Emotional Transactions in the Paris Subway

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Combining naturalistic videotaping, objective facial coding, and sequential analysis in the study of nonverbal emotional behavior

Abstract. *We report on what, to our knowledge, represents the first study of nonverbal emotional behavior in crowded public places combining naturalistic videotaping of situated activity, objective coding of facial movement, and sequential analysis of behavior. In the first part of the study we argue that passengers do not lose emotional sensitivity to physical contact as density (passengers per square meter) increases, which indicates that physical contact is experienced as a territorial intrusion regardless of crowdedness. In the second part of the study, we suggest that passengers resolve the emotions due to intrusive physical contacts through two interactional strategies involving facial movements usually interpreted as "expressions of emotions." Since proxemic violations seem to represent a pervasive emotion elicitor, the protocol can be extended to other means of transportation and replicated in other locations. We conclude that the methodology provides an effective tool for theory-building in the study of nonverbal emotional behavior.*

Keywords: emotions, facial movement, behavior patterns, crowding, public transportation

The aim of this article is to present a novel methodology to study emotional transactions in crowded public places where verbal interaction is minimized. Several authors have argued that emotions can be studied in the context of ongoing transactions with other people or with the environment at large (Frijda, 1986; Griffiths & Scarantino, 2005; Lazarus, 1991; Parkinson, 1996). In particular, behaviors assumed to express emotions can be considered not only in terms of the internal states of a single individual, but also from the strandpoint of the role they play in a "negotiation" (Hinde, 1985) or "interchange" (Goffman, 1967) involving two or more individuals. The present paper aims to contribute to the consolidation of a methodology for studying interpersonal emotional transactions in real-life situations.

In crowded public places, as Goffman (1966) has emphasized, social interactions tend to be governed by the norm of civil inattention, a mostly nonverbal pattern of coordination among strangers. Within the constraints of this type of setting, we devised a heuristically useful methodology to study nonverbal emotional behaviors that we applied in the Paris subway. The innovation consisted in combining three research techniques: naturalistic videotaping of behavioral specimens, objective description of facial activity, and sequential analysis.

The paper is avowedly eclectic and somewhat heterodox in style. It begins with a review of the three techniques involved and continues with a brief introduction to the Paris métro study. The two successive stages of the research are then reported, each being subdivided in an initial preliminary (or informal) phase and a later systematic phase.

The design of the research is exploratory. It is carried out through a cycle of inferences to the best explanation, i.e. explanatory inferences that are neither deductive nor inductive.[1] We start with a naturalistically observed fact, which we attempt to explain with a reasonable and parsimonious theory. We then draw an implication from that theory that motivates a question, leading to a new phase of naturalistic observation aimed at establishing some new fact. We then try to explain this new fact with a reasonable and parsimonious theory, and so on. Of course, such explanations are not based on experimental evidence, but on careful analysis of real-life situations.

[1] Pragmatist philosopher C. S. Pierce called them "abductive". See Fann (1970) for an account of Peirce's thoughts about abduction.

In the first stage of the research, we examine the correlation between density (number of persons per square meter) and the probability of an emotional response to physical contact. As passengers get on and off between the train and the platform, do they become emotionally insensitive to being pushed as crowdedness increases? In the second stage we seek to identify the ways in which passengers resolve the emotional situations created by physical contact. How do people manage contact-related annoyances in the Paris subway? The results of the study support the theoretical significance of the proposed methodology.

Combining Naturalistic Videotaping, Objective Facial Coding And Sequential Analysis

The use of audio-visual recording technology in the collection of behavioral specimens was pioneered by anthropologists Bateson and Mead (1942) and is widespread today in various studies of face-to-face interaction. While videotaping is inevitably selective, any cinematographic shot of the world of everyday life always contains far more information than can be possibly foreseen. Screening naturalistic audio-visual records thus provides a genuine field of exploration within which real discoveries can be made (Kendon, 1990).

A number of studies in psychology have used objective coding of facial activity in the description of natural specimens of behavior (Camras, 1992; Fernández-Dols, Carrera, & Crivelli, 2011; Fernández-Dols & Ruiz-Belda, 1995; Mehu & Dunbar, 2008; Messinger, Fogel, & Dickson, 2001; Ruiz-Belda, Fernández-Dols, Carrera, & Barchard, 2003; K. R. Scherer & Ceschi, 2000). By objective coding we mean the description of facial activity through a set of movement descriptors that are attributed to changes in the face on the basis of standardized observable conditions (e.g. Ekman and Friesen's (1978) Facial Action Coding System).

The naturalistic studies that have based their descriptions of facial activity on objective coding systems represent instances of what is usually called a components study. The aim of research in this paradigm is to specify the facial response to a known antecedent condition, like a feeling or some emotion-relevant event. For the present report some experimental components studies are also relevant, insofar as their objective has been to discover patterns of response specific to particular kinds of stimulus

situations (Ekman, Friesen, and Simons 1985; Rosenstein and Oster 1988; Craig, Hyde, and Patrick 1991; Prkachin 1992; Keltner 1995; Chong et al. 2003).

Sequential analysis of behavior structures finds classical application in the study of face-to-face interactional events and of complex behavioral systems in animals. Social interactions in general (Goffman, 1971), their conversational (Sacks, Schegloff, & Jefferson, 1974) and gestural (Kendon, 2004) dimensions in particular, and the reproductive behavior of birds (Tinbergen, 1951) have been effectively accounted for as sequentially accomplished structures. The methodological aim of this article is to extend this approach used in sociological, linguistic and ethological studies to the naturalistic analysis of objectively described emotional expressions.

The Paris Subway, A Crowded Public Place

In order to maximize the chances of elaborating our method, we chose to conduct the collection of data in the Paris Subway. This environment presented us with three qualities that made it an ideal choice for a methodological exploration. First, the subway is a good representative of the more general class of mostly anonymous and often crowded urban public spaces. It is an environment common to many cities around the world and often even a feature of their identity. Second, we knew from previous research on subway sociability that riders do not speak very much in this setting (Fried & DeFazio, 1974; Levine, Vinson, & Wood, 1973; Tonnelat, 2012). Third, the subway ride presented us with several types of recurrent situations likely to cause emotions among riders. For example, two recent studies showed the importance of crowding and territorial encroachment, whether spatial or visual on the emotional comfort of riders of the New York City subway. Evans and Wener (2007) showed how the immediate seating density proximate to the passenger significantly affected three indices of stress (self-report, salivary cortisol, performance aftereffects). In a study based on personal diaries by teenage riders, Ocejo and Tonnelat (2013) documented the emotions elicited by perceived territorial breaches, especially staring. Because we needed an event that was directly observable in the Paris subway, we chose to focus on physical contact between strangers as the emotion elicitor.

Contact has become a matter of concern for riders and managers alike, in Paris and elsewhere, because the usual density levels of the morning and evening rush hours make it inevitable and frequent. In addition, while margins of improvement are severely limited by technical constraints, density levels in rush hours show a sustained tendency to increase over years, worsening the conditions of travel.[2]

In the Western European cultural tradition, and in France in particular, physical contact between strangers in public places can be interpreted as offensive. In the language of Erving Goffman (1971), it is usually seen as a violation of the ultimate form of personal space, the "sheath," defined as the surface of the body and the clothes that immediately cover it. Edward T. Hall (1966), in his "proxemic" analysis of the cultural rules underlying the use of interpersonal space, situates physical contact in the sphere of "intimate distance." On the basis of observations of everyday situations, both authors called attention upon the fact that violations of "personal space" or "intimate distance," proxemic violations for short, constitute powerful elicitors of emotional responses. Experimental research in proxemics has shown that indeed intrusions of personal space induce feelings of discomfort (cf. Newman and Pollack 1973; Hayduk 1981)

Hall also emphasized the unconscious or immediate nature of the appraisals underlying our experience of being close to, or distant from, others. Viewing physical contact between strangers as an unreflectively estimated territorial violation allows us to connect research on the use of space in face-to-face interactions with work on the emotions in the tradition of appraisal theories (Arnold, 1960; Frijda, 1986; Lazarus, 1991; Scherer, 1987). A common assumption to appraisal theories is that an emotion is a response to an object or whole situation evaluated as beneficial or harmful to a motivation (concern, goal, preoccupation) of the individual. The response is thought to involve coordinated changes at several levels, including the experience of action tendencies (impulses to perform specific acts) and the display of corresponding facial expressions. In our case, the most obvious appraisal criterion for the evaluation of a territorial violation is compatibility with proxemic standards – compliance with norms of interpersonal distance.

[2] According to data released by the RATP, traffic increased over 25% between 2000 and 2011, reaching a high yearly number of 1,500 million travels.

Bringing together elements of proxemics with elements of appraisal theory, we began the inquiry with the following hypotheses:

1. To the extent that physical contact is appraised as a proxemic violation, riders of the Paris subway will respond emotionally to events of physical contact with strangers;

2. Emotional responses to physical contact will be observable in facial changes.

Before going to the field, we knew from a number of sources based on self-reports and from common experience that passengers of the Paris subway rebuff physical contact with strangers. In 2012, a survey was conducted under the auspices of the Parisian transportation authority RATP asking passengers to report recently witnessed *incivilités*, i.e. offensive behaviors in public, in particular in the premises of the subway and in bus lines (n=1400). Two wrongdoings directly related to physical contact with strangers feature in the survey's "top ten." In the course of the previous month, 71% of respondents reported having seen somebody pushing others while getting on/off and not apologizing, whereas 78% had seen somebody getting on the train before onboard passengers could get off (TNS Sofres pour RATP 2012). In 2012, the RATP also created an open web platform where riders could post anecdotes related to *incivilités* in the subway or in the bus[3]. By the end of 2012, out of a total of nearly 1200 messages, 224 where addressed to a "dear shover" (*cher bousculeur*). In 27 messages, contact incidents where explicitly described with words such as "unpleasant" or "annoying."[4] In 30 messages reference was made to retaliation, actual or imagined[5]. Was this reported emotional quality also visible on passengers' face?

