Emblems and Improvised Gestures are Structured to Guide their Own Detection

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Abstract

Emblems (also called conventional gestures) are a powerful, yet often overlooked part of humans' communicative tool-kit. These everyday gestures rapidly express encapsulated messages, such as waving a hand to greet someone, head shaking to express disagreement, and shoulder shrugging to reveal a lack of knowledge. We hypothesized that these emblems are shaped by a universal pressure to reveal their communicative purpose, and they should therefore be unconfounded with movement typically produced to accomplish non-communicative goals. We present evidence for this hypothesis using a novel dataset of over 250 emblematic gestures from around the world: Over 95% of these gestures have forms that support observers' inferences, suggesting that emblems are shaped to ease observers' inferential burden. Finally, in a gesture-creation experiment, we show that these inference-guiding features emerge spontaneously without the need for observer feedback or cultural transmission. Taken together, these complementary approaches provide new insight into how basic goal inferential processes may explain the shape of communicative actions across cultures.

Keywords: communication; social cognition; emblems

Introduction

Human social experience is characterized by our ability to rapidly communicate about a broad range of sentiments and subjects. Consider how easily you can greet a friend even when they are far away, convey your dissatisfaction to the driver that just cut you off, or communicate to your waiter from across a noisy restaurant that you would like the check. Depending on where you are from, you may be able to express your intended message without saying a single word.

Emblems, such as waving a hand to greet someone, raising a middle finger as an insult, and miming writing in the air to request the check, are conventionalized gestures shared within a cultural group (Ekman & Friesen, 1969; Gawne & Cooperrider, in prep.; Kendon, 1997; Matsumoto & Hwang, 2013; McNeill, 1992). With a quick single movement, we can reliably express an encapsulated message without additional context, which can be particularly helpful when spoken language would be inefficient (e.g., when verbalizing would take longer or would require us to interrupt speech), inappropriate (e.g., in particular social settings such as a courtroom) or outright unavailable (e.g., if it is too loud or your recipient is too far away; Gawne & Cooperrider, in prep.; Kendon, 1981).

The success of these movements, however, hinges on observers' ability to realize that they are communicative. In other words, fluent gestural communication is simply not possible unless receivers can, in real time, detect when a movement is meant to communicate (Sperber & Wilson, 2001). Therefore, under standard action understanding frameworks, the success of emblems seems to fall on the shoulders of the observer's inferential capacities since they must decipher whether a particular body movement is being produced to communicate or for an unrelated, non-communicative goal. However, this perspective misses a key aspect of communicative interactions: namely that both parties are invested in the interaction's communicative success (Clark & Wilkes-Gibbs, 1986; Sperber & Wilson, 2001). Consequently, gesturers should be motivated to ensure that their communicative actions are easily and efficiently understood as such. Thus, the gestures that they produce might be structured to ease the inferential burden that they impose on observers. Specifically, we hypothesized that emblems may be shaped to help guide observers' attention to the relevant motion by revealing their communicative intent. If so, the striking cross-cultural diversity that is characteristic of emblems (Eastman & Omar, 1985; Kita, 2009; Matsumoto & Hwang, 2013; Payrató, 1993; Safadi & Valentine, 1988) should be grounded on a universal structure designed to ease the inferential burden that emblems impose on observers.

What universal features should emblems share if they are structured to reveal their communicative goal? Recent work has found that people are more likely to interpret an action as communicative if its movement reveals that it is not produced in the service of a world-directed goal (i.e., not aimed at interaction with the physical world, like reaching for and manipulating objects; Royka et al., 2022). Therefore, if emblems are shaped to ease observers' inferential burden, the body positions and movements that make up an emblem should overlap as little as possible with the distribution of body movements that people produce in non-communicative contexts. To illustrate why, consider hypothetical emblems that could be confounded with world-directed action (e.g., extending your hand towards a region where objects are commonly placed or touching your head, etc.). Such emblems would introduce ambiguity for observers, burdening them to discern whether the movement is a conventionalized gesture or simply an attempt to complete a world-directed goal (e.g., reaching for a nearby object or fixing your hair).

