Is Your Product in the Right Place?

The Effect of Objects' Elongation and Spatial Disposition on Size Perception

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ABSTRACT

Is Your Product in the Right Place? The Effect of Objects' Elongation and Spatial Disposition on Size Perception

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Product packaging is a key source of information consumers use to make choices and inferential judgments about products (Greenleaf and Raghubir 2008). Consumers rarely read volume labels or unitary prices (Dickson and Sawyer 1990; Yang and Raghubir 2005) and rely instead on visual cues in product assessment; as a result, consumers are subject to visual biases (Raghubir and Krishna 1999). Raghubir and Krishna (1999) as well as Wansink and Van Ittersum (2003) find support for an elongation bias, that is, a positive and consistent bias in size estimation as elongation (i.e., ratio of height to width) increases. However, both the process underlying the elongation bias and its boundaries still remain unexplored.

Based on assimilation/contrast theories and a proposed "spatial disposition bias", this research demonstrates in six studies that the elongation bias (i.e., the positive effect of elongation on size perception) is bounded by 1) elongation level and 2) the objects' spatial disposition with regard to a reference object (i.e., side by side versus one above the other). The first study (chapter 2) demonstrates that the elongation effect operates at low levels of elongation difference between objects but is reversed at higher levels when objects are presented side by side. In the second study (chapter 3), the elongation effect and its boundaries are investigated when the objects' cardinal orientation is rotated by 90

degrees. Study 3 (chapter 4) shows that when objects are presented one above the other, the effects identified in studies 1 and 2 are reversed: contrasting width leads to a negative effect on elongation estimates at lower levels of elongation, which disappears at higher levels of elongation. These results are replicated in study 4 (chapter 5) when the vertical objects' cardinal orientation is rotated by 90 degrees. In study 5 (chapter 6), an elongation effect reversal is shown to occur more rapidly for a more complex shape. Finally, study 6 (chapter 7) demonstrates that automatic processing underlies the elongation bias, as cognitive load does not alter the elongation effect or its reversal. A general discussion of findings, theoretical and managerial implications, as well as limitations and future research directions are presented in chapter 8.

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Chapter 1: Introduction

Product packaging often represents the first contact between the consumer and the product. It is a key source of information consumers use in product evaluation and judgment (Greenleaf and Raghubir 2008; Gupta and Rominger 1996). On the other hand, consumers rarely read volume labels or unitary prices (Dickson and Sawyer 1990; Yang and Raghubir 2005). For instance, Dickson and Sawyer (1990) found that only 4% of their participants read the unitary price information to compare brands and only 8% read labels to compare product size. Consequently, consumers are likely to make evaluations based on a more global visual assessment and are subject to visual biases (Raghubir and Krishna 1999). An important body of research in cognitive psychology (Logvinenko 2002) and consumer research (see Chandon and Ordabayeva 2009; Deng and Kahn 2009; Raghubir and Krishna 1999; Wansink and Van Ittersum 2003) demonstrates that individuals are subject to various sensorial and cognitive biases that induce illusory perceptions. In consumer research, the study of the impact of product and package shapes on consumption related phenomena, such as size estimation and actual consumption, is steadily growing (see Folkes and Matta 2004; Krider, Raghubir, and Krishna 2001; Raghubir and Greenleaf 2006; Yang and Raghubir 2005). The seminal research of Raghubir and Krishna (1999) that was further supported by Wansink and Van Ittersum (2003) shows that package elongation produces a positive and consistent bias in volume assessment that translates into higher actual consumption. As Raghubir and Krishna (1999) highlighted, both the process and the boundaries of the effect of elongation on size estimation remain unexplored.

Based on past work in experimental psychology (Goto et al. 2007; Marr 1977, Marr and Nishihara 1978, 1982; Quinlan and Humphreys 1993; Sutherland 1968), this research seeks to demonstrate that the positive effect of elongation (i.e., ratio of height to width) on size perception stems from a combination of assimilative/contrasting judgments and a spatial disposition bias. This dissertation consists of six experimental studies. The first study aims at demonstrating the elongation bias reversal at higher levels of elongation difference between objects, when objects are presented side by side and when the lengthier dimension is vertically oriented. In the second study, the elongation effect and its boundaries are investigated when the objects' cardinal orientation is rotated by 90 degrees. In study 3, spatial disposition (i.e., side by side or one above the other presentation) of objects is manipulated in order to show that the elongation bias is reversed when objects are presented one above the other. Moreover, at high levels of elongation difference between objects, the spatial disposition bias is expected to trigger salience of height, and therefore, activate the elongation bias. These results are replicated in study 4 when vertical objects' cardinal orientation is rotated by 90 degrees. In study 5, a more complex shape is used (shampoo bottle) to show that both elongation effect and its reversal disappear more rapidly than it was the case for a simple, rectangular shape. Finally, in study 6, cognitive load is manipulated in order to evaluate the extent to which the elongation effect is based on automatic processes.

Chapter 2: Study 1: What are Elongation Bias Boundaries across a Range of Levels of Elongation and for Different Baseline Elongations?

In his pioneering experiment on volume estimation, Piaget (1968) asked primary school children to report whether the quantity of coloured liquid poured from a tall cylinder into a shorter one has changed or remained identical. Through several studies, he consistently found that children believe volume reduces when liquid is poured from a taller and thinner to shorter and wider glasses. Based on his experiments, he concluded that young children make volume judgments based on object height exclusively. Based on these findings, he formulated the "centration hypothesis", referring to individual's reliance on one piece of information (i.e., height) when making overall judgments about three-dimensional objects. In an extension of Piaget's findings, Holmberg (1975) proposed that individuals do not process height in absolute terms but relative to width. This was referred to as the "elongation hypothesis", elongation being the height-to-width ratio of a figure or an object. Holmberg (1975) found support for his elongation hypothesis stating that the higher the height-to-width ratio of an object is the higher is the perception of its volume.

2.1 The Elongation Effect in Consumer Research

In consumer research, object shape has gained substantial interest in recent years (see Folkes and Matta 2004; Krider, Raghubir, and Krishna 2001; Raghubir and Greenleaf 2006; Yang and Raghubir 2005). Raghubir and Krishna (1999) were the first to examine the elongation bias, which is the positive effect of containers' elongation (i.e., a container's height divided by its width) on perceived volume, and its impact on actual consumption. They investigated this effect among undergraduates and found that elongation has a positive impact on volume perception, actual consumption, package preference, and package choice. The effect of elongation on size estimation was robust and consistent across seven studies. Wansink and Van Ittersum (2003) replicated and extended Raghubir and Krishna's (1999) results in a context where consumers and bartenders poured drinks by themselves. The authors found that elongated glasses lessen the general tendency to overpour while short-wide glasses produce the opposite effect, thus corroborating the elongation positive effect on size estimation. Yang and Raghubir (2005) supported these findings by reporting an elongation effect on volume perception using scanner data and experiments with real product packages offered in the market. They demonstrated that purchase quantity was lower for more elongated products, indicating that consumers overestimated their size. By explicitly considering the package volume information shown on product labels, the authors showed that consumers use visual cues for volume assessment and do not rely on the volume information provided on the product package. This finding highlights the importance of understanding how consumers make their visual assessment of size and identifying the extent to which consumers are subjects to biases in this evaluation.