[3] www.chervoisindetransport.fr

[4] Situations described as "unpleasant" were identified by searching instances of the following adjectives (usually employed ironically): *agréable*, *plaisant*, *jouissif*. Situations described as "annoying" were spotted through uses of the reflexive verb : *s'énerver*.

[5] Only seven messages describe the situation as "unpleasant" or "annoying" and at the same time make reference to retaliatory response.

Part 1: Probabilistic Analysis Of Contact Incidents

Preliminary Stage

Method. The first step of the research consisted in building a database of contact episodes in the Paris subway in order to measure the degree to which riders react emotionally, as evidenced in facial activity. We chose to focus on a ubiquitous episode of subway travel, the moment when riders get off and on the train, between the time when the doors open and close. We chose to film riders from the platform, facing them as they get off the train and following them as they get on and often turn around to face the train doors. This set up maximized the number of faces captured in a minimum of time. Also, the train stop offered many occasions of physical contact, as riders getting off pushed riders getting on, or as they pushed the person in front of them. In order not to influence riders, we used a camera concealed in a pair of glasses. A poster was affixed in the station informing riders that they may be filmed and that they could ask to retrieve images of themselves and have them erased from the database if they wished so. In compliance with the French National IRB (CNIL), we promised not to show the videos outside of the lab, unless the riders were rendered unrecognizable. In brief, the method was chosen so as to avoid influencing riders in any way more than a regular rider waiting to board a train would.

In order to vary the setting, we filmed these episodes in two stations (République and Montparnasse) on two different subway lines (line #5 and line #13) respectively during evening (5:30 pm to 7 pm) and morning peak hours (8:00 am to 9:30 am).[6] The lines and stations were chosen because they were among the most crowded and offered platforms without automated doors. The trains and the size of the platforms were comparable. Informal observation indicates that the riding population at the République station in the evening was more ethnically and economically diverse than the population at the Montparnasse station in the morning. These differences are mostly due to the destinations served by these lines and the nature of economic activities in the station area. The data was collected every day over a period of one month in June 2012.

[6] Each videotaping session lasted for about 90 minutes. The duration was limited by the battery life of the camera.

The dataset is made of 735 units of "rider exchange" (*échange voyageurs*) distributed in the two stations (respectively 436 and 299). A unit of rider exchange describes a sequence that takes place between the train and the platform of a station, during the period of time starting with the opening of the doors after arrival and the closing of the doors before departure. The relevant activity occurs around one door of a train. The average duration of a unit in the data set is about 30 seconds.

In order to code and analyze the collection of units we identified a "contact incident" when the following events occurred in close sequence: 1) first, a physical contact between two people, which was usually visible through body movements indicating a shock between two bodies, or between a bag and a body, or any other part of the "sheath" (Goffman, 1971) of a given rider; 2) second, the person touched by another rider displayed a facial change immediately following the physical contact. However, not all physical contacts followed by a facial change on the part of the victim qualify as contact incidents. In what follows we clarify this issue by distinguishing between a reflex and a properly emotional facial response to physical contact.

Results: physical contact is routinely experienced as a territorial intrusion. The distinction between a reflex and an emotional component in the facial response to physical contact is not based on a correlation between facial changes and self-reports. What we correlated facial behavior to, instead of passengers' self-reports, was passengers' social relationship to one another. In particular, we found that touch between riders who travel together or help each other does not elicit the same kind of facial response as touch between fully anonymous riders. These distinct types of social relationship, however transient, prescribe, allow or forbid physical contact and consequently can be seen as normative sources of distinct responses to its occurrence. You might become furious if a stranger attempts to kiss you in the street, but also if your partner declines your invitation to a kiss or if your child refuses to kiss auntie Emma. The emotional significance of physical contact depends on the nature of the social relationship between the individuals involved.

In a preliminary analysis of our dataset we identified a peculiar type of social interaction episode that we called "boarding *in extremis*." Such episodes involve at least one passenger that attempts to get on the train as the doors start closing, or when the

alarm announcing the closing of the doors sounds. As attested by the messages posted on the web and by common experience, such acts are interpretable as offensive. One reason is that the passenger that embarks in such a fashion risks preventing the closing of the doors, thereby delaying the train's departure. These passengers typically perform what Goffman (1971) calls "remedial work." In particular, they convey to the others present, through some form of exaggerated facial or bodily expression, that they acknowledge the inappropriate character of their conduct[7].

We identified seven episodes of passengers boarding *in extremis* that represent variations of this generic scenario. The first variation involves not one but two passengers that attempt to get onboard at the last second. Together, they constitute a "with" (Goffman, 1971, p. 19), i.e. a group of two or more individuals that appear to travel together. The second variation involves what can be called a "colluder," namely another passenger that somehow facilitates the boarding *in extremis* (e.g. by holding the doors open).

Members of the with and colluders also broadcast "body glosses" in situations of *in extremis* boarding. In these seven episodes, members of the with, or the embarking passenger and the colluder, push each other in a clearly intense fashion. The circumstances of such shoving are manifold: excess of impetus, desynchronization, sudden arrest, etc. What is striking here is that the receiver of the push *does not react facially*, or alternatively limits the reaction to a movement of the eyelids, either in the form of a blink or by raising the upper lids briefly.

In contrast to the pattern of facial reaction in these special situations of *in extremis* boarding, we noticed that facial responses to physical contact in "normal" conditions (in a sense to be clarified) appeared to involve more than a brief eyelid movement. The receiver of a "normal" push seemed to respond with facial movements engaging more encompassing areas of the forehead and the mouth: brow lowering or raising, lip pressing or parting, etc (see Figure 1). These additional movements in response to physical contact

[7] Goffman calls such expressions "body gloss" because they provide additional information about the relationship that the offender has to the norms. The body gloss, by conveying to the others present that the offender herself sees her conduct as offensive, makes the transgression more excusable or less severe than if the offender proceeded as nothing had happened.

in “normal” situations, as compared to contact in the situations of *in extremis* boarding, required an interpretation.

Discussion: an emotional reaction to physical contact distinct from a reflex. Given that eyelid movement is present in both scenarios, it seems reasonable to explain it in terms of a generic reflex response to a sudden intense stimulus. Eyelid movement, in particular eye closure, is indeed present in the startle response (Ekman et al., 1985). If eyelid movement can be attributed to a reflex, how can we account for movements in the forehead or mouth areas? In order to provide a best explanation, we resorted to Goffman’s model of the territories of the self, in particular to his typology of territorial violations.

Goffman (1971) distinguishes “preclusiveness” from “encroachments” and “self-violations.” Preclusiveness is “the effort of an individual to keep persons at a distance he has no right (in their eyes) to maintain.” (Goffman, 1971, p. 58) Preclusiveness can be offensive because the very existence of a social relation between two individuals presupposes the existence of a shared territory, which means giving up certain territorial claims. Hence, it is the nature of the social relation between participants that makes some interactional acts appear offensive or, in contrast, acceptable. In our case, physical contact that is offensive in the “normal” situation is acceptable for colluders or fellow members of a with.

Following Goffman, we can now define the “normal” situation of the subway ride as an “unfocused interaction” governed by the norm of “civil inattention.” Assuming that the appraisal of physical contact depends on the social relation between the individuals concerned, and that relations with colluders or members of a with nullify the offensive character of physical contact, we can now relate these two contrasting appraisals of contact with the two patterns of facial response described above. Forehead or mouth movements (see Figure 1) additional to eyelid activity can be accounted for in terms of a negative evaluation of physical contact in situations of unfocused interaction under the rule of civil inattention (“normal” situations). Most passengers in the passive position of receiving a physical contact (let us call them “patients of contact”) display what appears to be a reflex response to this brute stimulus, namely eye closure or eyelid raising. But only patients of contact in “normal” conditions additionally exhibit facial activity in the

forehead or mouth areas. Since the latter additional movements seem to be correlated to a negative evaluation of contact, and emotion can be conceptualized as a pattern of evaluation coupled with a pattern of response including and expressive component (cf. Frijda, 1986), we interpret these facial movements as *prima facie* expressions of emotion.

This discussion leads to a more precise definition of the contact incident. It is a sequence made of two parts: the first part is a physical contact between two or more individuals, and the second part is a facial reaction on the part of the patient of contact *beyond eye closure or eyelid raising*.

On the basis of this distinction between reflex and emotional responses to physical contact we made the following prediction.

3. The probability of a contact incident (i.e. a two-parts sequence made of a contact and a facial response beyond blinking or eyelid raising) will decrease as density (i.e. number of passengers per square meter) increases.

Nobody likes experiencing a negative emotion. On the other hand, passengers know that in the subway the chance of physical contact with strangers increases with density. Given the former preference and the latter knowledge, if passengers were rational agents they should become less emotionally sensitive to physical contact as density increases – as if they were now part of a larger with. More operationally, above a certain density level we should be able to observe a plateau or a decrease in the probability of observing a contact incident. We will now see that this is not the case.

Systematic Stage

Method

Method. In order to examine whether riders became emotionally insensitive to physical contact above a density threshold, we correlated density level and the probability of a "contact incident" (i.e. the probability of observing a sequence made of a physical contact and a facial response beyond eyelid movement on the part of the victim or patient).

Measuring the probability of a given event involves comparing the number of times the event occurred with the number of times the event did not occur. One possible way of proceeding would have been to take the number of contact incidents as the dividend, the number of observed contacts as the divisor, and the quotient as the probability of a

contact incident. This is not the procedure we employed. Our divisor is not the number of observed physical contacts, but *the number of rider exchanges* (i.e. the number of observation periods).