In this paper we seek to not only investigate the structure of emblems around the world, but to also probe their possible origins as well. While emblems exhibit substantial diversity in their physical forms, they may share a common set of features that help observers to infer that the movement is meant to communicate. It is possible that, through a gradual process of cultural evolution, emblems take on shapes that reveal their communicative purpose. Under this view, emblem creation might begin with an arbitrary mapping from body movements onto meanings. Over time, emblems that ease the inferential burden for observers might be more likely to succeed, survive, and be transmitted across generations. Alternatively, emblems may reveal their communicative goal from their very inception. That is, people may be able to use their basic ability to infer the goals of others to shape their own communicative actions in real-time and guide observers to correctly infer that their goal is communicative.

To explore the structure and origins of emblems, we first ask whether everyday emblems in use around the world are also structured to ease the inferential burden imposed on observers (Study 1). Next, we investigate how these properties become embedded into the forms of everyday emblems by testing whether people spontaneously create gestures that ease observers' inferential burden (Study 2).

Study 1

We explored our first question regarding the structure of emblems by compiling a set of 271 emblems used in over 20 countries. We then coded emblems for a general feature we call rarity: how uncommon each movement would be under the distribution of movements that people produce when performing non-communicative world-directed action. Importantly, a movement that is high in rarity is not one that is statistically infrequent, but rather one that is almost never produced when people are performing non-communicative world-directed action. Rarity also differs from inefficiency. While rare actions are often inefficient, certain types of inefficiency are common when one has a world-directed goal (e.g., behaving inefficiently while pursuing a world-directed goal due to lack of knowledge or competence) and thus are not rare. Thus, if emblems are shaped to ease observers' inferential burden, then they should be high in rarity since people expect communicative movements to efficiently reveal that they are not pursuing world-directed goals (Royka et al., 2022).

Oftentimes, a movement can be high in rarity because it does not resemble anything like a world-directed action (e.g., an entirely nonfunctional static handhold, such as creating a fist with your index and thumb extended to the side; an emblem meaning "a little"), but past work has identified that one particularly important type of rarity is repetition. Repetitive bursts of the same action without affecting the world efficiently reveal that the movement's goal is nothing more than to produce the action itself (de Weerd et al., 2015; Newman-Norlund et al., 2009; Royka et al., 2022; Schachner & Carey, 2013; Scott-Phillips et al., 2009). Therefore, we predicted that, on the whole, emblem shapes should be distinct from world-directed goal movement, and that repetition should be a common feature that enables them to achieve that distinction. As such, here we evaluated both the rarity and repetitiveness of emblems.

Gesture Collection

We sampled emblems from three types of sources: published books (126 emblems; Armstrong & Wagner, 2003; De Jorio, 2000; Epstein & Raffi, 2014; Hamiru-aqui, 2008; Wylie, 1977), online videos and websites (96 emblems from websites, and 80 emblems from YouTube), and in-person interviews (38 emblems). For each emblem, we also conducted an additional internet search to identify a video or gif of people performing the gesture. For a small set of emblems (n=16), no online reference video was found, and we therefore produced recordings of people within the [University] community that were familiar with the emblem (found via personal acquaintance and departmental affiliation). Finally, we obtained 38 additional emblems from in-person interviews conducted in public spaces (Metropolitan Museum of Art, Central Park, and Times Square; 30 gestures total), and with the [University] Polish Society (8 gestures total).

Our emblem dataset consisted of an initial 340 emblems, out of which 69 were excluded (see AsPredicted #47517 for gesture exclusions), for a final set of 271 emblems (see OSF for the complete dataset). Each entry contains five definitional foundations (emblem meaning, region of use when specified, a description of how the emblem is produced, and a video or gif of someone performing the gesture) added during this gesture collection phase. Next, additional coders rated the emblems on two predicted dimensions (rarity and repetition) related to our central hypothesis, 6 additional exploratory variables, and 3 variables used for emblem exclusion (see OSF for pre-registrations listing additional variables).

Gesture Coding

Our coding scheme consisted of a multi-stage process involving a total of 10 coders. These phases are described in detail in our pre-registrations (see OSF), but here we restrict ourselves to detailing the variable coding process only for those variables relevant to these hypotheses.

