Self-regulators - a hidden dimension of interaction: movement similarity and temporal proximity increase the perception of interpersonal coordination in third party observers

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Abstract

In everyday circumstances, humans use a variety of cues to draw rich inferences about the nature of interaction. Among these, we focus on sequences of self-regulatory movements, such as touching behaviours and postural changes, that have long been related to interpersonal coordination understood both in terms of mimicry and synchrony. So far, there has been a severe lack of studies on the third party perception of interactional phenomena, including self-regulators. Here, we investigate which elements of the interactional dynamics induce the perception of interactants' behaviours (represented by self-regulators) as casually related, and show that the most important factor responsible for such attribution is the similarity of observed movements On a more general plane, we hope to make a step towards uncovering perceptual biases that evolved for interpersonal coordination, thus shedding some light on the human interactional potential and its evolution.

Highlights

- Self-regulatory movements and their perception are of direct interest to the theory of the cooperative signalling characteristic of language.
- Movement similarity and temporal proximity are the most perceptually salient characteristics of self-regulators.
- The perceptual biases towards mimicry and synchrony could have evolved for interpersonal coordination.

1. Introduction

How do people make sense of interaction? In everyday circumstances, humans use a variety of cues to draw rich inferences about the nature of observed interaction between other individuals, such as their relation, affiliation, or relative status. Drawing accurate inferences about the relations between other individuals is key to creating the course of one's interpersonal politics, which has particular significance when considered from an evolutionary perspective. In line with the social brain hypothesis (Dunbar, 1995, 1998; cf. Byrne and Whiten, 1988), diagnosing and navigating one's social environment has been among the major adaptive skills in the ultra-social niche occupied by the members of the genus Homo – present as well as past. This ultrasociality, and the social "platform of trust", are the foundations of and phylogenetic prerequisites to large-scale cooperation between non-kin, which in turn enables the unique type of cooperative signalling characteristic of human language (cf. Tomasello 2008, Dor et al. 2014).

Extant research on interaction has focused on identifying and describing specific manifestations of interpersonal synchrony between interactants[1] themselves. But how is this phenomenon perceived by others in the social group? There has been a severe lack of studies on the perception of interactional phenomena, perhaps with the notable exception of the research using the eye tracking technology (e.g. Augusti et al., 2010; Keitel et al., 2013; Holler and Kendrick, 2015).

Our starting point is the evolutionarily grounded reflection on perception. The standard position, appealing to the Universal Darwinism position (Dawkins, 1976; Dennett, 1995; Blackmore, 1999), is that natural selection favours veridical perception, i.e. such that is 'consistent with the actual state of affairs in the environment' (Palmer, 1999; for a discussion see Hoffman and Prakash, 2014). However, a competing branch of research using game-theoretic models and genetic algorithms (Mark et al., 2010; Hoffman et al., 2013; Marion, 2013; Mark, 2013) points to the fact that evolution does not favour perceptions that are accurate reports of the environment but rather perceptions that increase fitness, i.e. evolution promotes perceptual systems that are simple to grow ontogenetically and robust, use few calories, work fast and are selective in picking up only these elements of the environment that have fitness-related consequences (for a discussion see Hoffman

[1] We follow the Goffmanian usage: 'interactants' refers to parties engaged in an interaction and 'conversants' to parties engaged in a conversation (Goffman 1969).

and Prakash, 2014). In terms of this new approach, sometimes referred to as the Interface Perception Theory (Hoffman, 2009; Koenderink, 2011; Hoffman and Prakash, 2014), the perception of interactional phenomena should likewise be geared towards increasing fitness of interacting individuals. We should then expect perceptually salient characteristics of interaction to be of particular fitness-related value to interacting agents.

Specifically, we are interested in how people make sense of interaction - the question that in our research is operationalised in terms of attributing causality between interactional events (cf. the interpretation of social signals in Poggi and D'Errico [2012]): our goal is to determine which elements of the interactional dynamics, understood as both interactants' behaviours and their conversational/discursive roles, induce the perception of these behaviours as casually related (cf. Mehu et al., 2012 and Żywiczyński 2010). We focus on sequences of self-regulatory movements (described below), such as touching behaviours and postural changes, that have long been related to interpersonal coordination understood both in terms of mimicry (LaFrance, 1979; Bernieri, 1988; Chartrand and Bargh, 1999; Butzen, 2005) and synchrony (Condon and Ogston, 1967; Kendon, 1970). In doing so, we hope to make a step towards uncovering perceptual biases that evolved for interpersonal coordination, thus shedding some light on the human interactional potential and its evolution.

1.1. Self-regulatory movements

Self-regulatory movements comprise self-touches, object manipulators, and body position changes, and are largely coextensive with Ekman and Friesen's (1969) adaptors, and specifically, self-, object- and alter-adaptors. Adaptors are usually performed with no communicative intention (sensu Sperber and Wilson, 1986) and with little awareness; however, they are potentially informative in that observers may be able to ascribe meanings, e.g. interpreting them as emotional cues (Ekman and Friesen, 1969). Where we depart from those authors is in the focus on their current role rather than origin. To Ekman and Friesen, adaptors are mostly defined through their ontogeny: they are usually learned early in life, maintained by habit and executed during social interaction (often in reduced form). In contrast, we account for self-regulatory movements not in terms of how interactants have come to acquire these behaviours but in terms of their function, which we take to be primarily emotional and cognitive self-regulation.

Self-touching We define self-touching as an action in which '[the] hand comes in contact with any part of the body' (Goldberg and Rosenthal, 1986, p. 69). Research on self-touching behaviours (also labelled as self-manipulators [Rosenfeld, 1966], body-focused movements [Freedman, 1972] and self-adaptors or self-manipulators [Ekman & Friesen, 1969; Friesen et al., 1979]) indicates that this type of motor activity may play a role in regulating psychological processes. Initially, self-touching was viewed as regulating negative emotions and arousal (e.g. Dittman, 1972; Ekman and Friesen, 1969; Freedman et al., 1973; Waxer, 1977). Later, these motor actions began to be interpreted in the cognitive context as manifestations of disruption in attentional processes and efforts to overcome such distractions (e.g. Barroso et al., 1978; Barroso et al., 1980; Barroso and Feld, 1986). Furthermore, there are studies which examine self-touching along interactional lines. For example, Butzen et al. (2005) determined that self-touches may be motivated by external factors and modelled by self-touching performed by another person. A similar conclusion was drawn by Chartrand and Bargh (1999), who argue that people are more likely to engage in face-rubbing and foot-shaking (i.e. actions that these authors describe as mannerisms) if their co-interactants frequently execute similar actions.