Let us recall that the rider exchange is the time window between the opening and the closing of the train's doors when the train is at the station. We searched for contact incidents in 735 rider exchange units. If at least one contact incident was observed during a rider exchange unit, the count was positive; if no contact incident was found, it was negative. In other words, the probability of a contact incident is the quotient of positive counts divided by the total number of units of rider exchange. This procedure is analogous to the one Hall and Veccia (1990) used in their naturalistic study of touching in dyads. Their time frame was a ten-seconds observation period during which touch was either observed or not[8].

Independent variable: density. In order to correlate, for a given unit of rider exchange, the probability of a contact incident with density level, we calculated the number of persons per square meter for each unit. In order to build density intervals, we referred to a scale consistent with the one used by transporters for evaluating crowdedness and ease of standing and circulation (Transit Cooperative Research Program, 2003). We also distinguished between density measures of standing passengers, on the one hand, and walking passengers, on the other hand.

Dependent variable: contact incident. Due to visibility constraints, we did not count all contact incidents occurring in the course of a given unit of rider exchange (time window between the opening and the closing of the train's doors). The count was limited to the occurrence of *at least one* contact incident during a single unit[9]. However, since passengers' anecdotes focused on situations in which passengers are prevented from getting off because others get on prematurely, we distinguished three types of contact incidents: between two riders getting off, between two riders getting on, and between a rider getting off and a rider getting on. This allowed us to measure in three different ways

[8] In this study the probability of a touch in a dyad was defined as the quotient of the number of times that at least one touch was seen during an observation period divided by the number of observation periods, a probability that turned out to be around 15% (Hall & Veccia, 1990, p. 1157)

[9] That is, we did not count all observable contacts and then calculated the ratio of contacts followed by facial responses. Neither did we consider facial changes that were not preceded by observable physical contacts.

the actual occurrence or not of a contact incident (contact followed by facial change beyond eyelid activity).

During the screening of the videos, we noticed that the most visible contact incidents involved two riders getting onboard, which allowed us to introduce an internal differentiation for this type of incident. We distinguished between incidents involving only two persons, three persons or four persons and more. Often times, a rider being pushed by another rider ends up pushing the person in front of her, in a form of chain reaction we called a "transitive" incident. In certain situations, a rider may also push two other passengers at the same time, creating what we called a "non-bijective" incident[10]. When both criteria are met by a single incident, it means that at least four passengers are affected by a single contact event.

Since the second stage of the research (reported below) is exclusively based on videotapes at the station République, in the following section we restrict the presentation of results to that station. But the observed trends are common to the Montparnasse station as well (see appendix 1).

Results. In both stations there was a strong correlation between density and the probability of a contact incident.

[10] In mathematics, a bijection or one-to-one correspondence is a function giving an exact pairing of the elements of two sets. By analogy, a bijective contact incident involves one author of the contact and only one receiver. A non bijective incident, in contrast, involves one author and two or more receivers.

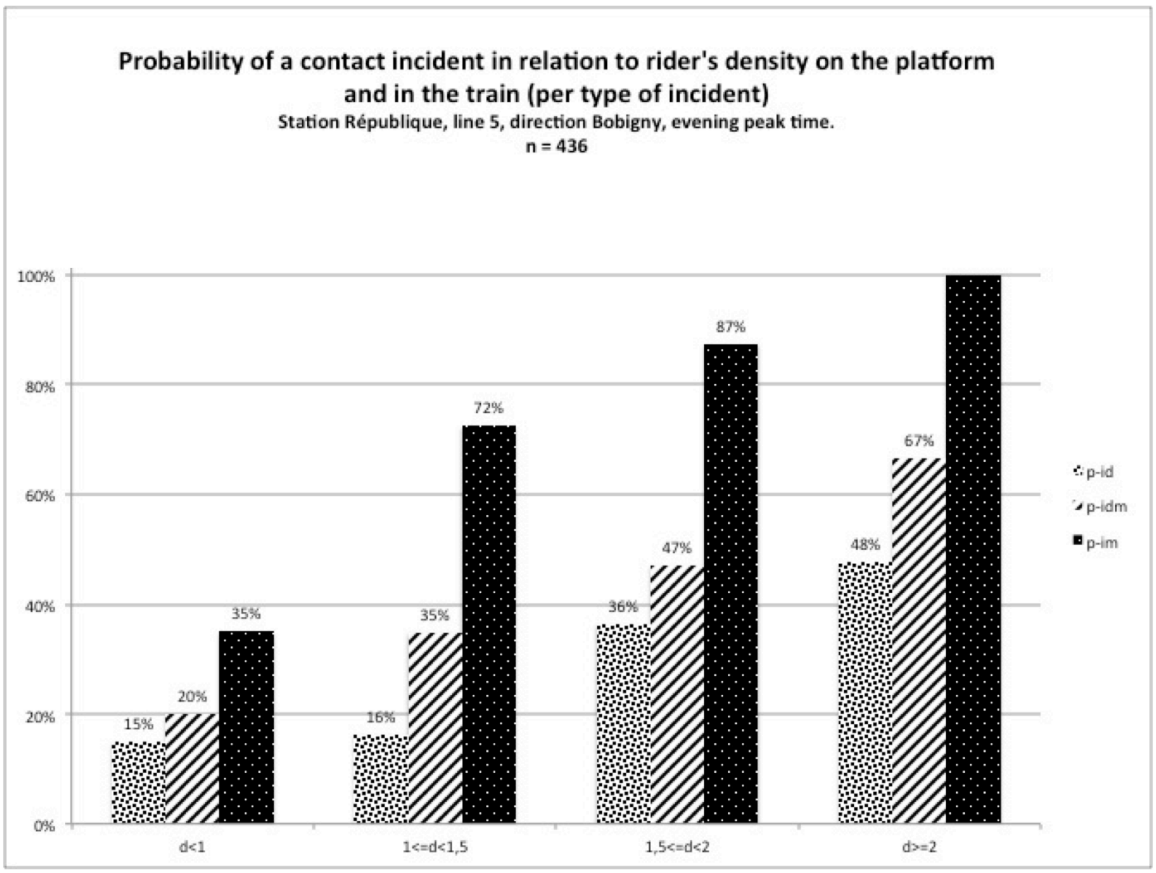

Figure 2 represents the correlation between density level and the probability of observing, during the time window between the opening and the closing of the train's doors, at least one contact incident (i.e. a contact followed by facial activity beyond blinking or eyelid raising) of each type (two persons getting off, one person getting off and one person getting on, two persons getting on. The figure is based on 436 rider exchange units at the République station.

At a density of less than 1 walking person per square meter, the probability of a contact incident is low, between 0.15 and 0.35 depending on the type of incident. This number rapidly increases with density and reaches a high between 0.48 and 1 at a density greater than 2 walking persons per square meter. Remarkably, although anecdotes posted on the web focus on incidents between passengers getting on and passengers getting off, the most probable contact incident actually involved two passengers getting on. At a density over 2 moving persons per square meter, the likeliness of at least one such contact incident per unit is certain.

Figure 3 illustrates the complexity of contact incidents between riders getting on the train, this time according to the density of passengers standing in the car at the end of the rider exchange (i.e. once the doors close). Here again, density bears a direct relation with incident complexity. At a density of less than 2.5 standing persons per square meter (not crowded), there is a 76% chance that no contact incident will occur during a unit of rider exchange. However, as density rises, this proportion rapidly drops down to a low level of 2% at a density of more than 5 standing persons per square meter (very crowded). Interestingly, as density rises, most contact incidents involve at least 4 riders, while the proportion of simpler incidents involving only 2 or 3 riders remains low. At a density of more than 5 persons per square meter, 85% of units present at least one incident involving at least 4 riders, three of which exhibited a facial reaction to contact.

Discussion. The results show that passengers do not lose sensitivity to physical contact as density rises. Instead, the probability of observing at least one *prima facie* emotional response to physical contact during a unit of rider exchange increases proportionally with density level. At the same time, the probability that a single physical contact will evoke emotional responses in more than one passenger also increases with density levels.

An important qualification is in order. We considered that a unit of rider exchange contained a contact incident if we could observe *at least one* physical contact followed by a facial reaction beyond blinking and eyelid raising. But it is not sound to assume that all passengers are sensitive to the same extent to physical contact. The at-least-one criterion means that our results are more valid for hypersensitive passengers than for hyposensitive ones. We cannot rule out the possibility that the positives we counted involve mainly the subset of passengers that are hypersensitive to physical contact. At any rate, it seems clear that at least this population responds emotionally (i.e. with facial movements beyond eyelid activity) to physical contact at all density levels. Also, in this research we did not observe events of physical contact that could be categorized as clear instances of sexual harassment.

The fact that the most likely contact incidents involve passengers getting on, while most of the episodes reported concern incidents between passengers getting on and passengers getting off, could be accounted for in terms of what sociologist Harold

Garfinkel (1956) calls a "degradation ceremony." The latter consists in "communication work" (e.g. some form of denunciation, like posting a message on the web) whereby an individual is publicly depicted as a violator by another individual who speaks in the name of the normative order. Although they are less probable than incidents between boarding passengers only, incidents between passengers getting on (prematurely) and passengers getting off offer a more conspicuous and uncontroversial case of normative violation. Hence, although they are less likely to occur, they are more likely to be denounced.

Another side finding of this analysis, consistent with ethological research (Judge & De Waal, 1997), is the rarity of overt aggression despite levels of crowdedness that make proxemic violations inevitable. Out of the 735 units, only a few contained verbal exchanges and only one situation led to insults[11].

Overall, the above results suggest that the subway is an environment that routinely provokes emotional situations. But at this stage of the research, it seemed that emotions linked to physical contact, instead of giving rise to publicly noticeable scenes, were mostly contained and only expressed via discreet behavior (e.g. facial expressions).

If riders do not vent their emotions with screams and insults as car drivers do (Katz, 1999; Parkinson, 2001), how do they cope with so many violations of their personal territory? Are emotions really stifled and not carried over beyond the immediate facial reaction? In order to answer these questions, we extended the duration of the unit of analysis beyond the contact incident. Do any behavioral structures prolong the two-components sequence that begins with a physical contact and continues with a facial change?

