Assessing with the head: a motor compatibility effect

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ABSTRACT

Research within the embodiment perspective has found that cognitive processing proceeds easier when bodily actions (mostly arms motion) are *compatible* with the conceptual meaning of verbal expressions (concrete or abstract, or with positive and negative values). Facilitation effects involving head motion, however, have not yet been investigated. The present work aims to test the motor compatibility hypothesis between directional head movements, usually performed to communicate agreement and disagreement, and truth evaluation. Five experiments were designed: participants were asked to assess a series of sentences as true or false, according to their meaning (objectively) or on the basis of personal preferences (subjectively), in compatible and incompatible motion conditions and with different response modalities. Response times were shorter only when true sentences, or about a liked content, were moved vertically, and when false sentences, or about a disliked content, were moved horizontally, with the head. Results confirm the hypothesis that higher cognitive processing is grounded in bodily motion, and shed light on the possibility to manipulate vertical and horizontal head movements in order to reveal attitudes.

CCS CONCEPTS

• **Computing methodologies → Motion capture** • **Computing methodologies → Cognitive science** • Applied computing → Psychology • Applied computing → Sociology

KEYWORDS

Head movements, truth evaluation, embodiment effect, motor compatibility

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1 INTRODUCTION

According to the embodiment view, cognition is grounded on sensorimotor mechanisms, which lead to partial simulations of sensory, motor, and affective states [1]. These simulations are based on previously acquired information and are supposed to be the result of the evolution of mechanisms which originally allowed individuals to make inferences and represent information in absence of physical stimuli. Thus, the effects of this grounding occur even when cognition is disconnected from the environment in which the sensorimotor patterns were acquired or activated [2-4]. These effects, generally, show up as a facilitation or interference in cognitive processing, based on whether bodily states and cognitive states are compatible or not.

Two famous facilitation effects found within this perspective are, for example, the "Action-sentence Compatibility Effect "(ACE) [5] and the "Approach and Avoidance Effect (AAE) [6]. As regards the first effect, in a task where participants were asked to judge whether a series of sentences expressing actions were sensible or not, by moving the arm, faster response times were found when the arm movement to be executed was in the same direction of the action expressed by sentences (both concrete and abstract). The second effect, similarly, was observed with the evaluation of positive and negative valenced stimuli: response times were faster when the direction of the movement to do in order to evaluate a positive stimulus was an approach movement (arm flexion toward the body), and vice versa an avoidance movements (arm extension away from the body) when the stimulus was negative.

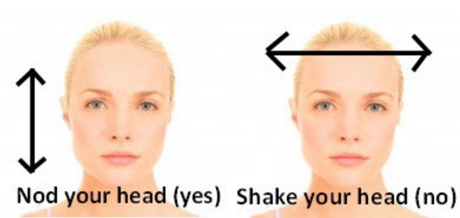

Figure 1: Meaning of head nod and shaking in Western culture.

This kind of embodiment effects have been found mostly with arm movements, while other body parts have not yet been sufficiently investigated. The aim of the present research was to test a motor compatibility between head movements and truth evaluation.

2 OVERVIEW OF THE STUDY

2.1 Head nod and shake in embodiment perspective

Head nod and shake are considered one of the first nonverbal behaviors acquired by infants [7-8], and they are of particular interest for the embodiment perspective since their habitual use from early communication makes these movements physically embodied habits [9]. In Western culture, indeed, the vertical movement of nodding is used to communicate agreement or acceptance and it typically accompanies positive and affirmative responses (Yes), while the horizontal movement of shaking commonly accompanies negative responses (No) and it is used to communicate dissent or denial (Fig. 1).

A relevant idea within the embodiment perspective is that gestures are simulated actions [10] and that sensorimotor simulation is one of the main mechanisms underlying compatibility effects [11] which occur because the affected cognitive processing entails a mental simulation that reactivates the same neuronal paths that were active while experiencing the situation expressed verbally [4].

According to this hypothesis, evaluating information as true may activates the simulation of vertical head movements typically executed with affirmative responses, like agreeing or approving, (head nod), and, likewise, when evaluating information as false, the simulation of horizontal head movements performed with negative responses (head shake) is likely to be activated. Hence, the aim of the present study was to test whether a motor compatibility effect occurred when the direction of the movement to do in order to evaluate a true or a false statement was the same of the typically experienced movement associated with a positive/affirmative or negative/dissenting response.

In order to test this hypothesis, we planned an experimental study consisting of 5 experiments, in which the interaction between vertical and horizontal head movements and the assessment of the truth-value of a sentence is analyzed with different tasks and response modalities: the first experiment required to evaluate the truth-value of a series of objectively true and false sentences, through head motion; in the second experiment, the same sentences were evaluated by moving the arm; in the third experiment, the truth evaluation task was replaced by a classification task with head movements; the fourth experiment required to evaluate as true or false a series of sentences whose truth-value is subjectively assessable, with the head; in the last experiment the same sentences were evaluated with arm movements.