2.2 The Elongation Effect: Process and Boundaries

A review of experimental psychology research on size estimation, similarity judgment and shape perception provides insight on how figures and objects are processed and provides a foundation for how and to what extent the elongation bias operates. Borg and Leutner (1983) analyzed the average dissimilarity ratings for rectangles with varying size and shape. They showed that perception and similarity judgment of rectangles are based on the height and width dimensions rather than on a combination of these dimensions such as area (i.e., height * width) or shape (width/height). This finding suggests that the processing of figures and their area is actually based on the evaluation of individual components rather than on a holistic assessment of these figures. This view is consistent with the literature on object recognition, which provides significant evidence that object perception is based on the recomposition of the representation of salient parts of this object based on encoding of the spatial relations among these parts (Marr and Nishihara 1978; Sutherland 1968). It is also coherent with piecemeal information processing where consumers form their overall judgment by adding up their evaluations of individual components (Meyers-Levy 1991; Chernev and Gal 2010). Such decomposition of an object into its original dimensions is expected to occur in a visual size assessment and size comparison process. This research is based on the proposition that a two-steps process takes place when two identically-sized figures, varying only in terms of their elongation, are visually compared: first, an assimilation and contrast response occurs, and afterwards, a spatial disposition bias progressively orients an individual's judgment.

2.2.1 Assimilation-Contrast

Goto et al. (2007) investigated how assimilation and contrast correlate with the generating processes of various optical illusions. Based on a series of experiments (see Goto 1992, Goto et al., 2007 etc.), the authors concluded that the generation and magnitude of a geometric optical illusion is the result of the interaction among three factors: (1) angle/direction, (2) space/position, and (3) assimilation/contrast. The last two factors are the main focus of this work. Past research on assimilation/contrast showed that illusions of contrast (such as the Ebbinghaus-Titchener illusion where a circle surrounded by smaller circles appears to be larger than a circle of the same size surrounded by larger circles) accentuate differences in size while assimilation processes integrate them (such as the Delboeuf illusion where the inner circle size is overestimated when it is surrounded by a slightly larger circle) (Jaeger 1999). The two mechanisms can operate simultaneously (Brigner 1977; Jaeger 1999). Congruent with past research on how assimilation and contrast in size-judgment processes influence optical illusions (see Goto et al. 2007 for a review), it is proposed in this research that when comparing the size of two identically-sized two-dimensional items, people first try to detect both their similar and discriminant geometrical dimensions. If no difference in the length of the two dimensions is apparent (i.e., assimilation), individuals are expected to perceive them as identical. However, if a difference between the two figures on the length of one dimension (e.g., height) is perceptible (i.e., contrast) while no noticeable difference appears on the other dimension (i.e., assimilation), individuals are expected to base their size assessment on the contrasting dimension solely. Such an approach is similar to minimal mental accounting, where people would consider only what differentiates two choice options, disregarding the features that these options have in common (Joyce and Shapiro 1995; Tversky and Kahneman 1981). The adoption of this type of processing was shown to be context-dependent (Bonini and Rumiati 2002). It is argued that side by side product presentation favours the adoption of such a process where the height dimension is contrasted and the width is assimilated, which simplifies decision making. When objects are presented side by side, the proposed process leads to the elongation bias reported in the literature.

H1: At low levels of elongation difference between two objects, the *more* elongated one is perceived as bigger, when the objects are presented side by side.

2.2.2 Spatial Disposition Bias

When both dimensions' lengths contrast, the simpler assimilation/contrast mechanism does not allow for size assessment and more complex processing is needed. First, individuals are expected to fruitlessly try to use both dimensions in a compensatory manner, thus leading to no difference in choice share. At this level, as both dimensions contrast, some individuals put more weight on width and others on height, so that no pattern of the impact of a specific dimension on size estimation is expected to emerge. When a significant difference between the elongations of the two figures exists and the easier assimilation/contrast processing cannot be used, another heuristic, which maximizes accuracy while still minimizing effort (Payne, Bettman, and Johnson 1993), is likely to be adopted. Another bias is expected to appear then among most individuals. In this research, the term "spatial disposition bias" is used to describe this proposed bias. Past research in shape perception has demonstrated that individuals code the spatial dispositions of objects using a reference frame or some form of coordinate system (Hinton 1981). Quinlan and Humphreys (1993) described object recognition as a two-step process, based on Marr's (1977; 1982) experiments on the recognition of biological shapes: first, individuals derive an axis-based description of the object, in which they specify the spatial position for its components (i.e., geometrical dimensions), and second, they associate this coordinate-system based representation with the internally stored shape counterpart. The underlying logic of this process is that individuals use bottom-up heuristics to first capture the intrinsic axes of an object, irrespective of the individual's level of familiarity with the shape. These findings underline the importance of the axis along which individuals capture the information to be analyzed. They are in line with Goto et al.'s (2007) assertion that an object's position in space influences both the generation and magnitude of a geometric optical illusion. In a marketing context, Krider, Raghubir, and Krishna (2001) highlight the importance of contextual cues in shape comparison by influencing a dimension's salience. Coherent with this framework, it is proposed that an objects' spatial disposition triggers salience of one dimension (referred to as "the spatial disposition bias"), where the horizontal presentation increases salience of width. When comparing objects presented on a horizontal axis (i.e., side by side), an individual's eyes go back and forth along that axis. Given that there is no possibility of comparing one dimension at a time, individuals are expected to develop a bias toward the horizontal axis along which objects are presented, and thus base their comparisons on differences in terms of the width dimension. It is proposed here that objects' spatial disposition bias operates progressively as differences between the dimensions of the two objects increase, until the object presenting the longer salient dimension will be more often selected as the bigger one (i.e., the wider object in horizontal presentation).

H2: At high levels of elongation difference between two objects, the *less* elongated one is perceived as bigger, when the objects are presented side by side.

