Is a difficult task literally heavy?

Weight biases difficulty judgements

Mirjana Tonković, Mario Brdar, and Kristina Š. Despot

University of Zagreb | University of Osijek | Institute for the Croatian Language and Linguistics, Zagreb

The conceptualization of abstract concepts is very often metaphorical, meaning that we think and talk about abstract concepts in terms of other, usually more concrete experiences. Recent research suggests that many abstract concepts are linked to bodily sensations. In two experiments, we tested a hypothesis about weight as an embodiment of difficulty. We hypothesized that participants wearing a heavy backpack would judge a psychomotor task to be more difficult than participants wearing an empty backpack. We also hypothesized that manipulation of psychomotor task difficulty would affect judgement of backpack heaviness. In line with our hypothesis, the results demonstrated that participants wearing a heavy backpack judged the task to be more difficult. The results of Experiment 2 demonstrated that, regardless of task difficulty, there was no difference in weight judgement when backpack weight was estimated on a 7-point scale. However, we found a difference in the judgement of backpack weight when participants were asked to express it in kilograms, where weight was judged to be lower by participants doing the easy task than by those doing the difficult task.

Keywords: heavy and difficult, metaphor, embodied cognition, primary metaphor, asymmetry, bidirectionality

1. Introduction

Following Aristotle, metaphors have traditionally been viewed as figures of speech, decorations in language with the highest ornamental, symbolic and poetic value that is a privilege of only the most linguistically and literarily talented figures (Fauconnier, 1985; Lakoff & Johnson, 1980; Ungerer & Schmid, 1996). With the establishment of conceptual metaphor theory (Lakoff & Johnson, 1980, henceforth CMT), the importance of metaphor for the 'ordinary' speaker of a language was recognized and an understanding of metaphors as an important part of our conceptual system became widely acknowledged. The view that metaphors are important for the way people encode, store, represent and retrieve concepts, and that thinking about an abstract concept relies on activating relevant metaphorical structures, is now widely accepted, not only in linguistics and literature studies, but in psychological, cognitive, sociological and neural research as well (Bowdle and Gentner, 2005; Gentner & Grudin, 1985; Pollio, Smith, & Pollio, 1990).

According to CMT, conceptualizations of abstract concepts are largely metaphorical (Lakoff & Johnson, 1980), and in the case of primary metaphors closely tied to a relevant perceptual experience (Grady, 1997; Johnson, 1997). The conceptualization of abstract concepts like love, friendship or morality is almost always metaphorical, meaning that people think and talk about these concepts in terms of other (usually more concrete) experiences like warmth, closeness or cleanliness.

Much early criticism of CMT was based on dissatisfaction with the linguo-centric nature of the early theory, which was built using only linguistic evidence, but made assumptions of a much broader scope involving thought and cognition. At the time, there was no evidence outside language that people really *think* using conceptual metaphors (see Gibbs, 2017, p. 168). More recently, many empirical research results are being interpreted as a confirmation of the theory of the embodiment and figurativeness of language and thought[1] (Landau, Meier, & Keefer, 2010). In a large number of experiments, it has been shown that there exists a cognitive link between metaphoric sources and targets, particularly in the cases involving sources and targets of primary metaphors (for an overview see Dancygier & Sweetser, 2014, pp. 36–38). The theory of conflation (Johnson, 1997)[2] and primary metaphor theory (Grady, 1997) are based on the fact that, in all cultures, humans during early childhood develop the connections between co-occurring physical sensorimotor experiences and subjective judgment. This then leads to the conflation of these experiences and the formation of mechanisms for source to target metaphorical mappings (primary metaphors).[3] For example, the fact that we move forward to carry out an intended action results in a strong connection between the concepts of PURPOSEFUL ACTION and FORWARD MOTION, which produces the primary metaphor PURPOSEFUL ACTION IS FORWARD MOTION, a pervasive metaphor in thought and language that determines conceptualizations of event structure.[4]

[1] For an overview of the types of empirical methods used to uncover the psychology of conceptual metaphors in verbal metaphor use, see Gibbs (2017), chapter 5.

[2] Johnson (1997) studied how children acquire metaphors and discovered three stages of acquisition: (1) source domain only; (2) primary metaphors (children learn to use words from the source domain to denote meaning from the target domain); (3) the metaphorical use of words.

[3] According to the neural theory of metaphor, these associations formed during the conflation are actual neural connections between the two brain regions (Lakoff, 2008).

