which goal was shared. However, this process involves more than generalization and is closely related to what factors the participants consider if no or only a weak goal-based generalization effect is found. In any case, when the observation did not match the belief of goal commonness, the participants turned into another state, which is different from when the observation matched the belief in a common goal, thus indicating that the generalization of the action goal is constrained by the group-related belief.

Constraints on Action Generalizations

The violation of the monotonicity effect during generalization is assumed to result from people holding specific beliefs or knowledge of to-be-generalized properties (Cimpian et al., 2010; Hayes & Heit, 2018; Voorspoels et al., 2015) because, in this situation, the extent of generalization cannot be determined by the perceived statistical evidence alone, and generalization of this corresponding property is usually observed only when the content of available beliefs is consistent with the statistical evidence. The current research found that the goal violates monotonic generalization, suggesting that the specific belief or knowledge is related to group members' goals. Given that this property is generalized to a new group member only when observed samples share a goal, it can be concluded that this knowledge is manifested as a top-down belief that group members should pursue a common goal. Hence, action generalization is not driven primarily by statistical evidence in the form of observed data but is also governed by the prior belief as a top-down modulation. It may be argued that the findings regarding movement-based generalization would be combined with some knowledge of action movements. For instance, group members' movements can differ, and the prevalent movement can be generalized. However, such speculation does not negate our conclusion that action generalization is constrained by specific beliefs about group members' goals but adds a new point to the conclusion.

Even when two kinds of action properties (i.e., goal and movement) competed for the to-be-generalized content, seemingly, the prevalent or majority (i.e., more than 50% of known members in a social group) action property would be considered, and accordingly, the group-related belief of goal commonness held when the goal was prevalent. As in Study 5, when the prevalent property was the goal, monotonic generalization was not present, but the common goal was generalized to a new group member only when all sampled group members shared this target property; in contrast, when the prevalent property was the movement, the more group members performed the same movement, the more likely this movement was to be generalized to an unknown group member, showing monotonic generalization. These two effects were almost the same as those when the goal and movement were operationalized separately in Study 1 and Study 3. Although the revealed relation between the prevalence of action properties and the tendency of generalization was similar when presenting two kinds of action properties separately and simultaneously, the processing mechanism underlying them may be different. This speculation could be explored in further studies.

If action generalization is a form of Bayesian revision, the belief about group members' actions–pursuing a common goal–can be treated as prior knowledge and integrated with sampled evidence to update current beliefs about to-be-generalized properties. Taken together, these findings suggest that social groups not only provide boundaries for action generalization but also introduce group-related beliefs to constrain this generalization.

Psychological Essentialism About Social Categories

Property generalization on the basis of the group or category membership is usually taken as evidence of psychological essentialism (Haslam et al., 2000; Prentice & Miller, 2007; Rhodes et al., 2012; Vasilyeva & Lombrozo, 2020), which is a tendency to attribute an association between a category (e.g., dogs) and a property (having hairs) to inherent, deep, and possibly essential characteristics of the group. Usually, the detected descriptive regularity (i.e., prevalent property) in a group or category is assumed to be accounted for by the existence of a deep essence, and accordingly, a property might be expected to extend to nearly all members of the kind (Bastian & Haslam, 2006; Gelman, 2013; Haslam et al., 2000; Medin & Ortony, 1989; Yzerbyt et al., 2001). Even without knowing what the essence is, a placeholder is created for unknown properties and can be filled gradually (Gelman et al., 2018).

