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Short Communication

Sick man walking: Perception of health status from body motion

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ABSTRACT

An ability to detect subtle signs of sickness in others would be highly beneficial, as it would allow for behaviors that help us avoid contagious pathogens. Recent findings suggest that both animals and humans are able to detect distinctive odor signals of individuals with activated innate immune responses. This study tested whether an innate immune response affects a person's walking speed and whether other people perceive that person as less healthy. 43 subjects watched films of persons who were experiencing experimental immune activation, and rated the walking individuals in the films with respect to health, tiredness, and sadness. Furthermore, the walking speed in the films was analyzed. After LPS injections, participants walked more slowly and were perceived as less healthy and more tired as compared to when injected with placebo. There was also a trend for the subjects to look sadder after LPS injection than after placebo. Furthermore, there were strong associations between walking speed and the appearance of health, tiredness, and sadness. These findings support the notion that walking speed is affected by an activated immune response, and that humans may be able to detect very early signs of sickness in others by merely observing their gait. This ability is likely to aid both a "behavioral immune system", by providing more opportunities for adaptive behaviors such as avoidance, and the anticipatory priming of biochemical immune responses.

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1. Introduction

The arms race between pathogens and host organisms takes place on several levels. While there is abundant knowledge on how the host fights pathogens following infection, there is less knowledge on how organisms avoid being infected in the first place. The ability to detect contagious individuals in order to avoid them would be highly beneficial (Schaller, 2011), but the mechanisms of such behavioral systems have rarely been studied in humans. Besides detecting odor signals (Kiesecker et al., 1999; Olsson et al., 2014) and observing obvious morphological signs and behavioral characteristics of disease (such as skin lesions and sneezing), it is likely that we use a variety of subtle cues to interpret other people's health (Schaller, 2011). While facial cues can be used to assess apparent health (Jones et al., 2005) or even sleep history (Axelsson et al., 2010), the way in which an individual moves is also known to be important in social communication. The kinematics of biological motion – even if only represented by point-light displays – readily reveals properties such as age, emotional state, and intentions to an observer (Troje, 2013). Both advanced age and depression are characterized by reduced walking speed (Michalak et al., 2009b; Schimpl et al., 2011), and lipopolysaccharide (LPS)-induced systemic inflammation reduces motor activity in animals as part of a sickness response (Dantzer et al., 2008). Thus, patterns of motion may reveal basic aspects of health status to others. To test this hypothesis, we investigated whether an acute but mild innate immune activation (by means of an LPS injection) could be detected by others by mere gait observation. We hypothesized that LPS would reduce walking speed in healthy human subjects, and that the changed gait pattern would make persons look less healthy, more tired, and sadder, as perceived by others.

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2. Materials and methods

2.1. Participants

43 Swedish-speaking participants (27 women, mean age 24 ± 5 years) were recruited from Karolinska Institutet campus, to observe and rate 12 films with walking individuals. The study was approved by the regional ethical review board in Stockholm.

2.2. Stimulus acquisition

The stimulus material consisted of films of six walking healthy males (mean age 22 ± 1 years), who had taken part in a double-blind, placebo-controlled randomized crossover study with two conditions: intravenous injection of 0.8 ng/kg body weight *Escherichia coli* LPS and saline (placebo) (as described in detail in Karshikoff et al. 2014). The walkers were injected with LPS and placebo on two different occasions, and were similarly groomed and filmed 75 min after injection in each condition. This was close to tumor necrosis factor alpha (TNF-α) peak blood levels in the LPS condition, but before the increase of body temperature (see Fig. 1). Two films were shot at each time, during standardized walking procedures: one with the instruction to walk "as usual" to the end of a corridor, knock on the door, and then walk back; the other with the instruction to walk "as usual" to the end of the corridor and back, but without knocking on the door. Both films were later used for analyzing walking speed, but only the second was used for observational ratings in order to minimize rater fatigue and because the second films were more consistent across subjects. Data from the same subjects have been reported previously (Karshikoff et al., 2014; Olsson et al., 2014).