Object manipulators

Object manipulators comprise such actions as rubbing against, playing with or manipulating a non-animate object, e.g. one's seat, clothing, glasses, pen or pencil, etc. In the psychological literature, they have also been designated as object-adaptors (Ekman and Friesen, 1969, 1972), indirect symbolic movements (Freedman, 1972) or anticipatory movements (Mahl, 1967). Their defining property is the use of objects at which the touching behaviour is directed outside their primary instrumentality (Ekman and Friesen, 1972). According to Ekman and Friesen (1969), although functionally similar to the other adaptor types, object manipulators are acquired originally as instrumental activities and are then incorporated into social exchanges, most of the time in reduced form. In the psychoanalytical context, they are commonly interpreted as representations of repressed thoughts (Mahl, 1967). Despite their relative frequency in communicative encounters, object manipulators have not been subject of much research.

Body position changes

We define body position changes as modifications of body and limb alignment, comprising posture shifts and trunk movements. Although this type of movements is usually considered in the context of utterance production and discourse organisation (Condon and Ogston, 1971; Kendon, 1972; Scheflen, 1964), a number of researchers postulated that these actions may also serve functions other than structuring conversational exchanges. For example, Ekman and Friesen (1969) subsumed these behaviours under the category of alter-adaptor, claiming that they can provide information related to a degree of tension and emotional arousal.

Self-regulatory movements spontaneously appear over the course of interaction in the form of discrete units, either simple or complex. This quality of discreteness makes it relatively easy to identify them in the stream of behaviours and categorise them. They are also characterised by a relatively weak link with the tempo and semantics of speech, i.e. self-regulators are neither thematically related to the utterances that they co-occur with nor synchronised with the flow of speech or conversational units (but see the recent finding of Żywiczyński et al., 2016). Generally speaking, self-regulators operate outside verbal communication (unlike e.g. illustrative gestures and regulators, cf. Ekman and Friesen, 1969; Ekman and Friesen, 1972) and, in fact, can be produced in the complete absence of verbal exchanges. Such a combination of features makes self-regulatory movements particularly interesting as objects of study in researching the perception of interactional synchrony and, on a wider plane, of the cognitive infrastructure for diagnosing and navigating one's social environment.

2. Method

2.1. Design

The participants of the study were shown short video clips taken from naturalistic conversations between two interactants. Each clip contained one sequence of self-regulatory movements (SRs): one person performed an SR, then – no later than 4 seconds – the other person performed an SR (see Stimulus below). The participants' task was to decide whether they saw the two SRs as causally related.

An essential element of the study was a qualitative, post hoc analysis geared towards describing the self-regulatory movements (henceforth SRs) found within the 4-second window. This prepared the ground for the actual task of studying the third person perception of SRs in sequences. Specifically, we were concerned with:

- The character of SRs in a sequence, i.e. whether SRs represented movements of the same type, as in the case of mimicry, or they had different behavioural characteristics.
- The timing of SRs in a sequence. Given the 4-second delimitation, we were interested in the exact temporal distance between the SR movements in a sequence.
- The relation of SR sequences to the conversational and discourse structures. As the recorded interactions were placed in a conversational setting, we wanted to see if the initiation of an SR sequence is correlated with the role of either current speaker or current listener. The conversations were semi-scripted with the conversants assuming the role of either interviewer or interviewee, and we likewise wanted to know if the sequence initiation was tied to any of these roles.

2.2. Participants

54 volunteers (undergraduate students of psychology at the Maria Curie-Sklodowska University in Lublin, Poland) participated in the study: 47 female and 7 male; the mean age was 20.2 years. Written informed consent was obtained from all participants.

2.3. Apparatus

The original videos of short conversations were recorded with three Panasonic HC-V700 video cameras mounted on tripods. The ELAN Linguistic Annotator (Sloetjes and Wittenburg, 2008) was used to annotate the material and Ulead Video Studio to prepare short video clips containing sequences of self-regulatory movements, which formed the stimulus for the study. The stimulus was presented with a video projector SONY VPL-EX5 on a 3m by 2m white screen. The participants, all seated in front of the screen, viewed the material from the distance of 4-5 metres.

2.4. Stimulus

The stimulus consisted of 57 video samples (6 to 28 seconds long), each containing one self-regulatory movement (SR) sequence, i.e. two SRs each performed by a different interactant – e.g. Conversant A scratched his cheek, and then Conversant B touched her glasses. We chose such SR sequences that the interval between the two SR movements did not exceed 4 seconds (see Bailenson’s work on collaborative virtual environments [2004], which indicates that people cease to perceive movements as related if they are separated by longer than 4 seconds). The clips were sampled from the total of 137 minutes of our video material: 10 semi-scripted but naturalistic conversations in dyads, with one conversant performing the role of the interviewer and the other of the interviewee, were recorded with a central plane camera. We used a three-step procedure to select the clips.

- First step: identification of the SRs. The entire recorded material was annotated with the use of the ELAN software for the presence of self-regulatory movements, as defined above. The annotation of the 10 experimental videos began only after the experts had reached a high level of interrater agreement in annotating sample material recorded in a similar regime (Cohen's kappa coefficient K = .75). Each expert annotated 5 different conversations, making annotations independently for each recorded person, i.e. separately for the interviewer and interviewee.[2] Second step: selection of the SR sequences. We isolated sequences containing sequences of SRs, i.e. fragments in which the initiation of an SR from one person is followed by the initiation an SR from the other person within 4 seconds (i.e. 4 second windows with at least one SR initiated by each conversant; see above for the explanation of adopting the 4 second window). Following this procedure, we singled out 119 clips containing self-regulatory sequences.