[4] Based on the work of Grady (1997), and in the databases MetaNet (Dodge et al., 2015) and MetaNet.HR (Despot et al., in press), primary metaphors include: AFFECTION IS WARMTH, IMPORTANT IS BIG, HAPPY IS UP, INTIMACY IS CLOSENESS, BAD IS STINKY, DIFFICULTIES ARE BURDENS, MORE IS UP, CATEGORIES ARE CONTAINERS, SIMILARITY IS CLOSENESS, LINEAR SCALES ARE PATHS, ORGANIZATION IS PHYSICAL STRUCTURE, HELP IS SUPPORT, TIME IS MOTION, STATES ARE LOCATIONS, CHANGE IS MOTION, ACTIONS ARE SELF-PROPELLED MOTIONS, PURPOSES ARE DESTINATIONS, PURPOSES ARE DESIRED OBJECTS, CAUSES ARE PHYSICAL FORCES, RELATIONSHIPS ARE ENCLOSURES, CONTROL IS UP, KNOWING IS SEEING, UNDERSTANDING IS GRASPING, and SEEING IS TOUCHING.

The discovery of primary metaphors served as an impulse for introducing experimental methods into metaphor research. This, in turn, provided evidence for the embodied nature of human cognition (cf. Boroditsky, 2000; Casasanto & Boroditsky, 2008; Gibbs, 1984, 2006; Harmon-Jones, Gable, & Price, 2011; Jostmann, Lakens, & Schubert, 2009; Williams & Bargh, 2008a; Zhong & Leonardelli, 2008). These studies have demonstrated that physical experiences can influence abstract processing in a way that can be predicted on the basis of metaphoric associations.

For example, studies have indicated that inducing physical sensations of warmth increased perceived emotional attachment to friends and family members (IJzerman & Semin, 2009), or led participants to perceive others as ‘warmer’ (Williams & Bargh, 2008a). Similarly, cleaning one’s hands can influence the feeling of guilt (Zhong & Liljenquist, 2006) and moral judgment (Schnall, Benton, & Harvey, 2008); manipulation of physical distance can influence perceived psychological distance (Williams & Bargh, 2008b) or evaluative judgments (Cacioppo, Priester, & Berntson, 1993). And spatial position can influence processing of abstract concepts of power (judgment of a group’s power is influenced by the group’s vertical position in space, Schubert, 2005), divinity (people encode God-related concepts faster if presented in a high (vs. low) vertical position, Meier, Hauser, Robinson, Friesen, & Schjeldahl, 2007) or affect (evaluations of positive words are faster for words in the up rather than the down position, whereas evaluations of negative words are faster for words in the down rather than the up position, Meier & Robinson, 2004) (for an overview, see: Landau, Meier, & Keefer, 2010, Meier, Schnall, Schwartz, & Bargh, 2012, or Lee & Schwartz, 2014). Similar predictions can be drawn from the theory of embodied cognition (Barsalou, 2008), which states that cognitive representations are grounded in and shaped by sensorimotor systems.[5] In short, experimental work does show that metaphoric connection is not just linguistic, but also cognitive, because effects of concrete experiences on abstract thought are obtained with no linguistic mention of the source domain (Dancygier & Sweetser, 2014).

Consistent with previous experimental testing of the embodied and cognitive nature of primary metaphors described above, the present paper will examine the entrenchment of the primary metaphor DIFFICULT IS HEAVY in the Croatian language. Based on empirically supported views regarding the cognitive and embodied connection between sources and targets of primary metaphors, we hypothesize that the abstract concept of difficulty is grounded and embodied in the sensory experience of weight and that the concepts from both domains are related to one another by virtue of how people are physically constituted, their cognitive abilities and their interactions with the world (or human embodiment). The conceptual metaphor DIFFICULT IS HEAVY is considered to be a primary metaphor arising from recurring and co-occurring embodied experiences (Grady, 1997) and conflation (Johnson, 1997) of the sensorimotor or perceptual domain (muscular exertion) and the conceptual domain (subjective judgment of difficulty). The experiential basis for this metaphor is the discomfort or disabling effect of lifting or carrying heavy objects (Lakoff & Johnson, 1999), and the fact that difficult things require more mental or emotional effort, more thought, more elaborate thinking or are

[5] There are two sources of controversy related to embodiment and metaphor research. The first one relates to failed attempts to replicate some (but not all) of the most popular experiments in this field (e.g., Lynott, Corker, Wortman, Connell, Donnellan, Lucas, & O'Brien, 2014). The second issue refers to the general conclusion that evidence of metaphorical representation necessarily implies that mental metaphors are embodied in modality specific simulations. Contrary to this notion, neuroimaging studies do not always confirm that source-domain representations are detected in modality-specific areas of the brain corresponding to the linguistic or cognitive process of interest (Casasanto & Gijssels, 2015). However, a full discussion of the debate surrounding these issues is beyond the scope of this paper.

more cognitively demanding. We can therefore hypothesize that the abstract concept of difficulty is grounded and embodied in the sensory experience of weight.