2.3. Procedure

2.3.1. Observational ratings

The 12 stimulus films of 15 s each were presented 3 times each on a large projector screen in an auditorium, and were rated by the observers with respect to health, tiredness, and sadness of the walker. The ratings of the people walking in the films were made with respect to health (5-graded scale where 1 = very poor, 5 = very healthy), tiredness, and sadness (4-graded scales, with 0 = not at all, 3 = very tired/sad).

2.3.2. Walking speed

Analysis of walking speed was carried out based on both films of each condition. Walking speed was analyzed with respect to the time it took the participants to walk the 10 first steps in each direction in the corridor (all 24 films were used for this, resulting in 48 data points).

2.4. Data analysis

Data were analyzed using the xt-mixed procedure (multilevel mixed effects linear regression) in STATA 12.1 (STATACorp, Texas, USA). The fixed effect was sickness (the effect of LPS as compared to placebo) and the random effects accounted for variation between the six males walking (on film) and also for variation between observers' ratings of the films. Pearson correlations were used for analyzing the relationship between observational ratings and walking speed. Two-tailed p-values <0.05 were considered significant.

3. Results

Following injection with LPS, the walkers took more time (β = +.1 ± .1 (SE) s, i.e. 3% slower, p = .048) to complete the first 10 steps compared to placebo (baseline intercept = 4.8 ± .1 s). When injected with LPS, walkers were also rated as less healthy (β = −.1 ± .1 units on the scale, p = .027) and more tired (β = −.1 ± .1 units on the scale, p = .032), and tended to be rated as more sad (β = −.1 ± .1 units on the scale, p = .058) than after injection with placebo.

The idea that a slower walking speed causes these effects was further illustrated by analyzing their direct relationships (Fig. 2). It became clear that a slower walking speed was strongly related to looking less healthy (r = −.43, p < .001), more tired (r = .58, p < .001), and more sad (r = .43, p < .001). These effects were slightly smaller but still significant on the p < .001 level after adjusting for individual differences between walkers and between raters using empirical Bayes estimates.

4. Discussion

We demonstrate that a transient and mild stimulation of the innate immune system reduces otherwise healthy individuals' walking speed, and that they appear less healthy and more tired to others when judged from short video clips of gait patterns. From an evolutionary perspective, the ability to detect signs of infection in someone else promotes survival, as it would allow for avoidance of contagious individuals as well as for preparation of a more efficient immune response when contagion is anticipated (Kiesecker et al., 1999; Schaller et al., 2010). This notion is supported both by findings of stress-mediated priming of immune cells such as microglia in animals (Frank et al., 2012), and by increased IL-6 responses to LPS *in vitro* after exposure to

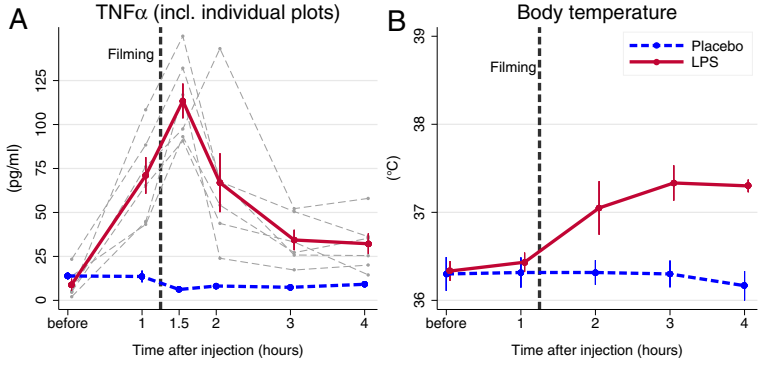

Fig. 1. Timing of filming. Filming occurred 75 min after injection with LPS and placebo in a double-blind and balanced crossover design. The timing occurred (A) close to the robust peak of TNF-α (mean ± SE) and (B) immediately prior to the temperature rise (mean ± SE).

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