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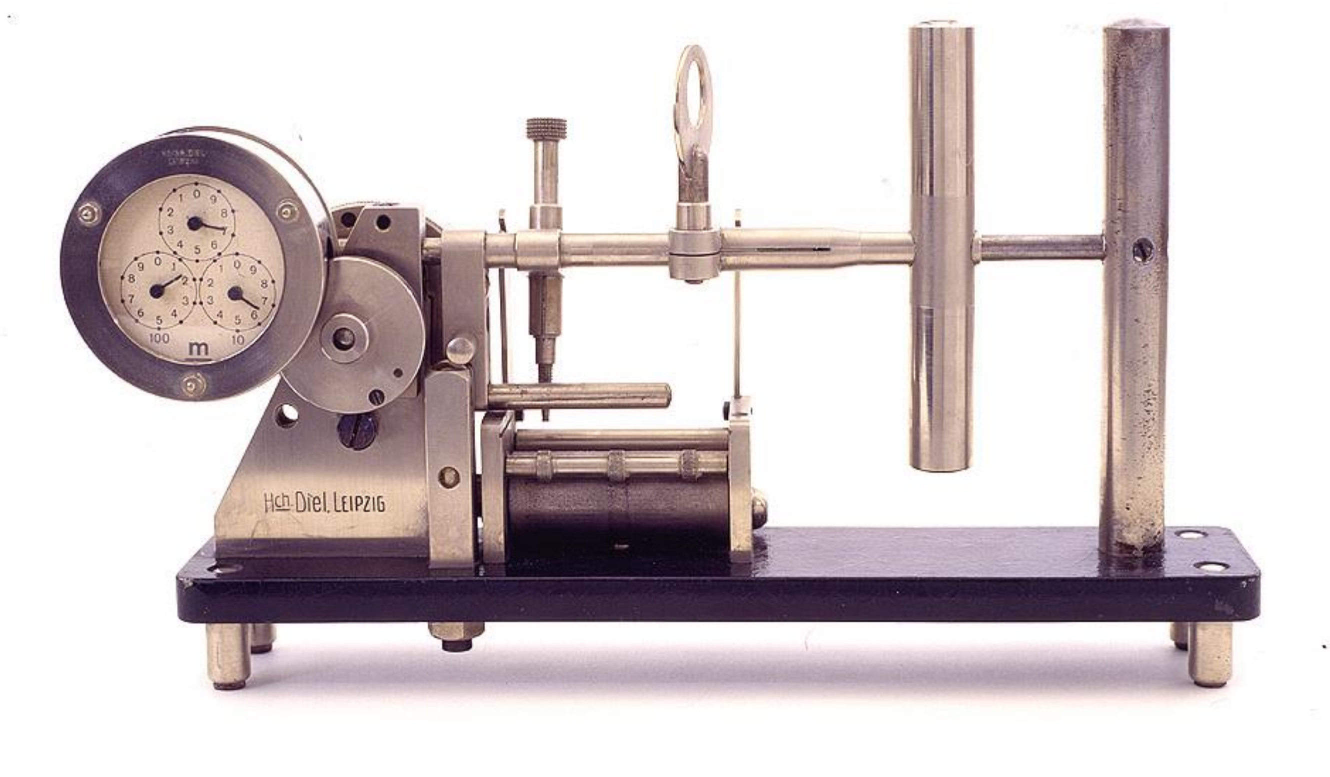
# EMPIRICAL STUDIES IN PSYCHOLOGY

MARCH 29TH – 31ST, 2019
FACULTY OF PHILOSOPHY, UNIVERSITY OF BELGRADE

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# Inferences of Vertical Projectile Velocity and Acceleration: Task Characteristics Consideration

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## Abstract

Human intuitive knowledge about physics mechanics is inherently flawed and characterized by various misconceptions. The primary aim of this study was to examine whether these misconceptions, in particular about velocity and acceleration of vertical projectile, are sensitive to task presentation format. Sample consisted of 250 undergraduate students (76.7% female), whose task was to infer the point of maximum velocity and acceleration characteristics of a ball thrown vertically upwards. Task format was varied in four conditions between-subjects design (stick-drawing vs. textual, with three different positions of stick-figure hand, at 45, 90 or 135 degrees from the body). Results indicated that inferences about maximal velocity point and acceleration characteristics are not influenced neither by stick-figure hand positions, nor by the change in task format, i.e. stick-drawing compared to textual task. Overall results indicate that our misconceptions regarding velocity and acceleration of vertical projectile are not sensitive to task presentation format.