- Third step: The sequences were then evaluated by an independent pair of experts, whose task was to sieve out cases in which a sequence of self-regulatory movements was accompanied by other movements, e.g. illustrators. Specifically, the experts were confronted with the question 'Does the clip contain a clearly visible sequence of self-regulatory movements, each of which is performed by a different participant, and the perception of which is not disturbed by other movements … such as illustrators or other noticeable movements', and were asked to tag each of the 119 clips with the answer 'Yes', 'No' or 'Difficult to determine'. Only the clips that received two positive answers, i.e. a 'Yes' from both judges, were used in following analyses, resulting in a pool of 57 clips.

2.5. Qualitative description of the stimulus

Types of SRs in sequences. To organise our material, we used the following categorial distinctions. We distinguished tactilic sequences, only comprised of touching behaviours (i.e. self-touches and object manipulators; cf. Rosenfeld, 1966; Ekman and Friesen, 1969; Chartrand and Bargh, 1999), and kinesic sequences, only comprised of body posture changes (cf. Condon and Ogston, 1971; Kendon, 1972; Scheflen, 1964). Together, they were designated as 'pure sequences', to indicate that both movements in the sequence were of the same type, i.e. either tactilic-tactilic or kinesic-kinesic. This contrasted with 'impure' sequences, which contained one movement of each

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[2] Such a method was used to ensure that the participants would be confronted with naturalistic stimulus: phenomena that actually occur in interactions and, more so, in proportions that these phenomena actually occur in interactions.

type, i.e. tactilic-kinesic or kinesic-tactilic. Our stimulus contained 42 pure sequences and 15 impure sequences (N=57; pure sequences amounting to 73.7% of the sample and impure ones, to 26.3%). Within the class of pure sequences (N=42), 28 tactilic sequences (66.7%) and 14 kinesic sequences (33.3%) were identified.

Additionally, with regard to the tactilic sequences, we distinguished between touching behaviours performed with same hands (e.g. a self-touch performed with the right hand followed by a self-touch performed by the right hand) or with different hands (e.g. a self-touch performed with the right hand followed by a self-touch performed by the left hand) - as the conversants faced each other, the ‘same hands’ sequences defied the mirror display configuration, while the ‘different hands’ sequences accorded with it. Altogether, there were 28 tactilic sequences (N=28), with 18 belonging to the different hands group (64.3%) and 10 to the same hands group (35.7%).

<table>
<tr><td colspan="3">pure (N=42)</td><td>impure (N=15)</td></tr>
<tr><td colspan="2">tactilic (N=28)</td><td>kinesic (N=14)</td><td></td></tr>
<tr><td>same hands (N=10)</td><td>different hands (N=18)</td><td></td><td></td></tr>
</table>

Table 1. The configuration of types of SR movements in the stimulus. Pure sequences consist of the same SR movement types: either the tactilic type (e.g. a self-touch followed by a self-touch) or the kinesic type (e.g. a posture change followed by a trunk movement). Impure sequences consist of different types of SR movements (e.g. a self-touch followed by a posture shift). In the pure tactilic type, we also distinguish sequences of touching movements that are performed by interactants with same hands (e.g. with their right hands) and different hands (with the right vs. left hand).

Timing of SRs in sequences. In accounting for this aspect of SRs, we adopted the limit of .5s, equivalent to a conversational mini-pause, which is often used in studying short interactive units (Sacks et al., 1974; Roberts et al., 2006; Heldner et al., 2010). Accordingly, we grouped the recorded behaviours into two classes. The 'prompt response’ group contained all the sequences in which the two SRs occurred less than half a second apart, that is the second SR began ≤ .5s after the initiation of the first SR. The 'delayed response’ group contained the sequences where the second

SR began > .5s after the initiation of the first SR. With N=57, the prompt response group contained 43 sequences (75.4% of the sample) and the delayed response group, 14 sequences (24.6%).

Conversational and discourse roles. Of the total of 57 sequences, 42 were initiated by the current speaker, amounting to 73.7% of the sample, with the remaining 15 cases being initiated by the current listener (26.3%). As to the initiator’s discourse role, 33 sequences were initiated by the interviewer (57.9%) and 24 by the interviewee (42.1%).

2.6. Procedure

The study was conducted in groups consisting of 10-12 participants in a small lecture room, with each participant rating the clips individually. The participants (N = 54), who volunteered their participation, were asked about their intuitive impression as to the two movements in each clip being causally related or not. Accordingly, they were to rate each of the 57 clips on the Likert scale: ‘1 - clearly unrelated', '2 - probably unrelated', '3 - difficult to say', '4 - probably related' and '5 - clearly related'. Assessments were made immediately after seeing each clip.

2.7. Hypotheses

Hypothesis 1. Reasoning along the lines of mimicry (LaFrance, 1979; Bernieri, 1988; Chartrand and Bargh, 1999; Butzen, 2005), we expected that pure SR sequences (tactilic-tactilic or kinesic-kinesic) would induce stronger judgements of causality than impure ones (tactilic-kinesic or kinesic-tactilic).

Hypothesis 2. Turn-taking research suggests that turn-projection rules, repairs or turn-responses tend to occur below the threshold of .5s (e.g. Levinson and Torreira, 2015; Roberts et al., 2015; Kendrick, 2015). In consonance with this, we expected that ‘prompt response’ sequences (i.e. the ones in which the second SR began ≤ .5s after the initiation of the first SR) would induce stronger judgements of causality than ‘delayed response’ (i.e. the ones in which the second SR began > .5s after the initiation of the first SR).

Hypotheses 3 and 4. Given the general predictions from the social brain hypothesis (Dunbar, 1995, 1998; Byrne and Whiten, 1988)), we expected that the sequences initiated by the current speaker (H3) and the interviewer (H4), i.e. the dominant interactants in conversational and discourse terms, would induce stronger judgements of causality than the sequences initiated by the current listener and the interviewee.