Coding Predicted Dimensions 5 coders blind to our hypotheses viewed videos of all emblems in the dataset and coded them for rarity and repetition. This occurred in two stages: two initial coders (AsPredicted #17262) and three additional coders (AsPredicted #103989).

Rarity was coded as an integer ranging from 0 to 10. Coders were instructed to assume that the movement was not a gesture, and then to rate how "uncommon" it would be to see the action performed for non-communicative purposes. An uncommon action would be any action that seems unusual or like an action that would not be frequently seen in one's day-to-day life (0 being definitely unremarkable and 10 definitely uncommon).

Repetition referred to how many times the movement was repeated. Specifically, we defined a repetition as producing the same movement that was originally produced, independent of the direction. For example, moving a hand left to right and then right to left has one repetition (because the first lateral movement was repeated once). However, the same movement in a different location is not a repetition (e.g., moving a hand left to right above the neck, and then moving it again left to right below the neck does not have any repetitions).

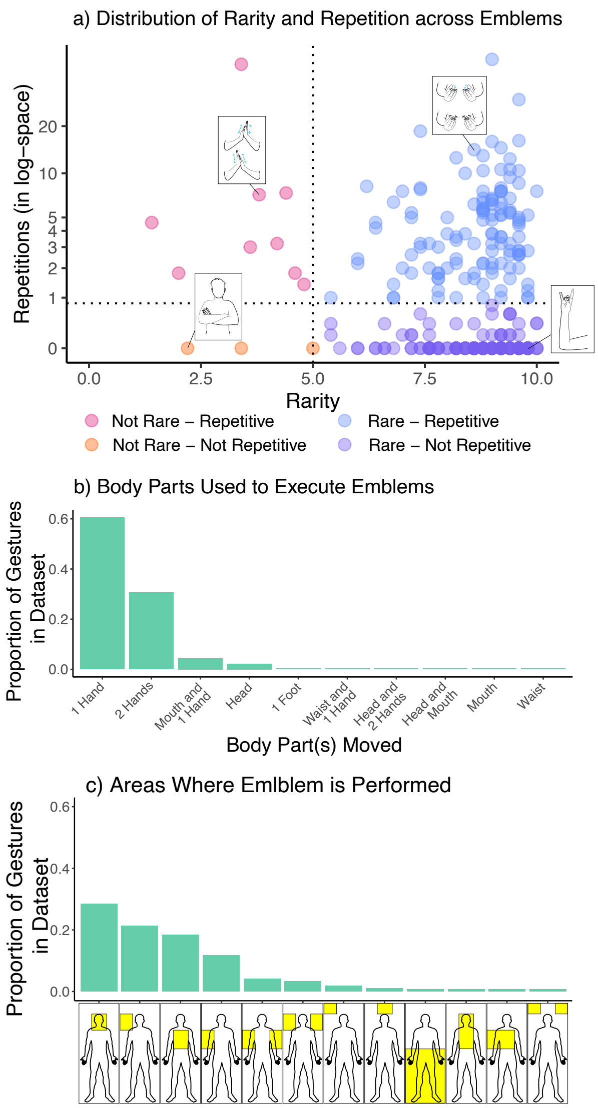

Figure 1: a) The distribution of emblematic gestures in our dataset, coded as rare when average rarity score (x-axis) was greater than 5/10, and coded as repetitive (y-axis; shown in log-space) when producing the gesture required movements to be repeated at least once with line drawings of representative gestures from the dataset. b) The distribution of body parts (and combinations of body parts) used to produce the gestures in our dataset. c) Proportion of gestures in our dataset (y-axis) that are produced in different regions (x-axis), excluding 18 outliers.

Agreement Across Predicted Dimensions To measure inter-rater reliability for our final rarity and repetition scores, we used intraclass correlation coefficients. Since all unexcluded emblems were evaluated by the same set of 5 coders, we used a two-way random effects model to estimate the consistency for the average of the 5 ratings. Agreement among coders' rarity ratings was high (ICC = 0.821, $CI_{95\%}$ = 0.785–0.853; assessed using an intraclass correlation coefficient based on a mean-rating, k = 5, consistency, 2-way random effects model). For our analyses, we averaged together the ratings for each gesture to arrive at a final rarity score (0-10 via five coders). The five coders also counted the number of repetitions performed within each gesture with high agreement (ICC = 0. 942, $CI_{95\%}$ = 0.931–0.952).

