2012

The study of human interaction when playing rock-paper-scissors

Drew, N.

Drew, N. (2012) 'The study of human interaction when playing rock-paper-scissors', The Plymouth Student Scientist, 5(1), p. 119-139.
http://hdl.handle.net/10026.1/13969

The Plymouth Student Scientist
University of Plymouth

*The Plymouth Student Scientist, 2012, **5**, (1), 119-139*

The study of human interaction when playing rock-paper-scissors

Neil Drew

Project Advisor: Patric Bach, School of Psychology, Plymouth University, Drake Circus, Plymouth, PL4 8AA

Abstract
It has been suggested the mirror neuron system provides an important neural substrate for humans' ability to imitate. Thus, the purpose of this experiment was to measure whether you can predict winning and losing frequencies in games of rock-paper-scissors (RPS), using techniques governed by the known effects of mirror neurons and imitation. Winning and Losing sequences were created for the experimenters use against participants, and Autistic-spectrum-quotient measures were taken to determine whether autism affects imitation. Results found no significant difference in the two sequences and no correlation between participants' autism scores and their imitation levels. This suggests participants didn't show significant imitation in RPS, possibly due to specific strategies participants used or the competitive scenario. These implications are discussed further.

Preface

The study involved human participants so the experiment included an informed consent form that each participant had to sign before participation, and each participant was fully debriefed after taking part. The study was set out in accordance to the "Ethical principles for conducting research" section in the School of Psychology Stage 4 handbook, and it meets the ethical requirements set by the British Psychological Society.

Introduction

The imitation of others is likely to occur on multiple occasions throughout a person's day to day life both consciously and unconsciously. This can be the result of mere observations of other humans', leading to imitation of arm movements (Kilner, Paulignan, & Blakemore, 2003), body posture (Bernieri, 1988), facial expressions (Dimberg, 1982), tone of voice (Neumann & Strack, 2000), emotions (Schacter & Singer, 1962) and many more. For instance this can begin with morning breakfast imitating a relative's posture when sitting at the table, or when waiting in line for that morning coffee on the way to work and finding yourself swaying from left to right in the queue, which little did you know is because the person in front of you is displaying the same swaying movement (Shockley, Santana, & Fowler, 2003). This shows imitation can be a cycle, where one person is influenced and then that person can unconsciously influence the next. These regular imitations are very important as they mediate and influence everyday social interactions, influencing rapport and liking (Chartrand & Bargh, 1999), and also play a role in much more than just social interactions and relationships. Therefore, due to the high importance imitation plays in a person's life, we look at imitation from a top-down neurological approach, seeing whether a method governed by the known effects of mirror neurons can influence a person's imitative actions.

The chameleon effect

A major aspect of mimicry which is particularly illustrative of bodily information when in a social setting is known as the chameleon effect (Chartrand & Bargh 1999). This is where people mimic others' behaviours (gestures, posture, vocal tract etc.) somewhat automatically and are unconscious of it. Relating to the chameleon effect and mimicry, Tanner, Ferraro, Chartrand, Bettman, & van Baaren (2008) explored the impact of mimicry on choices and preferences in different contexts: when one is mimicking or is being mimicked. The choices made by participants were strongly influenced by the choices of other people that they had previously witnessed. Moreover, the mimickers exhibited a strong tendency not only to choose the same goods as their peers but also to rate them higher. This shows participants were influenced greatly by others' actions, leading them to mimic their actions as this is an easier and more fluent form of decision making compared to the thinking of, and then the choosing of a different option. Furthermore, posterior interviews revealed that participants were unaware of the influence of social interaction and mimicry on their preferences, reinforcing the point of how this form of mimicry is automatic and unconscious.

Individual differences in imitation

The majority of findings do suggest imitation and mimicry to be an unconscious act and very automatic, although what needs to be acknowledged is that we are all different. Some people will naturally engage in imitation more than others, thus different psychological dispositions may affect this. For example high perspective takers have been found to be more likely to imitate others (Chartrand & Bargh, 1999). People who experience high levels of social exclusion also imitate more (Lakin, Chartrand, & Arkin, 2008), which may be because of affiliation and a heightened need to belong (Baumeister & Leary, 1995) due to the threat of this exclusion.

Furthermore, women who are socially anxious are less likely to mimic others and less likely to portray mimicry from others in a positive manner (Vrijsen, Lange, Dotsch, Wigboldus, & Rinck, 2009). This may be because socially anxious women would not process mimicry due to much self-focused attention or not appreciate such social behaviour due to their negative attitude they have obtained. The different psychological dispositions that can affect a person's amount of imitation and their perception of it should be taken into consideration when under measurement, as the context in which the measures are taken may affect people in different ways and possibly alter their imitation levels.

Automaticity of imitation

Although there are individual differences in the way we imitate, the vast majority of imitation appears to be the result of underlying automatic processes that we cannot control. There have been many reports of overt automatic imitation, although imitative effects are very difficult to detect, so many researchers now believe that the incidence of overt imitation may be small compared with the incidence of more subtle, covert imitation (Dijksterhuis, 2005). Some insight into such covert mimicry can be detected through the use of electromyography (EMG), allowing researchers to detect and measure extremely subtle muscle movements. 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, mimicking the faces automatically. This is a clear example of how imitative actions can occur without any awareness at all and in a very subtle form. EMG has also been used in conjunction with transcranial magnetic stimulation (TMS) to detect even more covert imitative effects. For instance, when TMS is applied to an observer's primary motor cortex during action observation, the motor evoked potentials (MEPs) elicited 'mirror' the muscles required to perform the action being observed (Fadiga, Fogassi, Pavesi & Rizzolatti, 1995). This was shown by Strafella & Paus (2000) when they recorded stronger MEPs in participants' bicep muscles while observing arm compared to hand movements, and stronger MEPs from hand muscles while they observed hand movements. These results show that by viewing congruent movements that relate to the person, they then emphasise with it and show activation through a mirroring system.

Further to the above examples of automaticity, imitation shows the Simon effect, which is the stimulus–response compatibility for a task-irrelevant stimulus (Wilson, & Knoblich, 2005). For instance, Brass, Bekkering, and Prinz (2000) found participants were faster to make a finger movement to an arbitrary cue when an irrelevant but response-compatible visual finger movement was shown, and were slower to respond when an incompatible finger movement was shown. Similarly, Longo, Bertenthal, & Kosobud (2008) tested the automatic imitation of observed finger actions while manipulating whether the movements were biomechanically possible or impossible. When no mention was made of this difference, similar automatic imitation was elicited from possible and impossible actions. However, when attention was drawn to this difference, only the physically possible movements elicited automatic imitation. The imitative effects described represent compelling evidence that the sight of an action increases the likelihood of the motor execution of that action, and especially when that action observed is relevant to your observations and is biomechanically possible in order to empathise with it. Therefore, imitative actions may be thought of as a two-way system, with voluntary actions at one extreme and automatic reflex at the other (Haggard, 2008), thus making it very difficult to notice exactly when voluntary imitation becomes automatic imitation.

