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Size vs. Material: testing possible implicit associations with expected weight

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TABLE OF CONTENTS

ABSTRACT

The purpose of this thesis is to illustrate a research on weight illusions that I conducted under the supervision of dr. Michele Vicovaro (Department of General Psychology, at University of Padua).

We investigated the possibility of implicit association mediating the effects of respectively the size weight illusion (SWI) and the material weight illusions (MWI), to see if the hypothesis of the expectation model, currently the most widely accepted account for these illusions, could still be considered valid despite the fact that it cannot explain several dilemmas arising when comparing the two illusions. The hypothesis of this implicit mechanisms mediating the illusions was first advanced by Buckingham (2014) but has never been tested empirically until now.

In order to test this hypothesis, we devised and administer three experiments using the IAT, a test designed to measure the strength of the implicit associations the subject has while reacting to a set of stimuli. In the first two experiments the aim was to see if the implicit association hypothesis could explain the two illusions separately, while in the third one we combined the two properties to see if it could as well explain the problems arising when comparing the two properties together.

In this dissertation we start by reviewing the existent literature regarding both the illusion and the IAT and then analyzed the data obtained through the experiments to test our hypothesis.

INTRODUCTION

The study of perceptual illusion can give us a great deal of knowledge about the "nature of the psychological mechanisms that allow people to adaptively perceive, internally represent, and behaviorally respond to the properties of their environment" (A.J.M Dijker, 2008). In this context, weight illusions, which refer to a particular type of perceptual illusions in which the weight of an object is misperceived relatively to the weight of other objects, are particularly valuable as they shed light on particularly complex perceptual mechanisms given that inferences on weight are influenced by various physical properties as density, material composition and even social and motivational cues that can be discovered and measured through behavioral manipulation of objects (Saccone, Landry , Choinard, 2019; Dijker, 2008). As an example, Amazeen and Turvey (1996) demonstrated that perceived weight was influenced by the distribution of mass of the object by varying the rotational inertia of some long rods to which they attached weights on different locations. In their experiment they had participants holding and manipulating the rods and subsequently rate their heaviness. Analyzing their results, they concluded that the distribution of mass, and consequent rotational inertia, has a stronger influence on the perception of weight than mass alone.

The most studied of all weight illusions are:

- The Size-Weight Illusion (SWI; Charpentier, 1891) which refers to the phenomenon where objects that are objectively equal in weight but different in size or volume are perceived such that the smaller objects feel heavier than the larger ones.

- The Material-Weight Illusion (MWI; Seashore, 1899) which refers instead to the phenomenon whereby two objects objectively of the same physical weight but different surface materials are perceived such that the object with the less dense surface material (e.g.,polystyrene) feels heavier than the object with the denser surface material (e.g., wood).

The most widely accepted account for these illusions, among several existing explanations, is the Expectation Model (Flanagan et al 2008; Ross, 1969), stating that it is the discrepancy between the expectations the subject has of the weight of the object manipulated and the actual weight perceived after the manipulation happened that creates the illusion of weight. This seems to be true regardless of whether we consider the SWI or the MWI, but it does not succeed in explaining some dilemmas that arise when we compare the two illusions or when we investigate the role of different sensory modalities in exerting the illusion considered.

For instance, it does not explain why, although material seems to exert a stronger influence on weight expectations prior to lifting, ultimately the results of experiments lead by Vicovaro and Burigana (2017) comparing the participants' ratings of expected weight in both the material and size condition versus the perceived weight after the object was lifted "demonstrated that size influenced perception more strongly than material despite the stronger predictive value of the latter on the expected weight" (Saccone, et al 2019).

Furthermore, the Expectation Model does not explain the varying degrees of influence that different sensory modalities exert on SWI. As a matter of fact, it has been shown through different studies that the illusion is stronger when information is gathered through the somatosensory system than when it is obtained by visual representation only (Ellis & Lederman, 1993). This phenomenon cannot be explained by top-down processes, as the expectation model attempts to do, so there must be another explanation to it.

In order to save the Expectation Hypothesis, Buckingham (2014; see also Buckingham & Goodale, 2013; Buckingham & MacDonald, 2016) advanced the proposal of possible implicit associations mediating the effect, rather than explicit ones (the reported expectation of a particular physical property influencing the perceived weight). This implicit expectation would then be influenced more by size than by material, explaining why the former appears to exert a stronger illusion than the latter.

To test this hypothesis, we devised and administered three different experiments using the Implicit Association Test (IAT; Greenwald et al 1998), a useful tool to measure implicit associations that are not consciously evident to the subject.

