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On the belief that arthritis pain is related to the weather

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ABSTRACT There is a widespread and strongly held belief that arthritis pain is influenced by the weather; however, scientific studies have found no consistent association. We hypothesize that this belief results, in part at least, from people's tendency to perceive patterns where none exist. We studied patients (n = 18) for more than 1 year and found no statistically significant associations between their arthritis pain and the weather conditions implicated by each individual. We also found that college students (n = 97) tend to perceive correlations between uncorrelated random sequences. This departure of people's intuitive notion of association from the statistical concept of association, we suggest, contributes to the belief that arthritis pain is influenced by the weather.

For thousands of years people have believed that arthritis pain is influenced by the weather. Hippocrates around 400 B.C. discussed the effects of winds and rains on chronic diseases in his book *Air, Water, and Places* (1). In the nineteenth century, several authors suggested that variations in barometric pressure, in particular, were partially responsible for variations in the intensity of arthritis pain (2–4). To the current day, such beliefs are common among patients, physicians, and interested observers throughout the world (5–14). Furthermore, these beliefs have led to recommendations that patients move to milder climates or spend time in a climate-controlled chamber to lessen joint pain (15–17).

The research literature, however, has not established a clear association between arthritis pain and the weather. No study using objective measures of inflammation has found positive results (18, 19), and studies using subjective measures of pain have been conflicting. Some find that an increase in barometric pressure tends to increase pain (20), others find that it tends to decrease pain (21), and others find no association (22, 23). Some investigators argue that only a simultaneous change in pressure and humidity influences arthritis pain (24), but others find no such pattern (25). Several studies report that weather effects are immediate (20), whereas others suggest a lag of several days (26). Due to the lack of clear evidence, medical textbooks—which once devoted chapters to the relation of weather and rheumatic disease—now devote less than a page to the topic (27, 28).

The contrast between the strong belief that arthritis pain is related to the weather and the weak evidence found in the research literature is puzzling. How do people acquire and maintain the belief? Research on judgment under uncertainty indicates that both laypeople and experts sometimes detect patterns where none exist. In particular, people often perceive positive serial correlations in random sequences of coin tosses (29), stockmarket prices (30), or basketball shots (31). We hypothesize that a similar bias occurs in the evaluation of correlations between pairs of time series, and that it contributes to the belief that arthritis pain is related to the weather. We explored this hypothesis by testing (*i*) whether arthritis patients' perceptions are consistent with their data and (*ii*) whether people perceive associations between uncorrelated time series.

We obtained data from rheumatoid arthritis patients (n = 18) on pain (assessed by the patient), joint tenderness (evaluated by the physician), and functional status (based on a standard index) measured twice a month for 15 months (32). We also obtained local weather reports on barometric pressure, temperature, and humidity for the corresponding time period. Finally, we interviewed patients about their beliefs concerning their arthritis pain. All patients but one believed that their pain was related to the weather, and all but two believed the effects were strong, occurred within a day, and were related to barometric pressure, temperature, or humidity.

We computed the correlations between pain and the specific weather component and lag mentioned by each patient. The mean of these correlations was 0.016 and none was significant at $P < 0.05$. We also computed the correlation between pain and barometric pressure for each patient, using nine different time lags ranging from 2 days forward to 2 days backward in 12-hr increments. The mean of these correlations was 0.003, and only 6% were significant at $P < 0.05$. Similar results were obtained in analyses using the two other measures of arthritis and the two other measures of the weather. Furthermore, we found no consistent pattern among the few statistically significant correlations.

We next presented college students (n = 97) with pairs of sequences displayed graphically. The top sequence was said to represent a patient's daily arthritis pain over 1 month, and the bottom sequence was said to represent daily barometric pressure during the same month (Fig. 1). Each sequence was generated as a normal random walk and all participants evaluated six pairs of sequences: a positively correlated pair (r = +0.50), a negatively correlated pair (r = −0.50), and four uncorrelated pairs. Participants were asked to classify each pair of sequences as (*i*) positively related, (*ii*) negatively related, or (*iii*) unrelated. Positively related sequences were defined as follows: "An increase in barometric pressure is more likely to be accompanied by an increase in arthritis pain rather than a decrease on that day (and a decrease in barometric pressure is more likely to be accompanied by a decrease rather than an increase in arthritis pain on that day)." Negatively related sequences and unrelated sequences were defined similarly.