In short, we controlled whether a compatibility effect was present independently of head motion or independently of the evaluation processing, and whether it occurred when truth-value was subjectively assessable. In this way we could assess whether the interaction hypothesized with vertical and horizontal head movements was necessary or sufficient for the motor compatibility to occur.

2.2 Experiment 1

2.2.1 Participants. A total of 96 undergraduates participated in the experiment for course credits, randomly assigned to two groups (A, B).

2.2.2 Materials and apparatus. Stimuli were 120 simple sentences: 60 objectively true and 60 objectively false (i.e. “Football is a sport”, “Shadow glows”). Half of them where displayed in a first block and the other half in a second block. The two blocks differed for the position of the response bars: in Group A Block 1 was the compatible condition: “True” response bars were located at the top and at the bottom of the computer screen (vertically) and “False” response bars at the right and left sides (horizontally), while Block 2 was the incompatible condition, the position of the bars was reversed (Fig. 2). In Group B the order of the blocks was inverted. In order to make possible the sentence motion control on the screen with the head, the Enable Viacam v.1.7.2 free software was used, which through a webcam captures head movements and converts them into pointer motion.

2.2.3 Procedure. After a brief practice session, participants were asked to evaluate the truth-value of sentences by moving them vertically and horizontally with the head motion control towards one of the four side bars of the screen, in compatible and incompatible blocks.

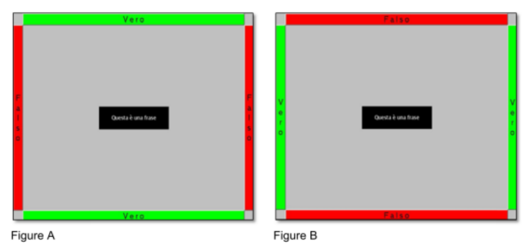

Figure 2: Screenshot examples of the main task: Compatible (Figure A) and Incompatible (Figure B) conditions. Caption text (in Italian): “This is a sentence” on the black box; “True” on the green side bars and “False” on the red side bars.

2.2.4 Data Analysis. Response times (RT) were recorded from when the black box was clicked and the sentence appeared to when the box movement started. The start of the movement was defined as when the cursor moved 20 pixels from its starting point. This measure was set as to maximize sensitivity to actual responses and minimize it to small random movements. To clean the data, trials 1-8 for each block were considered additional practice and were removed; wrong answers and response times shorter than 300 msec and longer than 3000 msec were considered invalid and also removed. A log transformation was performed on data and a Linear Mixed Modeling analysis was made in order to accounting for both participant and item variability.

2.2.5 Results. In line with expectations, the difference between Compatible and Incompatible conditions was significant [$F(1,93) = 3.91$, $SE = .011$, $p = .05$, eta squared = .07] (Figure 3). A difference between True and False sentences also resulted: True sentences were evaluated faster than False sentences [$F(1,129) =$

41.35, SE = .014, p < .001]. Interaction between Compatibility and Group was significant, too [F(1,176) = 6.05, SE = .035, p = .01].

2.3 Experiment 2

2.3.1 Participants. A total of 75 undergraduates participated in the experiment for course credits, randomly assigned to two groups (C, D). No one participated in the previous experiment.
2.3.2 Materials and apparatus. Stimuli and apparatus were the same as in Experiment 1.
2.3.3 Procedure. After a brief practice session, participants were asked to evaluate the truth-value of sentences by moving them with the arm, using the mouse, towards one of the four side bars of the screen. Group C started with the compatible condition and ended with the incompatible condition, while Group D first performed the incompatible condition and then the compatible one.
2.3.4 Data Analysis. Response times (RT) were recorded from when the black box was clicked and the sentence appeared to when the box movement started. The same criteria used in Experiment 1 for data cleaning were adopted: trials 1-8 for each block, wrong answers and response times shorter than 300 msec and longer than 3000 msec were removed. A log transformation and a Linear Mixed Modeling were performed on data.
2.3.5 Results. As expected, no difference between Compatible and Incompatible conditions resulted since no Block X Group interaction occurred [F(1,7103) = 0.93, SE = .013, p = .33]. Even in this experiment, True sentences were evaluated faster than False sentences [F(1,7127 = 125.06, SE = .006, p < .001].

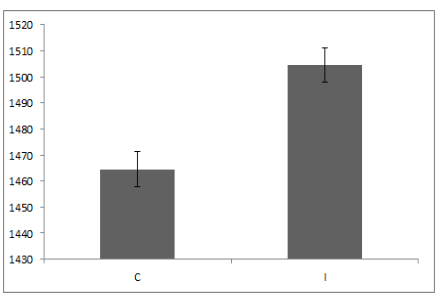

Figure 3: Mean RTs in Compatible (C) and Incompatible (I) conditions in Experiment 1. Error bars indicate SE.