**Keywords:** intuitive mechanics, vertical projectile motion, task characteristics

## Introduction

Intuitive knowledge of mechanics is knowledge of speed, acceleration, causes of movement, etc., acquired through experience. This knowledge is often found to be erroneous, and one of the earliest attempts to explain these errors, particularly in inferences regarding motion, was impetus theory developed by McCloskey (Caramazza, McCloskey, & Green, 1981; McCloskey, 1983). According to impetus theory, our inferences are based on the incorrect belief that, at the beginning of its movement, the object gains impetus, i.e. the internal force that influences object's movement. On the other hand, instead supporting the claim that we possess one general, "naïve" theory of impetus, some authors (see Cooke & Breedin, 1994) claim that during the process of inference about the movement many different information are taken into account (see also White, 1983). Also, they emphasize the crucial importance of the contextual factors, such as, for example, the type of motion, the characteristics of the objects in interaction, and the way in which the task is formulated. Some authors do not deny the significance of contextual factors, but they also do not reject the possibility of naïve theory of impetus (DiSsessa, Gillespie, & Esterly, 2004; Kaiser, Jonides, & Alexander, 1986; Ranney, 1994), because it is (although different from person to person, under the influence of the context and inconsistent), largely based on non-experiential, systematic and time-stable information (Ranney, 1994).

The aim of this study was to examine whether these misconceptions, in particular about the velocity and acceleration of vertical projectile, are sensitive to task presentation format.

## Method

### Design

Maximum velocity task format is varied in four conditions between-subjects design: stick-drawing tasks vs. textual task. Stick-drawing tasks have three different positions of stick-figure hand: 45, 90 or 135 degrees from the body. The task that did not contain the drawing had six answers: "Between the middle and furthest part of the trajectory", "In the middle part of the trajectory", "Between the initial and middle part of the trajectory", „At the initial part of the trajectory, immediately after the point of throw-out", "At the initial part of the trajectory - at the point of throw-out", At the furthest part of the trajectory, immediately before the point of stopping". The sequence of those answers had two variants.

On the other side of the paper, there was a question related to the acceleration of the ball, where the respondents should have chosen one of the six offered answers: (a) "The ball is initially decelerating, and then accelerating.", (b) "The ball is initially moving at constant velocity and then decelerating.", (c) "The ball is initially accelerating, and then decelerating.", (d) "The ball is continuously decelerating.", (e) "The ball is initially moving at constant velocity and then accelerating."

and (f) “The ball is continuously accelerating.“, The sequence of these answers had two variants, as well.

## Participants and procedure

The sample consisted of 250 undergraduate students at the University of Banja Luka (76.7% female), with group sizes from 61 to 63 participants. The average age of respondents was 21 years (*SD* = 1.97).

The respondents first evaluated the position in which the ball thrown vertically upwards moves at the maximum speed and then responded to the question regarding changes in the speed of the ball along its path.

## Results

Results, based on Fisher’s exact test, indicated there was no difference between stick-figure hand position conditions when it comes to the inference about the point of maximal velocity ($p$ = .884, $\varphi_c$ = .117; Figure 1) and for acceleration inferences ($p$ = .656, $\varphi_c$ = .151; Table 1).

The difference was not observed neither when stick-figure and textual format were compared regarding inference about maximum velocity point ($p$ = .217, $\varphi_c$ = .168; figure 1), nor for inferred acceleration characteristics (p = .051, $\varphi_c$ = .204; Table 1).

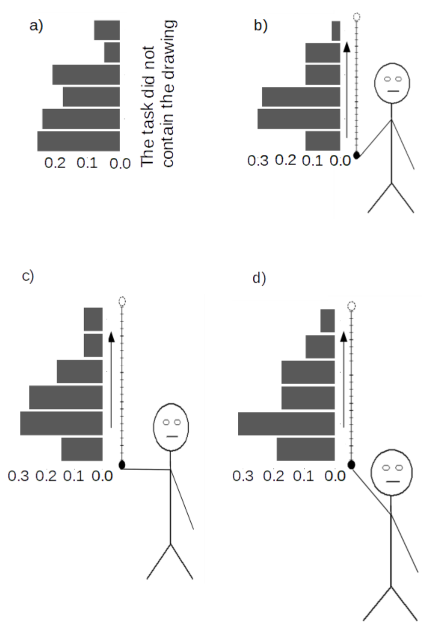


Figure 1: The inferred maximal velocity point of vertical throw in: (a) text condition, (b) 45° angle drawing, (c) 90° angle drawing, and (d) 135° angle drawing.