In order to find out if such implicit mechanism exists, we used the IAT first to measure the strength of the implicit association respectively for the size variable and for the material variable, such that an implicit expectation mediating the illusion should be observed in both conditions separately. Moreover, the third experiment is devised such that the two conditions (size and material) are put in contrast with each other. In this case, if the implicit association model works as a general explanation for both weight illusions, we should observe a stronger influence of size mediating the phenomena.

We start by giving a brief overview of the existing literature for both weight illusions and the IAT and then we follow through presenting our experiments and the findings.

CHAPTER 1

1.1 A BRIEF INTRODUCTION TO SWI AND MWI

Research into perceptual illusions has often provided us meaningful insights into the functioning of the human brain. As a matter of fact, not only they can tell us where the limits of our perception of the reality and the world around us are, they can also tell us how our cognition developed in order to quickly analyze the world around us and select the quickest and most reliable way to interact with it. In this contest of research "weight illusions demonstrate how our conscious experience of an object's weight is subject to influence by its other features. For example, "size (Charpentier, 1891), material composition (Seashore, 1889; Wolfe, 1898), distribution of mass (Amazeen & Turvey, 1996), shape (Dresslar, 1894; Kahrimanovic, et al. 2011), and color (De Camp, 1917; Walker, et al. 2010) are known to influence an object's perceived weight. This line of research points to a complex process by which the brain considers multiple types of visual and somatosensory information to make sense of an object's weight." (Saccone et al., 2019).

As previously stated, of all these features influencing our miss-perception in weight illusions, the most investigated ones are size in the Size-Weight Illusion (SWI) (Charpentier,1891), which is the strongest and most studied one, and material in the Material-Weight Illusion (MWI) (Seashore, 1889; Wolfe, 1898).

The SWI is a weight illusion in which, when lifting two objects of equal mass, participants perceive the smaller as being heavier than the larger one, apparently contradicting what we intuitively would assume from our experience (in which bigger objects are typically heavier than smaller objects). The illusion seems to be the strongest compared to the other weight illusions, as size seems to have a deeper influence on our understanding of an object's weight (Saccone & Chouinard, 2018). Furthermore, the illusion strongly persists even after the subjects are told the objects weight the same (Flournoy 1894) and it does not diminish with repeated trials of interactions with the objects (Chouinard et al. 2009). Furthermore, a SWI can be induced either from haptic feedback, hence by the sense of touch alone, or by visual feedback of the size differences, like by lifting the object trough a medium like a handle attached to the object or a string. Plaisier and Smeets (2012) demonstrated that lifting is not even required to experience the illusion: it can be induced even by pushing the objects that are attached to strings. Moreover, it is noteworthy that it is apparent size rather than actual size to produce a SWI as Buckingham and Goodale (2010) demonstrated that the expectation of weight based on previously viewed stimuli overrode the kinesthetic input that came after lifting the actual object while blindfolded. As we will dwell into the explanation, we will see the importance of expectations when talking about weight illusions. Finally another interesting aspect of SWI is that "the association between size and weight are thought to be reinforced during our lifetime, given that size often serves as a reliable cue about an object weight" (Chouinard, Saccone 2018), and as a matter of fact, developmental researches on the illusion are increasingly supporting the hypothesis that innate processes may play a key role in its strong influence (Robinson, 1964; Kloos & Amazeen, 2002).

The MWI is the second most studied weight illusion and it refers to the phenomenon whereby, when two objects of the same physical weight but different surface materials are wielded, the object with the apparently lighter material (e.g. polystyrene) usually feels heavier than the object with the supposedly heavier material (e.g. iron, Seashore, 1899). Although it has been established that the illusion has a smaller effect size than the SWI (Buckingham & Goodale, 2013), it still proves a reliable illusion and an especially useful one in understanding the role of expectation in weight illusion. As a matter of fact, as we will see in detail when analyzing the different explanatory theories behind weight misperceptions, the MWI is perfectly described by a conceptual expectancy account in which it is the discrepancy between our expectation, based on previous knowledge of materials and densities, and our ultimate experience when dealing with the objects that create the illusion (Buckingham, et al, 2010).