Imitation in newborns

Evidence which supports the automaticity of imitation is the spontaneous imitation found in infants. The suggestion is that at birth some primitive capacity for matching the acts of others exists, such as facial gestures including mouth opening and tongue protrusion (Meltzoff & Moore, 1977, 1983). Such ability would be an important building block for subsequent social and cognitive development; by simply learning through imitation. However this idea received much criticism as it only measured mouth opening and tongue protrusion. For example, it has been found that babies show a similar tongue protrusion response to any object approaching the face, such as a ball or a felt-tip pen (Jacobson, 1979). Meltzoff and Moore (1989) backed up their original findings by including a novel aspect in the study, head movement, which was a non-oral gesture that had not been tested before, as well as a tongue-protrusion gesture. Results showed imitation for both displays, showing that newborn imitation is not restricted to a few privileged oral movements. Furthermore, subsequent studies have also shown imitation in newborns for a range of behaviours including the onset of crying (Simmer, 1971), specific vowel sounds (Kuhl & Meltzoff, 1982), and multiple facial expressions (Termine & Izard, 1988). Therefore, these findings of spontaneous imitation shown by newborns can be argued to be hardwired, as it occurs literally hours after birth and is displayed in an automatic manner, which continues throughout that person's life affecting their social interactions and the decisions they make.

Mirror Neurons

The findings discussed above mainly highlight overt imitation, which results from perceiving others' body movement or hearing their tones of voice. However, neurological research has discovered the existence of imitative motor activation in the brain even when overt behaviour doesn't occur. It has been suggested that this is the result of so-called 'mirror neurons' which automatically map observed movements onto a motor program, thus leading to the widely held view that the mirror neuron system is crucial for imitation (Iacoboni 2005; Molenberghs, Cunnington & Mattingley, 2009). Mirror neurons are visuomotor neurons that fire when an action is performed and when a similar or identical action is merely observed, as though the neuron is adopting the other person's point of view and then reacting (Rizzolatti and Craighero, 2004). Mirror neurons were first observed using microelectrode recordings of single neurons in area F5 of the monkey premotor cortex, which is a region known to be centrally involved in the control of our own movements (di Pellegrino, Fadiga, Fogassi, Gallese & Rizzolatti, 1992, and Gallese, Fadiga, Fogassi, & Rizzolatti, 1996). More recently, these mirror neuron findings have also been shown in the PF/PFG complex within the inferior parietal cortex (Fogassi, Ferrari, Gesierich, Rozzi, Chersi, & Rizzolatti, 2005).

An issue which has had much speculation regarding mirror neurons is whether these mirror systems can be seen in, and generalised to humans. Brass et al (2000) found that participants respond faster to the congruent images of fingers compared to the incongruent. This shows that mirror systems can influence our speed of response and imitation. Also, an overlap in brain activation has been found between grasp observation and execution in the ventral premotor and inferior parietal cortex (area PF), in dorsal premotor, supplementary motor, middle cingulate, somatosensory, superior parietal, middle temporal cortex and cerebellum (Gazzola & Keysers, 2008). This is very significant evidence supporting the notion that human actions can be guided by these mirror systems. Further to this, if these 'mirror systems' are guiding our behaviours, then the mirror regions in the brain should only be activated for actions that we can empathise with, thus being actions that we can actually perform ourselves. This has been examined using fMRI measures, which found greater bilateral activations in premotor cortex and intraparietal sulcus, right superior parietal lobe and left posterior superior temporal sulcus when expert dancers viewed movements that they had been trained to perform compared to movements they had not (Calvo-Merino, Glaser, Grezes, Passingham & Haggard, 2005). These results show that the 'mirror system' integrates observed actions of others with an individual's personal motor repertoire, and suggests that the human brain understands actions by motor simulation, which can differ for each individual.

The data discussed regarding mirror neurons and their functions can be seen as a phenomenal discovery, and a great contribution to research on imitation, although it is important to be cautious in generalising the mirror system completely to the human case. For example, mirror neurons have been found to be restricted to object-directed hand and mouth movements (Ferrari, Gallese, Rizzolatti, & Fogassi, 2003), particularly grasping movements, and thus, the area of research is still far from having identified neurons that code for whole body imitation and for imitation of numerous, possibly novel, actions (Wilson & Knoblich, 2005). However, there are many different views and opinions on mirror neurons and their influence on humans, for example V.S Ramachandran (2000) quoted; "Mirror neurons are the single most important "unreported" story of the decade". Some may see this quote as an over the top and exaggerated statement, but it does illustrate how serious they are being considered.

Mirror Neurons and Autism

Autistic spectrum disorders (ASD) can be characterised by impairments in social interaction, imaginative ability and repetitive and restricted patterns of behaviour, which are increasingly being recognised as important causes of social disability (Fombonne, 1999). It has been proposed that these core impairments in ASDs may be partly due to impairments of the mirror neuron system (MNS). For instance if observed actions cannot be mapped onto the motor commands required for performance, higher order sociocognitive functions that involve understanding another person's perspective, such as theory of mind, may be impaired (Press, Richardson, & Bird, 2010). This would consequently hinder imitation that is driven by mirror neurons. For example, Baron-Cohen, Leslie, & Frith (1985) demonstrated that children with autism typically had special difficulties in understanding the beliefs and intentions of others and suggested that they lacked the ‘theory of mind’ (ToM) necessary to pass many tests. This could be due to their inability to empathise with other people’s actions and thoughts, arguably due to a MNS dysfunction. However, research on whether people with ASD suffer from MNS impairments is mixed, with much evidence for and against the matter.

This area has been measured with the use of Functional Magnetic Resonance Imaging (fMRI), which found activity in the right parietal lobe to be less extensive in an ASD group and was absent during non-imitative action execution compared to a control group. ASD participants also failed to show modulation of left amygdala activity during imitation that was evident in a control group (Williams, Waiter, Gilchrist, Perrett, Murray, & Whiten, 2006). This may have implications for understanding the imitation of emotional stimuli in ASD, considering emotion is linked to the amygdala. Further evidence using fMRI found children with autism to show no mirror neuron activity in the inferior frontal gyrus, when imitating and observing emotional expressions (Dapretto, Davies, Pfeifer, Scott, Sigman, Bookheimer, & Iacoboni, 2005). This suggests that a ‘dysfunctional mirror neuron system’ places limitation on their ability to imitate especially when in an emotional context, which is a very important necessity for life, and may underlie the social deficits observed in autism.

However, there is much evidence against the idea that people with autism suffer from a ‘broken mirror neuron system’. The performance of 25 children with ASD and 31 typical children of the same verbal mental age was examined on four action representation tasks. Both typical and autistic children were found to have the same tendency to imitate an adult's goals, to imitate in a mirror fashion, and to imitate grasps in a motor planning task (Hamilton, Brindley, & Frith, 2007). EEG measures have also been used to evaluate the mirror neuron functioning of high functioning autism (HFA), compared to typically developing peers, by measuring their mu suppression to self-executed and observed movements. Both groups showed significant mu suppression to both self and observed hand movements and no group differences were found in either condition (Raymaekers, Wiersema, Roeyers, 2009). This shows how HFA is not associated with a dysfunctional MNS, and that they are capable in showing activation in the mirror system. These are valid findings on the matter because they matched HFA participants and typically developing peers on age and intelligence, and they took into account symptom severity which helps rule out any other variables that may affect the results.