If riders experience physical contact between strangers in the Paris subway as a proxemic violation, one could expect "corrective interchanges" (Goffman, 1967) to take place. But our findings so far did not support this prediction. Was it the proof that such interchanges do not actually occur in the Paris subway? Or was it an indication that they are difficult to recognize? Maybe their unfolding involves a sequence of behaviors that proves equivalent in function but unusual in form, as compared to what the literature acknowledges to be the paradigmatic instantiations of corrective interchanges.

[11] In the probabilistic analysis of rider exchange units, as we calculated density and searched for occurrences of at least one contact incident, we made side notes on some interactional events, including some forms of conspicuous courtesy or hostility between strangers.

In an early application of sequential analysis to interaction in public, Goffman (1967) described a corrective interchange as a sequence of "moves" aimed at reestablishing a disrupted ritual equilibrium between individuals in public places. In particular, the ritual interchange minimizes the loss of face that a transgression can cause both to author and victim. The basic sequence begins with an offensive act. It continues with a "challenge" (to apologize) followed by an "offer" (an apology), and ends with an "acceptance." In the simplest form the offender and the victim consecutively perform the moves. However, the offender can challenge herself before the victim calls attention to the offence. Further, the victim's acceptance of the apology can be implicit. When alternative behaviors are displayed at choice points, the corrective interchange format usually experiences disorganization. Thus, if after the victim's challenge the offender does not offer an apology, the initial offensive act can be seen as a "run-in," and the ritual interchange becomes a "character contest". In the face of an overt run-in, the victim is left with the choice of retaliation or retreat.

When the corrective exchange method is impractical, Goffman (1971) suggests that "body gloss" can be used as a ritual substitute. In contrast to verbal apologies, body gloss is an ostensible (and sometimes quite theatrical) gesture directed to a diffuse audience[12]. Body gloss is a functional equivalent of verbal apology (i.e. behavior suited to fill the "offer" slot of the corrective interchange) insofar as it signals the offender's awareness of the offence and the claim not to be identified with it.

Following Goffman's analysis of corrective interchanges, we derived the following new hypotheses:

4. Physical contact, as a proxemic violation, will be the first "move" of two alternative sequential structures of behavior: corrective interchanges and character contests.

5. In the subway, diffuse nonverbal apologies will be offered for proxemic violations in the form of body gloss.

[12] For example, in contrast to the US, where traffic lights are sometimes equipped with a countdown, in France traffic lights for pedestrians only alternate between red and green. Without knowing at what stage of the countdown the red light may come, pedestrians sometimes attempt to cross the road anyway. If they are unfortunately caught by a green light for the cars in the middle of the road, they often signal their acknowledgement of the transgression to the impatient drivers by an exaggerated trot accompanied by ostensible expressions of surprise. The purely ritual meaning of the trot is revealed by occasions in which no apparent pace acceleration ensues, as compared to just walking.

Part 2: Sequential Analysis Of Emotional Transactions

Preliminary Stage

Method. In order to collect and analyze more detailed episodes of emotional reactions to physical contact, we videotaped more than 10 hours with two synchronized cameras. The first cameraperson followed the routine used in stage 1, videotaping from the platform, whereas the second cameraperson videotaped from within the train[13]. This procedure made possible to record in detail the activity of riders located in the region of the train car near the doors. We collected more than 70 units of rider exchange with this method. The resulting database forms the basis of all the remaining analyses of the article, unless otherwise indicated.

The first author (who passed the FACS proficiency test) coded the facial behavior of a number of riders involved in episodes of physical contact relevant to hypotheses 3 and 4. Regarding authors of contacts, we looked for patterns of facial movements that could be functioning as "face gloss," i.e. signals that the author understands the improper character of her conduct. As for the interaction between author and victim, once a clear event of physical contact could be identified we searched for behaviors (verbal, facial or other) that could be accomplishing a corrective interchange or a character contest.

Facial glosses, corrective interchanges and character contests are, of course, composed of a sequence of behaviors. But, being functionally defined, they can be instantiated by a whole variety of phenomenally different acts, depending on contextual variables. The aim of this section is to identify the precise form of the behaviors that, in the particular setting of the subway ride in Paris, instantiate these functionally defined interaction patterns.

Results. A preliminary screening allowed us to identify only a limited number of sequences (three out of the 70 units) presenting incidents that unfold according to Goffman's description of the corrective interchange. We also found a single instance of character contest. Since this kind of interchange is purposefully accomplished to be publicly perceived, and is therefore easily noticeable, we searched the larger dataset used in Stage 1 for character contests, drawing on the side annotations made during the count.

[13] The two streams were synchronized with the program Elan (Max Planck Institute for Psycholinguistics, n.d.) using for each pair of files the moment when the doors close as a common point of reference.

Out of 735 units, we found only one additional instance of character contest, which suggests that this interaction pattern initiated by a proxemic violation is quite rare in the Paris subway, at least compared to the number of proxemic violations that are resolved by other means.

In addition to the few corrective interchanges and character contests, we also identified, on the basis of FACS coding augmented by informal description of other behaviors, ten instances – across different density conditions – of what looked like a fully *nonverbal* form of corrective interchange. Further, the FACS description suggested a pattern in the facial response to the proxemic violation that we had so far considered solely in negative terms as any facial movement beyond blinking and eyelid raising. The expression 1+2+4 (a combination of Action Units 1, 2 and 4), involving the joint action of the muscles that raise and lower the brow, was a recurrent immediate reaction displayed by patients of contact (see Figure 1), often accompanied by a short-lasting raising of the eyelid (Action Unit 5). Typically, a "challenge" then materialized as a look directed towards the contact source (the putative offender), which often involved an ostensible head turn. In the following move slot, instead of a verbal apology, the "offer" took on the form of a facial display belonging to the class of actions usually interpreted as expressive of embarrassment (Keltner, 1995)[14].

The structure of the nonverbal corrective interchange, for the ten clear instances we found, involved the following sequence of molecular steps: 1) physical contact of patient by author; 2) patient displays 1+2+4+5, of which 5 ceases briefly but 1+2+4 remains; 3) patient turns head to look at author; 4) author lowers or averts gaze; 5) patient returns head to initial position and ceases 1+2+4.

Sometimes concurrent with the tacit corrective exchange, sometimes performed in isolation, we also found that authors of contact displayed what can be seen as a "face gloss," by analogy to Goffman's body gloss (1971). These face glosses were coded 12+17+23/24 (lip corner raise, chin raise and lip tightening/pressing) and 12+26+28 (lip corner raise and lip suck).

[14] Keltner's prototype includes, in order or appearance : gaze down, smile control (e.g. lip press), smile, head away, gaze shifts.

Also, an intriguing facial event that we coded in seven cases during the exploratory stage was Action Unit 14, in which the buccinator muscle tightens the lip corners inwards (see Figure 4). In instances in which both sides of the face were visible, we noted that different riders could perform AU 14 in a symmetric or in an asymmetric manner.

It is unlikely that riders use this facial behavior with communicative intent. We found no instance of a rider doing this facial action and trying to establish eye contact with another rider. In other cases, the rider tightens her lip corners inwards in a situation in which it is obviously unlikely that anybody witness the facial movement (for example, because riders around are clearly directing their gaze elsewhere).

Discussion. In the Paris subway, corrective interchanges provide a way of reestablishing ritual equilibrium disrupted by proxemic violations between riders. But we observed more nonverbal corrective interchanges (when the offender displays an "embarrassment expression") than verbal ones (when the offender offers an apology). On the other hand, overt character contests were rare.

Two additional reasons make it plausible to see the "expression of embarrassment" (Keltner, 1995) as performing an "offer" in the interpersonal context of the corrective interchange. First, it fills a sequential slot in which acknowledging an interactional fault is relevant. Second, following the offender's "embarrassment expression," the interaction reaches a closure and the victim's face returns to neutral. These remarks advocate for a functional interpretation of the "embarrassment expression" as an "offer" from the the offender that brings about the consequence of appeasing the victim.

Authors of proxemic violations, either involved in nonverbal corrective exchanges or not, also appeared to make use of facial gloss. Its morphology is strikingly similar to the lower face component of the embarrassment display studied by Keltner (1995). Because action units 17 (chin raise), 23/24 (lip tightening/pressing) and 28 (lip suck) counteract or obscure the smile that results from action unit 12, these AUs are usually grouped together in the superordinate class of "smile controls." Thus, in the Paris subway, smile controls may participate in face glosses motivated by proxemic transgressions. We were able to observe the other components of Keltner's embarrassment pattern, in particular gaze aversion, only in the interactive context of the corrective interchange (i.e. in what we interpret as an appeasing "offer").

Regarding the observed occurrences of AU14, interaction or component studies provided us with no ready-made interpretation. However, as the (asymmetric) AU14 has been interpreted as the universal facial expression of contempt in the basic emotions literature (Ekman and Friesen 1986; Izard and Haynes 1988; Ekman and Heider 1988) we derived the following new hypothesis:

6. Proxemic violations may elicit "contempt expressions" in the Paris subway.

Are these "contempt expressions" part of any larger interaction strategy? Do they accomplish any specific interpersonal function, in the same way as the "embarrassment expression" can be seen as accomplishing repair? In order to interpret the function of "contempt expressions" in the context of a larger interaction strategy, we conducted a sequential analysis in search of statistically significant patterns of event types including the AU14.

Systematic Stage

Method. On the basis of the videotapes made with the synchronized cameras, we built a collection of 45 episodes, each recording the activity of a single different rider. The selection criteria were 1) the presence of at least one instance of AU 14, symmetric or asymmetric, at some point of the sequence, and 2) an image quality sufficient to afford a FACS description of the relevant rider's face. We set the beginning of the episode at the moment in which, in response to a visible physical contact, a FACS code could be attributed to the face of the rider in the patient role (i.e. the person receiving the contact). The end of the episode was set at a later point in time when the face returned to neutral and no further events of physical contact could be observed. Episodes ranged from 4 to 47 seconds (mean = 17 s, median = 14 s).