1.2 THE UNIQUENESS OF SIZE IN EXERTING WEIGHT ILLUSIONS

As noted by Saccone, et al. (2019) what appears evident in the comparison of the two illusions is not only how "SWI is robust regardless of which sensory modality processes size information" and that "size–weight associations are deep-seated and that their influence still remains even after intensive training aimed to abolish their influence", but also how the comparison to the MWI leads to the conclusion that the former is a stronger illusion. This supports several studies in which the two illusions are measured together as for example did Buckingham, et al. (2015) in a neuropsychological investigation in which the control group experienced a SWI in 95.8% of trials but a MWI in only 35.1% of trials. Similar results were previously obtained by further experiments by Buckingham and Goodale (2013) in which they proved that the participants felt a greater difference in perceived weight between the size condition than between the material one. Naturally, given the results of these studies, the question of whether these differences are due to a stronger prediction value of size over material has been subsequently tested. Vicovaro and Burigana (2017) devised a series of experiments in which participants were asked to rate their expectation of weight of objects varying in size and/or apparent material before and after lifting them. Interestingly, what they found is that while expectation prior to lifting seemed to be indicate that the material condition would result in a more pronounced effect than by the size one, ultimately after the lifting size seemed to exert a stronger effect on the resulting misperception. Thus, their results, along with the studies previously cited (Buckingham & Goodale, 2013; Buckingham, et al. 2015), seems to prove that size influences perception more strongly than material despite the stronger predictive value of the latter on the expected weight. These findings pose a dilemma if we consider the theories that attributes the explanation behind weight illusion to the role of prior expectation.

Still, when we compare the two illusions it is noteworthy the scarcity of studies on MWI in respect to the ones on SWI. As a result, it is not to be underestimated the possibility that further investigation on the former could possibly make us understand better the mechanisms behind it, especially with a wider range of materials, as well as give us more data that could allow us to compare the two illusions in order to recognize whether or not the effect sizes are similar.

Last it should be noted that evidence of size being unique in its ability to influence weight perception can be found also in the way that size is processed visually by the brain, as compared to other object features that have associations with weight, such as material, concept, or identity (Saccone & Chouinard, 2018). Analyzing the division of labor between the magnocellular and parvocellular visual systems (Laycock, et al., 2008; Livingstone & Hubel, 1988) we can see that the magnocellular system transmits signals quickly, processing motion and low-spatial-frequency information, including the shapes and the sizes of objects but it does not process color, or other details such as material properties, that are left for the parvocellular system, which transmits signals more slowly, to analyze. Differences in processing speeds between the two systems are believed to be important for perception. As a matter of fact, “some authors have argued that the magnocellular system, which is the faster system, plays an important role in driving attention and prioritizing information that needs to be analyzed with greater scrutiny by the slower, parvocellular system (Laycock et al., 2008; Laycock & Crewther, 2008)” (Saccone & Chouinard, 2018).

1.3 AN OUTLINE OF THE EXISTING THEORIES AND OF POSSIBLE NEW EXPLANATIONS

While in the last sections we gave a general description of SWI and MWI and of what makes size special, we still have to give an explanation to these illusions.

Research into weight illusions has always struggled to find a general fitting theory that explains all of them and the problems arising in their comparison.

Recently, together with a general trend in the study of perception, some authors have asked themselves if a Bayesian framework could be applied to the SWI and MWI. In a Bayesian framework the brain inference that combines sensory signals with prior expectations to make sense of the environment (Ernst & Banks, 2002). However, “Bayesian frameworks do not seem to explain the SWI and other weight illusions to the same extent that they do other perceptual phenomena” (Saccone & Chuinard, 2018).

Sensorimotor hypothesis

One of the earliest accounts for weight illusions was the Sensorimotor Hypothesis (Davis & Roberts, 1976) that explained the illusions as being the result of a difference of fingertips’ force during the lifting of the objects (Davis & Roberts, 1976; Gregory, 1968; Müller & Schumann, 1889; for a review, see Buckingham, 2014). As a matter of fact, when lifting the object that it is expected to weight more the subject uses greater force than necessary in respect to the expected lighter one, resulting in a misinterpretation of weight that makes the lighter object apparently heavier because of a mismatch between expectation and action. As noted by Buckingham (2014) “this hypothesis is compatible with a range of well-established peripheral effects that can impact an individual's perception of how heavy an object feels, such as muscle fatigue (Jones & Hunter 1983; Burgess & Jones 1997), tactile sensitivity (Gandevia et al. 1980), gripping force (Flanagan et al. 1995), and even the fingers used to lift (Flanagan & Bandomir 2000). However, in a well-cited study, Flanagan and Beltzner (2000) showed that … a lifter's fingertip force errors will be rapidly corrected with practice, but their perceptual illusion remains strong and stable". Given this motor adaptation occurring after repeated liftings it is well established that the sensorimotor-mismatch theory cannot be considered the sole explanation for weight illusions.