Secondary Coding Phase The secondary coding phase was pre-registered (AsPredicted #47517), and had the goal of features are objective, easily defined, and unambiguous, we used a single coder that was blind to the hypothesis (and blind to all coding information from Stage 1). Two of these features were used as exclusion criteria to remove gestures that our theory does not make predictions about (deictic gestures and gestures involving physical contact between multiple people; see OSF for pre-registrations detailing exclusion criteria) and two were used for exploratory analyses of emblems' regions of production and body parts used in production.

Results and Discussion

As predicted, emblems were overwhelmingly distinct from world-directed action as operationalized by our rarity metric. 95.57% of emblems (n=259; Fig. 2a) received an average rarity score of greater than 5 (mean score=8.39; Z=14.0, p<0.001 by Wilcoxon signed rank test), suggesting that these gestures are perceived as distinct from other types of goal-directed movement. Of these 259 rare emblems, 49.03% (n=127) involved repetition, with an average of 5.38 repetitions (with the remaining n=132 being generated by a single motion).

Only 4.43% of emblems in our dataset (n=12) were confounded with world-directed action (average rarity=3.57). Of this subset, five gestures resembled itching behaviors (e.g., scratching one's head, rubbing one's index finger along one's cheek) and three resembled actions people do at rest (e.g., crossing arms, hands on hips, tapping one's foot; the remaining non-rare gestures resembled assorted other world-directed goals that did not fall into an intuitive category). Interestingly, several of the emblems rated as low in rarity are used to communicate about someone nearby (e.g., scratching under one's eye can be used to indicate that someone else is stealing). In these cases, the emblems' low rarity is conducive to the gesture's unusual goal of covertly communicating about someone nearby.

Our results show that rarity and repetition, which guide observers to detect communicative action (Royka et al., 2022), are prevalent in emblems across cultures. While our dataset was constructed from a broad range of sources in order to try to achieve a geographically diverse sample, we cannot assess the full extent of their usage: for each emblem, we only have information about one region where it is produced, rather than its place of origin or an exhaustive survey of where the gesture is used and understood. However, even using this conservative metric, our dataset achieves broad geographic coverage: the emblems in our dataset span 30 countries and 5 continents. Though we hope future work continues to investigate the common features of emblems as some continents are under-represented in our dataset. Additionally, our dataset does not specifically include emblems from non-market-integrated societies. Though, we would predict that patterns of rarity and repetition should hold constant across these cultures as well.

To further explore the features of emblems, we also analyzed what body parts they use, and in which regions of space they are produced. This secondary analysis revealed that 91.14% of emblems in our dataset are produced with only the hands (60.52% with one hand and 30.63% produced with two hands; Fig. 1b). For the emblems that were produced with one hand, 32.93% were produced to the side of the head, and 31.10% were produced adjacent to or in front of the head. For the emblems that were produced with both hands, 44.56% were produced in front of the gesturer's chest (see Fig. 1c for the distribution across the entire dataset). Overall, this suggests that emblems are biased to involve the head and hands, and are preferentially produced near higher, central regions of the body. These features might further reflect a pressure to ensure that emblems are both easy to produce and detect (consider how easy it would be to miss a thumbs-up gesture if it was performed next to your hip with your arm straight by your side, rather than held aloft in front of you or a "come here" gesture if produced with the foot). Thus, while rarity and repetition increase the effectiveness of communicative action, these and other features may also contribute to communicative success.

Having established that real-world emblems are overwhelmingly distinct from non-communicative world-directed actions, we next turned our attention to how this property emerges.

Study 2

We explored the origins of the structure of emblems by examining how people improvise novel communicative actions in the total absence of feedback and pedagogy. Specifically, we wanted to test whether improvised communicative actions are shaped to ease observers' inferential burden from their very inception. To do so, we had people create gestures in a tightly controlled grid world environment that enabled us to dictate the distribution of world-directed goals.