The findings discussed provide clear evidence against a general imitation impairment and a global mirror neuron system deficit in children with autism. The data seems to differ slightly depending on which brain areas are measured, suggesting multiple brain systems are used for different types of imitation and action understanding. Therefore, depending on the methods used to research this issue, the results gained may differ, adding to the confusion of this area due to the mixture of results being discovered.

Present Study

The aim of this experiment is to investigate the degree in which mirror neurons are a factor in influencing people’s actions when participating in a game of rock, paper, scissors (RPS). As we know from the research mentioned, humans have a tendency to imitate observed actions. Thus we hypothesised that the experimenter’s action in a game of RPS would be imitated by the participant in the following game, which would enable the experimenter to force a win or a loss by creating specific winning and losing sequences. If our hypothesis is correct the experimenter should win the games in the winning sequence rounds, and lose the games in the losing sequence rounds.

To explain the method in more detail, when a winning sequence is used in the first round, the third round will consist of a losing sequence, and vice versa. The second round will always be a “fake” round with no particular strategy used by the experimenter in aim to avoid the participant noticing any sequences. Each of the three rounds will consist of five games. Although a factor which may influence the results is whether the experimenter wins or loses a game, as participants may react differently to experiencing winning or losing. Thus this may have an effect on people’s imitative actions throughout the game, so this factor will also be tested.

Regarding the point of how autism may or may not affect imitation, participants will also fill out an Autistic Spectrum Quotient (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001) before playing RPS. Participants’ overall autistic scores will then be compared to the amount of times they imitated the experimenter to measure whether autism has any relationship to imitation levels.

Method

Participants

30 participants took part in the experiment who were both male (n=11) and female (n=19) ranging in age from 18 to 55. The majority of participants were approached via an online psychological experiment sign up program through the University of Plymouth, where 1st, 2nd and 3rd year students could sign up. Other participants were tested on the Plymouth Campus area by being approached by the experimenter. Each participant would be given an information sheet (Appendix 1) explaining the aims and procedures and their right to withdraw at any time, if they agreed they would then sign an informed consent form (Appendix 2) approved by the School of Psychology at the University of Plymouth. All participants were fully debriefed (Appendix 3) after completion, with contact details being given for any further related questions.

Materials and Apparatus

The experiment required a digital video camera in which the experimenter used to record each experiment when playing the game of RPS; this simplified the collection of data and was useful for further analysis. An information sheet, consent form, and debrief form were also provided to the participants. The study was carried out in a small lab room with a table and two chairs.

Design

The participants were randomly split into two groups, half of the participants would experience a winning sequence in the first 5 games, followed by 5 games with a fake/random sequence (to avoid the participant learning the sequences), and then followed by the 5 games with a losing sequence. This would mean the experimenter would try to win the first 5 games, play 5 fake/random games, and then change the sequence to try and lose the last 5 games. The other half of participants would experience the losing sequence first, followed by a fake round, and then the winning sequence round. Doing two different groups eliminates any variables that may occur by experiencing the winning or losing sequences first. Thus, this was a within participant design with sequence order (winning first, losing first) being counter balanced across participants. Because there are three different winning and three different losing sequences, participants in their group were randomly split into three sub-groups, so in total there were six groups. Thus, the independent variables will be the different sequences participants are in and the autistic spectrum quotient scores. The dependent variable will be the amount of imitation that is shown.

The sequences in the RPS games were governed by the known effects of mirror neurons. Therefore, according to mirror neurons and imitation, the experimenter assumed that when they chose “rock” in one game, the participant would then mirror this action in the following game and also choose rock. This could potentially enable the experimenter to choose whether to win or lose by selecting the appropriate option. For instance, in the just given example, the experimenter could ‘force’ a win by playing paper or a loss by playing scissors (sequence examples in Table 1 and Table 2).

Table 1: Example of Sequence Group Winning 1, which started with a winning sequence and ended with a losing sequence (P=Paper, S=Scissors, R=Rock)

Group		**Winning round sequence**	**Fake round sequence**	**Losing round sequence**
Sequence Group Winning 1	Experimenter’s action	R P S R P	S P S R P	R S P R S
	Participant’s predicted action	S R P S R	Unknown	P R S P R

Table 1 shows the predicted outcome of the participant imitating the experimenter’s previous action in both the losing and winning sequence. The “fake round” sequence is unknown for the participants because the experimenter is not trying to manipulate and influence their actions in this round, as it is random and the data is of less importance.

Table 2: An Example of the actions used in Sequence Group Losing 1 (P=Paper, S=Scissors, R= Roc

Group		**Losing round sequence**	**Fake round sequence**	**Winning round sequence**
Sequence Group Losing 1	Experimenter’s action	R S P R S	R R P S P	P S R P S
	Participant’s predicted action	P R S P R	Unknown	R P S R P

Procedure
After reading through the information sheet and then filling out an informed consent form, participants had to fill out an Autistic- spectrum quotient (ASQ) (Appendix 5). This consisted of 50 questions regarding people's personalities, imagination, observations and social lives. The questions could be answered on a scale of; "Definitely Agree", "Slightly Agree", "Slightly Disagree" and "Definitely Disagree". This took approximately 5-10 minutes. The answers of these questions were then added up and calculated to give an overall autistic ranking for each participant. This data gave the experimenter the opportunity to test whether autistic features prevents or increases imitation.

After completing the ASQ participants would then take part in 3 sets of 5 games of RPS against the experimenter whilst being video recorded. This applied for both the winning and losing sequences. In a RPS game, two players each present one of three alternative hand gestures typically after a count of three. Each player must make either 'paper' (an open hand), rock (a closed fist), or 'scissors' (index and middle finger parted). 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. After each game was played, the experimenter would briefly state the result of the game, for example say; "my rock blunts your scissors", or "your paper wrapped my stone", and then straight after continue with the next game. The reason behind stating the result of each game to the participant was to make it clear what action the experimenter used, which may increase the chances of the participant mirroring this action in the following game.

In the "fake" round sequences, in between either the winning or losing ones, the sequence of actions the experimenter used (rock, paper or scissors) were already determined before the games took place. Six different sequences were created for each of the sub-groups, with the aim for them to be dissimilar to the winning and losing sequences, as already stated, in aim to prevent the participant from catching onto the pattern of actions chosen by the experimenter. The procedure in this round would appear to be the same by the participants as the winning and losing round, still stating the results after each of the five games. Furthermore, for all of the six groups there would be breaks in between each of the rounds, and will be performed at a reasonably fast pace to avoid the participant catching onto the sequences. Once the experiment had finished a printed debrief (Appendix 3) was read out and given to the participants with contact details on, and they were also asked whether they had any questions regarding their participation.