1.1 Connection between bodily experience of weight and cognitive or emotional states

Two groups of experimental studies have focused on the association between the physical experience of weight and the cognitive or emotional experiences of difficulty respectively. Ackerman, Nocera and Bargh (2010) demonstrated that basic tactile sensations influence higher social cognitive processing. Specifically, participants who held a heavy clipboard while evaluating a job candidate's resume, rated the candidate more positively and as displaying more serious interest in the position. Furthermore, the physical experience of weight led participants to consider their task more important than they otherwise would have done. Similarly, Jostmann, Lakens and Schubert (2009) found that participants who held a heavy clipboard rated various issues as more important relative to those who made their ratings while holding a light clipboard. Holding a heavy clipboard also caused more elaborate thinking. Because weight and importance are connected through the embodied conceptual metaphor IMPORTANT IS HEAVY, people also view important things as more memorable (Libkuman et al., 2007). Alban and Kelley (2013) tested whether participants' perceptual experience of weight would increase their metacognitive judgments of learning. In line with their hypothesis, participants gave higher judgments of learning for words presented on a heavy clipboard or heavy pillow compared to words presented on a light clipboard or light pillow. At the same time, actual performance on memory tests was not affected by weight. As an alternative interpretation of the relationship between weight and judgments of learning, the authors note that lifting different weights may have embodied the investment of unequal amounts of mental effort.

Kouchaki, Gino & Jami (2014) have shown that the physical experience of weight is associated with the emotional experience of guilt. Participants who wore a heavy backpack experienced higher levels of guilt than those who wore a light backpack, and also processed guilty stimuli more fluently. More importantly, Slepian, Masicampo, Toosi and Ambady (2012) demonstrated that bearing secrets influences perception and action in a manner consistent with the conceptual metaphor SECRETS ARE BURDENS. In this study, the more thought was devoted to a secret; the more perception and action were influenced in a manner similar to carrying physical weight.

In this overview of previous research, it can be noted that all these studies have either examined the embodiment of the primary metaphor IMPORTANT IS HEAVY or the embodiment of complex metaphors such as SECRETS ARE BURDENS, or GUILT IS A BURDEN. These complex metaphors are derived from the primary metaphor DIFFICULT IS HEAVY by virtue of either the source or target subcase or both. However, none of these studies has been focused on the embodiment of the primary metaphor DIFFICULT IS HEAVY itself. As such, we have examined the direct association between the abstract concept of cognitive difficulty and the sensory experience of weight in the present study. In two experiments, we tested the hypothesis about weight as an embodiment of difficulty.

1.2 Assumptions

Based on the studies reported above, we expect that manipulation of the amount of weight placed on participants' shoulders will influence their judgment of difficulty of a presented task, regardless of their actual achievement on the task.

Moreover, we expect that the effects might exhibit bidirectionality, i.e. that the concepts of heaviness and cognitive difficulty could mutually activate one another. This is in part because bidirectionality has been well supported in previous similar experiments (Lee & Schwartz, 2012), but even more so because, in the Croatian language, a single adjective (*težak*) expresses both the concept of heaviness and cognitive/emotional/psychological difficulty and a single antonym adjective (*lagan*) expresses the concepts of ease and lightness. These adjectives are also used in related metaphors (e.g., IMPORTANT IS HEAVY). While other languages might have two pairs of lexical items for these concepts (e.g., in English, *heavy* vs *difficult* and *light* vs *easy*), the Croatian language seems especially appropriate for an exploration of the embodiment of cognitive difficulty through weight in the primary metaphor DIFFICULT IS HEAVY. In addition to behavioral research results that support such bidirectional effects, this linguistic characteristic of the Croatian language prompted the hypothesis that the connection between (COGNITIVE) DIFFICULTY as a target of the primary metaphor and WEIGHT as its source is not only embodied, but that it also might exhibit bidirectional effects. Therefore, we examined both concrete-to-abstract and abstract-to-concrete effects in this study and expected to observe effects in both directions.

Additionally, because most related research has been conducted on the English language, an important contribution of the work presented in this paper is the testing of hypotheses derived from conceptual metaphor theory and embodied cognition among native speakers of language families other than English.

It was important to choose a task in which participants would not gain a clear idea of their own achievement. In a task in which participants know how successful they have been, judgement of task difficulty would be based on objective performance and would therefore not leave room for any effect of manipulating the physical weight placed on participants' shoulders. Therefore, a psychomotor task – target tracking – was used. This task also allowed for the manipulation of task difficulty in Experiment 2.

In short, we hypothesized that participants wearing a heavy backpack would judge a presented psychomotor task to be more difficult than participants wearing an empty backpack. We also hypothesized that manipulation of psychomotor task difficulty would affect judgment of backpack heaviness, thus revealing bidirectional effects.

