Automatic imitation in a strategic context: Players of Rock-Paper-Scissors imitate opponents' gestures[*]

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ABSTRACT

A compelling body of evidence indicates that observing an action makes the execution of that action more likely. However, it remains unclear whether this so-called ‘automatic imitation’ is indeed automatic (i.e. reflexive and involuntary) or whether these effects are better characterised as voluntary actions. The present study sought to test the automaticity of automatic imitation by studying whether imitative responding emerges in a strategic context where it reduces payoffs. Participants were required to play Rock-Paper-Scissors, with the aim of achieving as many wins as possible, while either one or both players were blindfolded. While the frequency of draws in the blind-blind condition was precisely that expected at chance, the frequency of draws in the blind-sighted condition was significantly elevated. Specifically, the execution of either a rock or scissors gesture by the blind player was predictive of an imitative response by the sighted player. That automatic imitation emerges in a context where imitation reduces payoffs accords with its ‘automatic’ description, and implies that these effects are more akin to involuntary reflexes than to voluntary actions. These data represent the first evidence of automatic imitation in a strategic context, and challenge the abstraction from physical aspects of social interaction typical in economic theory and game theory.

1. INTRODUCTION

Reports of apparently unconscious, spontaneous mimicry date back several centuries. Recently these effects have been described as ‘automatic imitation’ and attributed to a human mirror neuron system (Heyes, under review). While this description implies that such imitation is somehow involuntary or stimulus-driven, there is surprisingly little evidence supporting this characterisation. For example, no previous studies have explicitly asked participants not to imitate or penalised imitative behaviours. The present study adopts the novel approach of using a strategic context to assess the automaticity of the tendency to imitate. Specifically, we sought to determine whether players of ‘Rock-Paper-Scissors’ imitate the gestures of their opponents, in a game where the only way to win is to avoid imitating your opponent.

Neurons have been discovered in the macaque premotor and parietal cortices which respond both to the sight and execution of a given action (di Pellegrino, Fadiga, Fogassi, Gallese & Rizzolatti, 1992; Gallese, Fadiga, Fogassi, & Rizzolatti, 1996; Rizzolatti, Fadiga, Gallese, & Fogassi, 1996). Since the discovery of these ‘mirror neurons’ in the macaque, considerable evidence has amassed suggesting that humans also have a mirror neuron system (MNS) (Iacoboni et al., 1999; Gazzola, Rizzolatti, Wicker & Keysers, 2007). The human MNS has been implicated in a range of social functions, including action understanding, empathy, and theory of mind (Gallese & Goldman, 1998; Rizzolati & Craighero, 2004). However, one of the most plausible functions of the human MNS is in the mediation of a range of imitative or mirror effects that may be broadly described as automatic imitation.

In the most straightforward cases, automatic imitation is overt - the sight of an action elicits visible execution of same movement. Experimental demonstrations of such overt imitation date back to Eidelberg (1929) and Hull (1933). Early researchers were hampered by methodological problems, but more recent research has confirmed that humans often spontaneously and overtly imitate each other’s body postures (Bernieri, 1988; Thirioux, Jorland, Bret, Tramus & Berthoz, 2009); facial expressions (Bavelas, Black, Lemery & Mullett, 1986); hand / arm gestures (Chartrand & Bargh, 1999; Kilner, Paulignan & Blakemore, 2003); and foot movements (Chartrand & Bargh, 1999). For example, Chartrand and Bargh (1999) showed that participants were more likely to engage in foot-tapping than face-touching behaviours in the presence of a foot-tapping confederate, while the opposite pattern was observed in the presence of a confederate prone to touching their face. Similarly, Kilner et al. (2003) required participants to make horizontal or vertical arm movements while observing either a human or robot agent making congruent or incongruent actions. The sight of the incongruent actions produced greater imitative interference when they were executed by a human rather than a robotic actor . Most recently, Thirioux et al. (2009) found that watching a virtual tightrope walker elicited correlated leaning movements in observers. Having asked participants to simply move forwards and backwards, in accordance with the forwards and backwards movements of the tightrope walker, the authors found that participants also spontaneously mimicked the random tilting movements of the virtual agent.