3. Results

Using the mean scores for each of the 57 sequences, we investigated which qualities of SRs had an impact on the attribution of causality. IBM Statistics SPSS version 23 was used for data analysis. Nonparametric tests, and specifically Mann-Whitney U tests, were performed with a view to determining the relation between the participants' perception of causality (expressed by the mean score) and the aspects of SRs defined in the stimulus section. As predicted in Hypotheses and 1 and 2, we found the first two variables – type and timing of SRs – to have an effect on the participants' perception of causality:

- type of resonance: the 'pure' sequences (N = 42, Me = 3.13) were rated as significantly more causally related than the 'impure' (N=15, Me = 2.43) ones (Mann-Whitney, U = 158.000, N = 57, Z = -2.846, p = .004, [medium effect size]);
- timing of SRs: the 'prompt' sequences (N = 43, Me = 3.11) were rated as significantly more causally related than the 'delayed' (N = 14, Me = 2.33) ones (Mann-Whitney, U = 149.000, N = 57, Z = -2.819, p = .005, [small effect size]).

Contrary to Hypotheses 3 and 4, we did not find a statistically significant effect for the other two variables, although both showed a trend (see Figure 1):

- conversational role: no significant difference between the sequences initiated by the current speaker (N = 42, Me = 3.09) or listener (N = 15, Me = 2.63) (Mann-Whitney, U = 222.500, N = 57, Z = -1.677, p = .094);

- discourse role: no significant difference between the sequences initiated by the interviewer (N = 33, Me = 2.76) or interviewee (N = 24, Me = 3.13) (Mann-Whitney, U = 287.000, N = 57, Z = -1.762, p = .078)

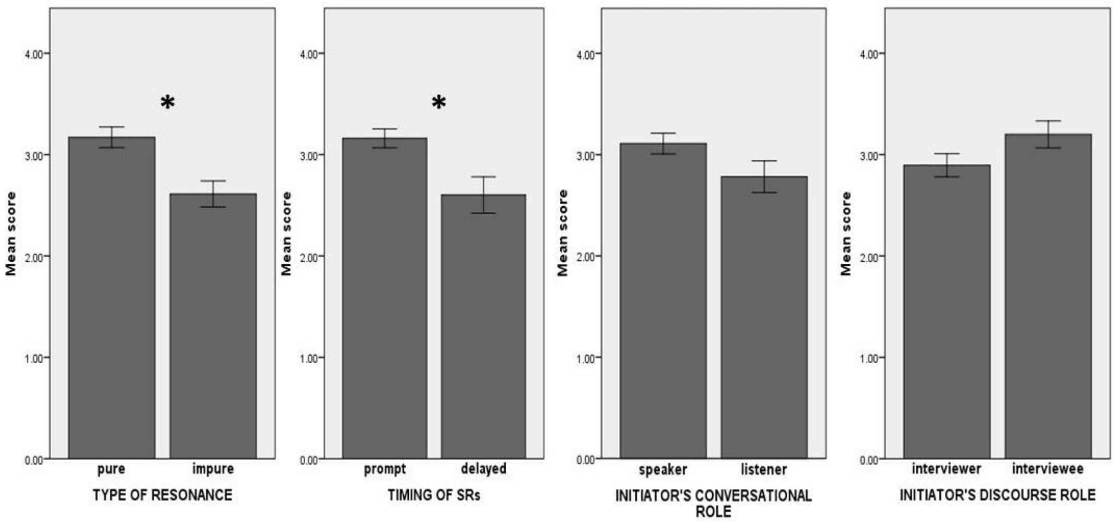

Figure 1. The relation between the perception of causality (as indicated by the mean score from the participants) and the type of sequence of the self-regulatory movements, timing of the self-regulatory movements, conversational role and discourse role. Asterisks indicate statistical significance at $p < 0.05$. Error bars indicate standard errors of the mean.

For the tactilic pure sequences, we additionally tested whether the fact that self-touches were performed with same (N = 10, Me = 2.90) or different hands (N = 18, Me = 3.13) had any impact on the attribution of causality; here too, we failed to obtain a significant result: Mann-Whitney, U =77.500, N = 28, Z = -.600, p = .549.

To further key in on the perceptual salience of the SR characteristics, we juxtaposed the group of sequences that were judged by the participants as the most and least likely to involve causality between the SRs: 14 highest ranking clips (4th quartile) and 14 lowest ranking clips (1st quartile). For the two variables in Hypotheses 1 and Hypothesis 2 (perceived causality between SRs is related to promptness with which they follow each other), the relation with the quartile membership reached or approached significance:

- type of resonance: Fisher's exact test (N = 28), p = .002, [large effect size],
- timing of SRs: Fisher's exact test (N = 28), p = .058.

We found no statistically significant results for the other variables tested by Hypotheses 3 and 4:

- conversational role: Fisher’s exact test, N = 28, p = .226;
- discourse role: Fisher’s exact test (N = 28), p = .299;
- same/different hand: Fisher’s exact test, N = 28, p = 1.000.

4. Discussion - perceptual salience

Purity. The most prominent perceptual feature in attributing causality turned out to be the 'purity' of SR sequence, which was related to the fact that the subjects were much more likely to see SRs in a sequence as causally related when the two movements were both either touching behaviours (pure tactilic sequences) or body shifts (pure kinesic sequences). The privileged status of this feature was confirmed by both testing it in relation to the mean 'causality' score and the inter-quartile comparison. Taken together these results seem to signal that both types of pure sequences, i.e. tactilic and kinesic ones, are responsible for the attribution causality to SR movements.

Promptness. The second feature in perceptual prominence regards the timing of SRs, with 'prompt' responses (i.e. the two SRs occurring within half a second) being more often seen as causally related than ‘delayed’ responses (the two SRs more than half a second apart). Although the inter-quartile comparison did not reach statistical significance, it came close to doing so.

No other characteristics of SR sequences showed significant results when correlated with the subjects’ judgments of causality. We noted, however, that the results for the variables 'conversational role' and 'discourse role' could be interpreted as showing a trend. Given the configuration of the data, this may indicate a tendency towards attributing causality to SR sequences that are initiated by the current speaker, on the one hand, and by the interviewee on the other.