2. Experiment 1

Experiment 1 examined the impact of physical weight on judgement of psychomotor task difficulty. We hypothesized that participants carrying a heavier burden would judge the task to be more difficult than those doing the same task without any appreciable burden, regardless of their actual achievement during the task.

2.1 Method

2.1.1 *Participants.*

40 (20% male) students from the University of Zagreb, Faculty of Humanities and Social Sciences participated in the experiment. For some students (all of whom were from the Department of Phonetics), participation in empirical research was a requirement of their study program and, as such, they were rewarded with a course credit for their participation. Students were recruited through an online advertisement or

were approached by the experimenter's assistant. Because we hypothesized that students of psychology might be more suspicious of an experimental procedure that involved deception, none of the participants in the present study were students of psychology. Participants were randomly assigned to one of two experimental conditions (wearing an empty or heavy backpack). The two groups were equal in size ($N = 20$) and did not differ in height (empty backpack: $M = 172.5$, $SD = 6.50$; heavy backpack: $M = 171.1$, $SD = 9.33$; $t(38) = 0.6$; $p = .579$), weight (empty backpack: $M = 62.8$, $SD = 12.58$; heavy backpack: $M = 66.2$, $SD = 13.56$; $t(38) = 0.8$; $p = .416$), body mass index (empty backpack: $M = 21.0$, $SD = 3.34$; heavy backpack: $M = 22.5$, $SD = 3.07$; $t(38) = 1.4$; $p = .166$) or gender (20% male in both groups). None of the participants had a disproportionally low or high BMI according to standard medical classification (below 16 or above 30).

2.1.2 *Design and procedure.*

Upon being invited to participate, participants were told that a new computer test of psychomotor skills was being developed. When they agreed to take part in the experiment, they were also informed that they could simultaneously take part in another, unrelated study conducted by the Department of Psychology in conjunction with a Physiotherapy course offered by the Health College and, should they agree to participate, the only thing that they needed to do was to wear a backpack for a couple of minutes and then judge its ergonomic features. Informed consent was obtained from all individual participants included in the study. The weight of the backpack worn by participants was manipulated, where one group ($N = 20$) wore a light (empty) backpack, weighing approximately 100g, while the other group ($N = 20$) wore a heavy backpack weighing 5kg. While sitting on a stool in front of a computer and wearing the backpack on their backs, the participants' task was to follow a target on the computer screen. The task was a shortened and modified version of the publicly available script for visuomotor tasks (Spapé & Serrien, 2010), programmed in the E-Prime 2.0 software (Psychology Software Tools, Pittsburgh, PA). The participants were asked to use a mouse (medium size dot on the screen) to follow as closely as possible a small black dot moving on the screen towards and away from a large black dot. The small dot moved relatively slowly and was therefore easy to catch or intercept, but because it was fairly small and the mouse relatively cumbersome to use, participants always lagged a little behind the small black dot.

After the task was finished (4 minutes), participants were asked to take off the backpack and judge the difficulty of the task on a scale from 1 (very easy) to 7 (very difficult) and their performance on the task on a scale from 1 (very bad) to 7 (very good). This was followed by a short questionnaire about the backpack. At the beginning of the questionnaire, there were questions about participant's gender, height and weight, followed by an estimation of backpack heaviness on a scale from 1 (very light) to 7 (very heavy), an estimation of backpack heaviness in kilograms as compared to a bag placed next to the participant (depending on the experimental condition, the weight of this bag was either 0.1 kg or 5 kg), and a few questions about the ergonomic features and likability of the backpack. Participants' body mass index was calculated on the basis of reported height and weight. Estimation of backpack heaviness on the 7-point scale and in kilograms served as a manipulation check, while the remaining questionnaire items were included to support the cover story about the parallel experiment in which participants believed they were participating. These additional questions included estimations of backpack comfortability, likeability and appropriateness for carrying a burden (on a scale from 1 to 7) and one open-ended question about possible purposes of the backpack. No further variables were measured. Following completion of the questionnaire, the experimenter asked participants whether they were suspicious about the true purpose of the experiment and what they thought was the hypothesis. None of the participants could guess the hypothesis or make any plausible connection between two studies they thought they had participated in. Participants were then thanked for their participation and debriefed.

2.2 Results

Descriptive statistics of the obtained results are presented in Table 1. As a manipulation check, we compared estimations of backpack heaviness for the two experimental groups. The results revealed the expected difference in heaviness judgments, both when it was estimated on a 7-point scale ($t(38) = 13.8$, $p < .01$ *Cohen's d = 4.35*) and when it was estimated in kilograms ($t(38) = 7.01$, $p < .01$; *Cohen's d = 2.22*).

