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The diffusion of novel signs beyond the dyad

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ABSTRACT

We present a study aimed at investigating how novel signs emerge and spread through a community of interacting individuals. Ten triads of participants played a game in which players created novel signs in order to communicate with each other while constantly rotating between the role of interlocutor and that of observer. The main result of the study was that, for a majority of the triads, communicative success was not shared by the three dyads of players in a triad. This imbalance appears to be due to individual differences in game performance as well as to uncooperative behaviors. We suggest that both of these are magnified by the social dynamics induced by the role rotations in the game.

1. Introduction

How do novel signs emerge and spread through a community? One might think that the answer to this question is fairly straightforward: When an individual proposes a sign, the person he or she is communicating with and other people around them adopt it, they then use the sign with other people, and so on. However, as we shall see in a moment, this answer is too simplistic. An individual's novel sign is not necessarily adopted by the conversational partner and, even if it is, it is not necessarily adopted by the larger community to which the two belong. The main goal of this paper is to provide further insight into the mechanisms that govern sign diffusion. Before describing how we pursued that goal, we provide some theoretical and methodological background.

1.1. Adoption of signs within the dyad

Recently, methods have been developed for experimentally investigating how novel communication systems emerge among humans. This line of research, which may be called *Experimental Semiotics* (Galantucci, 2009; Galantucci and Garrod 2010), is based on experiments in which people must communicate but are prohibited from using conventional means of doing so and, in consequence, must create novel communication systems. Strikingly, most people are able to create communication systems within hours (De Ruiter et al., 2007; Galantucci, 2005; Garrod et al., 2007; Scott-Phillips et al., 2009; Selten and Warglien, 2007).

An important result in Experimental Semiotics is that people who are communicating with a partner create different types of signs than people who are communicating with an imaginary audience (Garrod et al., 2007). Garrod and colleagues had participants communicate concepts (such as "cartoon" and "Robert De Niro") to each other. The only communication

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medium available to the participants was a whiteboard on which they were not allowed to write any symbols with conventional meanings, such as letters or numbers. Each concept was communicated several times by a participant, so that the researchers could witness the creation of a sign for that concept and then record how that sign evolved through the game. In most of the conditions of the experiment, people played in dyads, in which one person drew and the other guessed. But in one condition, participants drew without a partner (producing drawings for someone to identify later). The researchers found that the drawings produced by dyads evolved to become very simple and abstract, while the drawings produced by people playing alone did not undergo such evolution. Thus, an individual creates different signs in a dyad than he does alone.

In addition to being affected by the presence or absence of a partner, sign creation is also affected by the specifics of the partners. Several experiments employing graphical communication tasks have shown that, even under controlled conditions, different dyads of communicants converge on different signs (Fay et al., 2004; Galantucci, 2005; Garrod et al., 2007; Theisen et al., 2010). For example, Theisen et al. (2010) found that sets of signs created by players in the same dyad were more similar than signs drawn from players in different dyads, ruling out the possibility that all dyads in the experiment were creating the same signs. Thus, partners adapt the signs they create to each other. This is in line with what we know about how people adapt their use of a shared, conventional language to their partners (Brennan and Clark, 1996; Clark and Wilkes-Gibbs, 1986; Garrod and Anderson, 1987; Pickering and Garrod, 2004).

The fact that people adapt to their communicative partners means that an individual's innovation may or may not be adopted by the dyad to which the individual belongs. To see why, let's consider a would-be innovator and a partner. Once the innovator has created a novel sign, the innovator would not be expected to insist on using it with the partner if the partner does not seem to accept it. Further, the innovator may be less willing to make innovations with certain partners in the first place, perhaps adapting to the partner's abilities or biases.

1.2. Adoption of signs beyond the dyad

We have identified some issues surrounding the diffusion of a sign from an individual to the dyads which that individual forms with others. Viewing dialogue as the basic communicative situation (Pickering and Garrod, 2004), we might be tempted to stop there. But communication systems can be shared by whole communities of people, constantly switching communicative partners. Just as many of the dyadic effects that have been uncovered would have been virtually impossible to infer from experiments with isolated participants, larger configurations of interacting individuals might give rise to beyond-dyad effects which are difficult to predict on the basis of dyadic effects.

Indeed, Fay et al. (2008) show that the communicative behavior of dyads within a community can differ quantifiably from that of dyads who are not within a community. In particular, they found that graphical signs that evolve within a close community are more transparent and more easily learned by outsiders than those developed by isolated dyads. Further, Fay et al. (2004) showed that *which* community a dyad belongs to affects the signs they create. Specifically, graphical representations from members of the same community become more similar over time.

