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LEANING TO THE LEFT MAKES THE EIFFEL TOWER SEEM SMALLER: POSTURE-MODULATED THOUGHT

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Abstract

In two experiments, we investigated whether body posture influences people's estimates of quantities, heights, and percentages of entities in the world. According to an influential idea, people mentally represent numbers along a line with small numbers on the left and large numbers on the right. We hypothesized that surreptitiously making people lean to the right or left would affect their estimates. Participants answered estimation questions while standing on the Wii™ Balance Board. Posture was manipulated within subjects, so that participants answered some questions while they leaned slightly to the left, slightly to the right or while they stood upright. Crucially, participants were not aware of this manipulation. Subjects' estimates were significantly smaller when they leaned to the left than when they leaned to the right.

KEYWORDS: Decision making, Embodiment, Posture, Cognition, Mental number line.

Leaning to the left makes the Eiffel tower seem smaller:

Posture-modulated thought

What information do we use when we estimate something like the height of the Eiffel tower? Perhaps we think of the height of another building and then mentally compare it to the Eiffel tower: the well-known anchoring and adjustment heuristic (Tversky & Kahnemann, 1974). Recent theorizing suggests that bodily states also provide important cues to higher cognitive processes (Barsalou, 2008). Consistent with this idea, body posture has been shown to influence memory access and estimations (Bhalla & Proffitt, 1999; Dijkstra, Kaschak, & Zwaan, 2007; Riskind, 1983). In the present study, we examined whether posture affects the magnitude estimates in a judgment task. According to the notion of the *mental number line* (Restle, 1970), people mentally place magnitudes (symbolized by numbers) on a line, with small numbers on the left and large numbers on the right. Many studies have provided evidence for the fact that people associate their left hand (Dehaene, Bossini, & Giraux, 1993) or visual field (Schwarz & Keus, 2004) with small numbers and their right hand and visual field with large numbers. We hypothesized that people produce smaller estimates when they lean slightly to the left than when they lean slightly to the right. Moreover, we hypothesized that they do so, even when they think they are standing upright.

EXPERIMENT 1

Participants

Thirty-three undergraduate psychology students (24 female; age 18-27) participated in this study for course credit. They were randomly assigned to one of six lists, which differed with respect to the order of the postures and the order in which the questions appeared.

Apparatus

We used the Wii™ Balance Board (WBB) to manipulate and measure participants' centre of pressure (COP, a measure for body posture and balance). The WBB produces COP measures that are as reliable and valid as those produced by an expensive laboratory-grade force platform (Clark et al., 2010). Custom software enabled us to record event-related changes in COP.

Materials and procedure

Participants answered 39 estimation questions (see Table S1 in the Supplementary Online Materials) while standing on the WBB. They were told that they (1) probably did not *know* the correct answer to the questions, (2) therefore had to *estimate* their answers, and (3) had to stand upright during the experiment. To make sure that the neutral body posture was consistent with the center of a fixation cross, the WBB was calibrated for each participant before each experimental session. To help participants maintain their position, their COP was displayed on a computer screen. They were instructed to make sure their COP remained within a certain circle in the middle of crosshairs displayed on the screen. Failure to do so resulted in a warning signal on the screen, which prompted them to re-center their COP. We recorded x- and y-coordinates of the COP.

We wanted participants to think they stood upright during the experiment. The COP displayed on the computer screen always indicated that they were standing upright, but we surreptitiously manipulated body posture to be (1) slightly left from the middle, (2) slightly right from the middle or (3) upright. The magnitude of displacement was 0.77, approximating a 2% change in weight proportion on the left and right sensors. We included a one-minute balance game before each posture change to ensure that participants would remain unaware that their posture was being manipulated.

The estimation questions appeared on the screen above the COP visualization and were presented in three blocks of 13 questions each. Question order and body-posture order were counterbalanced across participants. Half the participants saw the sentences in one random order and the other half in the reverse order. In both cases, a third of the participants started in the left posture, a third in the middle posture, and a third in the right posture, followed by a different posture for the next third of questions, and the remaining posture for the final third of questions. Participants reported their answers orally and the experimenter wrote down the answers given by the participants. The experimenter sat in the same room as the participants, but remained invisible to them during the task. Each time a participant answered a question, the experimenter used a remote controller to advance to the next question. Afterwards, participants filled out a form, indicating for each question whether their answer was an estimate or whether they knew the answer. None of the participants indicated being aware that their body posture had been manipulated.