Table 1. Means (and standard deviations) for estimates of task difficulty, subjective and objective performance and backpack heaviness by experimental condition

	Experimental condition	
	Empty backpack	Heavy backpack
	M (SD)	*M (SD)*
Task difficulty	2.8 (1.33)	3.9 (1.80)
Subjective performance	3.7 (1.38)	3.3 (0.85)
Objective performance	49.8 (20.76)	45.7 (17.45)
Backpack heaviness	1.5 (0.61)	5.2 (1.04)
Backpack heaviness (in kg)	0.4 (0.60)	4.9 (2.79)

A comparison of the average estimates in the two experimental conditions demonstrates that participants wearing a heavy backpack judged the task to be more difficult than participants wearing an empty backpack ($t(38) = 2.29$, $p < .05$, *Cohen's d* = 0.73). At the same time, there was no group difference in participants' subjective judgment of performance ($t(38) = 1.24$, $p = .222$), nor in objective task performance. Objective performance was measured by the computer as the average distance between dots (in pixels) throughout the task, where a smaller distance indicates better performance. According to this measure, both groups performed equally well on the task ($t(38) = 0.68$, $p = .499$).

As shown in Table 2, **c**orrelations between the measured variables further confirm our hypothesis. Due to a deviation from normal distribution of the variables that were manipulated (i.e. backpack heaviness), we calculated non-parametric correlation coefficients. Here, task difficulty was significantly correlated with estimated backpack heaviness, while subjective and objective performance were not.

Table 2. Spearman's rank correlation coefficients between all measured variables in Experiment 1

	Task difficulty	Subjective performance	Objective performance	Backpack heaviness
Subjective performance	-.324*			
Objective performance	.315*	-.471**		
Backpack heaviness	.408**	-.198	.023	
Backpack heaviness (in kg)	.385*	-.197	.043	.881**

* $p < .05$; ** $p < .01$

3. Experiment 2

Experiment 2 examined the impact of the degree of psychomotor task difficulty on the judgement of physical burden, i.e. the weight of the backpack. It was expected that participants performing a more difficult task would judge the burden to be higher, i.e. the backpack to be heavier, than those performing an easier task.

3.1 Method

3.1.1 *Participants.*

As in Experiment 1, 40 (50% female) volunteers from the University of Zagreb participated in Experiment 2. Participants were mostly from the Faculty of Humanities and Social Sciences, where the experiment was carried out, while others were from the Faculty of Economics and Business. No participants in Experiment 2 had participated in Experiment 1 and none were psychology students. Participants were recruited via an online advertisement or were approached by the experimenter's assistant. Participants were randomly assigned to one of two experimental conditions (performing an easy or difficult version of the psychomotor task). The two groups were equal in size (N = 20) and did not differ in height (easy task: M = 175.4, SD = 11.75; difficult task: M = 176.3, SD = 8.20; $t(38)$ = 0.3; p = .780), weight (easy task: M = 72.7, SD = 16.75; difficult task: M = 69.5, SD = 10.38; $t(38)$ = 0.7; p = .475), body mass index (easy task: M = 23.3, SD = 3.75; difficult task: M = 22.3, SD = 2.38; $t(38)$ = 1.1; p = .298) or gender (55% male in the easy task group and 45% male in the difficult task group; χ^2 (1, N = 40) = 0.4; p = 0.752). None of the participants had a disproportionally low or high BMI (below 16 or above 34) [6].

3.1.2 *Design and procedure.*

The difficulty of the psychomotor task (following a dot on the screen) was manipulated. One group (N = 20) performed an easy version of the task, while the other group (N =

[6] According to standard medical classification a BMI above 30 falls in the category of obesity class I. There was one participant with a BMI above 30. Analyzing the data without that participant did not change arithmetic means or the results of the significance testing presented in the following paragraphs.

20) performed a more difficult version. Informed consent was obtained from all individual participants included in the study. The cover story presented to participants was the same as that used in Experiment 1.