The function of realizing a group's goal is assumed to be a deeper explanation for why groups exist (Guala, 2016; Noyes & Keil, 2020). Hence, the inherent characteristic of social groups might be realizing their common goal (at least deeper than other action properties). This assumption was supported by Yin et al.'s (2022) research, which indicates that when both goals and movements are prevalent to the same degree, the goal is selectively generalized. In this case, when observing the social group or category, the essence of the group can be considered a common goal, and accordingly, this property is generalized when all sampled individuals realize a common goal. However, if group members pursue two goals, the essence of the group is ambiguous; hence, the observed actions cannot provide explanatorily powerful information to support inductive generalization, which does not reflect monotonic generalization. Nevertheless, movement is always a superficial property, and whether this property is prevalent in a social category is unknown. The essence placeholder would imply that category members are alike in unknown ways and that a shared underlying basis causes the observed regularity. Although this shared basis is unknown, the more a movement is sampled, the more a certain basis generates this regularity, and thereby, this prevalent movement is extended to other group members as well; however, its generalization depends on the number of positive samples, that is, the prevalence of movement.

Limitations and Future Directions

We should be cautious in generalizing the findings to groups formed by social categories, such as race, gender, or ethnicity. The groups used in the current studies were more task-directed with, for instance, synchronous movement and talking to each other, often indicating coordination. A central feature of task groups is the degree to which their members are driven by common goals (Lickel et al., 2000). The nonmonotonic goal-based generalization might be specific to this feature of task groups. This specific generalization may be dubious because social groups are largely supposed to act collectively to obtain a common goal. Hence, goal-based generalization across group members is possibly prevalent in different types of groups, and the determining factor is whether we believe that a social group's function is to pursue a common purpose. However, this speculation must be further addressed to respond to the specificity of our conclusion.

Due to space limitations in the visual scene, the current study used only five agents for each group, and group size usually plays an important role in group processing (Gerard et al., 1968). With the increase in group size, the number of counterexamples is difficult to count and memorize exactly. If the social group is large enough, there probably exists a threshold at which a lone deviant individual does not undermine the generalization of a goal attribution to new members. For instance, if 9/10 known members perform the expected action, it may be more likely to be generalized than if only 3/4 perform it. Namely, an all-or-nothing belief constraint for goal-based generalization is probably quite unlikely. Whether the current findings are specific to the property prevalence, which is exactly computed, or general, that is, estimated with an approximate proportion, can be examined by including many group members. In any case, the group-related belief should hold and alter the evidence-driven generalization, but the group size may change the exact correlation between action generalization and prevalence.

Moreover, the action movement in implicit measurements involved jumping and moving straight to the external target, but there are many types of movements, such as approaching the target via the longest path instead of the shortest path and dancing. Therefore, whether movement type alters the effect on social generalization should be explored. The results from explicit measurements presented varied movements, but monotonic movement-based generalization was still found, suggesting that movement patterns do not matter for action generalization. However, some movements have cultural meanings and are rituals. Whether these movements are still monotonically generalized with the increase in their prevalence should be addressed.

Nevertheless, the focal goals were individually directed without exerting influences on others and were supposed to gain benefits for the actors themselves (Gergely & Csibra, 2003; Jara-Ettinger et al., 2016). However, actions also have social goals, have beneficial or detrimental consequences for others and have various moral valences (Gilbert et al., 2019; Jara-Ettinger et al., 2016). The social goal pursued by the majority seems not as collectively efficient and transmissible as a goal pursued by an individual because achieving the social goal could sometimes incur self-interested costs for actors (Ullman et al., 2009) and is promoted or regulated by social norms (Rakoczy, 2015), for example, helping and hindering. It is interesting to explore whether social goals are generalized to group members and the relation between social goal prevalence and inductive generalization.

Conclusion

In summary, our findings show that the action goal is generalized to a new group member only when this goal is shared by all sampled group individuals, showing that the relation between the prevalence of a goal and the strength of its generalization does not follow strict monotonicity. In contrast, the more group members perform the same movement, the more likely this movement is to be generalized to an unknown group member, showing monotonic generalization for a movement. Importantly, these dissociative generalizations rest on social groups. Thus, our findings shed light on the belief that social groups pursue a common goal and indicate that this specific belief constrains action generalization to a greater extent than the statistical evidence.

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