Data Recording and Analysis
Data was recorded via analysing the video recordings of each participant playing the experimenter in RPS. The action they chose for each game was entered into a spreadsheet on Excel, which computed which games they won, drew, and lost. Also, it computed what action they would choose regarding the result of the previous game, whether it was the experimenters previous action (imitating), repeating their own, or choosing the action that wasn't present previously (CD-ROM). This enabled an easy process for putting the relevant data into SPSS for Chi-square Goodness-of-Fit tests and a One-sample t-test. The Autistic spectrum quotient data was gathered via the paper base questionnaire participants filled out, and then entered into another Excel spreadsheet. This computed each score for the specific questions as they all had

different ratings relating to types of autistic features, and then gave an overall autistic score for each participant. A Pearson's correlation could then be carried out between participants' autistic score and the amount of times they imitated the experimenter during RPS.

Results

Data from 4 of the participants was excluded (3 from winning 1st sequence, 1 from losing 1st sequence) because they did not follow the experimental procedure correctly. More specifically, they would adopt a strategy which involved choosing the same action constantly, or they would get the timings wrong on when to show their action. These both would affect the sequences and may have influenced their actions throughout the task. The main analysis reported therefore reflects the data of the remaining 26 participants. Also in the analysis, the first games' results of each round were excluded as the participant wouldn't have viewed any action from the experimenter other than a demonstration, thus less likely to be showing imitation through mirroring.

Once all the data had been collected a Chi-Square Goodness-of-Fit (GOF) test was carried out for the main analysis to see if distribution of wins/losses was different for the winning and losing sequences. A one-sample t-test was also used to examine the relationship in more depth. Subsequent Chi-square (GOF) tests were then carried out in aim to discover more about the data concerning the actions participants would choose, and whether the experimenter winning or losing the previous game affected participants' actions. Also, ASQ data was compared with the amount of times the participant would imitate the experimenter's previous action through a Pearson's correlation. This was to see whether participants' autistic trait scores had any relationship with their level of imitation (SPSS output on CD-ROM for all tests).

Table 3: Table showing the experimenter's wins, draws, and losses for both the winning and losing sequence.

	Win	Draw	Lose	Total
Winning Sequence	37	34	33	104
Losing Sequence	39	37	28	104

Across all participants' results, the amount of wins, draws, and losses were quite evenly distributed, not showing much difference between the total amount of wins, draws and losses (Table 3). To determine whether the two sequences had any effect on the participants' results, these frequencies were analysed with a Chi-Square GOF test, and found no significant difference, $\chi 2(2, N=26) = .52, p = .77$. This suggests that the two sequences did not have a significant effect on the amount of wins, draws, or losses regarding the results of the RPS games.

A One-sample t-test was carried out to examine in more depth whether the relationship between wins and losses changes when excluding the results which were draws. This is because our hypothesis was only concerned with differences between wins and losses. Each participant had an overall score of the amount of wins and losses they had for each sequence, which we gained an average win/lose score by the sum as follows: wins – losses [divided by] wins + losses (table of means shown in Appendix 4). This sum was carried out for each participant's amount of wins and losses for the first round and the third round of RPS, but not for the random round as this didn't include a winning or losing sequence. The Independent samples t-test found no significant difference between the total number of wins and losses for each participant, $t(25) = -.34$, $p = > 0.5$ (.74), Cohen's $d = -.06$. Once again, this suggests that the two sequences created, which predicted participants would imitate the experimenter's previous action, did not have any effect on a person's winning and losing total sum.

Table 4: Display of the total amount of actions participants chose in both sequences. Own = participant using same action as they did in the previous game, Experimenter's = imitating experimenter's action, and New = neither repeating your own action nor imitating the experimenter.

	Own	Experimenter's	New	Total
Winning Sequence	6	24	40	70
Losing Sequence	11	22	37	70
Total sum of each action for both sequences	17	46	77	135

The results motivated the idea for further tests in a post-hoc manner to see if there were any specific strategies used by the participants. Table 4 shows that participants were much more likely to choose a new action than the ones present in the previous game, which can also be seen clearly below in Figure 1. So to determine whether there was a significant difference in the actions participants would use throughout the RPS games, a Chi-square GOF test was carried out for both the winning sequence and the losing sequence. The results of games that came after a previous draw between the experimenter and participant were excluded. This is because it wouldn't give the participant three different choices to pick from. For example, if they both drew with rock in the previous game a new action could be paper or scissors, and if they were to choose rock again you wouldn't be able to determine whether they were imitating the experimenter's action or repeating their own. The winning sequence showed significant results, $\chi2(2, N=26) = 25.8$, $p = >.01$. And the losing sequence showed significant results, $\chi2(2, N=26) = 14.6$, $p = .01$. This shows that participants were significantly more likely to use a new action in both the winning and losing sequences.

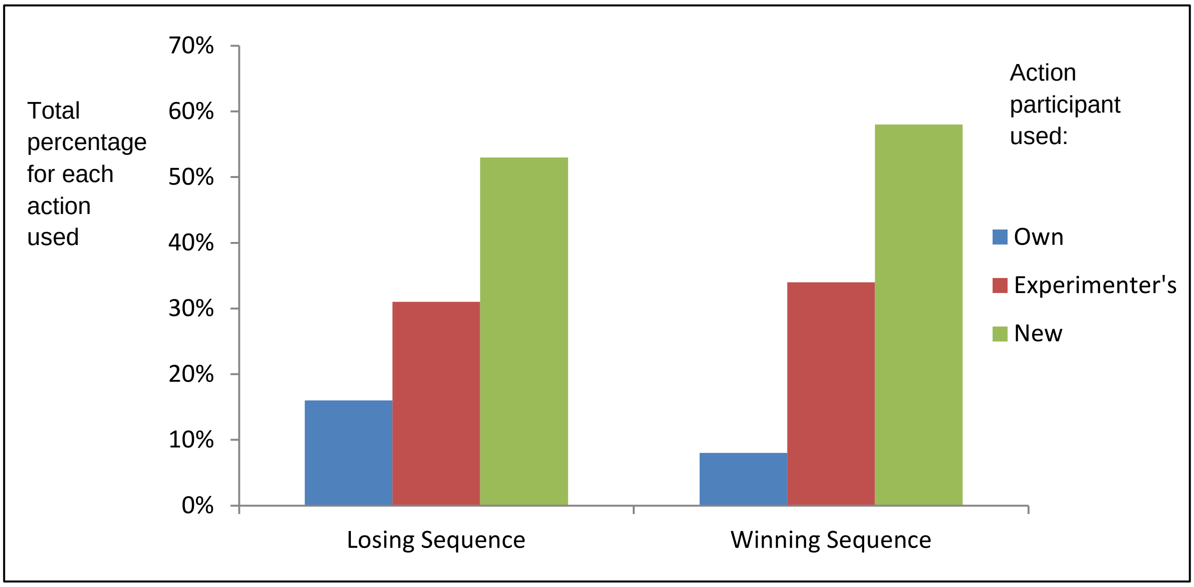

Figure 1: Bar chart graph showing percentages of actions participants chose for both sequences (n=26).