This means that a dyad's communicative innovation will not necessarily be adopted by the community to which the dyad belongs. The whole community needs to converge on any new sign, and the biases and communicative needs of community members other than the dyad who created the sign will affect the set of signs on which the community converges.

1.3. A gap in the literature

Thus, the straightforward answer to the question of how communication systems emerge in communities—that an individual introduces a sign, the people with whom the individual communicates adopt it, and then those people use it with others—is too simplistic because an individual's innovation will not necessarily be adopted by the partner in a dyad and, even if it is, it will not necessarily be adopted by the larger community of which the two are members. Is this all there is to the story?

In the communities described above, a person was always either a full participant in a communication act (i.e., either a speaker or an addressee), or completely excluded from it. Yet, in many situations involving the diffusion of communication systems, people who are not active participants in a conversation still observe it. This is a situation which limits one's ability to comprehend the signs that are being introduced into the communication system. For example, Schober and Clark (1989) found that observers exposed to exactly the same verbal content as addressees (but unable to participate in the interaction themselves) were less successful in comprehending descriptions of abstract geometric shapes than were the addressees. For a community to converge on a communication system, some people will need to adopt others' signs, and this in turn requires some people to comprehend others' signs. Thus, since observing affects one's comprehension of others' signs, it is plausible that observing affects whether a whole community can converge on novel signs.

This leads us to the core question of this study: What happens when members of a community in which novel signs might spread are not always speakers or addressees, but are sometimes just observers?

To address this question, we analyzed the results of a semiotic coordination game which extended the game introduced by Galantucci (2005) to triads of players. In particular, we manipulated the communicative setup of the game so that players in a triad constantly rotated between the roles of interlocutor and observer, allowing us to probe deeper into how communication systems emerge and spread in small communities.

2. Methods

The experiment presented here was conducted using the method introduced by Galantucci and his colleagues (Galantucci 2005; Galantucci et al., 2003). Here we provide an overview of the method; readers interested in its details are referred to the paper by Galantucci (2005). The basic idea of the method is to create a situation in which people need to communicate but cannot use a pre-established way to do so. In particular, three adults participate in a real-time videogame with interconnected computers located at different locations.

2.1. Participants

Ten triads of participants (18 men, 12 women) were recruited at Yale University via announcements on the website of a community composed of graduate students and postdoctoral researchers. Before playing the game, players received brief instructions and were informed that their partners received the same instructions. Participants were compensated at a rate of $ 10 per hour.

2.2. Game environment

The virtual environment consists of a number of rooms, each marked with an icon on the floor. In the first level, there are four rooms. The environment remains stable until the players reach a new level, when additional rooms marked by new icons are added to it. Level 2 consists of six rooms, Level 3 of nine rooms, Level 4 of 12 rooms, and Level 5 of 16 rooms.

Only two of the three participants actively play at any one time. Each of the two active players controls the movements of an agent in the environment. A player sees only the room in which his or her agent is currently located. The player does not see the full environment, and is not told what the layout of the environment is.

2.3. Playing/task

At the beginning of each round of the game, the agents of the active players are located in two different rooms at random. The goal of the players is to bring their agents into the same room without making more moves than necessary. For each round, the number of allowed moves is determined by computing the shortest path between the rooms in which the agents are initially located. If players make more moves than they are allowed, they lose the round.

If a player moves from one room to another twice in a row, that is, before the partner makes a move (we will refer to this behavior as making *consecutive moves*), the dyad immediately loses the round. This constraint forces both players to move during the round, fostering bilateral communication.

The round ends when the players have met in the same room, the players run out of moves, or one of the players has made consecutive moves. When a round is over, agents can no longer leave their rooms. Once both players terminate the round (by moving into one of four marked locations in the room), a new round of the game begins and agents are instantly relocated in two different rooms at random.

2.4. Communication medium

Players cannot see or hear each other but can communicate by using a magnetic stylus on a small digitizing pad. The horizontal component of the stylus' movements on the pad directly controls the horizontal movements of a trace that is relayed to the screens of both players. The trace's vertical component is independent of the player's movements and has a constant downward drift that causes the trace to disappear from the screen quickly. Under these conditions, the use of common symbols such as letters or numerals is practically impossible and the use of pictorial representations is severely reduced; players must converge on a non-obvious way of using the graphic medium in order to set up a communication system extemporaneously. Moreover, since the communication medium can be used simultaneously by both players throughout the entire duration of the experiment, players have to set up procedures to coherently organize their signaling activity.