2.3 Method

Fifty-one North American consumers participated in a fifteen minute online experiment. They were members of an existing consumer panel to which an invitation to participate in the study was distributed. Participants were blind to the purpose of the study. They were informed that they were “going to undertake a series of perceptual tests in which their reaction to new objects, colors and shapes, their ability to respond rapidly, and their reaction to time pressure” would be examined. Participants evaluated a series of figures as if they represented a shelf facing area of a product. They evaluated ten pairs of rectangles of identical size, presented side by side, and were instructed to select the bigger one. A paired comparison approach was selected because it is widely used in psychology as well as in recent marketing studies on volume judgment (Folkes and Matta 2004; Raghubir and Krishna 1999). This method increases external validity, as research using eye tracking demonstrated that consumers spend more time looking at two or three alternatives within a product category while shopping (Russo and Leclerc 1994). The pairs were shown in a random order. Each pair contained a baseline figure, which elongation (EL_{BF}) remained unchanged, and a manipulated figure, which elongation (EL_{MF}) varied (see Exhibit 1). A pretest (n=150) showed that baseline figure position in the pair (i.e., left versus right) does not significantly influence size perception. For the sake of generalizability, two baseline figures were used. Ten of the rectangle pairs contained a baseline figure for which elongation was 1.5 (i.e., height is 1.5 times the width of the figure); the other ten pairs contained a baseline figure for which elongation was 2. The first baseline elongation level was selected based on the levels specified in past literature (e.g., Raghubir and Krishna 1999; Raghubir and Greenleaf 2006; Wansink and Van Ittersum 2003). At this baseline elongation level (i.e., $EL_{BF=}1.5$), the elongations of the manipulated rectangles used were 1.6, 1.7, 1.8, 1.9, 2, 2.1, 2.2, 2.3, 2.4, and 2.5. The second baseline was determined based on an in-store examination of elongation level. An elongation level of 2 appeared to be widely used in grocery products (cans, jars, pasta boxes etc.). At this baseline elongation level (i.e., $EL_{BF=}2$), the manipulated rectangles' elongations used were 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, and 3. Rectangular shapes were used because they are among the most frequent shapes adopted in the marketplace (Greenleaf and Raghubir 2008). Therefore, they present two advantages: 1) managers are used to this simple packaging or product design and 2) consumers are familiar with this type of shape and with comparing its shelf facing areas. The average age of the participants was 37 years (range 19 – 49 years). Thirty-five participants were female (68.6%) and sixteen were male (31.4%). Forty-four participants (86.3%) were right-handed, four (7.8%) were left-handed, and three (5.9%) were ambidextrous. These variables were measured in order to ensure that samples in the six studies presented in this dissertation had a similar composition.

2.4 Results

Baseline figure elongation 1.5: As expected, a positive effect of elongation on size perception is found when $EL_{MF}=1.6$, a level close to the baseline figure, thus illustrating the hypothesized assimilation/contrast process (see Table 1). At that level, the more elongated figure's choice share (CS) is significantly higher than 50% ($CS_{MF}=78.43\%$, $Z=-4.06$, $p<.01$). This finding is in line with the elongation bias reported in the literature. It confirms H1 as this effect occurs at elongation levels close to the baseline. However, beyond 1.6 level of elongation for the manipulated figure, no significant effect of elongation on size perception is found up to a level of EL_{MF}=2.5, where the elongation effect is reversed (CS_{MF}= 27.45%, *Z*=3.22, p<.05). This finding is unprecedented in both consumer behaviour and cognitive psychology literatures. It reflects the spatial disposition bias proposed in this paper and confirms H2. The analysis applies the Holm-Bonferroni procedure on all p-values, whenever multiple tests were undertaken on a given set of data. It is a sequential approach in order to increase the power of statistical tests while controlling for the Type I error (Abdi 2010). Moreover, Cochran Q test (Cochran 1950) result demonstrates that there is a significant difference among choice shares for the more elongated figure across manipulated figures elongation levels (Cochran Q (9)=71.48, p<.01). This test is specific to within-subjects designs with binary outcomes (Morris 1969). It completes the results of the one-by-one comparisons provided by the Z-tests by analysing the overall set of data within conditions and demonstrating that responses do not have a random variation. Specifically, it assesses whether the marginal probability of a positive response for a binary variable is unchanged across the times or conditions. Its result provides additional evidence for a significant impact of elongation level on choice for the more elongated figure, congruent with H1 and H2. Furthermore, a McNemar test (McNemar 1947) shows that there is a significant difference between choice shares for the more elongated figure at EL_{MF}=1.6 and EL_{MF}=2.5: the latter is significantly lower than the former ($CS_{1.6}$=78.43, $CS_{2.5}$=27.45, $\chi^2(1)$=26, p<.01). This test demonstrates that change in choice for the more and the less elongated figure between the lowest and the highest level of the manipulated figure elongation did not occur by chance (see Morris 1969). As shown in Table 2, twenty-six participants (i.e., 52%) who selected the more elongated figure as the bigger when EL_{MF}=1.6 opted for the less elongated one when EL_{MF}=2.5. None of them did the opposite. Overall, these results provide support for both H1 and H2.

Baseline figure elongation 2: The positive effect of elongation on size perception is also found for levels of manipulated figure elongation close to the baseline figure (see Table 1). When EL_{MF}=2.1 and EL_{MF}=2.2, and EL_{BF}=2, the more elongated figure's choice share (CS) is significantly higher than 50% (respectively CS_{MF}=80.39%, Z=-4.34, $p<.01$ and CS_{MF}=70.59%, Z=-2.94, $p=.05$), therefore corroborating H1. As expected, when those levels of elongation are exceeded while the baseline figure elongation remained unchanged, no effect of elongation on size perception is found as choice share for each manipulated figure was not significantly different from 50%. Although choice share for the manipulated figure is not significantly lower than 50% at higher elongation level difference with the baseline and therefore H2 is not confirmed at EL_{BF}=2, the result was in the expected direction (CS_{MF}=35.29% when EL_{MF}=3). The result of Cochran Q test shows a significant difference between choice shares for the more elongated figure across manipulated figures elongation levels (Cochran Q (9)=56.32, $p<.01$). A McNemar test illustrates the existence of a significant difference between the choice shares for the more elongated figure at EL_{MF}=2.1 and EL_{MF}=3, the latter share being lower than the former ($CS_{2.1}$=80.39, CS_3=35.29, $\chi^2(1)=21.14$, $p<.01$). As shown in Table 3, twenty four participants (i.e., 45.05%) who selected the more elongated figure as the bigger when EL_{MF}=2.1 opted for the less elongated one when EL_{MF}=3. Only one participant out of fifty-one did the opposite and selected the less elongated figure as the bigger at EL_{MF}=2.1

while he chose the more elongated one at EL_{MF}=3. Overall, these results confirm H1 and partially support H2.