Results

Although some participants claimed to know the answer to some of the questions, they did not answer those questions correctly. We therefore assumed these answers were also estimations. To be able to compare across questions, we transformed our data to sets of z-scores per question. We then calculated a mean z-score for each participant across the sentences for each of the three conditions (left, middle, and right), which resulted in 33 z-scores (11 per condition). In an initial analysis, we submitted these data to a 3 (posture) by 3 (posture order) by 2 (sentence order) mixed analysis of variance (ANOVA), with posture as a within-subjects factor and the two orders as between-subjects factors. Because the two order factors did not interact with the factor of theoretical interest, posture, they were omitted from the final analysis

(Pollatsek & Well, 1995). There was a significant main effect of posture ($F[2,64] = 3.38$, $p < .05$, $\eta^2 = .10$). As we predicted, within-subjects contrasts analyses showed that participants gave smaller estimates while leaning to the left than to the right ($F[1,32] = 4.42$, $p < .05$, $\eta^2 = .12$). They also gave smaller estimations while leaning to the left than standing upright ($F[1,32] = 6.45$, $p < .05$, $\eta^2 = .17$). However, the estimates did not differ between standing upright and leaning to the right ($F < 1$; see Figure 1).

The estimates used in this experiment were on very diverse dimensions (e.g., the height of a building, the population of a city, the percentage of alcohol in a beverage) and scales (from centimeters to kilometers). In Experiment 2 we used a single dimension with a restricted range (from 1 to 10) to extend our earlier finding. Participants were asked, for example, how many number one hits Michael Jackson has had in the Netherlands (6) or how many grandchildren Queen Beatrix of the Netherlands has (8).

EXPERIMENT 2

Participants

Fifty-eight undergraduate students (43 female; age 18-29) participated in this study for course credit or pay (€3). They were all right handed and randomly assigned to one of six lists as in the first experiment.

Materials and procedure

The materials and the procedure used in this experiment were the same as in the first experiment except for the estimation questions participants answered. This time the real answers to all 39 questions (see Table S2 in the Supplementary Online Materials) were numbers from 1 to 10. Participants were told that all estimations they made had to be within this range. Again, none of the participants were aware of the posture manipulation.

Results

All participants indicated that they were able to answer the estimation questions and none of the participants really knew the real answer to one of the questions. As in the first experiment, we transformed our data to z-scores and calculated a mean z-score for each participant in each of the three postures. As in Experiment 1, we performed a 3 (posture) by 3 (posture order) by 2 (sentence order) mixed ANOVA. This time, the order factors interacted significantly with posture. Because the purpose of this analysis is to reduce error variance and the factors are theoretically irrelevant, we do not report the effects involving these factors, even though they were included in the analysis (Pollatsek & Well, 1995). There was a significant main effect of posture ($F[2,106] = 4.05$, $p < .025$, $\eta^2 = .07$). In accordance with our previous result, within-subjects contrasts analysis showed that participants gave smaller estimates while leaning to the left than to the right ($F[1,53] = 6.74$, $p < .015$, $\eta^2 = .11$). Participants' estimations were larger while standing upright than leaning to the left ($F[1,53] = 6.96$, $p < .015$, $\eta^2 = .12$). The estimates did not differ between standing upright and leaning to the right ($F < 1$; see Figure 1).

General discussion

Body posture influences quantitative estimates. We predicted that people would make smaller estimations while leaning slightly to the left as compared to leaning slightly to the right, and this is exactly what we found. Remarkably, this occurred while participants were unaware of their (true) posture. The mechanism behind this finding might be the following. According to the mental number line theory, people mentally represent small numbers on the left side and large numbers on the right side (Restle, 1970). Presumably, making an estimate involves retrieving instances from memory, which function as anchors (Tversky & Kahneman, 1974). Having people lean to the left therefore makes smaller numbers (relative to the anchors) more accessible

than larger ones and leaning to the right makes larger numbers relatively more available than smaller ones.

The upright position was statistically identical to the right-leaning condition in both experiments. The fact that we used each participant's neutral position as upright condition might have contributed to this finding. Given that all participants were right-handed, their neutral stance may have been already right of center. There is some evidence to suggest that people achieve postural control through a subtle bias toward the hip that is on the same side as manual preference (Balasubramaniam & Turvey, 2000). This hypothetical bias towards the right in the middle condition may have diminished or even eliminated the difference between the middle and right conditions with regard to their effects on estimation. Of course, this account is speculative. However, it could be tested in future research by examining a group of left-handed participants. It should also be noted that other studies on the mental number line have also found that a 'central' condition aligns with one of the extremes rather than occurring truly in the center (Nicholls & McIlroy, 2010).