2.5. Observing

The agent of the player who is inactive in a given round (henceforth, the *observer*) is seen by the active players and is tethered to the agent of one of them. The observer sees everything that is happening in the game but cannot produce signs and has a very limited range of motion around the agent to which his or her agent is tethered.

2.6. Role rotation

The dyad of active players switches every two trials so that—if we call the three players in a triad A, B, and C—there are two rounds of A and B playing, two rounds of A and C playing, two rounds of B and C playing, and so on. The agent of the observer is tethered to one of the agents of the active players in the first of the two rounds and then to the agent of the other active player in the second. For example, whenever A and B are active players, C is tethered to A in the first round and to B in the second. In consequence, over the course of six consecutive turns, players play and observe their teammates playing an equal number of times.

2.7. Goal and score

Players were instructed to focus on the score as their primary goal in the game. The score consisted of a numerical index that increased only when players won consistently in the game, that is, only when they found each other at a rate reliably above chance level (as illustrated below, this level was determined with Monte Carlo simulations). To introduce a time pressure in the game, the score decreased one point every minute. The score was shared by all three players in a triad, and a triad advanced through levels based on its shared score. The performance of each dyad in the triad was constantly monitored to prevent underperforming dyads from stalling the triad's progress in the game. When a dyad performed consistently worse than the other dyads in the triad, its relative contribution to the triad's score began to decrease, until it reached a point at which its impact on the triad's score was negligible. If the underperforming dyad recovered, its relative contribution to the triad's score quickly went back to the same level as the other dyads. As mentioned above, with each new level, new rooms were added to the game environment. The triad's goal was to reach the highest level possible over three playing sessions lasting two hours each.

3. Two outcome scenarios

Essentially, players forming small communities have to create signs in order to communicate with each other (as in previous work by Galantucci and colleagues), but players are now able to observe the other members of their community communicating with each other. What might happen in this situation?

The communities might converge on signs, that is, all players in a triad might co-create a communication system. This result would echo those from the community experiments reviewed above (e.g., Fay et al., 2004), in which communities converged on some way of communicating (even if particular signs did not survive). Accordingly, this outcome would be predicted if only community dynamics were at play, that is, if having community members observe the conversations of other community members had no effect on the diffusion of signs into the whole community. This is plausible. Imagine that two players in the triad, A and B, have established a sign. The other player, C, may not understand it while she is still only observing her partners using it. Soon afterwards, however, A and C play together and have to communicate. A may try to use this new sign with C. C may learn the sign through her interaction with A. Or, A and C may converge on a different sign. As the roles of playing and observing are rotated through this community, the three players could slowly converge on signs that work for all of them.

An alternative to this scenario is that some communities do not converge on signs. There are a few reasons why this might happen. In the scenario envisaged above, perhaps A and B continue to develop signs together and C is never able to catch up. C's inability to comprehend A and B's signs might cause other problems, such as frustration or a feeling of exclusion (cf. Williams et al., 2000), which further impede progress. Also, A and B, given that they are successful together, may become intolerant of C and stop trying to communicate with her.

4. Results

In order to find each other within the game environment, players must successfully communicate their locations to their partners and coordinate their moves. Therefore, success in the game requires that players create signs to refer to the rooms in the environment and that their partners adopt these signs. That is to say, success rate patterns directly reveal effective communication (Galantucci, 2005). In consequence, our analysis focuses primarily on success rate.

Within each triad (consisting of players A, B, and C), there are three dyads that play together (AB, BC, and AC). For each dyad in each triad, we computed the success rate in each level played by the dyad. In particular, a dyad's success rate in a given level is computed as the proportion of the trials won by the dyad in that level. For example, if dyad AB played 50 trials in Level 3 and won 45 of these trials, dyad AB's Level 3 success rate would be .9.

Our first analysis concerns the last game level each triad completed, which varied across triads. We examined whether the success rate of each dyad in the triad in this level was significantly above or below chance. The chance success rate for a given level is the success rate that we would expect if the players were moving at random but following the rules of the game (avoiding consecutive moves and staying within the maximum number of moves allowed for that level). We determined the chance success rate by performing Monte Carlo simulations of the game. (One million trials were simulated for each level.) The chance success rates ranged from .5 for Level 1 to .37 for Level 5. We used a binomial test to determine, for each dyad in a triad, whether their success rate in the last successfully played level was significantly above or below chance. The results of the tests are presented in Table 1.