Table 1: Choice Shares for the Manipulated Figures (More Elongated) and the Baseline Figures when Objects are Presented Vertically and Side by Side

Elongation Level for the manipulated figure	Choice share (in%) for the manipulated figure	Choice share (in%) for the baseline figure	Z-test (p-value) Compared to 50%	Holm-Bonferroni corrected p-value
Baseline=1.5				
1.6	**78.43***	**21.57**	**-4.06 (p<.01)**	**<.01**
1.7	62.75	37.25	-1.82 (p=.09)	.45
1.8	47.06	52.94	.42 (p=.78)	.78
1.9	49.02	50.98	.14 (p=1)	1
2	41.18	58.82	1.26 (p=.26)	.78
2.1	35.29	64.71	2.10 (p=.05)	.30
2.2	31.37	68.63	2.66 (p=.01)	.08
2.3	31.37	68.63	2.66 (p=.01)	.08
2.4	37.25	62.75	1.82 (p=.09)	.45
2.5	**27.45**	**72.55**	**3.22 (p=.002)**	**.018**
Baseline=2				
2.1	**80.39**	**19.61**	**-4.34 (p<.01)**	**<.01**
2.2	**70.59**	**29.41**	**-2.94 (p=.005)**	**.045**
2.3	54.90	45.10	-.70 (p=.58)	1
2.4	49.02	50.98	.14 (p=1)	1
2.5	43.14	56.86	.98 (p=.40)	1
2.6	49.02	50.98	.14 (p=1)	1
2.7	41.18	58.82	1.26 (p=.26)	1
2.8	43.14	56.86	0.98 (p=.40)	1
2.9	47.06	52.94	0.42 (p=.77)	.77
3	35.29	64.71	2.1 (p=.05)	.40

* Each significant result at 95% is presented in bold

Table 2: McNemar Crosstabs for Baseline Elongation 1.5

Baseline=1.5 Manipulated figure=1.6	Baseline=1.5 Manipulated figure=2.5	
	Choice for the less elongated	**Choice for the more elongated**
Choice for the less elongated	11	0
Choice for the more elongated	26	14

Table 3: McNemar Crosstabs for Baseline Elongation 2

Baseline=2 Manipulated figure=2.1	Baseline=2 Manipulated figure=3	
	Choice for the less elongated	Choice for the more elongated
Choice for the less elongated	9	1
Choice for the more elongated	24	17

Exhibit 1: Examples of Identically-Sized Rectangles Used in Study 1

Figure 1: EL= 1.5 versus Figure 2: EL=1.6

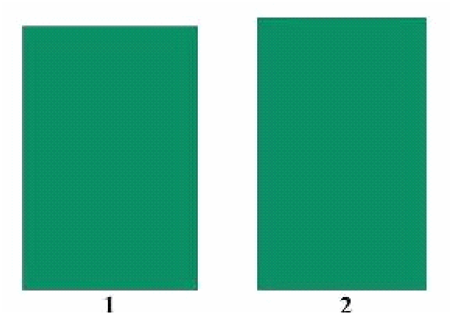


Figure 1: EL= 1.5 versus Figure 2: EL=2.5

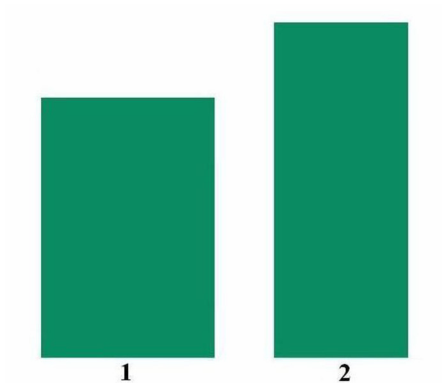


Figure 1: EL= 2 versus Figure 2: EL=2.1

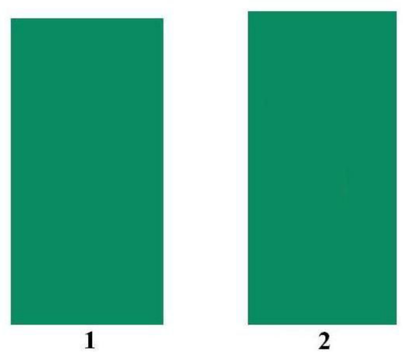
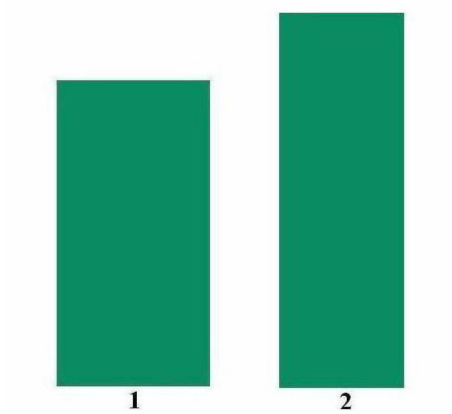


Figure 1: EL= 2 versus Figure 2: EL=3



2.5 Discussion

As expected, the elongation effect, which refers to the positive impact of elongation on size perception, is bounded. Study 1 results show that elongation has a positive effect on size perception only when there is a low difference between the elongations of the two identically-sized objects, which confirms hypothesis 1. When baseline elongation is 1.5, choice share for the manipulated figure with elongation 1.6 was 78.43%; this is significantly higher than 50%. Furthermore, when baseline elongation is 2, choice shares for the manipulated figures with elongation 2.1 and 2.2 are 80.39% and 70.59%, respectively, which are also significantly higher than 50%. This result supports the elongation bias in size estimation when objects are presented side by side as demonstrated in past research (Raghubir and Krishna 1999; Wansink and Van Ittersum, 2003; Yang and Raghubir 2005). The findings of this study show, however, that this effect occurs only at low elongation difference between the figures. The elongation effect disappears when both dimensions contrast, as expected. Evidence for the proposed spatial disposition bias is provided by the elongation effect reversal at high levels of difference in terms of elongation between the two figures when baseline elongation is 1.5. At that baseline level, choice share for the figure with elongation 2.5 is 27.45%, which is significantly lower than 50%. This result partially confirms hypothesis 2, given that it was found for baseline elongation 1.5 but not for 2, although the choice share for elongation 3 was in the expected direction (35.29%). These results demonstrate that the elongation effect is not only bounded and disappears after small elongation increases; it reverses at higher levels of elongation. This choice reversal shows that the operating process of size comparison and assessment cannot be anchoring and adjustment as proposed by Krider, Raghubir, and Krishna (2001), as such model hypothesizes a steady increase of perceived size as elongation increases and does not account for either its disappearance or its reversal when spatial disposition of figures remains the same (i.e., side by side). This study demonstrated that when figures are presented side by side, choice for the more elongated one dramatically falls when elongation increases. It significantly drops from 78.43% and 80.39% to for the lowest elongation level to 27.45% and 35.29% for the highest elongation level, when baseline elongation levels are 1.5 and 2, respectively.