In relation to the previous significant findings that participants were more likely to choose a “new” action, we wanted to see whether this differed depending on which of the two sequences participants were in via a Chi-square GOF test. This showed no significant difference, $\chi 2(2, N=26) = 2.7, p = .26$. These results propose that whether participants would choose the “new” action did not differ significantly depending on if they were in the winning first sequence or the losing first sequence, showing that the choice of actions the opposition uses does not affect this potential strategy displayed by participants.

Table 5: Table displaying the three actions participants would choose depending on whether the experimenter won or lost the previous game (the totals differ because the experimenter won more games than lost).

	Own	Experimenter’s	New	Total
Experimenter Lost	6	26	34	66
Experimenter Won	11	20	44	75

The finding that participants were more likely to choose a “new” action motivated the notion to measure if this choice in action is influenced by the experimenter losing or winning the previous game (figures shown in Table 5). To determine this, another Chi-square GOF test was carried out, comparing the total amount of times the participant chose the “new” action when the experimenter won or lost the previous game. These results were found to be significant, $\chi 2(2, N=26) = 5.9, p = .05$. This suggests that participants were significantly more likely to choose the “new” action when the experimenter won the previous game. The difference can be seen more clearly below in Figure 2.

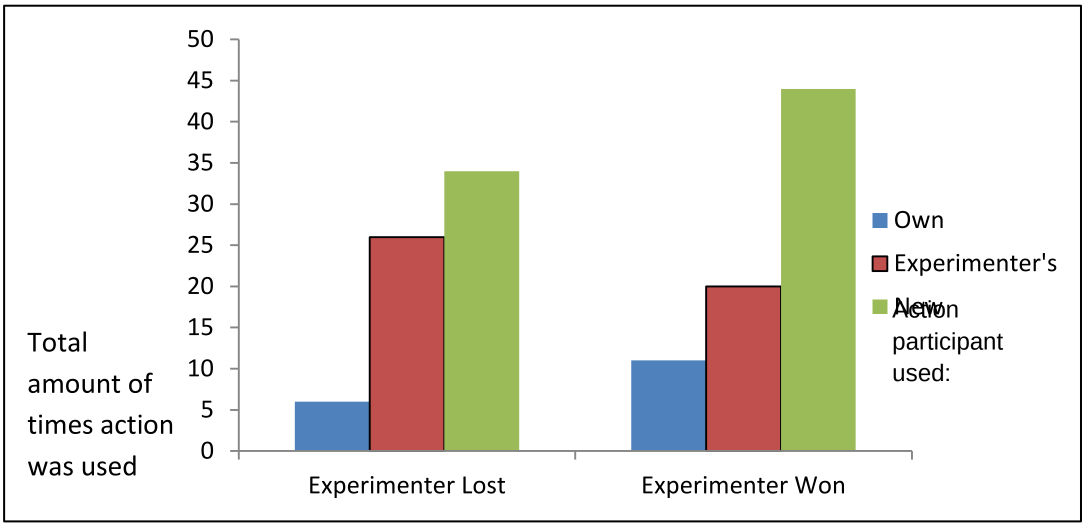

Figure 2: Bar chart graph showing the participants actions they chose when the experimenter won and lost the previous game (n=26).

The final tests which were carried out wanted to measure whether a participant's Autistic spectrum quotient score had any relation to the amount of times they imitated the experimenter in RPS. To investigate the relationship between these two, a Pearson's correlation was computed. The correlation between the two was found not to be significant, r=.05, p = .81. This suggests that a person's autism score does not have any relationship with participant's degree of imitation.

Going back to the significant finding of participants being more likely to choose a "new" action, a subsequent Pearson's Correlation was computed to see whether there was any relationship between participants' autism scores and the amount of times they would choose the "new" action. This was to see if autism levels affected this potential strategy used by participants. The results were found not to be significant, r = -.11, p = .58. This suggests that a participant's autism score does not have any relationship with the amount of times that they would choose a "new" action in RPS.

Discussion

As a brief summary, the main aim of this study was to investigate the degree in which mirror neurons are a factor in influencing people's actions when participating in a game of rock, paper, scissors, that being. This was measured by seeing whether the experimenter can force wins and losses by the use of the different sequences that were created. Also, participants' autistic trait scores were examined to determine whether there was any relationship between autism and imitation.

Main Analysis of The Sequences

The results suggest that there was no significant difference between wins, draws and losses depending on the winning or losing sequence (Table 3). This suggests that the two sequences had no effect on the results of the RPS games, supporting the null hypothesis. So, the sequences that were created in attempt to win or lose against the participant did not work, as the participant showed no significant imitation of the experimenter's actions. This notion was backed up by the additional One-sample t-test which showed when eliminating the results which were draws, because our hypothesis only concerned wins and losses, still found no significant differences between the total number of wins and losses for each participant. Therefore, the idea of the participant seeing the experimenter's action in the previous game, empathising with it due to potential neurons firing within the brain (Rizzolatti and Craighero, 2004), and then using it through imitation in the next game was found not to be the case.

These results can be seen as inconsistent with those discussed in the background literature. This concerns such findings that suggest imitation is an automatic process which occurs without people being consciously aware of it (Dimberg et al 2000), or the fact that the experimenter's previous action will be more easily accessible for the participant and therefore will be likely to imitate it (Strafella & Paus 2000). More specifically, the findings are not consistent with a very similar study which gained significant findings that players of rock, paper, scissors do tend to imitate their opponent throughout the game (Cook, Bird, Lunser, Huck, & Heyes, in press).

When acknowledging these main findings they could argue that imitation is not always automatic, and in fact may be controlled at a level below our conscious awareness. For instance, it has been stated that no processes are entirely free from some type of control (Longo et al, 2008). In addition to this, Logan and Cowan (1984) pointed out that typical examples of supposedly automatic processes such as reading or driving, are in fact under robust cognitive control in that a person can easily decide to stop reading or driving at any time. Thus this brings upon the argument that a person may be able to stop their imitative actions when they decide to do so, this especially relates to the present study considering the mind would be very active and aware during the competitive environment, which may make participants more reluctant to just "mirror" the experimenter's actions. This may have been a conscious decision to not imitate, or just below the conscious level. Therefore, whether a particular stimulus will elicit automatic imitation seems to depend on the task the participant is in. Regarding the present study where no significant imitation was shown, this suggests that it may have been the context of the task which prevented imitative actions.

The Actions Played In Rock-Paper-Scissors

Throughout the collection and interpretation of data it became very apparent that a pattern was occurring throughout participants' results for both the winning and losing sequences, and this pattern may have been a specific strategy by the participants. This influenced further tests (Table 4 & Figure 1) which found participants to show a significant difference in choosing a "new" action in RPS rather than imitating the experimenters' previous one, or using their own action once again. This is the opposite of how mirror neurons would work, as they are not mirroring the experimenter's actions, nor are they mirroring their own. Thus this particular strategy led to an avoidant imitation approach. It is difficult to suggest what made the participants choose this technique, as they may not have been conscious of the fact that they were performing the task with this method.