The first thing to notice is that in at least two cases, success was balanced: In Triads 1 and 6 all three dyads were above chance. There are two other cases (Triads 3 and 7) in which success could be said to be fairly balanced; in each of these two triads, two dyads were significantly above chance, while the third dyad was marginally above chance. Overall, these cases of

Table 1
Success rates for each dyad in each triad, during the triad's last successfully completed level. Italic values represent significant below-chance performance, bold values represent significant above-chance performance and normal values represent at chance performance. Underlined italic values represent marginally below-chance performance, underlined bold values marginally above-chance performance. Single, double, and triple asterisks represent significance ($p < .05$, $p < .01$, and $p < .001$, respectively). An 'm' indicates marginal significance ($p < .1$). The ratios in parentheses are the number of successful trials over the total number of trials played by that dyad in that level.

Triad/dyad	AB	BC	AC
T1: Level 4,	**.88****	**.88****	**1.00****
Chance success rate: .41	**(7/8)**	**(7/8)**	**(7/7)**
T2: Level 1,	*.39**	**.69*****	**.63****
Chance success rate: .5	*(37/96)*	**(70/101)**	**(64/101)**
T3: Level 5,	.58^{m}	**.84*****	**.70****
Chance success rate: .37	(11/19)	**(16/19)**	**(14/20)**
T4: Level 2,	*.34**	***.44***	**.74*****
Chance success rate: .48	*(16/47)*	***(20/46)***	**(34/46)**
T5: Level 4,	***.43***	**.73*****	***.42***
Chance success rate: .41	***(29/67)***	**(48/66)**	***(28/67)***
T6: Level 4,	**.76****	**1.00*****	**.79*****
Chance success rate: .41	**(19/25)**	**(24/24)**	**(22/28)**
T7: Level 3,	**.72*****	**.66****	.54^{m}
Chance success rate: .45	**(51/71)**	**(46/70)**	(39/72)
T8: Level 2	**.71****	*.29**	***.48***
Chance success rate: .48	**(46/65)**	*(18/63)*	***(32/67)***
T9: Level 2	**.82*****	***.50***	*.36*^{m}
Chance success rate: .48	**(41/50)**	***(25/50)***	*(18/50)*
T10: Level 3,	*.14**	***.39***	**1.00*****
Chance success rate: .45	*(2/14)*	***(5/13)***	**(12/12)**

balanced success indicate that triads can converge on novel signs even when people are sometimes observers and sometimes active participants in conversation.

Turning to the remaining six triads, we find that in no triad were all three dyads either at chance or below chance. In other words, success was not evenly distributed across dyads within the triad in the majority of cases in the study (Triads 2, 4, 5, 8, 9, and 10). In the remainder of this section we focus on the unbalanced success in those triads.

One triad (Triad 2) included two above-chance dyads and one below-chance dyad. Two of the players performed well when playing with the third but performed poorly when playing with each other. This triad only successfully completed the first level, which means that it performed more poorly than any other triad in the experiment. As observed by the experimenters, this happened because they were only able to create a rudimentary communication system, which depended on a number of silent coordinative strategies (cf. Galantucci, 2005). The player who played in both of the successful dyads was largely responsible for this coordination, and without him, the two other players failed. Since the focus of this section is overt communication and not silent coordinative strategies, we will set this triad aside for the remainder of the section.

Strikingly, the remaining five triads (Triads 4, 5, 8, 9 and 10) display a similar pattern of success: In each of these triads, one of the dyads achieves above-chance success and the other two are either at or below chance. This means that two of the players are successful when they play with each other but neither is successful when playing with the third. In other words, the signs that emerged in the successful dyad did not diffuse across the whole triad. Even when two players created signs, the third did not necessarily adopt them – despite the clear advantage they provide in the game.

In the next sections, we will suggest two explanations for this unbalanced success: (1) a mismatch in the game performance of the players, and (2) uncooperative behavior from the players. The explanations are not mutually exclusive and, as we will show, both are related to the social structure imposed on the players.