Chapter 3: Study 2: Does the Elongation Effect and its Reversal Occur when Objects' Cardinal Orientation is Modified?

Changes in perspective or cardinal orientation can have a critical influence on visual perception of objects (Sekuler and Swimmer 2000). As the perception of an object is closely tied to its frame of reference, it will appear different depending on which frame of reference is assigned to it. A classical example is Mach's square/diamond phenomenon demonstration (1886/1959) where two squares are presented next to one another, but the one on the right is rotated by 45 degrees. The rotated shape on the right is typically perceived as a diamond while the shape on the left is seen as a square, despite being identical except for a rotational transformation. In other words, different cardinal orientations lead to different perceptions of the same figure. In line with this idea, Jolicoeur (1985) found that when the orientation of an object deviates increasingly from the vertical axis, individuals take more time to name the object. Thus, given that the visual system assigned a frame of reference aligned with the cardinal axes in both cases, the position of each figure dimension inside the reference frame differs depending on the orientation of the object, and therefore its perception is altered too (Sekuler 1996). Accordingly, it is expected that when an object is rotated by 90 degrees, its salient dimension change, and therefore choice share for the object also changes. For instance, at low levels of difference of elongation, when two rectangles which longer dimension was parallel to the vertical axis are rotated by 90 degrees (see Exhibit 2), the side by side disposition of objects still triggers assimilating width and contrasting height (H1). However, the rectangle which appeared bigger when the longer dimension was parallel to the vertical axis now appears smaller, given that it becomes the less elongated object after rotation. The same phenomenon is expected to occur at higher levels of elongation when the spatial disposition bias takes place (H2). The less elongated figure will then be perceived as the bigger, although it was the smaller before the 90 degrees rotation.

3.1 Method

Fifty-two North American consumers participated in a fifteen minute online experiment. They were members of an existing consumer panel to which an invitation to participate in the study was distributed. In this study, participants evaluated the same twenty rectangle pairs used in study 1, rotated by 90 degrees, such that their elongation was lower than unity (i.e., their height was a fraction of their width: see Exhibit 2). The same data collection procedure used in study 1 was applied. The study did not last longer than 15 minutes. Participants' average age was 36 years (range 19 – 49 years). Thirty-seven participants were female (71.2%) and fifteen were male (28.8%). Forty-eight participants (92.3%) were right-handed, three (5.8%) were left-handed, and one (1.9%) was ambidextrous. The composition of this sample was very similar to study 1 sample.

Exhibit 2: Examples of Identically-Sized Rectangles Used in Study 2

Figure 1: EL= 1.5 versus Figure 2: EL=1.6

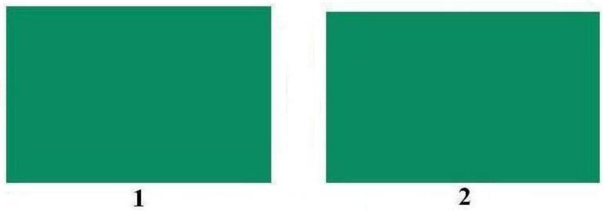


Figure 1: EL= 1.5 versus Figure 2: EL=2.5

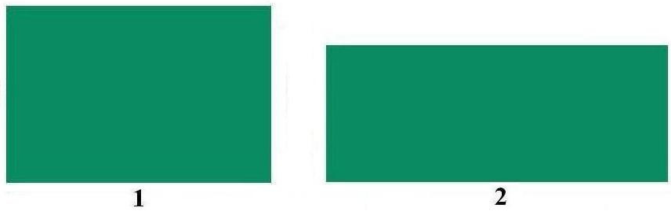


Figure 1: EL= 2 versus Figure 2: EL=2.1

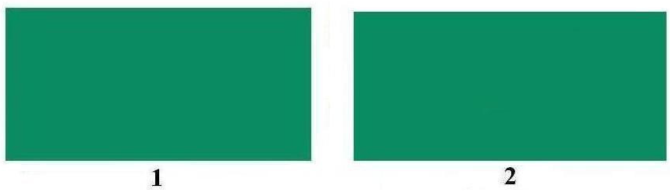
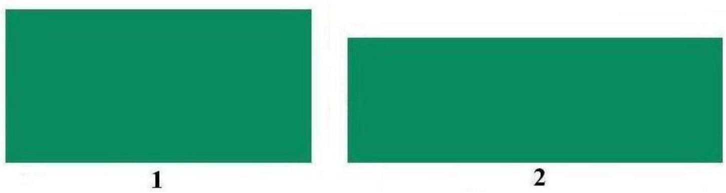


Figure 1: EL= 2 versus Figure 2: EL=3



3.2 Results

Baseline figure elongation 1/1.5: As expected, the choice share for the same figure but rotated drop from 78.43% in study 1 (EL_{MF}=1.6) to 36% in study 2 (EL_{MF}=1/1.6). Similar to study 1, the more elongated figure (i.e., the baseline here) is more often chosen than 50% when EL_{MF}=1/1.7 (CS_{BF}=75%, Z=3.61, p<.01), which confirms H1, and significantly less selected than 50% when EL_{MF}=1/2.4 (CS_{BF}=26.92%, Z=-3.33, p<.01), as hypothesized in H2 (see Table 4). Cochran Q test result shows a significant difference between choice shares for the less elongated figure across manipulated figures elongation levels (Cochran Q (9)=68.51, p<.01). A McNemar test shows that the choice share for the more elongated figure (i.e., the baseline here) is significantly higher when EL_{MF}=1/1.6 than when EL_{MF}=1/2.5 ($CS_{1/1.6}$=63.46, $CS_{1/2.5}$=32.69, $\chi^2(1)$=9.14, p=.005). As shown in Table 5, twenty two participants (i.e., 42.31%) who selected the more elongated figure as the bigger when EL_{MF}=1/1.6 opted for the less elongated one when EL_{MF}=1/2.5. Only six participants (11.53%) did the opposite. Overall, these results provide additional support for both H1 and H2.