A hierarchy of perceptually salient features when attributing causality between SRs in a sequence:

1. type of SRs → pure sequence of either tactilic or kinesic type

2. timing of SRs → prompt response (≤ .5s) to the first SR in a sequence
3. conversation and discourse roles of the initiator → the initiator is the current speaker; the initiator is the interviewee

5. General discussion: an evolutionary perspective on mimicry and synchrony

Whenever humans interact, local interdependencies develop in the patterns of their behaviours, resulting in interpersonal coordination. For descriptive purposes, it is useful to foreground either the form of such coordinated behaviours or their timing. In the first instance, we speak of nonconscious mimicry, or behaviour matching, that is the 'tendency to mimic or mirror the behaviours of interaction partners' (Lakin et al., 2003, p. 148). Examples of this type of coordination include mimicking accents (e.g. Giles & Powesland, 1975), rates of speech (e.g. Webb, 1972), tone of voice (e. g. Neumann & Strack, 2000), postures (e. g. Bernieri, 1988, LaFrance, 1979, 1982), mannerisms (Chartrand & Bargh, 1999), facial expressions (e. g. Dimberg, 1982), yawning (Provine, 1986), and many others (for a detailed review see Hatfield, Cacioppo & Rapson, 1994). It is assumed that the effects of these phenomena are generally affiliative, via aiding rapport (e.g. LaFrance, 1979) or solidarity and involvement (Bavelas et al., 1988). Interestingly, several authors have discussed the evolutionary adaptiveness of such mechanisms and speculated about their evolutionary roots (e.g. Chartrand et al., 2002; Lakin et al., 2003; Van Baaren et al., 2004;

The temporal dimension of interpersonal coordination manifests itself in synchrony – the convergence or alignment of interactants' behaviours with respect to their timing rather than their form (see Condon and Ogston, 1967; Kendon, 1970). Recent research reveals its connection to a number of socio-emotive dispositions, such as cooperation (Wiltermuth and Heath, 2009), joint focus (Richardson et al., 2009), mutual comprehension (Brennan et al., 2010), compassion (Valdesolo and DeSteno, 2001), affiliation (Hove and Risen, 2009), recognition of satisfaction and dissatisfaction (Julien et al., 2000) or perception of rapport (Miles et al., 2009).

The results of our study show that these two dimensions of interpersonal coordination also operate at the perceptual level: here, movement purity captures the sameness of form sensu mimicry and promptness captures the temporal pattern of synchrony. Accordingly, we found that the similarity in the form of the movements constitutes the most salient feature when attributing causality to interactional events. This high acuity for perceiving a relation between movements of the same type (represented in our stimulus by sequences of tactilic-tactilic behaviours or kinesic-kinesic behaviours) may point to a deeper perceptual bias towards detecting similarities between interactants. The work on mimicry, quoted above, emphasises its affiliative and rapport-making function. Accordingly, if we see our finding in the context of the interface theory of perception (see Introduction), whereby the perceptual acuity for similarity would have evolved because it provided fitness-related information, we can speculate that its emergence was the result of the pressure to be able to recognise genuine or prospective coalition partners. On this interpretation, consistent with the social brain hypothesis, the perceptual bias towards ascribing mimicry could be seen as part of the cognitive infrastructure for diagnosing and navigating one's social environment.

Next, our result for a stronger tendency to attribute causality to movements that follow each other in close proximity seems to be related to the temporal organisation of interaction and more specifically, of talk. When preparing the stimulus we used a 4-second window, based on Bailenson's work of collaborative virtual environments, which showed that people cease to perceive movements as related if they are separated by longer than 4 seconds (2004). In the ecology of face-to-face conversational interaction, the 4-second window is a sizeable stretch of time, representing a short conversational turn (Roberts et al., 2015; cf. Żywiczyński et al., in press). In the study itself, we used the threshold of .5 second for identifying prompt sequences, which is equivalent to a mini-pause. As the growing research on turn-taking indicates, the half-a-second unit represents an important constraint on the organisation of conversation: most turn reactions, irrespective of the context and language, come within 500 ms from the end of the preceding turn (Stivers et al., 2009; Levinson and Torreira, 2015; Roberts et al., 2015), which is impressively short in view of the fact that it takes 600 ms to plan for the articulation of a single lexeme (Levelt et al., 1999) and as much as 1500 ms for the articulation of a simple utterance (Griffin and Bock, 2000; Gleitman et al., 2007). Given all this, it is difficult to ignore the possibility that our result, showing the perceptual bias towards responses coming within .5 second, is part of the behavioural system responsible for regulating turn-transitions. In terms of the interface theory of perception, we could see this particular type of perceptual acuity to have emerged because the synchronisation of SR movements itself became an element supporting the turn-taking mechanism (for a discussion Żywiczyński et al., in press).

6. Conclusion

It is imperative that further studies on the perception of interactional phenomena should employ both naturalistic and controlled settings to investigate factors regulating salience, with a focus on both the formal characteristics of movements and their synchronisation. Non-trivial for evolutionary considerations would be research into the relation between the perception of mimicry and the perception of affiliation, e.g. with the use of the game-theoretic methodology. A project that deserves a separate line of study concerns the role of SR movements and their synchronisation in turn-taking. Although our study did not reveal that conversational (speaker vs. hearer) and discourse (interviewer vs. interviewee) roles constitute characteristics of prominent salience in the perception of interaction, this finding should be tested in a more elaborate research programme, in which sociolinguistic variables, e.g. status, could be controlled. On a wider plane, our research and its future extensions accord with the approaches stressing the inherently multimodal character of linguistic interaction, particularly in its prototypical use – face-to-face conversation. Consistent with Levinson’s “interaction engine hypothesis” (2006), behaviours transmitted in the motor-visual channel - gestures, postures, facial expressions - but also SR movements, which are not related to language in an obvious way, together with the perceptual mechanisms for their detection and categorisation can be seen as forming a platform which enables us to engage in a highly coordinate mode of interaction. What makes SR sequences particularly interesting from the evolutionary perspectives is that they entail little cost, are easily repeatable, and which furthermore can be used by conversants to diagnose their mutual commitment to engage in future cooperation involving higher cost, such as sharing important information. In our view, it is then worthwhile to consider the proposal that the coordination of SR movements may be a mechanism for bootstrapping cooperation, which is one the crucial prerequisites for the emergence of language.