Bottom-up hypotheses

Other theorized explanations describe several different third-party object features that cause the illusions. These accounts propose that it is not directly mass that influence our misperceptions but that there are other features that during handling cause our perception to be misguided in a bottom-up approach (Ross & Di Lollo, 1970; Stevens & Rubin, 1970). One example of this bottom-up argument suggests that we mistake weight for density, since perceived weight and physical density seem to have a strong positive relationship, but it is not clear how the two are erroneously exchanged (Buckingham, 2014). Some authors explained it following Gibosn (1979) ecological view in which we perceive objects attributes in terms of their action-relevant properties (affordances) rather than abstract physical properties, like mass. A perfect example is the experiment conducted by Amazeen and Turvey (1996) cited in the introduction, in which they demonstrated that perceived weight was influenced by not only its mass, but also the distribution of it. Another study by Zhu and Bingham (2011) demonstrated that differences in perceived weight in the SWI were related to judgments of their throwability.

Another interesting factor to take in consideration when analyzing bottom-up explanations is that “it can allow for varying effects of sensory modality on the SWI given that sensory channels process information somewhat independently” (Saccone, et al., 2019) something that, as we will see in the next section, is does not happen in top-down accounts. While this is true it should also be noted that “studies that have compared different sensory modalities and different object features are mixed and few in numbers” (Saccone, et al., 2019), so further research is required to better understand the role of bottom-up processes in weight illusions.

Top-down hypothesis

Aside from bottom-up hypothesis, the other accounts typically given for weight illusions are conceptual expectancy based. According to this line of research, it is the contradiction between what we expect, based on our understanding of the relationship between size and weight, and what we experience that ultimately produce the illusion, in a top-down fashion (Buckingham, 2014). “Conceptual expectancy accounts are supported by studies that manipulate expectations of object weight (Buckingham & Goodale, 2010; Ellis & Lederman, 1998; Flanagan et al.,2008)” (Saccone, et al., 2019). For example, an experiment conducted by Buckingham and Goodale (2010) they showed that a SWI can be elicited entirely by the expected rather than actual size of objects by having their participants’ vision occluded when lifting a medium sized cube after having previewed either a smaller or bigger cube prior. Their findings where in line with a typical size-weight illusion. Perhaps one of the most famous examples of weight illusion elicited by conceptual expectancies is the golf ball illusion (Ellis and Lederman, 1998), in which they had golfers and nongolfers judge the weights of real and practice golf balls. As a matter of fact, practice golf balls are lighter than real ones despite their near identical appearance-a detail known among golfers mostly. In the experiment two groups judged the weight of balls that seemed either practice ones or normal ones that were in reality adjusted to weight the same. The experienced golfers were the only of the two groups to experience a weight illusion in which the apparently practice ones felt heavier than the apparently normal ones. Lastly, another cited example of weight illusion well explained by conceptual expectancies is the MWI given the expectation that material elicits when interacting with objects.

The problem that arises when considering top down hypothesis are the already cited dilemmas arising when we compare the strength of the SWI compared to the MWI, despite the expectation prior to lifting implying the contrary (Vicovaro & Burigana, 2017) and when we compare different sensory modalities in the SWI given that studies report it being stronger when information is gathered through the somatosensory system than when the presented visually (Ellis & Lederman, 1993). In the first case, since size is not a greater predictor of weight than material, we cannot understand why size ultimately influences weight perception more than material, while in the second, if the expectation model was applicable, the SWI should be consistent regardless of the sensory modality considered (Saccone, et al., 2019). Given these findings the Expectation model cannot fully account for weight illusions.

Explicit and Implicit expectations

Buckingham (2014) proposed a revised version of the expectation model, according to which perception, when we experience weight illusions, is affected by implicit, rather than explicit, weight expectations. Since the totality of the experiments lead until now refer to explicit rather than implicit associations the possibility remains to be tested. "Explicit weight associations can be directly measured by asking participants to predict the weight of an object on the basis of its visual appearance…implicit weight associations would instead be impervious to consciousness and would depend on ontogenetic and phylogenetic development" (Vicovaro and Burigana, 2017). If the implicit expectation model is valid, we should notice that while the expectations of weight are explicitly influenced more by the material of an object, they are ultimately implicitly affected more by the size of an object. The aim of this dissertation is to find out whether the revised expectational model has validity through the analysis of the results of an experiment devised to measure possible implicit associations. In order to measure this associations and their strength, we used the Implicit association test, a test designed to estimate the strength of implicit associations. In the next section we give a brief overview of the test.

CHAPTER 2: METHODS

2.1 A BRIEF EXPLANATION OF THE IAT

Among the issues that have stimulated particular interest in psychology, and cognitive science in general during the last decades, is whether we can find reliable ways to access and measure thoughts and feelings that are not consciously accessible by the subject being tested.