All participants wore the same backpack, weighing 2.5kg, and were again instructed to follow a target on the computer screen. The task was identical to the task used in Experiment 1, except that the speed of the dot was manipulated in order to make it easier or more difficult. The speed of the dot in the difficult version was such that it was virtually impossible to 'catch' the dot, while the speed of the dot was quite slow in the easy version. In both the easy and difficult conditions, the task lasted 4 minutes. After the task was finished, participants were asked to remove the backpack and complete a questionnaire. After answering questions about their gender, weight and height, participants judged the weight of the backpack on a scale from 1 (very light) to 7 (very heavy) and then estimated the weight of the backpack in kilograms, as compared to a bag weighing 2.5 kg that was placed close to the participant. This was followed by a few questions about the ergonomic features and likability of the backpack. Participants' estimation of the heaviness of the backpack on a 7-point scale and in kilograms served as a measure of the dependent variable, while the remaining questions were included to support the cover story regarding the parallel experiment in which the participants thought they were participating. These additional questions included estimations (on a 7-point scale) of backpack comfortability, likeability and appropriateness for carrying a burden, as well as a single open-ended question about possible purposes of the backpack. Finally, participants answered two questions about the task: how difficult it was and how well they performed it. These questions served as a manipulation check. The questions included in the questionnaire were the same as those used in Experiment

1, but were presented in a different order. In Experiment 2 questions about the backpack were presented first, followed by questions about the task. On the basis of participants' reported height and weight, we calculated body mass index. No further variables were measured. As in Experiment 1, the experimenter asked participants what they thought was the hypothesis of the experiment. Again, none could guess or make any connection between two studies they thought they had participated in. At the end of the procedure, participants were thanked for their participation and debriefed.

3.2 Results

Descriptive statistics of the results obtained in Experiment 2 are presented in Table 3. As expected, a manipulation check indicated that participants performing an easy task estimated task difficulty to be lower than those performing a difficult task ($t(38) = 3.7$, $p < .01$, *Cohen's d* = 1.17). The same was true for participants' subjective judgement of performance ($t(38) = 3.46$, $p < .01$, *Cohen's d* = 1.10), as well as an objective measure of performance ($t(38) = 4.44$, $p < .01$, *Cohen's d* = 1.39).

Table 3. Means (and standard deviations) for estimates of backpack heaviness, task difficulty and subjective and objective performance by experimental condition

	Experimental condition	
	Easy task	Difficult task
	M (SD)	*M (SD)*
Backpack heaviness	2.7 (1.04)	2.8 (0.95)
Backpack heaviness (in kg)	2.2 (1.13)	3.3 (1.50)
Task difficulty	2.3 (1.07)	3.7 (1.31)
Subjective performance	4.1 (0.79)	2.9 (1.33)
Objective performance	30.4 (11.23)	57.3 (25.03)

Analyses demonstrated that there was no difference in participants' judgement of backpack weight, regardless of whether they performed an easy or difficult task. On a 7-

point scale, participants in both the easy and difficult task groups judged the backpack to be below a medium heaviness level. The difference between groups on this item was not significant ($t(38) = 0.48$, $p = .637$). However, there was a difference in judgement of backpack weight when participants were asked to express their estimate in kilograms (as compared to a 2.5 kg bag placed next to participants). Here, the backpack's weight was judged to be lower by participants performing the easy task than by those performing the difficult task ($t(38) = 2.65$, $p < .05$, *Cohen's d* = 0.83).

Again, correlation coefficients confirm the results of the t-tests. Estimation of backpack heaviness in kilograms was related to judgement of task difficulty, while estimation of heaviness on a 7-point scale was not. The correlation matrix is presented in Table 4.

Table 4. Spearman's rank correlation coefficients between all measured variables in Experiment 2

	Backpack heaviness	Backpack heaviness (in kg)	Task difficulty	Subjective performance
Backpack heaviness (in kg)	,085			
Task difficulty	.170	.447**		
Subjective performance	.034	-.097	-.427**	
Objective performance	.054	.338*	.324*	-.335*

* $p < .05$; ** $p < .01$

4. Discussion

In the first experiment, we examined the effect of manipulating the weight placed on participants' shoulders on their judgment of psychomotor task difficulty. Consistent with our expectations, participants wearing a heavy backpack judged the task to be more difficult than participants wearing an empty backpack. The observed effect falls in the range of a medium effect size (Cohen, 1992). Both objective and subjective performance on the task were the same for both groups of participants, suggesting that it was the physical experience of weight that led participants to consider the task more difficult than they otherwise would have done.

In the second experiment, we manipulated task difficulty and observed differences in estimation of backpack weight. Although we did not find any differences in judgements of backpack weight when estimated on a scale from 1 (very light) to 7 (very heavy), participants who completed an easier version of the task gave lower estimates than participants who completed a more difficult version of the task when estimating the weight of the backpack in kilograms. This effect of task difficulty on heaviness perception was somewhat larger than the effect of backpack heaviness on perception of task difficulty observed in Experiment 1, falling in the range of a large effect size (Cohen, 1992). Although the difference observed between estimation of backpack weight on a 7-point scale and estimation of its weight in kilograms might be somewhat surprising in light of the fact that these are two similar dependent variables, a possible explanation for this difference probably lies in the fact that participants had a reference point when making judgments in kilograms. In this case, their task was to estimate the backpack’s weight in kilograms by comparing it to a 2.5 kg bag. In contrast, when judging weight on a scale for which only the extreme points were defined (1=very light and 7=very heavy), participants likely assumed that the middle point meant ‘neither light nor heavy’. We would argue that the 2.5 kg backpack participants in the ‘heavy’ group wore on their shoulders was in fact neither light nor heavy, which is probably why participants predominantly estimated the backpack’s heaviness to fall below the middle point of the scale, regardless of the experimental condition. On the other hand, comparing the backpack with a 2.5 kg bag represented a more straightforward task.