Baseline figure elongation 1/2: No significant difference with 50% is found for all the levels of manipulated figure's elongation (see Table 4). However, results are in the expected direction. Cochran Q test result shows a significant difference between choice shares for the less elongated figure across manipulated figures elongation levels (Cochran Q (9)=68.24, p<.01), which shows that choice for the more elongated figure did not remain unchanged across elongation levels. The McNemar test shows that the choice share for the more elongated figure (i.e., the baseline) is significantly higher when EL_{MF}=1/2.1 than when EL_{MF}=1/3 ($CS_{1/2.1}$=65.38, $CS_{1/3}$=34.62, $\chi^2(1)$=11.64, p=.001). As shown in Table 6, nineteen participants (i.e., 36.53%) who selected the more elongated figure as the bigger when EL_{MF}=1/2.1 chose the less elongated one when EL_{MF}=1/3. Only three participants (5.80%) did the opposite. Overall, these results provide directional support for both H1 and H2.

Table 4: Choice Shares for the Manipulated Figures (Less Elongated) and the Baseline Figures when Objects are Presented Horizontally and Side by Side

Elongation Level for the manipulated figure	Choice share (in%) for the manipulated figure	Choice share (in%) for the baseline figure	Z-test (p-value) compared to 50%	Holm-Bonferroni corrected p-value
Baseline=1/1.5				
1/1.6	36.54	63.46	1.94 (p=.07)	.35
1/1.7	**25***	**75**	**3.61 (p<.01)**	**<.01**
1/1.8	36.54	63.46	1.94 (p=.07)	.35
1/1.9	50	50	0 (p=1)	1
1/2	51.92	48.08	-.28 (p=.88)	1
1/2.1	65.38	34.62	-2.23 (p=.04)	.24
1/2.2	59.62	40.38	-1.39 (p=.21)	.63
1/2.3	67.31	32.69	-2.50 (p=.02)	.16
1/2.4	**73.08**	**26.92**	**-3.33 (p=.001)**	**.009**
1/2.5	67.31	32.69	-2.50 (p=.02)	.16
Baseline=1/2				
1/2.1	34.62	65.38	2.22 (p=.04)	.28
1/2.2	38.46	61.54	1.66 (p=.13)	.52
1/2.3	36.54	63.46	1.94 (p=.07)	.21
1/2.4	48.08	51.92	0.28 (p=.89)	1
1/2.5	55.77	44.23	-0.83 (p=.49)	.98
1/2.6	65.38	34.62	-2.22 (p=.04)	.28
1/2.7	69.23	30.77	-2.77 (p=.01)	.09
1/2.8	69.23	30.77	-2.77 (p=.01)	.10
1/2.9	67.31	32.69	-2.50 (p=.02)	.16
1/3	65.38	34.62	-2.22 (p=.04)	.28

* Each significant result at 95% is presented in bold

Table 5: McNemar Crosstabs for Baseline Elongation 1/1.5

Baseline=1/1.5 Manipulated figure=1/1.6	Baseline=1/1.5 Manipulated figure=1/2.5	
	Choice for the less elongated	**Choice for the more elongated**
Choice for the less elongated	13	6
Choice for the more elongated	22	11

Table 6: McNemar Crosstabs for Baseline Elongation 1/2

Baseline=1/2 Manipulated figure=1/2.1	Baseline=1/2 Manipulated figure=1/3	
	Choice for the less elongated	**Choice for the more elongated**
Choice for the less elongated	15	3
Choice for the more elongated	19	15

3.3 Discussion

The results of study 2 corroborate study 1 results and demonstrate the boundaries of the elongation effect. In line with hypothesis 1, elongation has a positive effect on size perception only when there is a low difference between the elongations of the two identically-sized objects. When baseline elongation is 1/1.5 (i.e., EL_{BF}=0.67), choice share for the baseline figure when the manipulated figure was elongation 1/1.7 (i.e., EL_{MF}=0.59) was 75%, which is significantly higher than 50%. When baseline elongation is 1/2 (i.e., EL_{BF}=0.5), choice share for the baseline figure when the elongation of the manipulated figure was 1/2.1 (EL_{MF}=0.48) is not significant, but it is in the expected direction (CS_{BF}=65.38%). Based on Krider, Raghubir, and Krishna's (2001) model of size assessment and comparison based on anchoring and adjustment depending on dimension salience, the wider object is expected to be perceived as bigger because the more salient dimension is width. This research demonstrates that at low elongation difference between the two figures, it is elongation (which is defined as height divided by width irrespective of which dimension is longer) that drives size assessment. These results provide additional support for the proposed assimilation/contrast mechanism through which the elongation effect operates at low levels of elongation difference with the reference figure.

Study 2 provides additional evidence for the spatial disposition bias at high levels of difference in terms of elongation between the two figures. At elongation baseline level 1/1.5 (i.e., EL_{BF}=0.67), baseline figure when the manipulated figure is elongation 1/2.4 (i.e., EL_{MF}=0.42) is 26.92%, which is significantly lower than 50%. At elongation baseline level 1/2, the choice share for elongation 1/3 (i.e., EL_{MF}=0.33) is in the expected direction (CS_{BF}=34.62%), although not significantly different from 50%. Overall, at high difference between the elongation levels of the two figures, the less elongated figure (in study 2, the manipulated figure) is more often selected as the bigger figure than the more elongated one. These results, combined with those obtained in study 1, confirm hypothesis 2. Consistent with study 1 findings, elongation increase leads to a drastic lowering of choice share for the more elongated figure when figures are presented side by side. Choice shares for the baseline figure (i.e., the more elongated one) significantly decrease from 75% and 65.38% to for the lowest elongation level of the manipulated figure to 26.92% and 34.62% for its highest elongation level, when baseline elongation levels are 1.5 and 2, respectively. These results provide additional support to the proposed spatial disposition bias, which occurs at high levels of elongation difference between the two figures, as the two dimensions of both of them contrast. Overall, it appears that elongation and spatial disposition biases are the main drivers of size perception. At baseline elongation 1.5 (study 1) and 1/1.5 (study 2), the choice shares for the same manipulated figure with elongation 1.6 and 1/1.6 are 78.43% and 36.54%, respectively. On the other hand, at these baseline elongation levels, the choice shares for the same manipulated figure with elongation 2.5 and 1/2.5 are 27.45% and 67.31%, respectively. Therefore, presenting the same object along a vertical or a horizontal axis of elongation is likely to result in a significantly different choice share.

The results of studies 1 and 2 hold when objects are presented side by side (e.g., when two products are presented on the same shelf). However, it is not rare that products in the same category occupy more than one shelf (i.e., they are presented one above the other). The effect of relative position of elongated versus reference figure is investigated in study 3.

Chapter 4: Study 3: How Does Spatial Disposition Influence the Elongation Effect and its Reversal?