This objective turns out to be quite a challenge, especially since the aim is to find a way to design a test that can convince even the most skeptics on the validity of such tool, but the Implicit Association Test (IAT; Greenwald, et al., 1998), a test created within the social psychology field in 1998 by Anthony Greenwald, Debbie McGhee, and Jordan Schwartz, has gained through the years enough popularity and back up from its applications to be considered a compelling instrument.

What makes the IAT a useful tool and quite distant to self-reports and other ways to gather information about preferences "is that it may resist masking by self-presentation strategies…the implicit association method may reveal attitudes and other automatic associations even for subjects who prefer not to express those attitudes" (Greenwald, et al., 1998). As a matter of fact, this aspect of the test makes it especially handful in measuring associations that could be rejected by the conscious mind of the participant for example when trying to assess associations that comprise stereotypes and self-concepts, for example racial and gender biases.

The IAT is designed to estimate the strength of associations between two or more concepts by measuring the reaction times that participants take to positively respond to a connection. As a matter of fact, during the execution of the test, which is performed on a computer, participants are required to use two different keyboard keys in order to respond to inputs appearing on the screen: two concepts (e.g. “male” and “female”) are asked to be associated to an attribute dimension (e.g. “rational” and “emotional”) such that the easier it is for the participant to associate a certain concept, hence the faster he or she is in associating it to the chosen attribute, the stronger the association. The test is composed by alternate trials in which the concepts and attributes dimensions are firstly introduced, and then associated in a certain combination (e.g. “male” concept associated to “rational” attributes and “female” associated to “emotional”) and afterwards in a reversed combination (e.g. “male” associated to “emotional” and “female” associated to “emotional”). The order in which either combination is presented first is counterbalanced among the participants in such a way that half will be presented with a certain order and the other half with opposite.

Moreover, what makes the IAT a useful tool in research setting is its high internal consistency along with the fact that the IAT is not much fakeable compared to self-report methods and that external influences or attempts to overcome bias can be distinguished trough experimental and statistical methods (Nosek et al. 2007).

Furthermore, Nosek et al. (2007) pointed out that “Schmukle and Egloff (2004) concluded that the IAT has satisfactory test–retest reliability while also showing evidence of both trait-specific variation (an individual difference that is stable across time) and occasion-specific variation”.

In addition of the test having gained through the years growing validity it is also quite easy to devise and administer as reported by Greenwald, et al. (2003), who summarized a standard IAT scheme, a typical test involves a procedure of seven tasks. In the first task or block (B1) the participant is asked for 20 trials to associate a key, let's say "E", to a category, let's say "picture of white face", and another key, let's say "I", with an opposite category, let's say "picture of black face". Then the test proceeds with the second block (B2) composed as well of 20 trials in which the keys remain the same, "E" and "I", but they must be associated with words, let's say "E" for "good" and "I" for "bad". Block three (B3) consists again of 20 trials in which the participant is asked to associate keys "E" and "I" with the concept as well as with the attribute, in our case the keys will have to be associated either with "picture of white face" and "good" for key "E" or "picture of black face" and "bad" for key "I". Block four (B4) is devised as B3 but is made of 40 trials. Block five (B5) goes on for 20 trials in which the keys are reversed from B1, that means key "E" is for "picture of black faces" and key "I" is for "picture of white faces". Block six (B6) goes on for 20 trials as B3 but with keys reversed, which means key "E" is for "picture of black faces" and "good" and key "I" is for "picture of white faces" and "bad". Finally block seven (B7) is 40 trials with reversed keys as block B6. The blocks used for collecting the data are B3, B4, B6 and B7, the ones in which the concepts and the attributes are put in contrast and an association can be observed.

Following these steps, we devised a series of three IAT tests in order to test our hypothesis of which description and results we proceed to unfold and discuss in the following chapter.

CHAPTER 3: THE EXPERIMENT

3.1 METHODS AND PROCEDURE

In order to test our hypothesis, we devised three different IAT tests in which we analyzed three different conditions: firstly the size condition, secondly the material condition and lastly a conflict condition in which the two parameters previously analyzed individually were put in contrast between each other. The experiment was built using PsychoPy and was administered in an online platform called Pavlova. We decided to administer the test remotely, since the data was gathered during the COVID-19 lockdown, by sending a link to the participants in which they were guided during the entire process by the instructions on the screen. We tried to minimize the possibility of extraneous variables by asking participants to perform the test in a quiet room. Also, because of the use of some words that could create a confound effect in English (e.g. "light" being interpreted either as referring to weight or to color), we constructed the test in Italian in which this problem does not exist as the word referring to light-weight (e.g. "leggero") is not the same as the one referring to light-color (e.g. "chiaro").
Each experiment was administered to 60 participants separately, for a total of 180 participants, so that they were not influenced by a previous experiment in their answers. In the first two experiments the 120 participants (composed of 76 females and 44 males) had a mean age of 24.38 years, 95% CI [22.87, 25.88], the third experiment saw the participation of 60 participants (58 females and 2 males) with a mean age of 22.55 years, 95% CI [21.13, 23.97]. For each one of the experiments the participants taking part had to give their informed consent through a form approved by the Ethics

Committee of the Department of General Psychology of the University of Padua as well as give general information about personal information such as age, gender and their favourite hand.