While there have been several reports of overt automatic imitation, often imitative effects are too subtle to be detected by the naked eye. Consequently, many researchers now believe that the incidence of overt imitation may be small compared with the incidence of more subtle, covert mimicry (Dijksterhuis, 2005). Some insight into such covert mimicry has been provided through the use of electromyography (EMG), a technique which allows researchers to detect and measure extremely subtle muscle movements (Berger & Hadley, 1975; Blairy, Herrera & Hess, 1999; Dimberg, 1982). For example, Dimberg, Thunberg & Elmehed (2000) used EMG recording in conjunction with backward masking to present happy, angry and neutral faces for very brief durations. Even when stimuli were presented so briefly (30ms) that participants were not consciously aware of the stimuli, the authors detected muscle-specific EMG signals characteristic of the expressions presented.

EMG has also been used in conjunction with transcranial magnetic stimulation (TMS) to detect even more covert imitative effects. When TMS is applied to an observer’s primary motor cortex during action observation, the motor evoked potentials (MEPs) elicited typically ‘mirror’ the muscles required to perform the action being observed (Fadiga, Fogassi, Pavesi & Rizzolatti, 1995; Strafella &

Paus, 2000). For example, Strafella & Paus (2000) recorded stronger MEPs in participants' bicep muscles while they observed arm than hand movements, and stronger MEPs from hand muscles while they observed hand rather than arm movements.

A covert tendency to imitate has also been detected using reaction time measures (Brass, Beckering & Prinz, 2001; Dimberg, Thunberg & Grunedal, 2002; Heyes, Bird, Johnson & Haggard, 2005). For example, Heyes et al. (2005) found that participants were faster to make hand opening responses to the onset of hand opening stimuli than to the onset of hand closing. The finding that participants make faster imitative responses than non-imitative responses is extremely robust, having been found across a range of effector systems (Gillmeister et al., 2008; Leighton & Heyes, in press) for both transitive (Craighero, Bello, Fadiga & Rizzolatti, 2002) and intransitive actions (Bertenthal, Longo, & Kosobud, 2006; Press, Bird, Walsh, & Heyes, 2008).

The imitative effects described above represent compelling evidence that the sight of an action increases the likelihood of the motor execution of that action. However, they do not tell us whether 'automatic imitation' is automatic in the sense of being difficult or impossible to inhibit. Actions may be thought of as forming a continuum, with voluntary actions at one extreme and automatic reflexes at the other (Haggard, 2008). Reflexes, such as the classic knee-jerk response, are immediate reactions automatically triggered by an external event. Such actions are involuntary; that is, they cannot be inhibited. In contrast, voluntary actions are only very indirectly elicited by an external stimulus and are thus free from immediacy (Shadlen & Gold, 2004). Moreover, voluntary actions can, by definition, be inhibited.

We do not yet know how difficult it is to inhibit automatic imitation. This is because, in previous studies, participants had little or no incentive to inhibit imitative responses. In studies conducted in naturalistic settings, there were no costs associated with imitative behaviour (e.g. Chartrand & Bargh, 1999), and in more tightly controlled experiments, imitative tendencies interfered with the participants' capacity to obey task instructions, but did not incur any further penalties (e.g. Stuermer et al. 2000). For example, in experiments where participants were instructed to respond as quickly as possible, they reacted more slowly when their response did not match the action stimulus. However, they received the same expenses payment at the end of the experiment, regardless of their response speed.

In the present experiment, we adopted the entirely novel approach of studying automatic imitation in a naturalistic, strategic context. To find out how difficult it is to inhibit imitative responding, we observed participants while they were playing ‘Rock-Paper-Scissors’ (RPS) – a game in which imitative responding is costly. While it has been observed that competitors may emulate the strategies of rivals (Apesteguia, Huck & Oechssler, 2007; Huck, Normann & Oechssler, 1999; Offerman, Potters & Sonnemans, 2002), automatic imitation, whereby rivals copy the topography of rivals’ body movements, has never been demonstrated in a strategic context.