One suggestion which may explain this finding is the concept of inhibition of return

(IOR). IOR refers to the relative suppression or processing of stimuli that had recently been the focus of attention. By suppressing orienting towards previously inspected locations and objects, IOR encourages orienting towards novelty or “new” stimuli (Posner & Cohen, 1984). Further to this, it has been found that IOR promotes exploration of new, previously unattended objects in the scene during visual search (Klein, 2000). Although much of IOR research is concerning peoples’ selective attention and is usually measured with a cue-response paradigm, the effects can still be related to the findings of the present study concerning an environment based inhibition (featureless), where the object does not have to be present (Tipper, Weaver, Jerreat & Burak, 1994). For example, participants’ visual attention would be locked on the action the experimenter shows and on their own action used, and then when they are gone and in the brief amount of time they have to display another action, they use this IOR due to the natural exploration of new previously unattended objects, without their awareness. It has been found that IOR is more likely to occur when the time between interval tasks increases (Purves, Brannon, Cabeza, Huettel , LaBar, Platt & Woldorff, 2008), so this may also occur for RPS, being that the more time between games heightens the possibility of participants searching for new options. Therefore, this may have to be a factor which needs to be controlled for any future related research. Furthermore, if IOR does have an influence in this setting, then it seems to work in the opposite way to mirror neurons and imitation, thus hindering the hypothesis of the experiment.

In relation to the previous significant finding, we wanted to measure whether the two different sequences had any effect on the actions participants would choose. For instance, the experimenter is trying to win may influence the participant to react differently compared to when the experimenter is trying to lose. However, the results found that whether participants chose the “new” action did not differ significantly depending on the two sequences. This suggests that the specific methods or techniques (sequences) used by one player of RPS does not have much effect on what the opposition will choose, so it is almost like they have a set way of playing in which they may be consciously aware of or indeed unconscious to it, with imitation not playing any major role.

Effects of The Experimenter Winning or Losing

Taking into account the previous findings discussed, we wanted to try and discover what may be influencing the participant to choose this “new” action. Thus, a further Chi-square GOF test was carried out to discover if this method participants had been using was affected depending on if the experimenter had lost or won the previous game (Table 5, Figure 2). The results were significant, showing that participants were more likely to choose the new action when the experimenter had won the previous game. This shows that the overall result of each game in RPS is a very important predictor to what the participant may or may not select next.

One notion that could explain why the “new” action was used more when the experimenter had just won is the role competitiveness can have on us, especially when we have just lost. For instance, those who have just experienced losing in a competitive scenario have an increase in frustration and anger (Lawrence, 1976). These emotions that arise may play a role in preventing natural imitation, as emotions are highly linked to activation in the amygdala, which has been found to be required and active in order for mirror neurons to react through observation (Williams et al 2006). Thus, the amygdala activation due to heightened emotions may interrupt the specific activation needed for the mirror neuron system to work sufficiently. The emotions experienced may also alter the behaviour of participants as they are more likely to perceive the situation greater in competitiveness, and then set higher goals and use their optimal strategies, (Brown, Cron, & Slocum 1998), which by the looks of the data seems to be to select the “new” action. Therefore, in this type of scenario imitation is less likely to occur because of the nature of the experiment. For example, much of the findings on imitation regard the maintenance of relationships, liking from others and understanding people’s intentions and actions (Chartrand & Bargh 1999 & Lakin et al 2008). Also, the majority of findings have been displayed in many simple observation tasks and when working with others (Tanner et al 2008), but it is rare to come across findings of imitative behaviour when working against others. Therefore, imitation may have been avoided by the participant unconsciously due to the impact a competitive scenario can have on a person’s actions; wanting to avoid any similarity of the opposition.

In order to try and avoid competiveness influencing the actions of participants but still keeping a similar method, the participant could instead play RPS against a computer simulation program. People may be less likely to feel the need and desire to win against the computer, as it could be said that the computer does not really know it has won in the same way humans do, and therefore won’t get the same satisfaction feeling that a human would as they lack a certain presence (Weibel, Wissmath, Habegger, Steiner, & Groner, 2007). Thus, the human may not feel as disappointed if they lost, and would not get as much of an envy effect of the other winning. This could work well for the present study as participants may play RPS in a more natural manner which would be preferred for observing the role of mirror neurons and imitation.

Autism and Levels of Imitation

Further data analysed was the ASQ data from each participant and how many times they would imitate the experimenter. The Pearson’s correlation that was carried out suggested that autistic score and imitation did not correlate well, showing a participant’s autistic score having no significant relationship with imitative actions. This can relate to the research which suggests that people with autism, or those who have high autistic traits, do not differ in their imitative abilities compared to typically developing peers (Hamilton et al 2007, & Raymaekers et al, 2009). However, these current findings are inconsistent with the research suggesting Autistic spectrum disorder (ASD) patients do have major difficulties in imitative tasks and show less brain activation especially when observing emotional expressions in faces (Dapretto et al, 2005, & Williams et al, 2006). For that reason, a possible explanation of the inconsistencies in the research concerning MNS impairments in ASD is that the findings of impairments have tended to use facial actions, while the studies which have found no impairments have used manual actions (Hamilton et al, 2007). This suggests that there may be a face-specific impairment to representations within the MNS in ASD, implying that they do not develop in the same way as representations of other actions. Thus it could be an answer as to why in the present study there were no findings of autistic traits affecting imitative actions through any mirroring of the experimenter. Although it seems this argument may have been overcome in a recent study by Press et al (2010) which found ASD and control groups showing no difference in their ability to demonstrate automatic imitation when observing facial actions. Once again, this adds to the mass amount of mixed research on this matter, where the findings can easily alter depending on the methods used.

The final analysis of data carried out was another Pearson's correlation which was computed for participants' overall autistic scores and the total amount of times they would choose the "new" action in a game. This was to see if a person who scores high or low on the Autistic spectrum quotient affected their ability to carry out this potential strategy. The findings suggested that there was no significant correlation between the two, showing autistic trait scores to not have any effect on increasing or decreasing the choice of the "new" action. This shows that this strategy, be it conscious or unconscious, occurs irrelevant of autistic features, but it seems to be a natural reaction in the game to avoid imitating the two actions that were observed in the previous game, again working in an opposite way to the role of mirror neurons on imitation.

Potential Limitations and Future Research

Staying on track with the autistic related findings; these may be explained due to the use of the Autistic spectrum quotient. It has been found to be reliable and valid when testing people who have been diagnosed with autism and Asperger's syndrome (Hoekstra, Bartels, Cath, & Boomsma, 2008), although it may not be as accurate and effective in determining autistic traits on others who are not autistic or don't have Asperger's syndrome. This test can be very subjective to the individual, with people seeing questions differently to others and answering them on the basis of different contexts. Therefore, it may not give the greatest reflection of autistic traits. To make the results more significant and relevant to autism, half the participants could have been autistic subjects and the other half controls. This would be interesting to see if there is any difference in the methods autistic people would use in the game, and whether their imitation levels differ in any way to the controls, especially as it would be in a competitive environment.