Here, we might hypothesize that participants simply decided whether the backpack on their shoulders was lighter or heavier than 2.5 kg and, according to this decision, made an estimation in kilograms. As such, this decision could have been under the influence of the independent variable – task difficulty.

The observed differences in both experiments cannot be ascribed to the differing physical constitutions of participants in the two groups, because no differences were found in their height, weight or BMI. However, manipulation with the weight using backpacks could be problematic. Durgin et al. (2009) demonstrated that backpack effects could be judgmental biases that result from the social demands of the experimental context. Participants in the experiment made an estimation of the slope in degrees and the highest estimates were given by participants who correctly guessed that the heavy backpack was intended to affect their perception. On the other hand, when persuaded that backpack served another purpose, participants' slope estimates were no different from those of participants not wearing a backpack. Although similar concern about participants guessing the intention of wearing the backpack could be raised in the case of our experiment, we believe that this explanation of the obtained results is not very likely. Backpack heaviness could be more easily related to the slope estimation than to the task difficulty estimation. Both judging heaviness and slopes are perceptual tasks, while judging task difficulty is primarily a cognitive task. Furthermore, when explicitly asked, none of our participants guessed the hypothesis. Nevertheless, future experiments using backpacks, as well as any experiment including deception should carefully control the effects of experimental demand characteristics.

In line with our hypothesis, our experiments demonstrated that concepts of WEIGHT and DIFFICULTY are connected and that the more concrete sensory experience of heaviness remains part of the abstract representation of difficulty. In Experiment 1, we found that the physical experience of weight can activate the concept of difficulty among Croatian participants. However, as indicated by the results of Experiment 2, it is not absolutely clear that an increase in difficulty necessarily leads to a *subjective* feeling of increased weight, but rather that an increase in task difficulty led to an increased estimation of backpack weight in kilograms, thus suggesting bidirectional effects.

It should be noted that, by using a psychomotor task, the task performed by participants had a motor component and was not a purely cognitive task. This type of task was chosen in order to avoid the possibility that participants would be able to easily judge the difficulty of the task based solely on their own performance. In the target-tracking task, it was harder for participants to estimate their own objective performance than it would have been on a purely cognitive task, where objectively good or poor performance is usually more obvious. A second important feature of the task was its flexibility in terms of difficulty level. In the present study, three difficulty levels were required – an easy and difficult level for Experiment 2 and a middle difficulty level for Experiment 1. This kind of task allowed us to manipulate difficulty level according to the needs of each experiment. Future research should explore the same hypotheses using a different task with a more pronounced cognitive aspect. It should also be noted that an important limitation of this study lies in the small number of participants. Future research should attempt to replicate these findings using larger sample sizes.

Our experiments have demonstrated that the primary metaphor DIFFICULT IS HEAVY is embodied and that it exhibits bidirectional effects (as has been shown for other primary metaphors, such as AFFECTION IS WARMTH, MORALITY IS CLEANLINESS, IMPORTANCE IS WEIGHT, POWER IS UP, and GOOD IS UP). Our results are thus in line with the results of previous research on this topic, such as Lee and Schwartz (2012, p. 10), who argue that "online processing of a representational structure (a conceptual metaphor) can produce psychological consequences that are independent of linguistic patterns and potentially mediated by co-activation".

Bidirectional effects revealed in our study raise questions regarding the validity of the assumption of the unidirectional nature of conceptual metaphors (a common assumption arising from CMT; Lakoff & Johnson, 1999). Similar bidirectional effects have previously been found between concepts of weight and importance (Schneider, Parzuchowski, Wojciszke, Schwarz, & Koole, 2015; Schneider, Rutjens, Jostmann, & Lakens 2011), social exclusion and ambient physical temperature (Szymkow, Chandler, IJzerman, Parzuchowski, & Wojciszke, 2013; Zhong & Leonardelli, 2008) and affect and brightness (Meier, Robinson, Crawford, & Ahlvers, 2007), to name just a few. Because these studies examine either concrete-to-abstract or abstract-to-concrete effects, but not both, the bidirectionality of (primary) metaphors did not become obvious until Lee and Schwartz (2012) compared the results of all behavioral research and arrived at this conclusion. These results have often been interpreted as evidence for the invalidity of CMT, especially in relation to its approach to the irreversible source-target directionality of conceptual metaphors.