Methods

Participants 80 participants from the US and UK were recruited through Prolific for monetary compensation based on task duration. An additional 37 participants were recruited but not included in the study due to pre-registered criteria (see Procedure). While our pre-registration stated that we would recruit 80 participants without replacement, we opted to change the criteria to 80 participants with replacement before seeing any data relevant to our hypotheses due to unexpectedly high exclusion rates (see OSF for pre-registrations).

Stimuli The study was implemented using the p5.js library (https://p5js.org) for JavaScript and consisted of a virtual grid world environment where participants could move a robot around a series of simple 7x7 grid worlds (Fig. 2a) to get points. Each round, the robot started in the center square of the grid. Each grid had a different configuration of control panels represented by small green boxes in the outermost squares of the grid. The density of the control panel boxes was varied systematically across rounds such that one half of the outermost squares each contained 9, 6, 2, or 0 green boxes and the other half had 9 boxes each (see OSF for images of all possible control panel configurations).

Procedure At the beginning of the study, participants read a cover story in which they learned that they would be working together with a partner to operate a spaceship. The participant had to steer the spaceship, while their partner had to defend the spaceship from aliens whenever an alien alert occurred. Each round, participants had one of two possible goals. In *world-directed goal trials*, participants had to steer the ship by moving the robot next to the control panel with a red box (randomly chosen each world-directed goal trial). In *communicative goal trials*, the participants had to move to signal a partner that there was an alien alert. Participants were told that all of their movements would be shown to future participants (their "partners") who would have to guess whether or not there was an alien alert that round. In the directions, participants were told that their partners would see the participant's robot and the control panels, but could not see the participant's task or whether any of the boxes were red. Participants were told that their movements from each round would be shown to a different partner.

Each participant played 8 rounds (four of each trial type in a randomized order). Participants needed to move at least twice each round, but could subsequently move as many times as they wanted.

After completing the study, participants were asked whether or not they signaled to their partners and to explain their strategy. Finally, participants completed a post-test comprehension check question to verify that they understood what their partners would and would not be able to see. Data from participants who answered incorrectly regarding their partners' perspective were excluded from our analyses.

Results and Discussion

We used an inverse planning model to capture how an observer might infer the goal of participants as they moved around a given grid (see Baker et al., 2009, 2017; Jara-Ettinger et al., 2024 for detailed explanations of inverse planning models; see OSF for model code). Past work suggests that observers are more likely to infer communicative goals for actions that reveal themselves to be inconsistent with possible world-directed goals (Royka et al., 2022). Thus, typical inverse planning models used to infer which of several possible world-directed goals an agent is going for could be adapted for our purposes here to identify which action plans are inconsistent with the efficient pursuit of all world-directed goals (i.e., control panels) in a grid.

This model distinguishes between actions generated by a communicative goal and actions generated by a non-communicative world-directed goal using Bayesian inference. For non-communicative goals, we used probabilistic MDPs to calculate the likelihood that an action sequence would be generated given a target goal (i.e., one specific control panel box) and then integrated over the space of all possible world-directed goals under a uniform prior.

For this model, we assumed that observers would not have any strong expectation about the particular shape of actions directed at communicative goals. As such, we assumed a uniform distribution over actions (i.e., any movement can, in principle, be communicative). Given that there are four possible actions, this means that the likelihood of any sequence of actions is given by $(1/4)^s$ where s is the number of steps in the action sequence.

Given these likelihoods, we assumed a uniform prior such that the agent was equally likely to pursue a communicative or a non-communicative goal. This allowed us to calculate the posterior probability that an observer would infer that each participant-generated action sequence had a world-directed goal using Bayesian inference.

With this model, we first confirmed that, as participants pursued world-directed goals, the model detected this accordingly. Indeed, during world-directed action (i.e., moving to control panel boxes in different locations), the model's belief in a world-directed goal increased as a function of steps (β_{Step}=.089, p < .001; gray lines in Fig. 2b). By contrast, when participants had a communicative goal, the model's belief in a world-directed goal significantly decreased as a function of steps, compared to the model's belief during the baseline non-communicative goal ($\beta_{Step:Goal}$= –.197, p<.001; green lines in Fig. 2b), providing evidence that, even in this unfamiliar gesturing set-up, participants still moved in a manner that differentiated their communicative goals from their world-directed goals.