The first author coded the 45 episodes comprehensively. He was blind to density and other contextual features. In order to describe the activity of the relevant rider, all the FACS Action Unit and head-and-eye movement codes were used. They were supplemented with a limited number of *ad hoc* functional categories for locomotion and

gaze direction[15], which were also used for describing the activity of the author(s) of the physical contacts[16]. Other categories were added to indicate physical contact and the existence of mutual visibility between patient and putative author (or covisibility). The latter category is a strong indication that passengers can perceive each other's behavior, in particular facial.

Due to its frequency, the facial event 1+2+4 was coded as a compound unit. In most episodes, physical contact was observed to recur before the expression 1+2+4 could disappear from the patient's face. A new facial event was coded if visible changes in the expression could be interpreted as responding to the new physical contact. Operationally, this involved detecting relative intensity changes in the constituent facial units immediately after observing the contact.

As for AU 14, given the debate on the asymmetric appearance being the universal contempt signal (Ekman & Friesen, 1986; Ekman & Heider, 1988; Izard & Haynes, 1988), we discriminated between this appearance and the symmetric one. When both sides of the face were visible, the distinction was made between the symmetric and the asymmetric appearance (coded "a14"). 59 occurrences of AU14 and 17 of AUa14 were coded across 36 and 17 episodes, respectively. Three episodes contained at least one instance of AU14 and one instance of AUa14 at different points in time.

We subjected the 45 coded episodes to a t-pattern detection procedure, using the program Theme® (Noldus Information Technology, n.d.). A t-pattern is a fixed sequence of event types tied by critical interval relationships. A critical interval designates the time window after the occurrence of an event type during which the occurrence of another event type is considered to be non random (For a more technical definition, cf. Magnusson (2000). T-patterns thus provide useful indications for discovering sequential structures in behavior. The selected t-patterns were analyzed for overlaps, relations of

[15] An event using one of these *ad hoc* categories is, for example, "Patient looks Author". In all the cases in which the code *looks* was attributed to the Patient, we based the attribution on 1) a previously attributed head and eye movement descriptor as defined by the FACS and 2) a reasonable guess about what the Patient was looking at. If we thought that Patient was looking at Author, but no head and eye movement could be coded, the look itself was not coded.

[16] In order to specify who was the patient (the person receiving the contact) and who was the author of the contact, we used the codes "cp" and "ca". If the individual taken as the point of reference was the patient, the contact event was coded "cp"; if she was the author, it was coded "ca". For the sake of simplicity, in what follows we use the expression "physical contact", but the type of event to which reference is made is more precisely "cp".

precedence and relations of inclusion. Finally, we screened the episodes again in order to directly inspect the concrete correlates of the t-patterns and decide whether they could be interpreted as behavior configurations (or structures).

Results: t-patterns analysis. We selected t-patterns according to the following separate criteria : 1) at least one occurrence in more than 50% of episodes; 2) featuring AU 14, symmetric or asymmetric, as one of its components. No t-patterns satisfied both conditions, but six satisfied at least one condition. We considered for further analysis those that were found to overlap, or to hold relations of precedence or inclusion, with one another. These criteria reduced the list to four t-patterns[17], which are statistically described in table 1 and graphically represented in Figure , 6, 7, and 8. In order to facilitate reading of the present section, we present the t-patterns with a short verbal explication. "P" designates the Patient or victim of a physical contact, "A" the Author or offender. In the verbalization commas separate events that follow each other in a sequence.

p1: (contact P,1+2+4) = A touches P, P raises and lowers brow.

p2: (contact P,1+2+4 P,looks_A) = A touches P, P raises and lowers brow, P looks A.

p3: (contact P,1+2+4 P,14) = A touches P, P raises and lowers brow, P tightens lip corners inwards.

p4: (contact P,1+2+4 P,turns_head covisibility A,looks_away P,a14) = A touches P, P raises and lowers brow, P turns head, P and A see each other, A looks away, P tightens lip corners inwards (asymmetric).

We report here the main results of the t-pattern analysis, the details of which are available in appendix 2. The results concern the relationship between the t-patterns containing "contempt expressions" (p3 and p4) and the others (p1 and p2).

On the one hand, 18/24 instances of p3 were found to be closely preceded by p1 or p2. More precisely:

1. (contact P,1+2+4) closely precedes (contact P,1+2+4 P,14) in 9 cases.
2. (contact P,1+2+4 P,looks_A) closely precedes (contact P,1+2+4 P,14) in 9 other cases.

[17] For these t-patterns the program Theme® was set at significance level 0.0001.

On the other hand, 4/6 instances of p4 were found to contain a sequence made of p2 and then p1. In other words, in these cases the single t-pattern (contact P,1+2+4 P,turns_head covisibility A,looks_away P,a14) fully contains the pair of t-patterns (contact P,1+2+4 P,looks_A) (contact P,1+2+4).

Results: rescreening of episodes and units. Can these nonrandom sequences be understood as variations within the same structural matrix? In order to examine this possibility, we rescreened the units and the episodes containing occurrences of the t-patterns, in search of perceivable interactional configurations[18]. We found that the sequences could indeed be derived from the same structure by introducing two variables: 1) attempt at communicating and 2) establishing visual contact. The results reported here are based on our previous systematic coding, but in order to describe stereotypical patterns of behavior they add a less systematic narrative layer. We admitted a sequential narrative if it applied straightforwardly to at least two instances of each systematic sequential pattern, and if other instances could be reasonably interpreted as their variants.

In the sequences observed, the patient of a physical contact may attempt to communicate her discontent to the offender, and the attempt may be more or less explicit. Explicitness appears to be a matter of degree, with discreet "cues of non indifference" at one end and overt "interrogative challenges" (Goffman, 1971) at the other end. Both variants are covered by the event *P,looks_A*, which tells us without further interpretation that P has directed her attention to A, as evidenced by gaze orientation and head/eye movements (see footnote 12). Communication attempts, discreet or overt, may succeed in establishing visual contact, in which case the attempt is promoted to the status of a communication *act*, or else fail to establish visual contact, in which case discontent fails to be expressed to the presumed offender. The sequences identified through t-pattern analysis, as well as the nonverbal corrective interchanges we described before, can all be interpreted as typical variations within this common matrix. We labeled the tacit corrective interchange "structure 1," S1 for short, and we continued the list with the newly discovered sequences as they can be shortly described with a typical scenario.

[18] Combining systematic coding and perception of behavioral configurations (or wholes) is one of the usual descriptive procedures of classical ethology (Lorenz, 2003).

S2: (contact P,1+2+4) (contact P,1+2+4 P,14). The facial event 1+2+4 signals a negative response to the first contact. But the patient does not attempt to communicate her discontent to the offender. When the latter repeats the contact, the expression 1+2+4 is followed by AU14 in the face of the patient.

S3: (contact P,1+2+4 P,looks_A) (contact P,1+2+4 P,14). Here the patient does make an attempt at communicating her discontent. Typically, the signal is discreet; the offender is not stared at ostensibly. A slight head movement or a subtle change in gaze direction may suffice. In most cases the probability of establishing social contact ranges from moderate to null. Often, the offender is standing behind the patient, in such a way that the latter cannot know whether the cue (e.g. a lateral head movement) was transmitted. In other instances, it is the patient who turns out to stand behind the offender, and so she is fully aware that the offender, as the latter enters the field of vision, has not perceived the signal. When, after this precarious communication attempt, the offender repeats the contact, the patient first displays the AUs 1+2+4 and then the AU14.

S4: (contact P,1+2+4 P,turns_head covisibility A,looks_away P,a14) containing (contact P,1+2+4 P,looks_A) (contact P,1+2+4). The patient communicates her discontent in response to the contact, but the signal tends to be closer to an "interrogative challenge" than to a "cue of non indifference." Typical instances involve a quick head turn and an explicit stare right at the eyes of the presumed offender. Chances of establishing visual contact in such a way are substantially higher, as the gesture is difficult to ignore by the intended recipient. But when visual contact does occur as part of this sequence, in contrast with the nonverbal corrective interchange, the offender usually responds by looking away, in a manner suggestive of unconcern. When the offender repeats the contact after (or nearly at the same time as) this non-committal response to the interrogative challenge, the patient responds with 1+2+4 followed by AUa14.

During the rescreening of the episodes we collected new instances of AUs 14 and a14 by other riders. For structures S2, S3 and S4, we found new separate instances ending with AU14 or AUa14[19].

[19] Some researchers claim that the asymmetric AU14 is the universal contempt expression (Ekman & Friesen, 1986; Ekman & Heider, 1988), but the symmetric and asymmetric appearances of AU14 occupy

Discussion. The occurrence of a repeat offense is common to all structures ending with AU14. The "contempt expression" can be interpreted as effecting disapproval if one admits the premise that an offensive act, which in isolated occurrence can be seen as accidental ("it's not her fault"), may establish the neglect or malice of its author when it is repeated ("she does it on purpose"). Neglect or malice, as ways of describing not the brute behavior but the motivation of the offender, is what the victim of the physical contact disapproves.

Some qualifications are in order. First, repetition of physical contact is not necessarily equal to two events of physical contact. In most cases physical contact occurs many more times before the patient displays the AU14. Second, the prior attempt at communicating does not necessarily happen only once. Interestingly, when attempts of visual contact take place in a series, they typically occur in order of explicitness. In fact, some of the interrogative challenges we coded represent the most explicit look in a series that begins rather discreetly. Third, the repeat offense is mostly but not always (or not only) a physical contact. We found a variation of S4 in which the offender's display of unconcern after the interrogative challenge seemed to be sufficient to elicit the patient's AU14.