4.1. Mismatch in game performance

In some cases, less competent players fail because they are not ready to tackle more advanced levels. Recall that a triad – *all* of its dyads – advances through levels based on its score. In other words, because of the game's scoring mechanism, a triad's score can reach the criterion for advancement to the next level even if just one of its dyads is successful. This can have the result of advancing a dyad that is equipped with very limited (if any) communicative tools into ever more difficult levels. A player who is already finding it difficult to learn the signs created by the partners for a smaller game environment may have even more trouble in a larger environment, and may never be able to catch up with the partners. We see such a pattern in at least two of the triads (Triad 5 and Triad 10). For each of these triads, one dyad reached above-chance success quickly, without falling below chance for the rest of the game, whereas the other two dyads never achieved above-chance success. The successful dyad in both of these triads achieved above-chance performance within its first 10 trials. No other dyad in any other triad attained above-chance performance so quickly and maintained it for the whole game. This suggests that the speed with which these dyads attained above-chance performance and advanced to the next level played a role in the failure of the other two dyads in their triads.

There is another reason to suppose that the problem is rapid advancement through the game: Complete failure at the game appears to be much less common in similar two-player studies (Galantucci 2005; Galantucci et al., 2010) than in the current study. This suggests that less competent players do have the potential to create, or at least adopt, novel signs. Of course, the comparison between the dyad study and the study presented here is not completely fair because in the current game players do not play in one third of trials, and they do not get an unlimited number of trials to succeed at any given level of the game. Rather, if one dyad becomes extremely successful, it can end a level and advance the triad as a whole to the next level all by itself. Even so, the comparison is informative because participants in the dyad studies played the same exact game as in the current study, except for the addition of a third player. Just 10.3% (3 of 29) of the dyads reported in Galantucci (2005) and Galantucci et al. (2010) failed to establish communication systems in the first level. In contrast, in the current experiment 36.7% (11 of 30) of the dyads failed to achieve above-chance performance in the first level. This difference in failure rates is significant [$\chi^2(1, N = 59) = 8.12, p = .005$] and is even more surprising when one considers the advantages of observing. If anything, we expected lower failure rates in the current study, since less competent players are able to witness more competent players' successful communication systems in action. That is, if players are unable to create signs on their own, they could copy them from others. The difference in failure rates clearly indicates that this was not the case. Simply *seeing* a solution in action is often not enough; players may need to acquire communicative competence in the dyads in which they are *active* communicators in order to succeed.

In sum, part of the unbalanced success across dyads in a triad appeared to relate to the interplay between the playing abilities of the participants and the scoring mechanisms of the game.

4.2. Uncooperative behavior

Another factor in the unbalanced success of dyads within a triad was that players sometimes became uncooperative, actually *trying* to lose trials. This is evidenced by the fact that some dyads (in Triads 2, 4, 8, and 10) managed to perform significantly below chance. Note that the chance success rates for each level indicate the success rate that players who move at random—but follow the rules of the game—would achieve. If players are just failing to communicate successfully, they should perform at chance level. Players in below-chance dyads appear to be actively avoiding even chance success, behaving uncooperatively. In what follows we illustrate some examples of uncooperative behaviors.

4.2.1. Examples of uncooperative behavior

First, sometimes a player prevented the establishment of a communication system with the partners. For example, the least competent player in Triad 8 gave up on using the stylus altogether, commenting that there was no use for it. In another triad (Triad 4), the least competent player continued to produce signs despite the lack of success with them. The two other players (who were successful together) admitted after the experiment that they had not been even trying to understand these signs.

Players could also be uncooperative by moving one's agent before one's partner had communicated any information. If a player moves before any communication, it would seem that he or she is no longer trying to be successful. One player in one unsuccessful dyad (in Triad 2) moved before communicating in 46% of their trials. (Players in this unsuccessful dyad were only unsuccessful with each other; each was successful when playing with the third player.)

Further, some players appeared to be breaking the rules of the game on purpose. In particular, recall that players were prohibited from making consecutive moves and lost the trial instantly if they broke this rule. A few triads included players who seemed to make consecutive moves *in order* to end their trial. For example, towards the end of their game, 60–90% of one dyad's trials (in Triad 10) were ended by consecutive moves. Such a high rate of rule violations was never observed in previous studies (Galantucci, 2005; Galantucci et al., 2010) or in the successful dyads of the current study. (Below we explore whether it is the competent or the incompetent player performing this trial-ending behavior.)

More generally, all of the kinds of uncooperative behaviors described here were observed much less frequently in the basic, dyad version of the game (Galantucci, 2005; Galantucci et al., 2010) and seem to be reactions to the triadic social structure of the current experiment.