Under our hypothesis, however, gesturers should not only be motivated for their communicative action to eventually look distinct from world-directed action, but they should want this differentiation to happen quickly. To examine the efficiency of participant-generated communicative actions, we used our computational model to compare how quickly randomly-generated action sequences revealed the absence of a world-directed goal (average shown in purple line, Fig. 2b) relative to the participant-generated gestures. At each successive step, participants' communicative paths generated significantly lower posterior values from the model relative to the arbitrary gesture baseline (after one step: $\beta_{Action\ Type}$= –.025, p=.004; two steps: $\beta_{Action\ Type}$= –.149, p<.001; three steps: $\beta_{Action\ Type}$= –.173, p<.001; four steps: $\beta_{Action\ Type}$= –.044, p=.003), providing evidence that participants created communicative actions that more quickly disambiguated themselves from possible world-directed goals relative to random action sequences.

This task provides evidence that people spontaneously create gestures that guide their observers to the correct, communicative goal inference even in a modality that was very different from how humans typically gesture (i.e., using a two-dimensional icon's movements navigating a grid rather than an arm or head movements). These findings are consistent with evidence that people spontaneously use inefficient movements to signal (de Ruiter et al., 2010; Scott-Phillips et al., 2009), but our task removes any observer feedback, revealing that the differentiation between world-directed and communicative movements does not depend on observers' reactions.

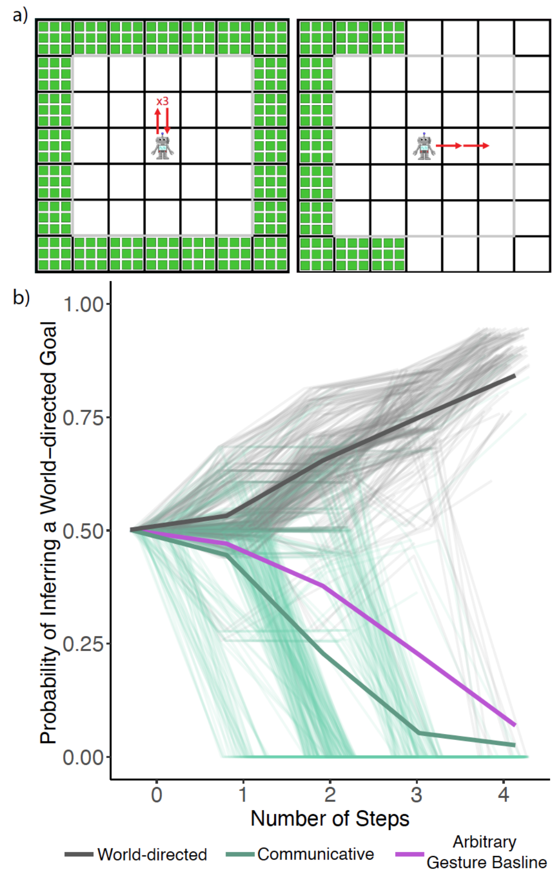

Figure 2: a) Example grid configurations (red arrows added to depict representative trajectories produced by participants when communicating with their partner). b) Results from Study 2. Lines indicate how the probability that an observer would infer a world-directed goal (y-axis) changed with each additional step participants made (x-axis). Lines that are faded represent individual actions made by participants; darker lines represent the averages across participants in the world-directed goal trials (shown in gray) and communicative goal trials (shown in aqua). The purple line represents the average across randomly-generated arbitrary gesture baseline.

General Discussion

From the thumbs-up of approval to the Grecian mountza, people around the world communicate with each other using a dazzling array of emblems. Although emblems seem to exhibit substantial diversity in their physical forms (Eastman & Omar, 1985; Matsumoto & Hwang, 2013; Payrató, 1993; Safadi & Valentine, 1988; Fig. 1), here we find that emblems across different cultures share a common feature: they are shaped to ease the inferential burden for observers. We specifically found that emblems use body movements that are rarely or never produced under the distribution of actions used to pursue world-directed goals—a feature we call rarity. Because people are more likely to infer a communicative goal when an action is high in rarity (Royka et al., 2022), our findings show that emblems are shaped so that observers can easily and correctly infer their communicative goal – independent of the specific messages that the gestures express. This finding is broadly consistent with the principles of communicative inference as articulated in relevance theory (Sperber & Wilson, 2001) and the principle of least collaborative effort (Clark & Wilkes-Gibbs, 1986). Our findings can be seen as a computationally precise instantiation of how communicators advertise their actions' "relevance" to minimize the effort that observers' need to expend to uphold their end of the interaction.