We found that the positively correlated pair and the negatively correlated pair were correctly classified by 89% and 93% of respondents, respectively. However, some uncorrelated pairs were consistently classified as related. For example, the two uncorrelated sequences in Fig. 1*A* were judged as positively related by 87%, as negatively related by 2%, and as unrelated by 11% of participants. The two uncorrelated sequences in Fig. 1*B* were judged as positively related by 3%, as negatively related by 79%, and as unrelated by 18% of participants. The remaining two pairs of uncorrelated sequences were correctly classified by 59% and 64% of participants. Evidently, the intuitive notion of association differs from the statistical concept of association.

Our results indicate that people tend to perceive an association between uncorrelated time series. We attribute this phenomenon to selective matching, the tendency to focus on

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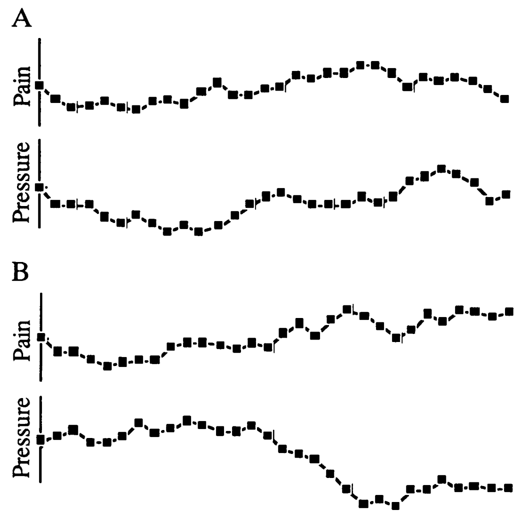

FIG. 1. Random walk sequences. The upper sequence in each pair represents daily arthritis pain for 30 consecutive observations; the lower sequence represents daily barometric pressure during the same period. For both *A* and *B*, the correlation between changes in pain and changes in pressure is 0.00.

salient coincidences, thereby capitalizing on chance and neglecting contrary evidence (33–35). For arthritis, selective matching leads people to look for changes in the weather when they experience increased pain, and pay little attention to the weather when their pain is stable. For graphs, selective matching leads people to focus on segments where the two sequences seem to move together (in the same or opposite direction), with insufficient regard to other aspects of the data. In both cases, a single day of severe pain and extreme weather might sustain a lifetime of belief in a relation between them. The cognitive processes involved in evaluating graphs are different from those involved in evaluating past experiences, yet all intuitive judgments of covariation are vulnerable to selective matching.

Several psychological factors could contribute to the belief that arthritis pain is related to the weather, in addition to general plausibility and traditional popularity. The desire to have an explanation for a worsening of pain may encourage patients to search for confirming evidence and neglect contrary instances (36). This search is facilitated by the availability of multiple components and time lags for linking changes in arthritis to changes in the weather (37). Selective memory may further enhance the belief that arthritis pain is related to the weather if coincidences are more memorable than mismatches (38). Selective matching, therefore, can be enhanced by both motivational and memory effects; our study of graphs, however, suggests that it can operate even in the absence of these effects.

Selective matching can help explain both the prevalent belief that arthritis pain is related to the weather and the failure of medical research to find consistent correlations. Our study, of course, does not imply that arthritis pain and the weather are unrelated for all patients. Furthermore, it is possible that daily measurements over many years of our patients would show a stronger correlation than observed in our data, at least for some patients. However, it is doubtful that sporadic correlations could justify the widespread and strongly held beliefs about arthritis and the weather. The observation that the beliefs are just as prevalent in San Diego (where the weather is mild and stable) as in Boston (where the weather is severe and volatile) casts further doubt on a purely physiological explanation (39). People's beliefs about arthritis pain and the weather may tell more about the workings of the mind than of the body.

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