Past research in cognitive psychology has shown that differences in the relative positions of object dimensions with respect to their reference frames can lead to different perception of the objects (Sekuler and Swimmer 2000). For instance, Künnapas (1959) reported that the apparent length of a vertical line viewed through an artificial elliptical frame decreased as the frame was changed from a horizontal (i.e., similar to the natural frame imposed by the eye) to a vertical orientation. In line with study 1 and 2, salience of object height versus width is likely to differ depending on objects' spatial disposition: while heights of two figures are expected to more easily contrast in a horizontal presentation context (i.e., side by side), widths of two figures are expected to more easily contrast in a horizontal presentation context than a vertical one (i.e., one above the other). A wider object should therefore appear bigger, thus reversing the positive elongation effect on size perception.

H3: At low levels of elongation difference between two objects, the *less* elongated one is perceived as bigger, when the objects are presented one above the other.

H4: At low levels of elongation difference between two objects, the *more* elongated one is perceived as bigger when the objects are presented side by side than one above the other.

According to the spatial disposition bias illustrated in study 1 and 2, when objects are presented one above the other and there is no possibility of comparing one dimension at a time, individuals are expected to develop a bias toward the vertical axis. Thus, presenting objects one above the other enhances salience of objects height, when both dimensions contrast.

H5: At high levels of elongation difference between two objects, the *more* elongated one is perceived as bigger, when the objects are presented one above the other.

H6: At high levels of elongation difference between two objects, the *more* elongated one is perceived as bigger when the objects are presented one above the other than side by side.

4.1 Method

Fifty-one North American consumers participated in a fifteen minute online experiment. They were members of an existing consumer panel to which an invitation to participate in the study was distributed. In this study, participants were shown the same twenty rectangle pairs as in study 1, presented one above the other (see Exhibit 3). The same data collection procedure used in the previous studies was adopted. Participants' average age was 38 years (range 19 – 50 years). Thirty-three of them were females (66%) and seventeen were males (34%). Forty-four of them (88%) were right-handed, five (10%) were left-handed, and one (2%) was ambidextrous. The composition of this sample was very similar to studies 1 and 2 samples.

Exhibit 3: Examples of Identically-Sized Rectangles Used in Study 3

Figure 1 : EL=1.6 versus Figure 2 : EL= 1.5

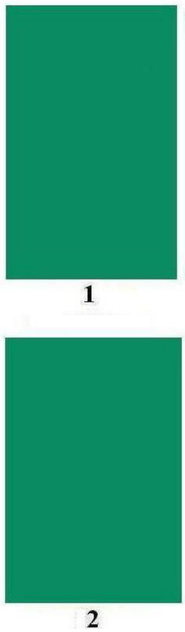


Figure 1 : EL= 2.5 versus Figure 2 : EL=1.5

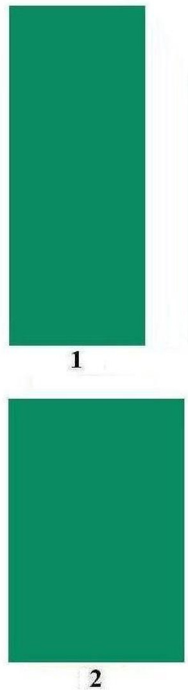


Figure 1 : EL= 2.1 versus Figure 2 : EL=2

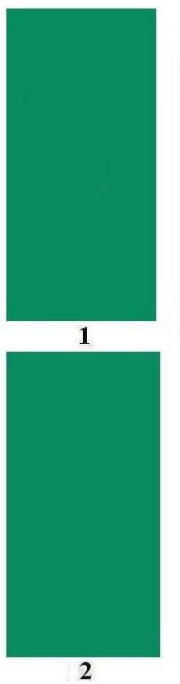
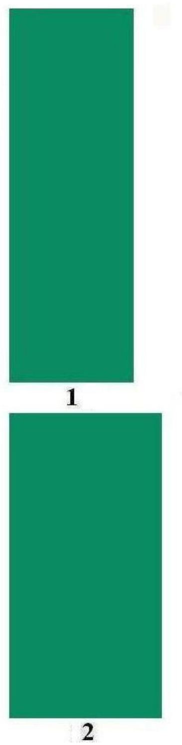


Figure 1 : EL= 3 versus Figure 2 : EL=2



4.2 Results

4.2.1 Elongation Effect when Objects are Presented One above the Other

Baseline figure elongation 1.5 (see Figure 1): As expected, the positive effect of elongation was reversed (see Table 7). Across all elongation levels, the more elongated figure did not have a choice share significantly higher than 50%. In addition, the more elongated figures' choice shares were significantly lower than 50% when EL_{MF}=1.7, EL_{MF}=1.8, and EL_{MF}=1.9 (respectively CS_{MF}=20%, Z=-4.24, p<0.01; CS_{MF}=24%, Z=-3.68, p<0.01, and CS_{MF}=22%, Z=-3.96, p<0.01), which confirms H3. It is interesting to note that at EL_{MF}=1.7 for instance, the choice share for the same more elongated figure dropped from 62.75% in study 1 to 20% in study 3 (Z=-4.42, p<.01). Starting EL_{MF}=2, although steadily increasing, no choice share for the more elongated figure became significantly different from 50%. H2 is therefore not supported: choice share for the more elongated figure did not significantly exceed 50% at all elongation levels when figures were presented one above the other. The result of a Cochran Q test shows a significant difference between choice shares for the less elongated figure across manipulated figures elongation levels (Cochran Q (9)=36.65, p<.01). A McNemar test (see Table 8) demonstrates that there is no significant difference between EL_{MF}=1.6 and EL_{MF}=2.5 choice shares, but as expected the latter's share is higher than the former's ($CS_{1.6}$=36, $CS_{2.5}$=50, $\chi^2(1)$=1.81, p=.25).

Baseline figure elongation 2 (see Figure 2): At this baseline level, elongation's positive effect on size estimation disappeared completely when objects were presented one above the other (see Table 7). The more elongated figures' choice shares were significantly lower than 50% when EL_{MF}=2.1, EL_{MF}=2.2, and EL_{MF}=2.3 (respectively CS_{MF}=24%, Z=-3.68, $p<.01$; CS_{MF}=18%, Z=-4.53, $p<.01$, and CS_{MF}=28%, Z=-3.11, p=.02), which confirms H3. When these levels were exceeded, no significant positive or negative effect of elongation on size perception appears. H5 is therefore not supported. In addition, Cochran Q test result shows a significant difference between choice shares for the less elongated figure across manipulated figures elongation levels (Cochran Q (9)=38.09, $p<.01$). A McNemar test shows that there is a significant difference between the choice shares for EL_{MF}=2.1 and EL_{MF}=3, the latter shares being higher than the former's ($CS_{2.1}$=24, CS_3=56, $\chi^2(1)$=21.14, p=.001). As shown in Table 9, nineteen participants (i.e., 38%) selected the less elongated figure as the bigger when EL_{MF}=1.6 opted for the more elongated one when EL_{MF}=2.5, which is in line with both H3 and H5. On the other hand, only three participants (i.e., 6%) did the opposite. Overall, these results provide support for H3 and some evidence for H5 through Cochran Q and McNemar tests.