In the RPS game, two players each present one of three alternative hand gestures. Each player must make either ‘paper’ (an open hand), rock (a closed fist), or ‘scissors’ (index and middle finger parted) gestures, typically following a count of three. A paper gesture beats a rock gesture; a scissors gesture beats a paper gesture; and a rock gesture beats a scissors gesture. If both players make the same gesture, the round is drawn. Consequently, for any given round between players 1 and 2, there are nine possible combinations of gestures, three of which result in wins for player 1; three which result in wins for player 2; and three which result in a draw. The normal form of Rock-Paper-Scissors is shown in Table 1. In this zero-sum game, where one player's victory (1) results in the other player's defeat (−1), the only ‘Nash equilibrium’ (where each player behaves optimally given what all others do) is in mixed strategies. Regardless of which action one player chooses (rock, paper, or scissors), there would always be one specific action for the other player that ensures a win, and vice versa. Thus, there is a ‘best-response structure’: the best reply against rock is paper, the best reply against paper is scissors, the best reply against scissors is rock. Consequently, there is no pure strategy equilibrium where every player takes one action for sure, and players can only achieve optimal outcomes if they *avoid* imitating each other.

Table 1 about here

The present study thus sought to determine whether performance in Rock-Paper-Scissors is influenced by automatic imitation. To address this question, players' performance was compared under two conditions. In the first condition, one of the players was blindfolded and the other sighted. In the second condition both players were blindfolded. If there is an effect of imitation, one would expect the proportion of drawn rounds to exceed a third in the blind-sighted condition, but not in the blind-blind condition, because only the sighted player has the capacity to imitate their opponent.

2. EXPERIMENTAL DESIGN AND PROCEDURES

Forty-five healthy adults (23 females) with a mean age of 24.9 years served as participants in the experiment. All had normal or corrected-to-normal vision, were familiar with the game, and were naive to the purpose of the experiment. None had studied economics at undergraduate level or higher. The study was approved by the University College London ethics committee and performed in accordance with the ethical standards set out in the 1964 Declaration of Helsinki.

The participants (recruited with ORSEE, Greiner 2004) were assigned to triads at random. Six of the triads comprised two males and a female; four comprised two females and a male; two comprised three males and three comprised three females. Within each triad, the three participants were arbitrarily designated players A, B and C. Triads were required to play nine matches of Rock-Paper-Scissors each of which consisted of 20 individual rounds. The first three matches were between players A and B, the second set of three matches were between A and C, and the final three between B and C. Matches were played under two conditions; either with one player sighted and one blindfolded, or with both players blindfolded. The first two matches played by each of the three player pairings were completed with one of the players blindfolded. The player blindfolded alternated across the first and second matches for each pairing. In the third match played by each pairing, both players were blindfolded. The sequence of matches is summarised in Table 2.

Table 2 about here

In each round, players faced each other and delivered their gestures simultaneously following a count of three made by the umpire. Prior to the delivery of each gesture, participants were required to present a clenched fist in front of their body. The third member of the triad, not involved in the match-pairing, recorded the gestures and outcomes using a computerised scoring sheet, and acted as umpire. The participants fulfilling the umpire role were asked to ensure that blindfolded players were unable to see their opponent; to ensure that players were facing each other throughout each round; to inform blind players of the gestures made; and to state aloud the outcome of the each round.

The experiment took place at the ELSE Laboratory, University College London, in a large, well-lit room. Data was collected over three sessions, each lasting approximately 70 minutes. Written instructions were presented at the start of the session, including a recapitulation of the rules of Rock-Paper-Scissors. Subjects were also shown the corresponding hand signs. Each subject received a small honorarium for participating (£5) which was supplemented by an additional payment based on their performance in the experiment. Players were informed at the start that if there was an overall winner of each match, that player would receive an additional £2.50 win bonus. However, if a match was tied, neither player would receive any bonus. The best-reply structure of the single-shot game was therefore preserved as long as no player becomes uncatchable.

The payment structure adopted meant that the Nash Equilibrium was in mixed strategies. The worst outcome for each pairing was a tied match, because in this eventuality neither player achieved the win bonus. However, the probability of a drawn match steadily increased as the number of drawn rounds increased, and the number of possible outcomes was thereby constrained. For example, if only 10 rounds of the 60 played were drawn, the probability of a tied match was only 1/51. However, if 30 rounds were drawn, the probability of a tied match increased to 1/31. Thus, only by minimising the proportion of drawn rounds could players maximise their chances of achieving the win bonus.

3. RESULTS

Data from one of the triads was excluded because participants did not follow the experimental procedure correctly – specifically, blindfolded players were not informed of their opponents' gestures. The analyses reported were thus conducted on the data from the remaining 14 triads. A further two data points were lost from the blind-sighted condition due to participant error. For the purpose of significance testing, neither the data from individual participants nor player pairings can be regarded as independent. As with all zero-sum games, a player's outcomes on Rock-Paper-Scissors are perfectly (negatively) correlated with their opponent's. Moreover, each player was a member of two of the three pairings within each triad. Thus, any tendency of a given individual could influence two pairings. The analyses reported therefore reflect the conservative approach of treating the data from each triad as a single observation.