Conflict of Interest Statement

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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References

Augusti, E.-M., Melinder, A., Gredebäck, G., 2010. Look who's talking: Pre-verbal infants' perception of face-to-face and back-to-back social interactions. Frontiers in Psychology 1, 161. http://dx.doi.org/10.3389/fpsyg.2010.00161

Bailenson, J. N., Beall, A. C., Loomis, J., Blascovich, J., Turk, M., 2004. Transformed Social Interaction: Decoupling Representation from Behavior and Form in Collaborative Virtual Environments. Presence: Teleoperators and Virtual Environments 13(4), 428–441. http://dx.doi.org/10.1162/1054746041944803

Barroso, F., Freedman, N., Grand, S., Van Meel, J., 1978. Evocation of two types of hand movements in information processing. Journal of Experimental Psychology: Human Perception and Performance 4(2), 321–329. http://dx.doi.org/10.1037/0096-1523.4.2.321

Barroso, F., Freedman, N., Grand, S., 1980. Self-touching, performance, and attentional processes. Perceptual and Motor Skills 50(3), 1083–1089. http://dx.doi.org/10.2466/pms.1980.50.3c.1083

Barroso, F., Feld, J. K., 1986. Self-touching and attentional processes: The role of task difficulty, selection stage, and sex differences. Journal of Nonverbal Behavior 10(1), 51–64. http://dx.doi.org/10.1007/BF00987205

Bavelas, J. B., Black, A., Lemery, C. R., Mullett, J., 1987. Motor mimicry as primitive empathy. In: Eisenberg, N., Strayer, N. (Eds.), Empathy and its development. Cambridge University Press, Cambridge, pp. 317–338.

Bavelas, J. B., Black, A., Chovil, N., Lemery, C. R., Mullett, J., 1988. Form and function in motor mimicry: Topographic evidence that the primary function is communication. Human Communication Research 14, 275–299. http://dx.doi.org/10.1111/j.1468-2958.1988.tb00158.x

Berger, S. M., Hadley, S. W., 1975. Some effects of a model's performance on an observer's electromyographic activity. American Journal of Psychology 88, 263-276. http://dx.doi.org/10.2307/1421596

Bernieri, F. J., 1988. Coordinated movement and rapport in teacher-student interactions. Journal of Nonverbal Behavior 12, 120–138. http://dx.doi.org/10.1007/BF00986930

Bernieri, F. J., Gillis, J. S., Davis, J. M., Grahe, J. E., 1996. Dyad rapport and the accuracy of its judgment across situations: A lens model analysis. Journal of Personality and Social Psychology 71(1). http://dx.doi.org/10.1037/0022-3514.71.1.110

Blackmore, S., 1999. The Meme Machine. Oxford University Press, Oxford.

Brennan, S. E., Galati, A, Kuhlen, A. K., 2010. Two minds, one dialog: Coordinating speaking and understanding. The Psychology of Learning and Motivation 53, 301–344. http://dx.doi.org/10.1016/S0079-7421(10)53008-1

Butzen, N., Bissonnette, V., McBrayer, D., 2005. Effects of modelling and topic stimulus on self-referent touching. Perceptual and Motor Skills 101(2), 413–420. http://dx.doi.org/10.2466/pms.101.2.413-420

Byrne, R. W., Whiten, A., 1988. Machiavellian Inteligence: Social Expertise and the Evolution of Intellect in Monkeys, Apes and Humans. Oxford University Press, Oxford.

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. http://dx.doi.org/10.1037/0022-3514.76.6.893

Chartrand, T. L., Cheng, C. M., Jefferis, V. E. (2002). You're just a chameleon: The automatic nature and social significance of mimicry. In: M. Jarymowicz, M, Ohme, R. K. (Eds.), Natura automatyzmow (Nature of Automaticity). IPPAN & SWPS, Warszawa, pp. 19–23.

Cohen, C. E., Ebbesen, E. B., 1979. Observational goals and schema activation: A theoretical framework for behavior perception. Journal of Experimental Social Psychology 15(4), 305–329. http://dx.doi.org/10.1016/0022-1031(79)90041-6

Condon, W. S., Ogston, W. D., 1967. A segmentation of behavior. Journal of Psychiatric Research 5, 221-235. http://dx.doi.org/10.1016/0022-3956(67)90004-0

Condon, W. S., Ogston, W. D., 1971. Speech and body motion synchrony in the speaker-hearer. In: Horton, D. J-, Jenkins, J. J. (Eds.), Perception and language. Merrill, Columbus (OH), pp. 150-173.

Dawkins, R., 1976. The Selfish Gene. Oxford University Press, Oxford.

Dennett, D., 1995. Darwin's Dangerous Idea: Evolution and the Meanings of Life. Simon and Schuster, New York.

Dimberg, U., 1982. Facial reactions to facial expressions. Psychophysiology 19, 643– 647. http://dx.doi.org/10.1111/j.1469-8986.1982.tb02516.x

Dittman A. T., 1962. The relationship between body movements and moods in interviews. Journal of Consulting Psychology 26(5), 480. http://dx.doi.org/10.1037/h0049279

Dunbar, R., 1995. Neocortex size and group size in primates: a test of the hypothesis. Journal of Human Evolution 28(3), 287-296. http://dx.doi.org/10.1006/jhev.1995.1021

Dunbar, R., 1998. The social brain hypothesis. Evolutionary Anthropology 6, 178-190. http://dx.doi.org/10.1002/(sici)1520-6505(1998)6:5<178::aid-evan5>3.0.co;2-8

Ekman, P., Friesen, W. V., 1969. The repertoire of nonverbal behavior: Categories, origins, usage, and coding. Semiotica 1(1), 49–98. http://dx.doi.org/10.1515/semi.1969.1.1.49

Ekman, P., Friesen, W. V., 1972. Hand movements. Journal of Communication 22, 353–374. http://dx.doi.org/10.1111/j.1460-2466.1972.tb00163.x

Freedman, N., 1972. The analysis of movement behavior during the clinical interview. In: Seigman, A., Pope, B. (Eds.), Studies in Dyadic Communication. Simon and Schuster, New York, pp. 153–175. http://dx.doi.org/10.1016/b978-0-08-015867-9.50012-5

Freedman, N., Blass, T., Rifkin, A., Quitkin, F., 1973. Body movements and the verbal encoding of aggressive affect. Journal of Personality and Social Psychology 26(1), 72–85. http://dx.doi.org/10.1037/h0034220

Friesen, W. V, Ekman, P., Wallbot, H., 1979. Measuring Hand Movements. Journal of Nonverbal Behavior 4(2), 97–112. http://dx.doi.org/10.1007/BF01006354

Gleitman, L. R., January, D., Nappa, R., Trueswell, J. C., 2007. On the give and take between event apprehension and utterance formulation. Journal of Memory and Language 57(4), 544-569. http://dx.doi.org/10.1016/j.jml.2007.01.007

Goffman, E., 1969. The Presentation of Self in Everyday Life. Penguin, London.