We did not compare the estimates given by the participants with the actual magnitudes because we were interested in relative differences as a function of body posture. However, the findings from Experiment 1 do warrant the conclusion that leaning slightly to the left makes people judge the Eiffel tower 12 meters smaller compared to leaning slightly to the right.

Author note

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Figure Caption

Figure 1. Mean z-score (+*SE*) for all three body postures in Experiment 1 ($N = 33$) and Experiment 2 ($N = 58$)

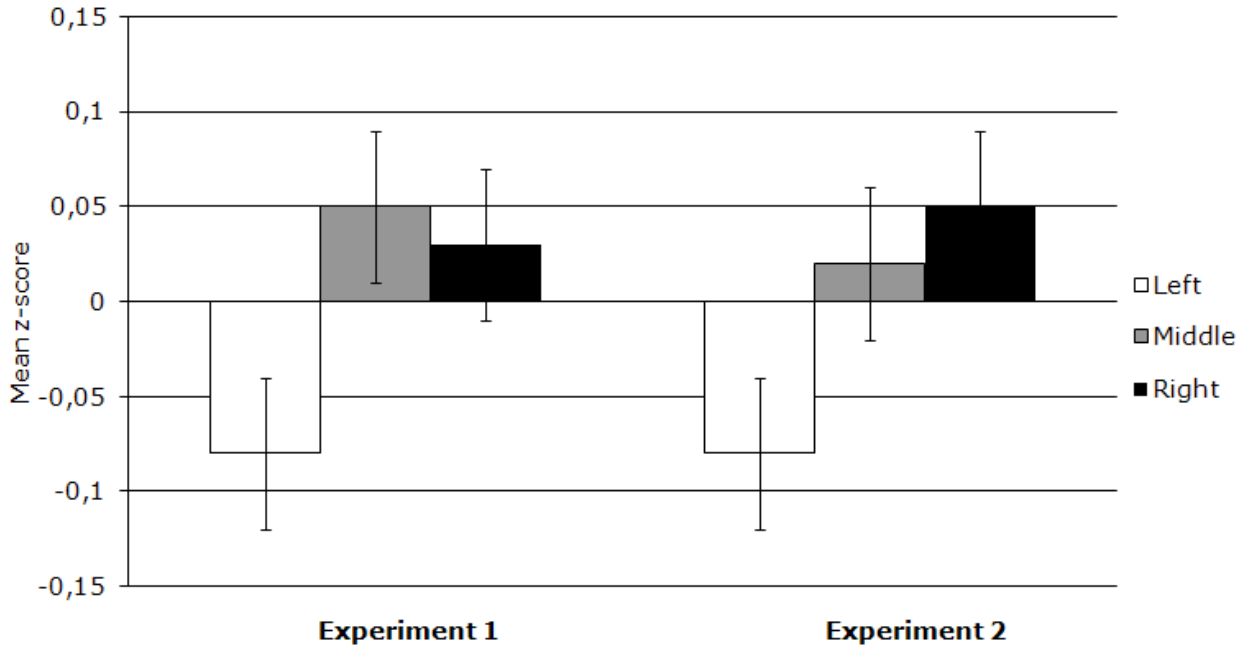
0,15
0,1
0,05
0
-0,05
-0,1
-0,15
Mean z-score
Left
Middle
Right
Experiment 1
Experiment 2

Table S1

Overview of all estimation questions used in Experiment 1 and the median answer given by participants for all three body postures ($N = 33$).

	Left	Middle	Right
What is the height of the Eiffel tower in meters?	300	320	312
How many people live in Antwerp?	500,000	400,000	1,000,000
How many kilos does a newborn calf weigh?	40	30	40
How many kilos does an adult elephant weigh?	1000	500	600
What is the distance in kilometers between Leeuwarden and Groningen as the crow flies?	100	100	65
How many number one hits did The Beatles have in the Netherlands?	5	10	5
What is the percentage of people older than 65 years in the Netherlands?	30	30	30
How many counties does Canada have?	10	20	13
How many students go to law school in the Netherlands annually?	2,000	3,000	8,000
How many languages exist worldwide?	185	300	400
How many rainy days are there in the Netherlands annually?	250	200	200
What is the length of the Erasmus Bridge in Rotterdam in meters?	175	300	500
What is the land area of the Netherlands in square kilometers?	1,500	1,000	3,000
How many times is Norway larger than the Netherlands?	8	5	12
How many kilo calories does a croquette (fast food snack) contain?	275	250	200
How many millimeters does hair grow in a month?	7	5	5
How many homicides are there in the Netherlands annually?	107	40	200
What is the percentage of families that had access to internet in the Netherlands in 2009?	74	75	80
What is the percentage of Dutch people with higher education?	38	50	32