2.4 Experiment 3

2.4.1 Participants. A total of 80 undergraduates participated in the experiment for course credits, randomly assigned to two groups (E, F). No one participated in previous experiments.
2.4.2 Materials and apparatus. Stimuli were 120 simple statements: 60 about animals and 60 about objects (i.e. "A cat meows", "A telephone rings"). Half of them where displayed in a first block and the other half in a second block. Blocks differed for the position of the response bars: in one block "Animal" response bars were located at the top and at the bottom of the computer screen (vertically) and "Object" response bars at the right and left sides (horizontally), while in the other block, the position of the bars was reversed.
2.4.3 Procedure. After a brief practice session, participants were asked to classify sentences and choose the respective category by moving them with the head to the appropriate side bar. Group E had the "object-vertical, animal-horizontal" condition in block 1 and the "animal-vertical, object-horizontal" one in block 2; Group F had the inverted order of conditions.
2.2.4 Data Analysis. Like in Experiment 1 and 2, response times were recorded from when the box was clicked and the sentence appeared to when the box movement started. The procedure of data cleaning was identical to the one adopted in the other experiments. A log transformation and a Linear Mixed Modeling were performed on data.
2.2.5 Results. Like in Experiment 2, no Block X Group interaction resulted [F(1,8650) = .75, SE = .01, p = .38] so that no further analysis about Compatibility effects was required.

2.5 Experiment 4

2.5.1 Participants. A total of 79 undergraduates participated in the experiment for course credits, randomly assigned to two groups (A, B). No one participated in previous experiments.

2.5.2 Materials and apparatus. Stimuli were 120 simple statements about 60 foods: 60 in a positive form (i.e. "I love chocolate") and 60 in negative (i.e. "I hate chocolate"). Half of them where displayed in a first block and the other half in a second block. Blocks differed for the position of the response bars: in compatible block "True" response bars were located at the top and at the bottom of the computer screen (vertically) and "False" response bars at the right and left sides (horizontally), while in incompatible block, the position of the bars was reversed (Fig. 2).
2.5.3 Procedure. After a brief practice session, participants were asked to evaluate the truth-value of sentences by moving them with the head towards one of the four side bars of the screen. Group A started with the compatible condition and ended with the incompatible condition, while Group B first performed the incompatible condition and then the compatible one. At the end of the task, participants were asked to rate their preference for each of the 60 foods in an explicit questionnaire, by choosing between three options: I don't like it, I like it, Indifferent.
2.5.4 Data Analysis. The procedure of data recording and data cleaning was identical to the one adopted in the previous experiments. In addition, responses about preferences different from the one given in the final questionnaire, or different between the two blocks, were eliminated. Further, responses on sentences about food rated as Indifferent in the final questionnaire were not considered in the analysis. A log transformation and a Linear Mixed Modeling analysis were performed on data.
2.5.5 Results. The difference between Compatible and Incompatible conditions was significant [F(1,69) = 22.40, p < .001]. A difference between Positive and Negative sentences also resulted [F(1,156) = 93.10, p < .001]. Interaction between Compatibility and Group was significant, too [F(1,120) = 44.49, p

< .001]. In order to analyze the interaction between attitudes towards sentence contents and head movement directions, true responses to positive sentences and false responses to negative sentences were recoded as "responses to liked food", and true responses to negative sentences and false responses to positive sentences as "responses to disliked food". As a result, response times were shorter when sentences about liked foods were moved vertically and when those about disliked foods were moved horizontally [$F(1,165) = 9.94$, $p < .01$].

2.6 Experiment 5

2.3.1 Participants. A total of 70 undergraduates participated in the experiment for course credits, randomly assigned to two groups (C, D). No one participated in previous experiments.

2.3.2 Materials and apparatus. Stimuli and apparatus were the same as in Experiment 4.

2.3.3 Procedure. After a brief practice session, participants were asked to evaluate the truth-value of sentences by moving them with the arm, using the mouse, towards one of the four side bars of the screen. Group C started with the compatible condition and ended with the incompatible condition, while Group D first performed the incompatible condition and then the compatible one.

2.3.4 Data Analysis. The procedure of data recording and data cleaning was identical to the one adopted in Experiment 4. A log transformation and a Linear Mixed Modeling analysis were performed on data.

2.3.5 Results. As expected, no difference between Compatible and Incompatible conditions resulted since no Block X Group interaction occurred [$F(1,5032) = 0.93$, $p = .35$]. Even in this experiment, Positive sentences were evaluated faster than Negative sentences [$F(1,5055 = 111.36$, $p < .001$].