Goldberg, S., Rosenthal, R., 1986. Self-touching behavior in the job interview: Antecedents and consequences. Journal of Nonverbal Behavior 10(1), 65–8 http://dx.doi.org/10.1007/BF009872060.

Griffin, Z. M., Bock, K., 2000. What the eyes say about speaking. Psychological Science 4, 274–279. doi:10.1111/1467-9280.00255

Hatfield, E., Cacioppo, J. T., Rapson, R. L., 1994. Emotional contagion. Cambridge University Press, Cambridge.

Heldner, M., Edlund, J., 2010. Pauses, gaps and overlaps in conversations. Journal of Phonetics 38(4), 555-568. http://dx.doi.org/10.1016/j.wocn.2010.08.002

Hoffman, D. D., 2009. The interface theory of perception. In M. Dickinson, M. Tarr, A. Leonardis, and B. Schiele (Eds.), Object Categorization: Computer and Human Vision Perspectives (pp. 148-165). New York, NY: Cambridge University Press. doi:10.1017/CBO9780511635465.009

Hoffman, D. D., Singh, M., Mark, J., 2013. Does evolution favor true perceptions? Human Vision and Electronic Imaging XVIII. doi:10.1117/12.2011609

Hoffman, D. D., Prakash, Ch., 2014. Objects of consciousness. Frontiers in Psychology 5, 00577. doi: 10.3389/fpsyg.2014.00577

Holler, J., Kendrick R. H., 2015. Unaddressed participants’ gaze in multi-person interaction: optimizing recipiency. Frontiers in Psychology 6, 00098. http://dx.doi.org/10.3389/fpsyg.2015.00098

Hove, M. J., Risen, J. L., 2009. It’s All in the Timing: Interpersonal Synchrony Increases Affiliation. Social Cognition 27(6), 949–960. http://dx.doi.org/10.1521/soco.2009.27.6.949

Julien, D., Brault, M., Chartrand, E., Begin, J., 2000. Immediacy behaviours and synchrony in satisfied and dissatisfied couples. Canadian Journal of Behavioural Science 32(2), 84–90. http://dx.doi.org/10.1037/h0087103

Gifford, R., 1991. Mapping nonverbal behavior on the interpersonal circle. Journal of Personality and Social Psychology 61, 279-288. http://dx.doi.org/10.1037/0022-3514.61.2.279

Gifford, R., 1994. A lens-mapping framework for understanding the encoding and decoding of interpersonal dispositions in nonverbal behavior. Journal of Personality and Social Psychology 66, 398-412. http://dx.doi.org/10.1037/0022-3514.66.2.398

Giles, H., Powesland, P. F., 1975. Speech style and social evaluation. Academic Press, London.

Keitel, A., Prinz, W., Friederici, A. D., Hofsten, C. von, Daum, M. M., 2013. Perception of conversations: The importance of semantics and intonation in children's development. Journal of Experimental Child Psychology 116(2), 264–277. doi:10.1016/j.jecp.2013.06.005

Kendon, A., 1970. Movement coordination in social interaction: Some examples described. Acta Psychologica 32, 101–125. http://dx.doi.org/10.1016/0001-6918(70)90094-6

Kendon, A., 1972. Some relationships between body motion and speech. In: Siegman, A., Pope, B. (Eds), Studies in Dyadic Communication. Pergamon Press, New York, pp. 177-210. http://dx.doi.org/10.1016/B978-0-08-015867-9.50013-7

Kendrick, K. H., 2015. The intersection of turn-taking and repair: the timing of other-initiations of repair in conversation. Frontiers in psychology, 6. http://dx.doi.org/10.3389/fpsyg.2015.00250

Koenderink, J., 2011 Vision as a user interface. Proc. SPIE 7865, Human Vision and Electronic Imaging XVI, 786504 (February 04, 2011). doi:10.1117/12.881671.

LaFrance, M., 1979. Nonverbal synchrony and rapport: Analysis by the cross-lag panel technique. Psychology Quarterly 42, 66–70. http://dx.doi.org/10.2307/3033875

LaFrance, M., 1982. Posture mirroring and rapport. In: Davis, M. (Ed.), Interaction rhythms: Periodicity in communicative behavior. Human Sciences Press, New York, pp. 279–298.

Lakin, J. L., Jefferis, V. E., Cheng, C. M., Chartrand, T. L., 2003. The Chameleon effect as social glue: Evidence for the evolutionary significance of nonconscious mimicry. Journal of Nonverbal Behavior 27(3), 145–162. http://dx.doi.org/10.1023/A:1025389814290

Levelt, W. J. M., Roelofs, A., Meyer, A. S., 1999. A theory of lexical access in speech production. Behavioral and Brain Sciences 22(1), 1-75. doi:10.1017/s0140525x99001776

Levinson, S. C., Torreira, F., 2015. Timing in turn-taking and its implications for processing models of language. Frontiers in Psychology 6:731. doi:10.3389/fpsyg.2015.00731

Mahl, G. F., 1967. Some clinical observations on nonverbal behavior in interviews. Journal of Mental and Nervous Disease 144(6), 492–505. http://dx.doi.org/10.1097/00005053-196706000-00007

Mark, J. T., 2013. Evolutionary Pressures on Perception: When does Natural Selection Favor Truth? Ph.D. Dissertation. University of California, Irvine (CA).