In this debate, our position is consistent with the previous arguments of Lee and Schwartz (2012, p. 10), who have stated that "contrary to a common misinterpretation, these bidirectional effects *are compatible* with conceptual metaphor theory". The fact that source and target concepts mutually activate each other does not change the fact that thought shaped by these connections and metaphoric mappings are not reversible (Dancygier & Sweetser, 2014, p. 30–31). Namely, we use sources to make sense of targets and not the other way around. Sources also usually belong to more concrete physical or sensory domains.[7] As Lee and Schwartz (2012) further argued, concrete domains involve more direct sensorimotor experiences, are acquired earlier in life, are easier to understand and have greater inferential richness and capacity than abstract domains. This explains why we use concrete concepts to talk about abstract ones and not the other way around. Therefore, the idea of unidirectional, asymmetric mapping remains basic to metaphor.[8]

Other theories of embodied cognition can also account for bidirectionality effects. Because representation of an abstract concept contains a physical experience, activation of an abstract concept can, through a process of simulation, activate the physical experience and vice versa (Barsalou, 1999; 2008). In other words, sensorimotor experiences and cognition are in dynamic interaction and “because knowledge is represented in bodily states or sensorimotor modalities, processing sensorimotor information should activate conceptual knowledge (concrete-to-abstract effects), and processing conceptual information should invoke the bodily states or sensorimotor modalities in which it is represented (abstract-to-concrete effects)” (Lee & Schwartz, 2012, p. 10). A recent study by Slepian & Ambady (2014) demonstrated abstract-to-concrete effects of novel and newly-learned metaphor created in the laboratory, suggesting that prior physical experience is not necessary for an abstract concept to have embodiment effects. Their work also suggests that embodied outcomes of a metaphor might be under the influence of knowledge about the metaphor. Therefore, effects observed in our experiments might be more pronounced in the Croatian sample

[7] This is more true of primary and general metaphors, and less so for more specific and complex metaphors.
[8] The neural theory of metaphor (Lakoff, 2008, p. 28) offers a plausible explanation for asymmetry of primary metaphors.

because the Croatian language uses a single adjective (*težak*) to express concepts of heaviness and difficulty. In the future, it would be interesting to compare the results of our experiments against the results obtained with populations of persons with varying linguistic backgrounds. More specifically, it would be useful to include languages that, instead of using a single adjective, use pairs of adjectives. In such adjective pairs, one member of the pair is semantically opaque, as far as the concept of weight is concerned.

5. Conclusions

Unlike other similar research examining complex metaphors (or source/target subcases) of the DIFFICULT IS HEAVY metaphor (e.g., Kouchaki, Gino & Jami, 2014) or the cognate primary metaphor IMPORTANT IS HEAVY (e.g., Jostmann, Lakens & Schubert, 2009), we have directly examined the primary metaphor DIFFICULT IS HEAVY in the present study. In addition, we have examined both concrete-to-abstract and abstract-to-concrete effects. In line with our hypothesis, our experiments demonstrated that one's sense of weight and difficulty are connected and that the concrete sensory experience of heaviness remains part of our representation of the concept of difficulty. We have demonstrated the existence of a clear concrete-to-abstract effect and a somewhat less clear abstract-to-concrete effect. As such, it is reasonable to argue that there is an embodied bidirectional link between the concepts of HEAVINESS and DIFFICULTY. Activation of the experience of weight significantly influenced mental simulation and abstract thought. We believe that these results are compatible with the basic tenets of conceptual metaphor theory, and theories of embodied cognition and, as such, are in line with contemporary research (Barsalou, 2008; Dancygier and Sweetser, 2014; Gibbs, 2017; Lakoff, 2008; Landau, Meier, & Keefer, 2010; Lee and Schwartz 2014).

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Address for correspondence

Mirjana Tonković
Faculty of Humanities and Social Sciences
University of Zagreb
I. Lučića 3
10000 Zagreb
Croatia

mirjana.tonkovic@ffzg.hr

Biographical notes

Mirjana Tonković is assistant professor at the Department of Psychology, Faculty of Humanities and Social Sciences, University of Zagreb. Her research interests are cognitive experimental psychology, psychology of language and mental representation of abstract concepts.

Mario Brdar is full professor at the Department of English Language and Literature, Faculty of Humanities and Social Sciences, University of Osijek. His research interests are cognitive linguistics, syntax, word formation and lexical semantics.

Kristina Š. Despot is research professor at the Institute for the Croatian Language and Linguistics. Her research interests are cognitive linguistics, conceptual metaphor theory and neural theory of language.