Table 3 about here

Across the whole experiment, the rock gesture was executed on 32.4% of rounds; the paper gesture on 33.3% of rounds; and the scissors gesture on 34.4% of rounds (Table 3). One-way ANOVA with gesture as a within-triad factor confirmed that the fourteen triads executed the three gestures with comparable frequency in both the blind-sighted [$F(2,26) = 1.24$; $p > .30$] and blind-blind conditions [$F(2,26) = .117$; $p > .80$].

Table 4 about here

The outcomes obtained by the fourteen triads across the two conditions are summarised in Table 4. Of principal theoretical interest, there was clear evidence of a tendency for the sighted player to imitate the blindfolded player (i.e. to choose the same gesture). As the imitation hypothesis would predict, there was a greater number of draws in the blind-sighted (36.3%) than in the blind-blind (33.3%) conditions across the fourteen triads. One-sample t-tests revealed that the proportion of draws was significantly above that expected at chance in the blind-sighted condition [$t(13) = 2.49$; $p < .025$ (one-tailed)] but not in the blind-blind condition [$t(13) =. 07$; $p >.90$ (one-tailed)]. In the latter case, the frequency of draws was almost exactly that expected by chance. Moreover, a paired-samples t-test revealed that the frequency of draws was significantly higher in the blind-sighted than in the blind-blind condition [$t(13) = 1.72$; $p = .05$ (one tailed)].

Figure 1 about here

In order to better understand the elevated frequency of draws in the blind-sighted condition, we performed logistic regressions on sighted subjects' likelihood to imitate. We ran three such regressions, shown in Table 5. Each regression estimated the likelihood of the sighted player would imitate depending on whether or not the blindfolded player chose one of the three actions (with robust standard errors and clustering on triad level). The regressions revealed that the execution of a scissors gesture by the blindfolded player significantly increased the probability that the sighted player would also choose scissors [$\beta = .266$; $p < .01$ (one tailed)]. A similar effect, with borderline significance, was observed when the blindfolded player chose rock [$\beta = .245$; $p < .05$ (one tailed)], but not when the blindfolded player chose paper [$\beta = .086$; $p > .25$ (one tailed)]. The contingencies between the gestures of the blind and sighted players' gestures are represented in Figure 1.

Table 5 about here

Finally, no evidence was found to suggest that sighted participants were able to predict the gestures made by their blind opponents. If being able to observe the opponent conveyed an advantage, one would expect sighted players to win a greater proportion of the sighted-blind rounds than blind players. However, across the fourteen triads the blind players actually won slightly more of the blind-sighted rounds (32.4%) than the sighted players (31.3%) with only five of the fourteen triads producing a greater number of sighted wins than blind wins. A paired-samples t-test confirmed that the difference in the number of wins achieved by the blind and sighted players across the fourteen triads was not significant [$t(13) = .779$; $p > .80$ (two-tailed)].

4. DISCUSSION

The results of this study indicate that players of Rock-Paper-Scissors tend to imitate their opponents, in spite of the costs associated with imitation in this game. Consistent with this hypothesis, we found a higher frequency of draws when one player could see the other than when both players were blindfolded (a 'draws effect'), and that the execution of the scissors and rock gestures by the blind players predicted the execution of matching gestures by their sighted opponents.

Although players of Rock-Paper-Scissors are formally required to present their gestures simultaneously, it is inevitable that on most rounds one of the players will present slightly earlier than the other. Our results suggest that, on those rounds where the blind player delivered their gesture first, observation of this gesture activated in their opponent a motor representation of the same action. This motor activation made the opponent more likely to select the same action as the blind player than to execute one of the two alternative actions. Thus, it appears that the psychological mechanisms responsible for the higher frequency of drawers in our blind-sighted condition are comparable with those that generate automatic imitation (Blairy et al., 1999; Brass et al., 2001; Dimberg, 1982; Dimberg et al., 2002; Heyes et al., 2005; Kilner et al., 2003; Thirioux et al., 2009). In a neuroimaging study, Dinstein, Hasson, Rubin and Heeger (2007) found that playing Rock-Paper-Scissors recruited areas of the mirror neuron system, including the ventral premotor cortex and intraparietal sulcus. There is evidence that mirror neuron system mediates automatic imitation (e.g Catmur et al, 2008). Therefore, like the results of the present study, these neuroimaging data imply that players of Rock-Paper-Scissors are subject to automatic imitation.