Figure summarizes our interpretation. Since we found no sequential evidence for attributing different meanings to the symmetric and the asymmetric AU14, the graphic does not discriminate between both appearances, all noted 14.

General Discussion

Among riders of the Paris subway, two patterns are distinguishable in the facial response to physical contact. On the one hand, a blink or an eyelid raise can be seen as a reflex response, particularly visible when the contact stimulus is at a high level of intensity. On the other hand, activity involving simultaneous brow lowering and raising (AUs 1+2+4), can be interpreted as the expressive component of an emotion triggered by an immediate appraisal of the physical contact as a territorial violation. The survey on offensive conduct in Paris buses and subways and the anecdotes posted by passengers on

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the same sequential slots in the behavior patterns that we discovered. Hence, there is nothing in these patterns that could indicate a different meaning for each appearance of AU14.

the web can be considered as indications that physical contact, when it is negatively evaluated, gives rise not only to emotional expressions but also to emotional experiences. The behavioral and the experiential data, taken together, point to the emotional quality of responses to physical contact appraised as a violation of proxemic standards in the Paris subway.

Our first finding is that passengers remain emotionally sensitive to physical contact at all density levels. The second is that the emotion evoked by contact as a territorial violation may unfold according to two sequential structures, namely nonverbal repair (S1) and silent disapproval (S2, S3, S4). This second family of sequential patterns interposes a repeat offense between the initial offensive contact and the final "contempt expression." Repair and silent disapproval are two opposite developments through which the emotions generated by territorial violations in the Paris subway can get resolved.

We propose to interpret repair and disapproval as emotional transactions. First, their object is a physical contact usually experienced as annoying, unpleasant and/or offensive on the part of the victim, as suggested by the survey and the riders' spontaneous anecdotes. Second, the negatively experienced physical contact initiates a behavior sequence that transforms the disturbed relationship between victim and offender. Repair reestablishes solidarity or affiliation between the apologizing offender and the forgiving victim. Through disapproval, the neglected victim places the persisting offender in the symbolic realm of the moral wrong. Repair re-affiliates victim and offender. Disapproval, in contrast, disaffiliates them.

Conclusion

This paper represents the first exploratory application of a novel methodology for studying emotional transactions in crowded public spaces where non-verbal behavior is dominant. Replications of the method can be carried out in other subways of the world, but also in other mass transport systems, and even in other crowded public places in cities such as marketplaces, elevators, concert halls, demonstrations and more. Also, while we focused on proxemic violations caused by physical contact, other stimuli could be used, provided they can be recorded on video or captured through self-reports.

The study is the first attempt to combine naturalistic data and objective description of the face in order to discover sequential structures in emotional nonverbal behavior. Naturalistic studies, such as this one, carry a high ecological validity, but they suffer from a lack of control of the conditions underlying observations. However, the naturally occurring emotions that can be thus observed are based on real-life, serious motivations. Their duration and intensity may go far beyond what can be induced by an experimental task. Theory-building can particularly benefit from the discoveries that can be made with this methodology.

Keeping these inescapable limitations in mind, the methodology presented in this article connects research on face-to-face interaction with studies of emotion components in a way that refreshes both our understanding of behavior in public and of emotional transactions. We hope that new studies in this line will help illuminate further transactional patterns and make the methodology more robust.

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Tables

	t-pattern[20] P=patient; A=author	occurrences	episodes (i.e. individuals)	mean duration	min/max duration
p1	(contact P,1+2+4)	247	45	0.4 s	0/2 s
p2	(contact P,1+2+4 P,looks_A)	49	29	0.7 s	0/2.1 s
p3	(contact P,1+2+4 P,14)	24	19	0.6 s	0.1/1.1 s
p4	(contact P,1+2+4 P,turns_head covisibility A,looks_away P,a14)	6	6	5.9 s	1.4/9.4 s

Table 1: description of t-pattern selection

[20] The notation of the t-patterns has been simplified in order to facilitate reading. We omitted hierarchy levels. For example, p3 is more precisely written as (contact (P,1+2+4 P,14)).

Figures

Figure 1: neutral (left) vs. forehead movement

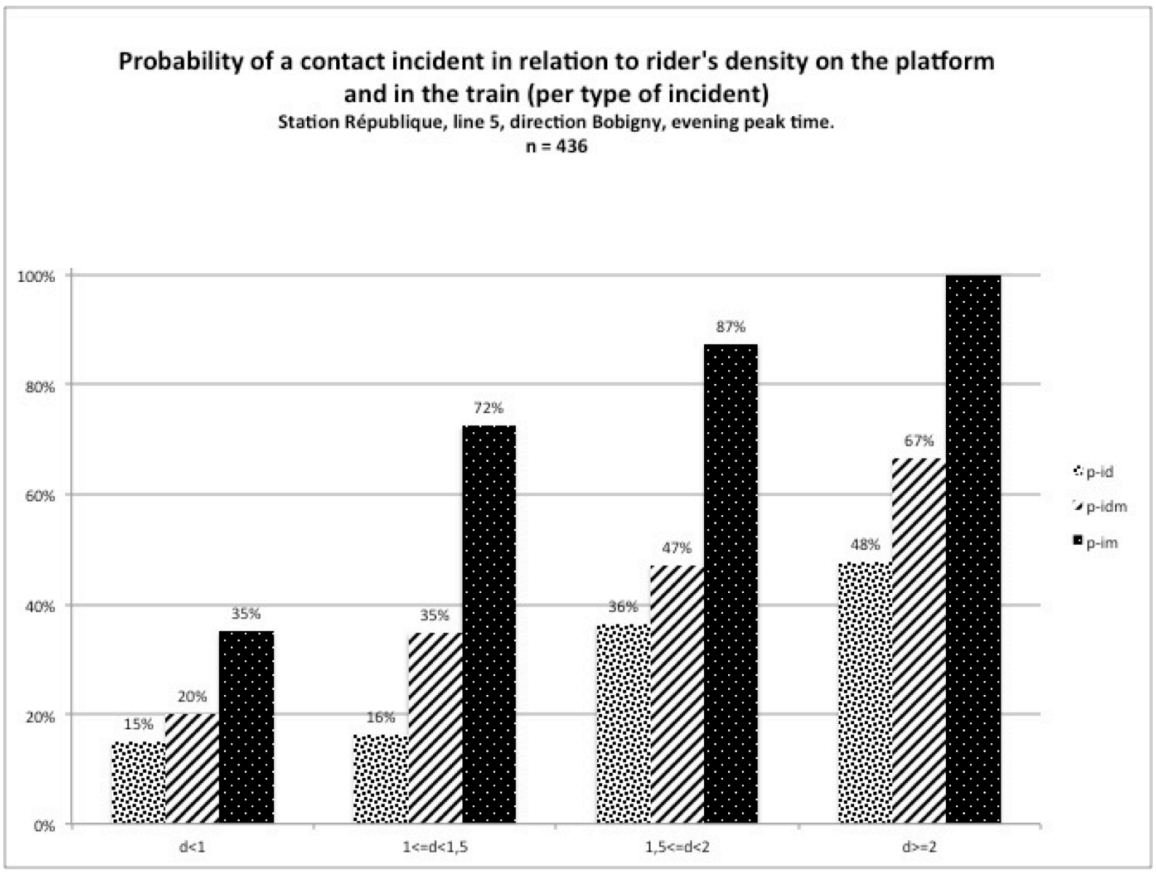


Figure 2: Probability of a contact incident of each type at different density levels (for walking riders).

p-id (***p**robabilité d'**i**ncident de **d**escente*) : probability of a contact incident between two riders getting off the train.

p-idm (***p**robabilité d'**i**ncident de **d**escente-**m**ontée*): probability of a contact incident between a rider getting off and a rider getting on the train.

p-im (***p**robabilité d'**i**ncident de **m**ontée*): probability of a contact incident between two riders getting on the train.

d: density of walking riders in persons per square meter in the train and on the platform next to the door. 1<=d<1,5: **d**ensity is equal or higher than 1 person per square meter and lower than 1.5 persons per square meter.

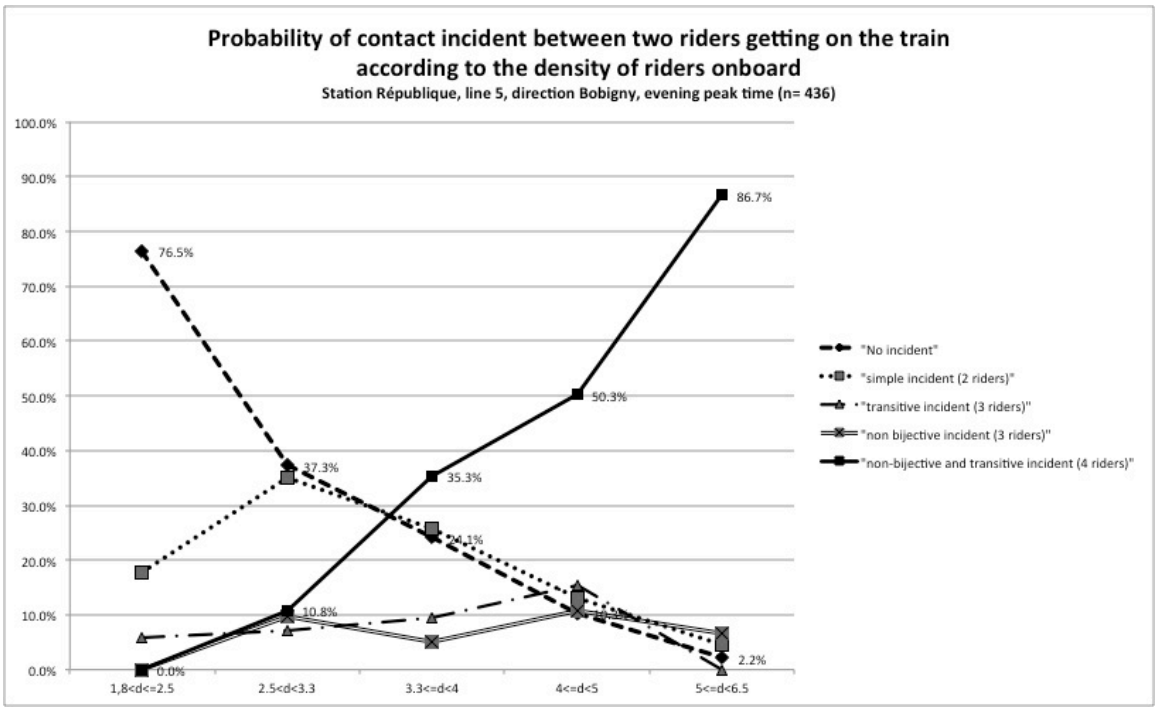


Figure 3: probability of diversely complex contact incidents according to density levels (for standing riders).