A potential reason that may have influenced the overall results of this study, and can be seen as a major limitation, is that many participants seemed to be able to figure out the sequences which the experimenter was using throughout the games. This was acknowledged when participants stated that they did notice a pattern of sequences after the experiment was conducted (Appendix 6). This is because the sequences created always followed a similar pattern where no one action was used in a row. Therefore the participant could have worked out that if the experimenter was to use rock, then there next action will either be paper or scissors, which would of course influence their choice of action. However, participants did mention that they lost the pattern throughout the second round, showing that the random round did throw off participants from the pattern temporarily. Therefore in order to avoid this problem, the number of random rounds needs to be greater than the number of rounds that are made up of specific sequences. This way participants may be less aware of any sequences and not be consciously thinking about what action to use next, but instead would play in a more natural state of mind where mirror neurons may play a greater role and influence imitation.

A final possible limitation is that RPS is a very generic game where almost all participants would have played in the past, some rarely, or others more occasionally. This could be seen as a positive factor for the experiment considering all participants would have been aware of how to play the game and the rules involved. However some may have their own strategies they use (for example, selecting “new” actions) or may simply favour one specific action, whereas others may not have a preference and play more at what they believe to be random. These differing techniques may have heavily influenced the results and would have prevented any natural automatic imitation.

Conclusion

Overall, the results of this experiment did not meet the hypothesis as participants were not influenced by the sequences created, showing no significant imitative actions. Thus, this is inconsistent with much of the background research on imitation and mirror neurons. Also, there was no significant relationship found between participants’ autistic trait scores and imitation. However, an intriguing finding that did arise from this experiment was that participants were significantly more likely to choose the “new” action throughout RPS; which arguably suggests that imitation is less likely to occur due to the concept of IOR having an impact, and the competitive environment which brings upon potential strategies. This effect became even more apparent when the participant had just been on the receiving end of a loss, which would heighten the perceived environment’s competitiveness, which seemed to act as a barrier to imitation for the participant. Through investigating this issue, there does seem to be a gap in the research. This gap demonstrates the need for more research focusing on examining imitation in a competitive scenario compared to a non-competitive scenario to see whether there are significant differences in mirroring others through imitation. This further research would determine whether the automaticity of imitation still exists when we are competing against one another, which is an important aspect as competing occurs regularly throughout people’s everyday lives. Therefore, the present study’s findings have been beneficial in placing emphasis on the fact that imitation can be a very sensitive topic to measure, and perhaps it’s not always as automatic and unconscious as it is led to believe.

References

Baron-Cohen S., Leslie A.M. & Frith U. (1985). Does the autistic child have a “theory of mind”. *Cognition, 21*, 37-46.

Baron-Cohen, S., Wheelwright, S., Skinner, R., Martin, J., & Clubley, E. (2001). The Autism-Spectrum Quotient (AQ): Evidence from Asperger Syndrome/High Functioning Autism, Males and Females, Scientists and Mathematicians. *Journal of Autism and Developmental Disorders, 31,* 1*.*

Baumeister, R.F., & Leary, M.R. (1995). The need to belong: Desire for interpersonal attachments as a fundamental human motivation. *Psychological Bulletin*, *117*, 497-529.

Bernieri, F.J. (1988) Coordinated movement and rapport in teacher–student interactions. *Journal of Nonverbal Behaviour 12,*120–138

Brass, H.B., Wohlschlager, A., & Prinz, W. (2000). Compatibility between Observed and Executed Finger Movements: Comparing Symbolic, Spatial, and Imitative Cues. *Brain and Cognition 44*, 124–143.

Brown, S.P., Cron, W.L., & Slocum, J.W. (1998). Effects of Trait Competitiveness and Perceived Intraorganisational Competition on Salesperson Goal Setting and Performance. *Journal of marketing, 62,* 88-98.

Calvo-Merino, B., Glaser, D.E., Grezes, J., Passingham, R.E., & Haggard, P. (2005). Action Observation and Acquired Motor Skills: An fMRI Study with Expert Dancers. *Cerebral Cortex, 15*, 8, 1243-1249.

Chartrand, T. L., & Bargh, J. A. (1999). The chameleon effect: The perception–behavior link and social interaction. *Journal of Personality and Social Psychology, 76,* 893–910.

Cook, R., Bird, G., Lunser, G., Huck, S., & Heyes, C. (in press). Automatic imitation in a strategic context: Players of Rock-Paper-Scissors imitate opponent's gestures.

Dapretto, M., Davies, M.S., Pfeifer, J.H., Scott, A.A., Sigman, M., Bookheimer, S.Y., & Iacoboni, M. (2005). Understanding emotions in others: mirror neuron dysfunction in children with autism spectrum disorders. Nature Neuroscience Advance Online Publication. Retrieved, February, 13th 2011, from http://www.nature.com/natureneuroscience.

Dijksterhuis, A. (2005). Why we are social animals: The high road to imitation as social glue. In S. Hurley & N. Chater (Eds.), *Perspectives on imitation: From cognitive neuroscience to social science,* 363 *Vol 2,* 207-220. Cambridge, MA:MIT Press.

Dimberg, U. (1982) Facial reactions to facial expressions. *Psychophysiology 19*, 6, 643–647.

Dimberg, U., Thunberg, M., & Elmehed, K. (2000). Unconscious facial reactions to emotional facial expressions. *Psychological Science, 11*, 86–9.

di Pellegrino, G., Fadiga, L., Fogassi, L., Gallese, V., & Rizzolatti, G. (1992). Understanding motor events: A neurophysiological study. *Experimental Brain Research, 91,* 176–180.

Fadiga, L., Fogassi, L., Pavesi, G., & Rizzolatti, G. (1995). Motor Facilitation During Action Observation: A Magnetic Stimulation Study. *Journal of Neuropsychology, 73,* 6*.*

Ferrari, P. F., Gallese, V., Rizzolatti, G., & Fogassi, L. (2003). Mirror neurons responding to the observation of ingestive and communicative mouth actions in the monkey ventral premotor cortex. *European Journal of Neuroscience, 8,* 1703–1714.

Fogassi, L., Ferrari, P.F., Gesierich, B., Rozzi, S., Chersi, F., & Rizzolatti, G. (2005). Parietal lobe: from action organization to intention understanding. *Science, 308*, 662-667.

Fombonne, E. (1999). The epidemiology of autism: a review*. Psychological Medicine, 29*, 769-786.

Gallese, V., Fadiga, L., Fogassi, L., & Rizzolatti, G., (1996). Action recognition in the premotor cortex. *Brain 119*, 2, 593–609.