Mark, J. T., Marion, B. B., Hoffman, D. D., 2010. Natural selection and veridical perceptions. Journal of Theoretical Biology 266(4), 504–515. doi:10.1016/j.jtbi.2010.07.020

Marion, B. B., 2013. The Impact of Utility on the Evolution of Perceptions. Ph.D. Dissertation. University of California, Irvine (CA).

Mehu, M., D'Errico, F., Heylen, D., 2012. Conceptual analysis of social signals: the importance of clarifying terminology. Journal of Multimodal User Interfaces 6(3-4), 179-189. doi: 10.1007/s12193-012-0091-y

Miles, L. K., Nind, L. K., Macrae, C. N., 2009. The rhythm of rapport: Interpersonal synchrony and social perception. Journal of Experimental Social Psychology 45(3), 585–589. http://dx.doi.org/10.1016/j.jesp.2009.02.002

Neumann, R., Strack, F., 2000. 'Mood contagion': The automatic transfer of mood be- tween persons. Journal of Personality and Social Psychology 79, 211–223. http://dx.doi.org/10.1037/0022-3514.79.2.211

Newtson, D., Engquist, G., 1976. The perceptual organization of ongoing behavior. Journal of Experimental Social Psychology 12, 436-450. http://dx.doi.org/10.1016/0022-1031(76)90076-7

Newtson, D., Enquist, G., Bois, J., 1977. The Objective Basis of Behavior Units. Journal of Personality and Social Psychology 35(12), 847–862. http://dx.doi.org/10.1037/0022-3514.35.12.847

Palmer, S. E., 1999. Vision Science: Photons to Phenomenology. MIT Press, Cambridge (MA).

Pike, K. L., 1954. Emic and Etic Standpoints for the Description of Behavior. In: Pike, K. L. (Ed.), Language in relation to a unified theory of the structure of human behavior. Summer Institute of Linguistics, Glendale, pp. 8-28.

Poggi, I., D'Errico, F., 2012. Social signals: a framework in terms of goals and beliefs. Cognitive Processing 13(2), 427-445. doi: 10.1007/s10339-012-0512-6

Provine, R. R., 1986. Yawning as a stereotyped action pattern and releasing stimulus. Ethology 72, 109-122. http://dx.doi.org/10.1111/j.1439-0310.1986.tb00611.x

Richardson, D. C., Dale, R., Tomlinson, J. M., 2009. Conversation, gaze coordination, and beliefs about visual context. Cognitive Science 33(8), 1468–1482. http://dx.doi.org/10.1111/j.1551-6709.2009.01057.x

Roberts, F., Francis, A. L., Morgan, M., 2006. The interaction of inter-turn silence with prosodic cues in listener perceptions of 'trouble' in conversation. Speech Communication 48(9), 1079–1093. http://dx.doi.org/10.1016/j.specom.2006.02.001

Roberts, S. G., Torreira, F., Levinson, S. C., 2015. The effects of processing and sequence organization on the timing of turn taking: a corpus study. Frontiers in Psychology 6, 509. http://dx.doi.org/10.3389/fpsyg.2015.00509.

Rosenfeld, H. M., 1966. Instrumental affiliative functions of facial and gestural expressions. Journal of Personality and Social Psychology 4(1), 65–72. http://dx.doi.org/10.1037/h0023514

Sacks, H., Schegloff, E. A., Jefferson, G., 1974. A simplest systematics for the organization of turn-taking for conversation. Language 50(4), 696–735. http://dx.doi.org/10.1353/lan.1974.0010

Scheflen, A. E., 1964. The significance of posture in communication systems. Psychiatry 27, 316–331. http://DOI:10.1521/00332747.1964.11023403

Scherer, K. R., 1978. Personality inference from voice quality - the loud voice of extroversion. European Journal of Social Psychology 8, 467–487. http://dx.doi.org/10.1002/ejsp.2420080405

Scherer, K. R., 1982. Methods of research on vocal communication: Paradigms and parameters. In: Scherer, K. R., Ekman, P. (Eds.), Handbook of methods in nonverbal behavior research. Cambridge University Press, Cambridge (MA), pp. 136–198.

Schmidt, R. C., Morr, S., Fitzpatrick, P., Richardson, M. J., 2012. Measuring the Dynamics of Interactional Synchrony. Journal of Nonverbal Behavior 36(4), 263–279. http://dx.doi.org/10.1007/s10919-012-0138-5

Sloetjes, H., Wittenburg, P., 2008, May. Annotation by Category: ELAN and ISO DCR. LREC.

Sperber, D. & Wilson, D., 1986. Relevance: Communication and cognition. Harvard University Press/ Blackwell, Cambridge (MA).

Stivers, T., Enfield, N. J., Brown, P., Englert, C., Hayashi, M., Heinemann, T., … Levinson, S. C., 2009. Universals and cultural variation in turn-taking in conversation. Proceedings of the National Academy of Sciences 106(26), 10587–10592. doi:10.1073/pnas.0903616106

Van Baaren, R. B., Holland, R. W., Kawakami, K., Van Knippenberg, A. (2004). Mimicry and prosocial behavior. Psychological science 15(1), 71-74.

Valdesolo, P., Ouyang, J., DeSteno, D., 2010. The rhythm of joint action: Synchrony promotes cooperative ability. Journal of Experimental Social Psychology 46(4), 693–695. http://dx.doi.org/10.1016/j.jesp.2010.03.004

Waxer, P. H., 1977. Nonverbal cues for anxiety: an examination of emotional leakage. Journal of Abnormal Psychology 86(3), 306–314. http://dx.doi.org/10.1037/0021-843X.86.3.306

Webb, J. T., (1972). Interview synchrony: An investigation of two speech rate measures in an automated standardized interview. In: Pope, B., Siegman, A. W. (Eds.), Studies in dyadic communication. Pergamon, New York, pp. 115–133. http://dx.doi.org/10.1016/B978-0-08-015867-9.50010-1

Wiltermuth, S. S., Heath, C., 2009. Synchrony and cooperation. Psychological Science 20(1), 1-5. http://dx.doi.org/10.1111/j.1467-9280.2008.02253.x

Żywiczyński, P., 2010. The Axiology of Spoken Interaction: An Essay on the Organisation of Conversational Behaviour. Wydawnictwo Naukowe UMK, Toruń

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