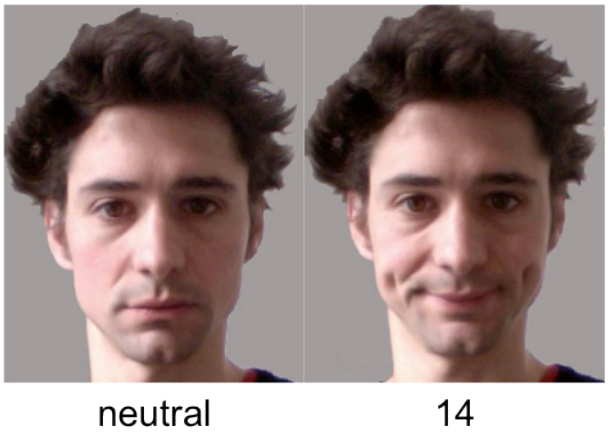


Figure 4: AU 14 (inward tightening of lip corners).

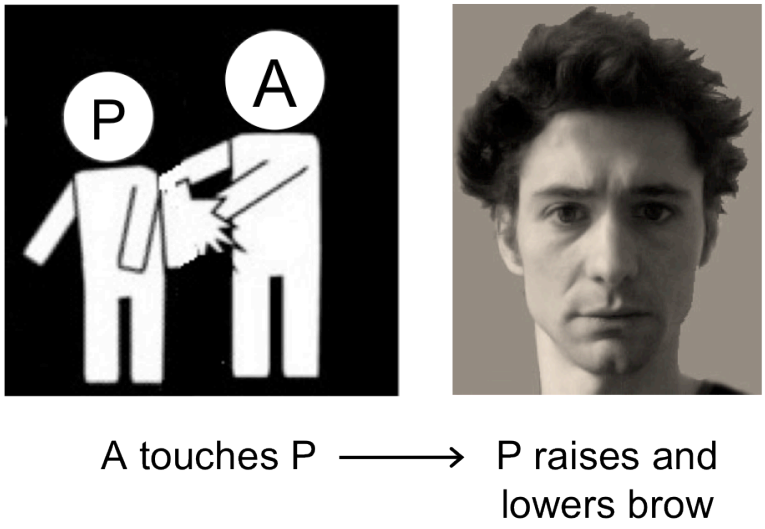


Figure 5: graphical representation of p1

Figure 6: graphical representation of p2

Figure 7: graphical representation of p3

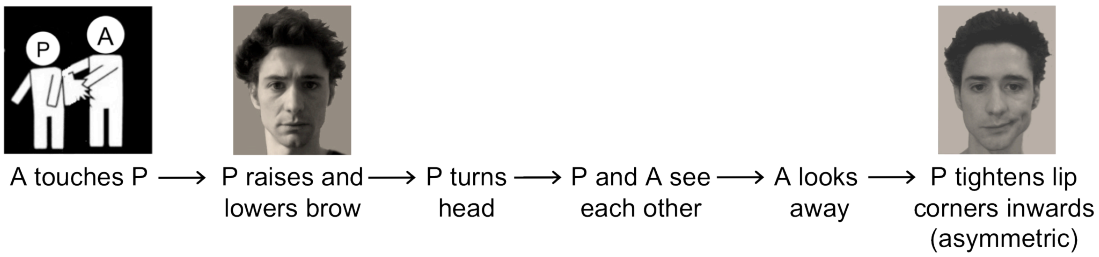


Figure 8: graphical representation of p4

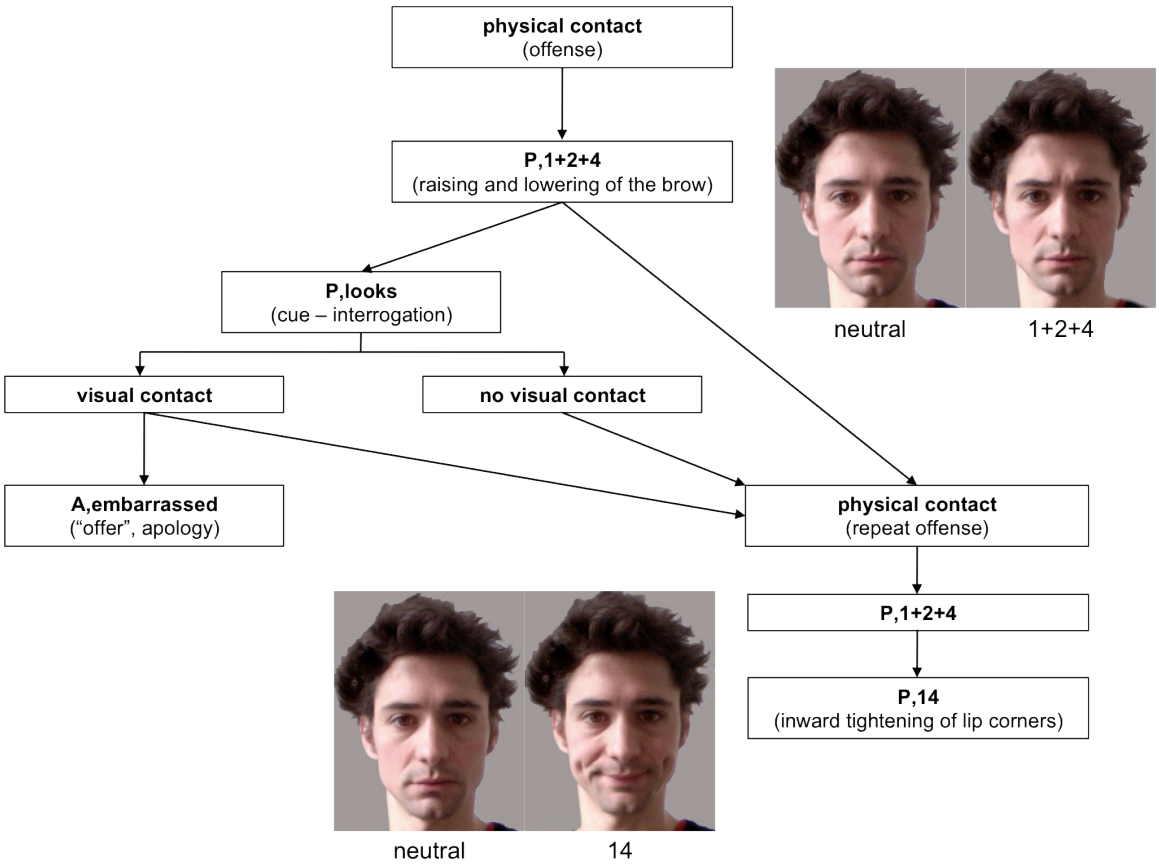
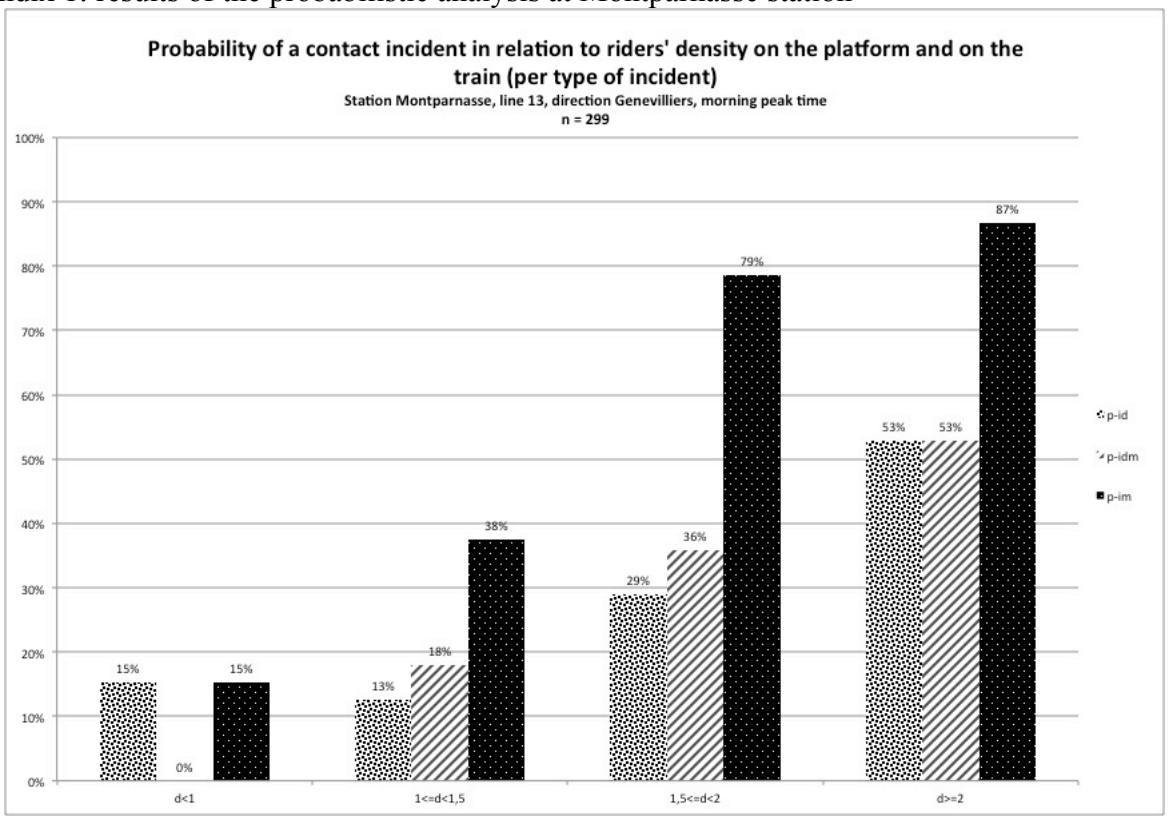


Figure 9: Sequential structures triggered by physical contact.