4.2.2. Who's not cooperating?

One might think that the less competent player (who is unsuccessful with both of the partners) begins actively ending trials, perhaps due to jealously from observing the partners developing a communication system and rising to success together (cf. Williams et al., 2000), or due to frustration caused by being unsuccessful (especially while observing others being successful). However, in none of our below-chance dyads does the less competent player execute the majority of trial-ending moves. Rather, one of the more competent players in the triad seems to play a significant role in ending the trials. In fact, if the unsuccessful player were solely responsible for below-chance performance, we would see below-chance performance in *both* of the dyads in which that player plays. Instead, the choice of partner for the unsuccessful player seems to affect the success rate. This suggests that one player who is otherwise successful in the other pairing actively engages in uncooperative behavior when playing with the less competent player. Indeed, this was often observed. For example, in Triad 8, 85% of the consecutive moves in the unsuccessful dyad were performed by the competent player in the dyad. It appears as if achieving success with one partner makes one less tolerant of other (less competent) partners. However, in previous community experiments, dyads within a community (i.e. players who switched partners) did converge on new signs. This suggests that the social structure of the game is another important factor – in particular, group's shared success. If a player's success in the game had depended on the performance with each of the partners, he or she presumably would have cooperated with each of them.

4.3. Summary of results

Success of dyads within a triad was often unbalanced. In five of the ten triads, two of the players were successful with each other but neither was successful with the third. One explanation for this seems to relate to the players' abilities: less competent players were unable to learn their partners' signs before their partners advanced them through the game. In addition, the finding that some dyads manage to play at a below-chance level suggests that some players were uncooperative. The uncooperative behavior took various forms, from refusing to even pick up the stylus to purposely breaking a game rule in order to end trials. Sometimes it was the incompetent player in the triad who behaved uncooperatively, but more often it was one of the competent players.

5. Conclusions

We posed a question in this paper: How do novel signs emerge and spread through a community? Previous work had already shown that there are at least two levels of convergence on communicative innovations—an individual may propose a new sign, but then it must be accepted by the current communication partner, and then it must be accepted by the larger community of interacting communication partners. That is, the emergence of a communication system shared by all members of a community requires convergence at progressively higher social groupings. The results from the study presented here confirmed this, as the particular signs that a dyad converged on were not always adopted by the whole triad.

Our study adds another piece to the puzzle, with the observation that a community of interacting dyads may not converge at all. That is, not only will a community not necessarily adopt a particular new sign (cf. Fay et al., 2004), but it is also not necessarily the case that the community will adopt *any* sign. In fact, some community dynamics can prevent dyads from converging because players may not be *willing* to converge. One might be tempted to disregard this unexpected result as an artifact of a peculiar scoring mechanism, specifically that a triad could succeed in the game even when not all dyads in it played successfully. However, the scoring mechanism of the game might reflect typical human cooperative endeavors, in which it is often possible for an individual to fail to contribute without completely derailing the overall progress of the undertaking. In any event, the result that signs do not automatically diffuse in such a small community is valuable independently from the fact that the dynamics of the game faithfully reproduce typical human dynamics. In the study presented here, players were repeatedly exposed to viable solutions for an urgent communicative problem. Such solutions were often very simple and players watched their successful implementation for extended periods of time, with full access to the context relevant for understanding them. The fact that some players did not learn such solutions in these conditions is a powerful demonstration that it is very difficult to learn a communication system from just passive exposure to it, a conclusion that is consistent with the finding that hearing children of deaf parents do not learn spoken language well from watching television (Sachs et al., 1981).

Previous work has shown that a comprehensive account of how communication systems emerge must bridge the gap between investigation at the level of the individual and investigation at the level of interactions occurring between and among individuals. We contributed to this line of research by identifying additional dynamics introduced when people engage in paired interactions within a closed community but can observe some interactions between other community members. In particular, we identified two factors—observing and success sharing—that could lead to further experimental investigations.

While the study presented here was mostly exploratory, future work could systematically manipulate the factors we identified, for instance, whether or not a player is able to observe the partners communicating (or simply takes a short break when not playing). Triads might or might not be more likely to converge when players do not observe others' conversations. One could also manipulate whether an individual's success depends on the success with each of the partners, for example by having dyads within a triad (rather than whole triads) advance to different levels of the game depending on their success. Experimental Semiotics offers many opportunities to study the social dynamics of emerging communication systems.

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