3 GENERAL DISCUSSION AND CONCLUSIONS

To the best of our knowledge, studies on head motion have limited themselves in examining the effects of the induction of the two head gestures on the subsequent evaluation of a stimulus [12-14]. For this reason, we considered contributing with a new experimental paradigm which made possible the evaluation of a series of stimuli directly with head motion. Our main goal was to test whether a cognitive processing like truth evaluation may activate the simulation of head movements usually performed in nodding and shaking. Overall results provide support for this hypothesis: response times were faster when the head movement required for evaluating a sentence as true or false was in the same direction of the typical movement involved in nodding or shaking respectively, compared to the condition in which the direction of the response action was reversed (Experiment 1 and 4). On the contrary, the effect did not show up with arm movements or with a simple categorization task (Experiment 2, 3 and 5). Most importantly, in Experiment 4 we found a more general compatibility effect between the two directional head movements and the attitude towards and object: sentences about liked foods were moved faster in vertical than in horizontal, and vice versa for disliked foods.

Figure 4: Childish actions of accepting food and keeping it in the mouth (on the left), and conversely of rejecting a spoonful of food (on the right).

This result shed light on the possibility that head nod, which is a vertical movement going from up towards the body, can be considered as an approach movement, while head shake, a movement going from side to side, away from the body, as an avoidance movement (Fig. 4). The approach and avoidance interpretation of the two head gestures, supported by our findings, is particularly interesting for the research in social psychology since they can be exploited for revealing implicit attitudes towards objects, which is the main goal of the project where the work here presented takes place.

REFERENCES

[1] Lawrence W. Barsalou. 2010. Grounded cognition: past, present, future. *Topics in Cognitive Science* 2, 322–327. DOI: http://dx.doi.org/10.1111/j.1756-8765.2010.01115.x

[2] Anna Maria Borghi and Felice Cimatti. 2009. Words as tools and the problem of abstract words meanings, in *Proceedings of the 31st Annual Conference of the Cognitive Science Society*, eds N. Taatgen and H. van Rijn, Amsterdam: Cognitive Science Society, 2304–2309.

[3] Vittorio Gallese and George Lakoff. 2005. The brain's concepts: The role of the sensory-motor system in reason and language. *Cognitive Neuropsychology* 22, 455–479. DOI: http://dx.doi.org/10.1080/02643290442000310

[4] Rolf A. Zwaan and Carol J. Madden. 2005. Embodied sentence comprehension. Grounding cognition: The role of perception and action in memory, language, and thinking, 224-245. DOI: http://dx.doi.org/10.1017/cbo9780511499968.010

[5] Arthur Glenberg and Michael P. Kaschak. 2002. Grounding language in action. *Psychonomic Bulletin & Review 9*, 558–565. DOI: http://dx.doi.org/10.3758/bf03196313

[6] Mark Chen and John A. Bargh. 1999. Consequences of automatic evaluation: Immediate behavior predispositions to approach or avoid the stimulus. *Personality and Social Psychology Bulletin* 25, 215–224. DOI: http://dx.doi.org/10.1177/0146167299025002007

[7] Michèle Guidetti. 2005. Yes or no? How young French children combine gestures and speech to agree and refuse. *Journal of Child Language* 32(04), 911-924. DOI: http://dx.doi.org/10.1017/s0305000905007038

[8] Charles Darwin. 1872. *The expression of the emotions in man and animals.* London: Murray (Reprinted, Oxford: University Press, 1998). DOI: http://dx.doi.org/10.1037/10001-000

[9] Gernot Horstmann and Ulrich Ansorge. 2011. Compatibility between tones, head movements, and facial expressions. *Emotion* 11(4), 975. DOI: http://dx.doi.org/10.1037/a0023468

[10] Martha W. Alibali, Boncoddo and Autumn B. Hostetter. 2014. Gesture in reasoning: an embodied perspective, in *The Routledge Handbook of Embodied Cognition*, ed. L. Shapiro, New York, NY: Routledge, 150–159.

[11] Katinka Dijkstra and L. Post. 2015. Mechanisms of embodiment. *Frontiers in Psychology* 6, 1525. DOI: http://dx.doi.org/10.3389/fpsyg.2015.01525

[12] Elena Andonova and Holly A. Taylor. 2012. Nodding in dis/agreement: a tale of two cultures. *Cognitive processing*, 13(1), 79-82. DOI: http://dx.doi.org/10.1007/s10339-012-0472-x

[13] Pablo Briñol and Richard E. Petty. 2003. Overt head movements and persuasion: a self-validation analysis. *Journal of personality and social psychology*, 84(6), 1123. DOI: http://dx.doi.org/10.1037/0022-3514.84.6.1123

[14] Jens Förster. 2004. How body feedback influences consumers' evaluation of products. *Journal of Consumer psychology*, 14(4), 416-426. DOI: http://dx.doi.org/10.1207/s15327663jcp1404_10