Each test was composed of 180 trials divided into seven blocks following a typical IAT design (Greenwald, et al. 2003) in which the participants were asked to press on their keyboard either key “E” or key “I”. To avoid the risk of the participants having a preference for either key the order in which they were given trials associating one key or the other to the stimuli was equally divided. Furthermore, each experiment was a within-subject design in which participants were tested both on a congruent condition and on an incongruent one. Taking in consideration the fact that subjects could get tired by the procedure and the monotony of the trials, we presented the congruent and the incongruent condition in a counterbalanced order in order to avoid possible noise affecting the results.

The trials consisted of the first two blocks presenting the stimuli, (B1) and (B2), either a pictures-stimuli one or a words-stimuli one, in which the participant is asked to associate one of the keys to either a stimulus referring to lightness (in association to weight) or a stimulus referring to heaviness. The word stimuli were always the same across the three experiments. In the table below they are reported with their corresponding English translation.

Lightness	**Heaviness**
“Aria” (Air)	“Martello” (Hammer)
“Bolla” (Bubble)	Macigno (Boulder)
“Farfalla” (Butterfly)	“Armadio” (Cupboard)
“Foglia” (Leaf)	“Elefante” (Elephant)
“Piuma” (Feather)	“Camion” (Truck)

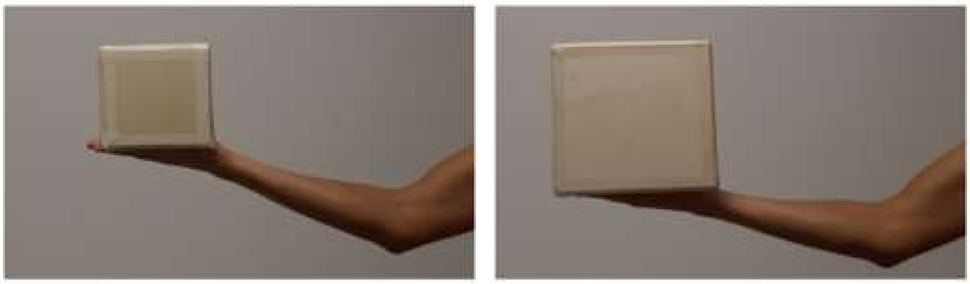
The third block (B3) was a short block of 20 trials presenting either a congruent or an incongruent condition in which the subject was asked to pair the stimulus type -word or picture- to his corresponding one. The fourth block (B4) was a block designed as block (B3) but consisting of 40 trials. The fifth block (B5) was another short block of 20 trials in which participants were presented with the pictures-stimuli only. The sixth block (B6) consisted of 20 trials of either the congruent condition, if they were firstly presented the incongruent one at blocks B3 and B4, or the incongruent one if instead they were previously given the congruent one. Lastly, the seventh block (B7) consisted of 40 trials designed like block B6. During each trial after a correct response, the experiment moved on to the next stimuli, or, if the response was incorrect, a red “X” together with the message “please press the correct key” appeared on the screen. The extra time the participant used to correct his response must be counted during the analysis of the collected data.

We now proceed analyzing better each experiment’s conditions and what we predict the results will show us.

Size Condition

In the size condition experiment we kept constant the material of the cubes depicted in the pictures by choosing wood ones, as it is a material with an intermediate density between the two used in the material condition, while modifying their measurements, thus using pictures of either small cubes or big ones. Thus, in this experiment we want to measure the strength of association between the size of cubes and words associated to concepts of lightness and heaviness by measuring the reaction time (RT) of the participants in connecting the stimuli, either in a congruent or incongruent situation.

In the results, by computing the *D* score, according to the RTs measured, we expect to see a positive *D* score if the small cube is implicitly associated with lightness concepts and the big one is implicitly associated with heaviness concepts. Otherwise, a negative one if there is an association in the opposite direction, demonstrating a SWI in the implicit associations.