Gazzola, V., & Keysers, C. (2008). The Observation and Execution of Actions Share Motor and Somatosensory Voxels in all Tested Subjects: Single Subject Analyses of Unsmoothed fMRI Data. *Cerebral Cortex, 10*, 10-93.

Haggard, P. (2008). Human volition: towards a neuroscience of will. *Nature Reviews Neuroscience, 9*, 401 934-946.

Hamilton, A.F., Brindley, R.M., & Frith, U. (2007). Imitation and action understanding in autistic spectrum disorders: How valid is the hypothesis of a deficit in the mirror neuron system? *Neuropsychology, 8,* 1859-68.

Hoekstra, R.A., Bartels, M., Cath, D.C., & Boomsma, D.L. (2008). Factor Structure, Reliability and Criterion Validity of the Autism-Spectrum-Quotient (AQ): A study in Dutch population and patient groups. *Journal of autism and developmental disorders, 38,* 8, 1555-1566

Iacoboni, M., (2005). Neural mechanisms of imitation. Current *Opinion in Neurobiology, 15,* 6, 632–637.

Jacobson, S. W. (1979). Matching behavior in the young infant. *Child Development, 50,* 425–430.

Kilner, J. M., Paulignan, Y., & Blakemore, S. J. (2003). An interference effect of observed biological movement on action. *Current Biology, 13,* 522–525.

Klein, R.M. (2000). Inhibition of return. *Trends in Cognitive Sciences 4,* 4, 138-47.

Kuhl, P. K., & Meltzoff, A. N. (1982). The bimodal perception of speech in infancy. *Science, 216,* 1138–1141.

Lakin, J. L., Chartrand, T. L., & Arkin, R. M. (2008). I am too just like you: Nonconscious mimicry as an automatic behavioural response to social exclusion. *Psychological Science, 19*, 816–822.

Lawrence, M.A. (1979). Effects of competition upon the aggressive responses of college basketball players and wrestlers. *Research Quarterly, 47*, 3, 388-393.

Logan, G. D., & Cowan, W. B. (1984). On the ability to inhibit thought and of motion perception: Selective neural encoding of apparent human movements. *NeuroReport, 11,* 109–115.

Longo, R.M., Bennett I. Bertenthal, I.B., & Kosobud, A. (2008). Automatic Imitation of Biomechanically Possible and Impossible Actions: Effects of Priming Movements Versus Goals. *Journal of Experimental Psychology: Human Perception and Performance, 34,* 2, 489–501

Meltzoff, A. N., & Moore, M. K. (1977). Imitation of facial and manual gestures by human neonates. *Science, 198,* 75-78.

Meltzoff, A. N.. & Moore. M. K. (1983). Newborn infants imitate adult facial gestures. *Child Development, 54,* 702-709.

Meltzoff, A. N., & Moore, M. K. (1989). Imitation in Newborn Infants: Exploring the Range of Gestures Imitated and the Underlying Mechanisms. *Developmental Psychology, 25*, 6, 954-962.

Molenberghs, P., Cunnington, R., & Mattingley, J.B. (2009). Is the mirror neuron system involved in imitation? A short review and meta-analysis. *Neuroscience and Biobehavioral Reviews, 33,* 975–980.

Neumann, R., & Strack, F. (2000). "Mood contagion": The automatic transfer of mood between persons. *Journal of Personality and Social Psychology, 79*, 211-223.

Press, C., Richardson, D., & Bird, G. (2010). Intact imitation of emotional facial actions in autism spectrum conditions. *Neuropsychology 48*, 3291–3297.

Posner, M.I., & Cohen, Y. (1984). Components of visual attention. In H. Bouma & D.G. Bouwhuis (Eds.), Attention & Performance, Vol. 10 (pp. 531 - 556). Hillsdale, NJ: Erlbaum.

Purves, D., Brannon, E.M., Cabeza, R., Huettel, S.A., LaBar, K.S., Platt, M.L., & Woldorff, M.G. (2008). *Principles of Cognitive Neuroscience*. Massachusetts: Sinauer Associates, Inc.

Raymaekers, R., Wiersema, J.R, & Roeyers, H. (2009). EEG study of the mirror neuron system in children with high functioning autism. *Brain Research, 1304,* 113-121.

Rizzolatti, G., Craighero, L., 2004. The mirror-neuron system. *Annual Review of Neuroscience 27,* 169–192.
Schacter, S., & Singer, J. E. (1962). Cognitive, social, and physiological determinants of emotional state. *Psychological Review, 69*, 379-399.
Shockley, K., Santana, M. V., & Fowler, C. A. (2003). Mutual interpersonal postural constraints are involved in cooperative conversation. *Journal of Experimental Psychology: Human Perception and Performance, 29*, 2, 326-332.
Simner, M. L. (1971). Newborn's response to the cry of another infant. *Developmental Psychology, 5*, 136-150.
Strafella, A. P., & Paus, T. (2000). Modulation of cortical excitability 437 during action observation: a transcranial magnetic stimulation study. *Neuroreport, 11*, 2289–2292.
Tanner, R. J., Ferraro, R., Chartrand, T. L., Bettman, J. R. & van Baaren, R. (2008). Chameleons and consumption: the impact of mimicry on choice and preferences. *Journal of Consumer Research. 34,* 754–766.
Termine, N. T., & Izard, C. E. (1988). Infants' response to their mother's expressions of joy and sadness. *Developmental Psychology, 24*, 223-229.
Tipper, S.P., Weaver, B., Jerreat, LM., Burak, AL. (1994). Object-based and environment-based inhibition of return of visual attention. *Journal of Experimental Psychology: Human Perception and Performance, 20,* 3, 478 499.
V.S. Ramanchandran (2000). MIRROR NEURONS and imitation learning as the driving force behind "the great leap forward" in human evolution. Retrieved, February 9th 2011, from http://www.edge.org/3rd_culture/ramachandran/ramachandran_index.html
Vrijsen, N.J., Lange, W., Dotsch, R., Wigboldus, D.H.J., & Rinck, M. (2009). How do socially anxious women evaluate mimicry? A virtual reality study. *Cognition and emotion*, *24, 5,* 840-847
Weibel, D., Wissmath, B., Habegger, S., Steiner, Y., & Groner, R. (2007). Playing online games against computer vs. human-controlled opponents: Effects on presence, flow, and enjoyment. *Computers in human behaviour, 24,* 5, 2274 2291.
Williams, G.D., Gilchrist, W.A., Perrett, D.I., Murray, A.D., & Whiten, A. (2006). Neural mechanisms of imitation and 'mirror neuron' functioning in autistic spectrum disorder. *Neuropsychology, 44*, 610–621.
Wilson, M., & Knoblich, G. (2005). The case for motor involvement in perceiving conspecifics. *American Psychological Association, 131,* 3, 460-473.

Acknowledgements
I would like to thank my supervisor Patric Bach for selecting me to carry out this piece of research, and also for supporting me with the work throughout the year.

Appendices for this work can be retrieved within the Supplementary Files folder which is located in the Reading Tools menu adjacent to this PDF window.