To produce the draws effect in games of Rock-Paper-Scissors, automatic imitation must occur very rapidly. That is, perception of the movement stimulus – the opponent's action – and activation of a corresponding motor representation, must occur in less than a second. Carefully controlled studies of automatic imitation have confirmed that this is possible. For example, EMG recording from facial muscles while participants view backward-masked facial expressions has revealed expression-specific muscle activation following only 35ms stimulus exposure (Dimberg et al, 2000). Similarly, participants execute imitative hand opening and closing gestures faster than comparable non-imitative responses, even when mean reaction times are approximately 400 ms (Heyes et al., 2005).

The results of our logistic regression analyses suggested that the imitation effect was strongest for the scissors gesture, weaker for the rock gesture, and absent for the paper gesture. This may have been due to variability in the salience and distinctiveness of the gestures relative to the clenched fist starting position. The scissors gesture, from which there are two protruding fingers, is very different from a clenched fist, and execution of the rock gesture typically involves an abrupt thrusting movement of the hand towards the player’s opponent.

The draws effect observed in this experiment provides evidence that automatic imitation is ‘automatic’ in the sense of being very difficult to inhibit. The payment structure used in this experiment meant that the Nash Equilibrium was in mixed strategies. The worst possible outcome for each pairing was a tied match, because in this eventuality neither player achieved the win bonus. The probability of a tied match steadily increased as the number of drawn rounds increased, and the number of possible outcomes was steadily constrained. Only by avoiding imitation could players maximise their chances of achieving the win bonus. Thus, players imitated their opponents’ actions in spite of having a clear financial incentive to prevent themselves from doing so.

More broadly, our results challenge the tendency in economic and game theory to ignore, or abstract away, the physical aspects of social interaction. The draws effect shows that physical factors are not only important in complicated strategic interactions, where strong emotional drivers such as fairness, trust and reputation play a role. Rather, the embodied aspects of cognition play a significant role even at the simplest level of game playing, and when they work against the player’s interests.

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TABLES:

Table 1: The Rock-Paper-Scissors game, where (0,0) denotes a drawn round; (1,-1) denotes a win for player 1; and (-1,1) denotes a win for player 2.

		Player 2		
		Rock	*Paper*	*Scissors*
Player 1	*Rock*	0,0	-1,1	1,-1
	Paper	1,-1	0,0	-1,1
	Scissors	-1,1	1,-1	0,0

Table 2: The sequence of the nine matches played by each triad

Player A vs. Player B	Player A blindfolded
	Player B blindfolded
	Both players blindfolded
Player A vs. Player C	Player C blindfolded
	Player A blindfolded
	Both players blindfolded
Player B vs. Player C	Player B blindfolded
	Player C blindfolded
	Both players blindfolded

Table 3: Distribution of the 3 gestures for the blind-sighted games; the blind-blind games and collapsed across all manipulations

	Rock	**Paper**	**Scissors**
Blind-Sighted	32.1%	33.1%	34.8%
Blind-Blind	32.8%	33.5%	33.7%
Overall	32.4%	33.3%	34.4%

Table 4: Summary of the outcomes observed across the fourteen triads.

		Mean	**SD**
Blind-Sighted	*Blind wins*	32.4%	4.1%
	Sighted wins	31.3%	2.9%
	Draws	36.3%	4.6%
Blind-Blind	*Wins*	66.7%	5.0%
	Draws	33.3%	5.0%

Table 5: Logistic regressions conducted on the tendency of the sighted player to imitate the blind-folded player.

Sighted player chooses rock:

		β	*se*	*p-value (one-tailed)*
Blind-folded player executes rock	**rock**	.245	.134	.034
	constant	-.874	.069	.000

Sighted player chooses paper:

		β	*se*	*p-value (one-tailed)*
Blind-folded player executes paper	**paper**	.086	.162	.298
	constant	-.677	.061	.000

Sighted player chooses scissors:

		β	*se*	*p-value (one-tailed)*
Blind-folded player executes scissors	**scissors**	.266	.105	.006
	constant	-.737	.066	.000