Table 1: Inferred acceleration characteristics of the vertical throw

| The ball is... | initially decelerating, and then accelerating. (%) | initially moving at constant velocity and then decelerating. (%) | initially accelerating, and then decelerating. (%) | continuously decelerating. (%) | initially moving at constant velocity and then accelerating. (%) | continuously accelerating. (%) |
|---|---|---|---|---|---|---|
| 45° | 6.3 | 19.0 | 49.2 | 7.9 | 3.2 | 14.3 |
| 90° | 0.0 | 14.5 | 51.6 | 14.5 | 4.8 | 14.5 |
| 135° | 1.6 | 21.0 | 45.2 | 16.1 | 4.8 | 11.3 |
| Text | 3.2 | 8.1 | 54.8 | 24.2 | 4.8 | 4.8 |

## Discussion and Conclusions

Results from the sick-drawing situations are in line with previous findings (Damjenić & Dimitrijević, 2016) (Damjenić & Dimitrijević, 2016), where solely stick-drawing condition with 90 degrees position of the hand relative to body was used. Correct answer (the ball reaches maximum velocity immediately when thrown-out of the hand) was given by 17% of respondents. Respondents who answered incorrectly, estimated on average that the maximum velocity point is in the middle of the ball path. The question about the acceleration of the ball thrown upward was correctly answered by 13% of the respondents. Most frequent answer was that the ball first accelerates and then decelerates (70% of the cases; Damjenić & Dimitrijević, 2016). Although in present research percentages are somewhat smaller (52%), we can conclude that the results in these two studies are similar to a large extent.

Considering different hand positions, according to the impetus theory (McCloskey, 1983), position of the thrower’s hand should have influenced maximum velocity point inferences, considering that in situations with 45° and 90° hand positions, the hand can exert additional force on the ball by moving further upwards, while further upward movement is not possible in 135° situation. Contrary to these predictions, the overall results of this study indicate that our misconceptions regarding the velocity and acceleration of vertical projectile are not sensitive of stick-figure presentation format.

Although some authors point out the significance of contextual factors, for example, the manner in which the task is presented, in this case there are no recorded differences between written and visual assignments. However, marginally increased accuracy in the text condition requires further investigation.

## References


Caramazza, A., McCloskey, M., & Green, B. (1981). Naive beliefs in “sophisticated” subjects: Misconceptions about trajectories of objects. *Cognition*, *9*, 117–123. https://doi.org/10.1016/0010-0277(81)90007-x

Cooke, N. J., & Breedin, S. D. (1994). Constructing naive theories of motion on the fly, *22*(4), 474–493.

Damjenić, M., & Dimitrijević, S. (2016). Intuitive mechanics: Inferences of vertical projectile motion. *Psihologijske Teme*, *25*(2).

DiSsessa, A. A., Gillespie, N. M., & Esterly, J. B. (2004). Coherence versus fragmentation in the development of the concept of force. *Cognitive Science*, *28*(6), 843–900. https://doi.org/10.1016/j.cogsci.2004.05.003

Kaiser, M. K., Jonides, J., & Alexander, J. (1986). Intuitive reasoning about abstract and familiar physics problems. *Memory & Cognition*, *14*(4), 308–312. https://doi.org/10.3758/BF03202508

McCloskey, M. (1983). Naive theories of motion. In D. Gentner & A. L. Stevens (Eds.), *Mental models* (pp. 299 – 324). Hillsdale, NJ: Erlbaum. Retrieved from http://files.eric.ed.gov/fulltext/ED223417.pdf

Ranney, M. (1994). Relative consistency and subjects’ “theories” in domains such as naive physics: Common research difficulties illustrated by Cooke and Breedin. *Memory & Cognition*, *22*(4), 494–502. https://doi.org/10.3758/BF03200872

White, B. Y. (1983). Sources of difficulty in understanding newtonian dynamics. *Cognitive Science*, *7*(1), 41–65. https://doi.org/10.1016/S0364-0213(83)80017-2