Material Condition

The Material condition experiment was a specular experiment to the size condition one. It was built in the same way as the aforementioned but the pictures stimuli, instead of being a big wooden cube or a small wooden cube, were an intermedium sized metal cube and an intermedium sized polystyrene cube. In the results likewise we expect to see a positive *D* score if the metal cube is associated more easily to concepts of heaviness and the polystyrene one to concepts of lightness. Otherwise, if the association is in the opposite direction, thus showing us a negative *D* score, a MWI would be detected by the implicit associations.

Conflict Condition

The conflict condition experiment, similarly to the first two experiments had the same structure but here we mixed the two properties, size and density/material, putting them in contrast between each other. Hence, the pictures stimuli were a small sized metal cube and big polystyrene cube, while the words stimuli were the same. In the results, since we set the congruent condition, according to size, as being large polystyrene cube associated to heaviness and small metal cube associated to lightness, a positive *D* score would mean that the association is in the congruent direction and more influenced by size, while a negative *D* score that the association is in the incongruent direction and thus more influenced by material. This is the experiment of which results' will show us if our initial hypothesis is confirmed, namely that not only there's an implicit association mediating the SWI and MWI, but also that the association is stronger for SWI.

3.2 OBTAINED DATA AND ANALYSIS OF THE RESULTS

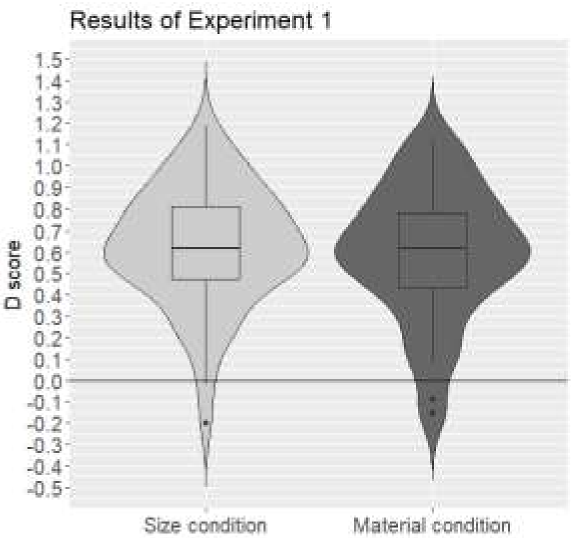
Using R Studio we imported our data obtained and organized them into a data set, a database in which the various relations are plotted in a table in which every column highlights a variable and every line an observation. We obtained this way three columns identifying the experiment each of which contained the information relative to its own 60 participants. For each subject we hence have 120 trials referring to the data obtained in blocks B3 (20 trials), B4 (40 trials), B6 (20 trials) and B7 (40 trials) that are the blocks meaningful for the results. Every trial was then divided into a congruent or an incongruent one keeping also in mind if it was a short block (B3, B6) or a long one (B4, B7) and also into a column identifying if it was presented a picture-stimulus or a word-stimulus. Then we had the columns referring to the scores divided for wrong and correct answers and their corresponding columns for reactions time, without or with penalty and the final reaction time. As a matter of fact, if the answer is wrong, we must count the additional reaction time the participant took in correcting it. This is our organized dataset; we now proceed analyzing it following Greenwald et al. (2003) recommended scoring algorithm steps for an IAT test.

Results and Analysis Size experiment and Material experiment

As reported by Nosek et al. (2007) "the algorithm recommended by Greenwald et al., (2003) has the following steps for IAT designs in which subjects must correct errant responses before continuing: (1) use data from Blocks 3, 4, 6, and 7 (see Table 6.1); (2) eliminate trials with latencies > 10,000 ms; (3) eliminate subjects for whom more than

10% of trials have latencies <300 ms; (4) compute one standard deviation for all trials in Blocks 3 and 6, and another standard deviation for all trials in Blocks 4 and 7; (5) compute means for trials in each of the four blocks (Blocks 3, 4, 6, 7); (6) compute two difference scores (one between 3 and 6 and the other between 4 and 7), subtracting what is intended to represent the high (positive) end of the measure from the block containing associations representing the low end; (7) divide each difference score by its associated standard deviation from Step 4; and (8) average the two quotients from Step 7.2". Following these steps in our analysis, what we observed in the dataset is that no participant registered RTs > 10 sec with the maximum being 9.28 sec and no one had more than 10% of trials with latencies < 300 msec with the maximum being 2.5% of trials. We then proceeded, after having computed mean and standard deviation for each experiment's congruent and incongruent condition and relative long and short blocks, by computing the relative mean Cohen's *D*, to measure how large the effect is for every subject' long and short blocks. Subsequently we compute another mean, first within subjects' resulting Cohen's *D* in the congruent and incongruent condition, then another mean with the results to obtain a value for every experiment, thus one for the Size condition (M = .62) and one for the Material condition (M= .59). These results show us the presence of a strong association in the expected direction, meaning that both size and material produce implicit expectations but at the same time, when we compare them separately, they seem of comparable magnitude given that the values are similar. Being these only qualitative considerations, and because we need to confront the strength of the associations as well, we proceeded by using a statistical test, the *t*-test, after having checked that the criteria to perform the test were met. We first performed the *t*-test to the conditions separately, to see if they are significantly different from 0. What we found through the one-tailed single-sample t-tests was that the D score in the size condition [$M = .62$, 95% CI [.55, .70], $t(59) = 17.33$ ($p < .001$, $d = 2.23$)] and the *D* score in the material condition [$M = .59$, 95% CI [.51, .67], $t(59) = 14.87$, $p < .001$, $d = 1.92$] were significantly different from zero. These results highlight the fact that, as expected, the strength of the implicit association between size and weight and material and weight.