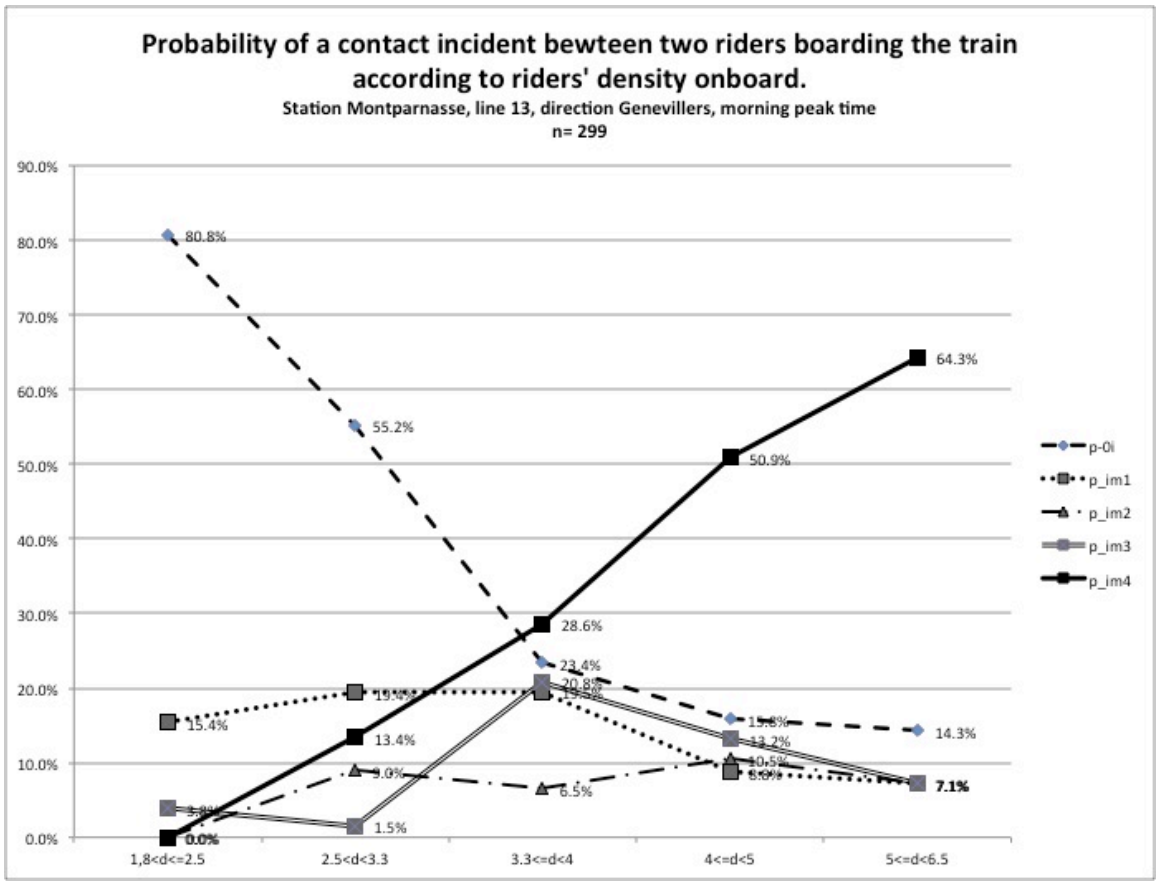
Appendix

Appendix 1: results of the probabilistic analysis at Montparnasse station



Probability of a contact incident of each type according to density on the platform and on the train at Montparnasse station, morning rush hour (8:00 – 9:30 am)

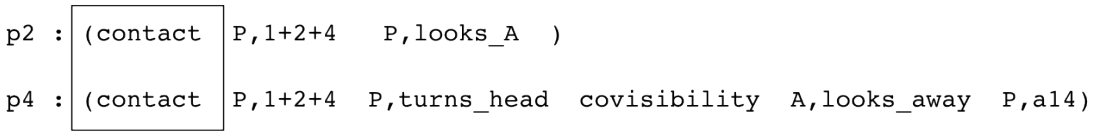
p-id (probabilité d'incident de descente) : probability of a contact incident between two riders getting off the train.
p-idm (probabilité d'incident de descente-montée): probability of a contact incident between a rider getting off and a rider getting on the train.
p-im (probabilité d'incident de montée): probability of a contact incident between two riders getting on the train.
d: density of walking riders in persons per square meter in the train and on the platform next to the door. 1<=d<1,5: density is equal or higher than 1 person per square meter and lower than 1.5 persons per square meter.



Probability of a contact incident according to density onboard at Montparnasse station, morning rush hour (8:00 – 9:30 am)

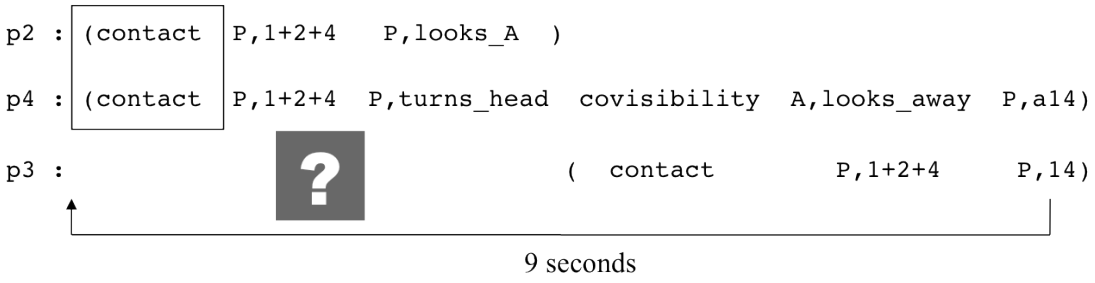
Appendix 2: rationale of t-patterns analysis

The analysis of t-patterns was guided by a comparison of t-patterns p3 and p4, respectively ending with AU14 and AUa14. The first step consisted in examining overlaps between shorter and longer t-patterns. Occurrences of two different t-patterns overlap if they share the first component, i.e. if they begin with the same coded event. The analysis revealed that all occurrences of p4 overlap with occurrences of p2. This means that p4's third component, *P,turns_head*, occurs nearly at the same time as p2's third component, *P,looks_A*.



All instances of p4 overlap with instances of p2.

The terminal component of p4 is *P,a14*, the whole t-pattern being 6 components long. Similarly, p3 ends with AU14, but it involves only 3 components. The maximum length of p4 is 9 seconds and, as we saw, it always overlaps with p2. By analogy, we considered the last component of p3 (P,14) as the last component of a hypothetical 6-component t-pattern. At the time at which this component occurred, we opened a time window of 9 seconds (p4's maximum duration, see table above[21]) backward and looked for occurrences of p2. We considered instances of p3 to be "closely preceded" by instances of p2 if: 1) the first component of p2 occurred no more than 9 seconds before the last component of p3; 2) p2 ended before p3 begun.



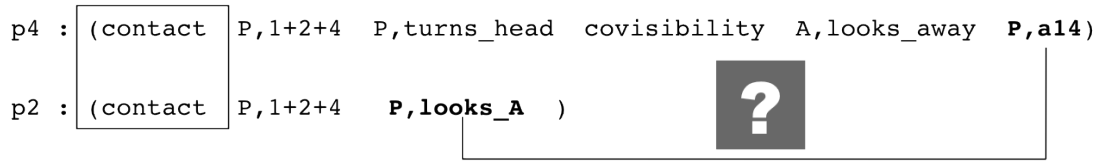
Looking for instances of p2 that closely precede instances of p3.

[21] In order to constrain the inevitable arbitrariness of time window duration, we took the duration of the longest t-pattern as the point of reference for this backward-looking time window.

We verified the relationship for 9 instances of p3 (minimum distance between initial component of p2 and terminal component of p3: 1.9 s; maximum: 8.6)[22].

For the remaining occurrences of p3, we examined if they were closely preceded by p1. As the resulting sequence would be 5 components long instead of 6, we shortened the time window proportionally from 9 to 7.5 seconds. We found 9 such associations between these t-patterns (minimum time distance 0.6; maximum 2.5). Overall, 18/24 instances of p3 appear to be closely preceded by instances of p1 or of p2.

We then compared occurrences of p4 with these occurrences of p3. The latter always involve at least two physical contact events. Could it suggest that instances of p4 also relate to more than one contact? We say that the occurrence of a t-pattern "contains" the occurrence of another t-pattern if the time coordinates of instances of the first one, singly considered, cover a period of time longer than the second one. In this sense, p4 contains p2, but the reverse is not true. In order to verify whether p4 was related to more than one contact, we examined whether p4 contained, after p2, also p1. We admitted instances of p1 that: 1) begun after p2's terminal component (*P,looks_A*); 2) ended before p4's terminal component (*P,a14*).



Looking for instances of p1 contained in instances of p4.

Four out of six instances of p4 were found to contain a p2 followed by a p1. The concrete correlates of these instances therefore involved two physical contacts.

[22] We refrained from using a more stringent sequential association analysis because we were less interested in establishing causal links than in finding descriptive similarities between p3 and p4.