While our work examined rarity as an intrinsic feature of emblems, it is also a feature that can be further manipulated in real-time to help observers detect communicative action. Gesture production in everyday life combines fixed components (such as the body parts used to produce a gesture) with flexible ones (such as how accentuated a particular arm motion is, or how many times a gesture is repeated; Goldin-Meadow & Brentari, 2017). These flexible dimensions might help us to modulate the signal in a gesture as the situation requires (e.g., we might gesture differently if we think that someone is paying attention to us compared to if our observer is distracted). Yet, the fact that all gesture production is flexible might, at the same time, be one of the very reasons why rarity is also a stable feature of emblems (e.g., people can modulate how many times they repeat a particular repetitive emblem, but some repetition must always be present): Regardless of whether you see a person moving their hand back and forth at head level with great enthusiasm or tepid reluctance, you can recognize both actions as waving. Thus, preserving inference-guiding features of emblems across all instances of production could bolster recognition despite this variation.

While our work shows that everyday emblems are structured to reveal their communicative goal, it leaves open several questions. First, it is unclear whether rarity shapes other types of manual communication beyond emblems. Although, to the best of our knowledge, no systematic review has been conducted on the rarity of other types of manual communication such as co-speech gesture and sign language, the characteristics of emblems (i.e., fast, isolated, used at a distance, etc.) may make rarity more critical to their communicative success compared to these other forms.

Additionally, our work did not examine other pressures that shape emblems. For example, forms of communication in the manual-visual modality are often linked to their meanings (Casasanto & Jasmin, 2012; Dingemanse et al., 2015; Kita, 2009; Occhino et al., 2017; Padden et al., 2013; Pyers & Senghas, 2020). For instance, two emblems used to request checks at restaurants both draw on the features of signing a check, but one involves miming the act, while the other resembles the rectangular shape of the check. This iconicity may help learners to link the forms and meanings of emblems, as has been shown in other forms of manual-visual communication (Baus et al., 2013; Magid & Pyers, 2017; Morett, 2015; Namy et al., 2004; Sato et al., 2020). Yet, how iconicity interacts with rarity is an open question.

Our gesture creation studies suggest that individual social cognition may play a significant role in the provenance of rarity in existing emblems. Since gesturers spontaneously prefer to communicate through rare actions, it is unlikely that rarity only emerges through gradual cultural evolution, but rather it is likely present at the very inception of emblems before they are conventionalized as such. However, the lack of feedback and cultural transmission allowed in Study 2 likely provided a limited picture of how these gestures are created. Indeed, in laboratory studies, repeated usage, observer feedback, and the introduction of new learners shape the efficiency and learnability of improvised communication systems (Fay et al., 2010; Garrod et al., 2007; Kirby et al., 2015; Motamedi et al., 2019). It is possible that gesturers may spontaneously innovate rare gestures, but feedback from observers may allow gesturers to increase or decrease the amount of rarity (e.g., number of repetitions or distance from the body where the gesture is produced) such that the gesture is still clearly differentiated from world-directed goals but requires less effort to produce. This may result in emblems situated in a gesturing "sweet spot": sufficiently high rarity and low production effort. Future work should investigate how real-time usage and transmission to new learners impact the conventionalization of new gestures.

Much of our social cognition is built on a basic capacity to make sense of other people's behavior (Dennett, 1989; Gopnik & Wellman, 2012; Heider, 1958). However, understanding others' behavior is not just useful for the observer—as social creatures, it is equally critical to us that we are understood by others. Gesture is a prime example of this: how successfully an individual can communicate through gesture is contingent upon whether their observer can correctly infer their communicative goal. In this way, gestures are not only a powerful example of how our foundational social cognitive abilities shape the way that we communicate with one another, but also an invitation to reconsider the role of the actor in human action understanding.

OSF Repository Available anonymized at https://osf.io/9gefu/?view_only=bfb2b69e86124701896199 7f13d2ba93

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