What is the percentage of the world population that is religious?	73	78	80
How many different kinds of fungus do you find in the Netherlands?	52	60	57
How many floors did both towers of the World Trade Centre in New York have?	100	105	117
How many nationalities are there in Rotterdam?	28	85	75
What is the length of the bowels of an adult in meters?	6	7	7
What is the length of the Chinese Wall in kilometers?	420	1,100	190
What is the world 10 k speed skating record for men in minutes?	9	10	14
What is the average life expectancy of a parrot in years?	14	20	25
How many kilo calories do you burn during a 30-minute run?	225	200	275
What is the distance in kilometers between Vienna and Bratislava as the crow flies?	625	800	650
How many people a day visit Wikipedia?	1,000,000	10,000,000	750,000
How many people entered the marathon of Rotterdam this year?	6,850	6,000	5,000
How many people are infected by HIV a year?	400,000	300,000	500,000
How many lakes are there in Finland?	155	55	549
How many people live in Italy in millions?	25	50	25
How long does a direct flight from Amsterdam to Dublin take in minutes?	120	60	84
What is the percentage of alcohol in traditional vodka?	40	43	40
How many soldiers are there in the United States army?	650,000	600,000	850,000
In what year was the Colloseum in Rome build?	200	-30	1,492
What is the length of the smallest man in the world in centimeters?	60	50	64

Table S2

Overview of all estimation questions used in Experiment 2 and the mean answer given by participants for all three body postures (N = 32).

	Left	Middle	Right
How many kilos of garbage does the average Dutch man produce in one week?	5.6	5.7	6.4
How many Wadden islands are inhabited?	4.8	4.5	4.6
What is the average age of children at which they learn how to swim?	5.9	6.2	5.7
How many number one hits did Michael Jackson have in the Netherlands?	7.5	7.1	8.2
How many times do people move in the Netherlands?	3.6	3.2	3.7
What is the average weight of a female koala beer in kilos?	7.1	7.0	7.0
How many people are needed for a water polo team?	7.5	7.7	7.4
How many people are needed for a handball team?	7.6	7.5	7.5
How many times did the Netherlands win the Eurovision Songcontest?	1.6	1.8	2.2
How many golden Olympic medals did Marianne Timmer win?	3.8	3.7	4.5
What is the average life expectancy of a rabbit in the Netherlands?	4.6	6.0	6.5
How many jeans does the average Dutch man buy a year?	3.5	4.7	5.1
What is the gestation period of a kangaroo in months?	6.9	7.0	6.3
How many times did a Dutch movie win an Oscar?	3.5	4.1	3.0
How many different types of deers are there in the Netherlands?	4.3	4.9	3.6
How many medical helicopters are there in the Netherlands?	7.7	8.2	7.5
How many submarines does the Dutch navy has?	5.7	5.3	5.4
How many hours a day does the sun shine on average in June in the Netherlands?	8.0	7.3	7.8
How many litres of blood does the human body contain?	7.0	6.3	5.7
How many Oscars did the movie Slumdog Millionaire win?	3.6	5.1	4.8
How many beers does the average Dutch man drink a week?	6.1	7.5	6.1
How many different types of owls are there in the Netherlands?	4.6	5.5	4.7
How many times a week does the average Dutch man eat potatoes?	3.6	3.6	3.4

What is the average weight of an adult cat in kilos?	5.7	5.7	5.5
How many millimetres do finger nails grow a month?	3.6	3.3	3.8
How many times did we have a white Christmas in the Netherlands since 1901?	6.4	7.1	5.9
How many times did Feyenoord win the national title since 1971?	3.2	2.9	3.7
How many kilos of liquorice does the average Dutch man eat a year?	4.7	4.3	4.7
How many times a year does the average Dutch man [barbeque]?	6.2	6.5	6.4
How many times a year does the average Dutch man call in sick at work?	4.4	5.1	6.0
How many cups of coffee does the average Dutch man drink a day?	3.2	3.7	3.6
What is the average temperature in November in the Netherlands?	5.3	6.2	7.5
How many different types of tigers are there in the world?	6.0	4.6	5.7
How many lilly pads are displayed on the flag of (the province of) Friesland?	5.6	5.2	6.1
How many times did Roger Federer win Wimbledon?	4.0	4.6	3.6
How many times a year does the average Dutch man go on vacation?	2.0	2.3	2.1
How many actors played the role of James Bond?	5.3	5.5	5.3
How many breads does an adult elephant eat in the zoo a day?	6.8	6.3	7.4
How many grandchildren does the Queen of the Netherlands have?	5.8	6.2	6.3