To check if the two illusions appear to have different strengths in their implicit expectations when compared, we performed a one-tailed independent-sample t-test comparing the D scores for the size condition and the D scores for the surface material condition which resulted in $t(116.8) = .59$, $p = .275$, $d = .1$, a value that being >0.05 tells us that is not statistically significant. This result informs us that contrary to what we expected, when compared separately, the strength of association for the size weight illusion seems equal to the material weight illusion.

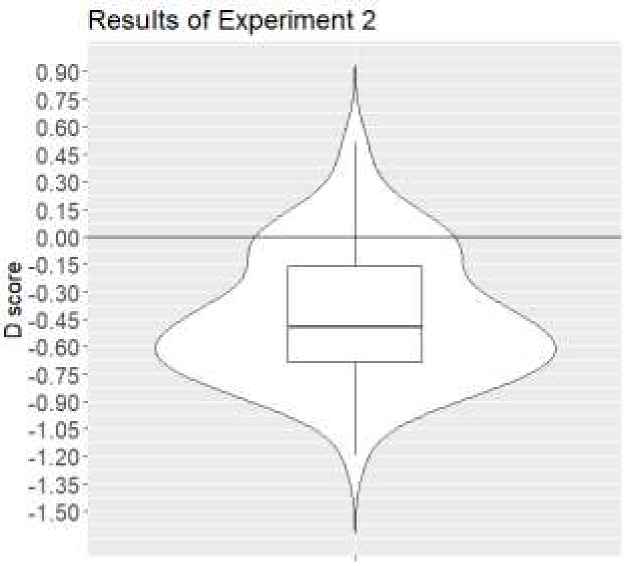


Results and Analysis Conflict Experiment

Following the same steps we went through in the previous experiments, we found in our dataset no participant with responses with RTs > 10 sec, with the maximum being 3.58 sec, as well as no one with more than 10% of trials with latencies < 300 msec, with the maximum being 2.5% of trials.

A negative mean *D* score was obtained, as *D*=-.48. This value indicates that the association is, contrary to what we expected, with the material rather than with size. As in the previous experiments, we performed a two-tailed single-sample *t*-test that showed that the *D* scores were significantly different from zero [M = -.48, 95% CI [-.53, -.35], $t(59) = -9.57$, $p < .001$, $d = -1.24$].

Also, the results from the *t*-test show the strength of the associations measured in this experiment and consequently Buckingham's hypothesis seems to be refused by the analysis of our results, as the implicit weight expectations seem to be mainly driven by material than by size.



CHAPTER 4: DISCUSSION OF THE RESULTS

The aim of this dissertation was to measure, through a series of IAT experiments, the possible implicit associations between size and weight and material and weight.

We started by giving an overview on weight illusions and the various theories advanced as an explanation for them and introducing the new speculative one, the revised expectation model, that were advanced in the last years of research (Buckingham, 2015; Vicovaro and Burigana (2017) in order to solve some conflicts in the previous ones; we then proceeded to describe the IAT test and its main features; finally, we introduced our experiments and our results with their relative findings.

What we managed to prove from our results is that there is an implicit association mediating the effect of the SWI and MWI. On the other hand, contrary to what we expected, we were not able to demonstrate that size exerts a stronger influence on an implicit level, thus leaving us still with an unresolved dilemma when considering the expectation model a broad weight illusion explanatory account given that the SWI seems to be stronger than other weight illusions.

Given our results and keeping in mind the fact that as Saccone et al. (2019) noted, there is still a scarcity of studies both on other weight illusions apart from SWI, and on different sensory modalities affecting the illusion, further research needs to be conducted to better comprehend how different cues contribute on weight expectations, both explicit and implicit, as well as broader effects mediating weight illusions.

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