Table 7: Choice Shares for the Manipulated Figures (More Elongated) and the Baseline Figures when Objects are Presented Vertically and One above the Other

Elongation Level for the manipulated figure	Choice share (in%) for the manipulated figure	Choice share (in%) for the baseline figure	Z-test (p-value) compared to 50%	Holm-Bonferroni corrected p-value
Baseline=1.5				
1.6	36	64	-1.98 (p=.06)	.36
1.7	**20***	**80**	**-4.24 (p<.01)**	**<.01**
1.8	**24**	**76**	**-3.68 (p<.01)**	**<.01**
1.9	**22**	**78**	**-3.96 (p<.01)**	**<.01**
2	34	66	-2.26 (p=.03)	.21
2.1	38	62	-1.70 (p=.12)	.60
2.2	42	58	-1.13 (p=.32)	1
2.3	42	58	-1.13 (p=.32)	1
2.4	56	44	.85 (p=.48)	.48
2.5	50	50	.00 (p=1)	1
Baseline=2				
2.1	**24**	**76**	**-3.68 (p<.01)**	**<.01**
2.2	**18**	**82**	**-4.53 (p<.01)**	**<.01**
2.3	**28**	**72**	**-3.11 (p=.003)**	**.024**
2.4	36	64	-1.98 (p=.06)	.36
2.5	36	64	-1.98 (p=.06)	.36
2.6	34	66	-2.26 (p=.03)	.21
2.7	42	58	-1.13 (p=.32)	1
2.8	44	56	-.85 (p=.48)	1
2.9	48	52	-.28 (p=.89)	.89
3	56	44	.85 (p=.48)	1

* Each significant result at 95% is presented in bold

Table 8: McNemar Crosstabs for Baseline Elongation 1.5

Baseline=1.5 Manipulated figure=1.6	**Baseline=1.5 Manipulated figure=2.5**	
	Choice for the less elongated	**Choice for the more elongated**
Choice for the less elongated	15	17
Choice for the more elongated	10	8

Table 9: McNemar Crosstabs for Baseline Elongation 2

Baseline=2 Manipulated figure=2.1	Baseline=2 Manipulated figure=3	
	Choice for the less elongated	**Choice for the less elongated**
Choice for the less elongated	19	19
Choice for the more elongated	3	9

4.2.2 Elongation Level and Spatial Disposition

Baseline figure elongation 1.5 (see Figure 1): Results of the choice shares comparison for the more elongated figure between the side by side (study 1) and the one above the other (study 3) objects' presentations are presented in Table 10. For elongation levels EL_{MF}=1.6, EL_{MF}=1.7, and EL_{MF}=1.9, there is a significant difference between choice share for the manipulated figure depending on spatial disposition (side by side CS_{MF}=78.43%, one above the other CS_{MF}=36%, $\chi^2(1)=18.59$, $p<.01$; side by side CS_{MF}=62.75%, one above the other CS_{MF}=20%, $\chi^2(1)=18.99$, $p<.01$; and side by side CS_{MF}=49.02%, one above the other CS_{MF}=22%, $\chi^2(1)=8.03$, $p<.01$, respectively). In these levels, the more elongated figure (i.e., the manipulated figure) is more often reported as bigger when presented next to the baseline figure than when presented above it, which confirms H4. Afterwards, from EL_{MF}=2 to EL_{MF}=2.5, no significant difference is found between the choice shares for the more elongated figure depending on spatial disposition. No significant difference in choice share appeared at higher level of difference in elongation between the baseline and the manipulated figure depending on the spatial disposition, although results were in the expected direction, with choice for the more elongated figure being higher when figures presented above the baseline figure rather than next to it. H6 is therefore not supported.

Baseline figure elongation 2 (see Figure 2): As presented in Table 10, a comparable pattern of results is obtained for the set of figures which baseline figure elongation is 2. From EL_{MF}=2.1 to EL_{MF}=2.3, choice share for the more elongated figure is significantly higher when it was presented next to the baseline figure than above it (side by side CS_{MF}=80.39%, one above the other CS_{MF}=24%, $\chi^2(1)=32.20$, $p<.01$; side by side CS_{MF}=70.59%, one above the other CS_{MF}=18%, $\chi^2(1)=28.26$, $p<.01$; and side by side CS_{MF}=54.9%, one above the other CS_{MF}=28%, $\chi^2(1)=7.25$, $p<.01$, respectively), which supports H4. Subsequently, for higher levels of elongation, there was no significant difference between the choice shares, although the difference was in the expected reversed direction at EL_{MF}=3. H6 is thus not supported.

Table 10: Choice Shares for the More Elongated Figure when Vertically-Oriented Figures are Presented Side by Side versus One above the Other

Elongation level for the manipulated figure	Choice share (in%) for the side by side presentation	Choice share (in%) for the one above the other presentation	χ^2 (p-value)	Holm-Bonferroni corrected p-value
Baseline=1.5				
1.6	**78.43***	**36**	**18.59 (p<.01)**	**<.01**
1.7	**62.75**	**20**	**18.99 (p<.01)**	**<.01**
1.8	47.06	24	5.85 (p=.02)	.14
1.9	**49.02**	**22**	**8.03 (p=.005)**	**.04**
2	41.18	34	0.55 (p=.46)	.92
2.1	35.29	38	0.80 (p=.78)	.78
2.2	31.37	42	1.23 (p=.27)	1
2.3	31.37	42	1.23 (p=.27)	1
2.4	37.25	56	3.57 (p=.06)	.30
2.5	27.45	50	5.42 (p=.02)	.14
Baseline=2				
2.1	**80.39**	**24**	**32.20 (p<.01)**	**<.01**
2.2	**70.59**	**18**	**28.26 (p<.01)**	**<.01**
2.3	**54.90**	**28**	**7.52 (p=.006)**	**.05**
2.4	49.02	36	1.75 (p=.19)	.95
2.5	43.14	36	0.54 (p=.46)	1
2.6	49.02	34	2.34 (p=.13)	.78
2.7	41.18	42	.007 (p=.93)	1
2.8	43.14	44	.008 (p=.93)	1
2.9	47.06	48	.009 (p=.92)	1
3	35.29	56	4.36 (p=.037)	.26

* Each significant result at 95% is presented in bold

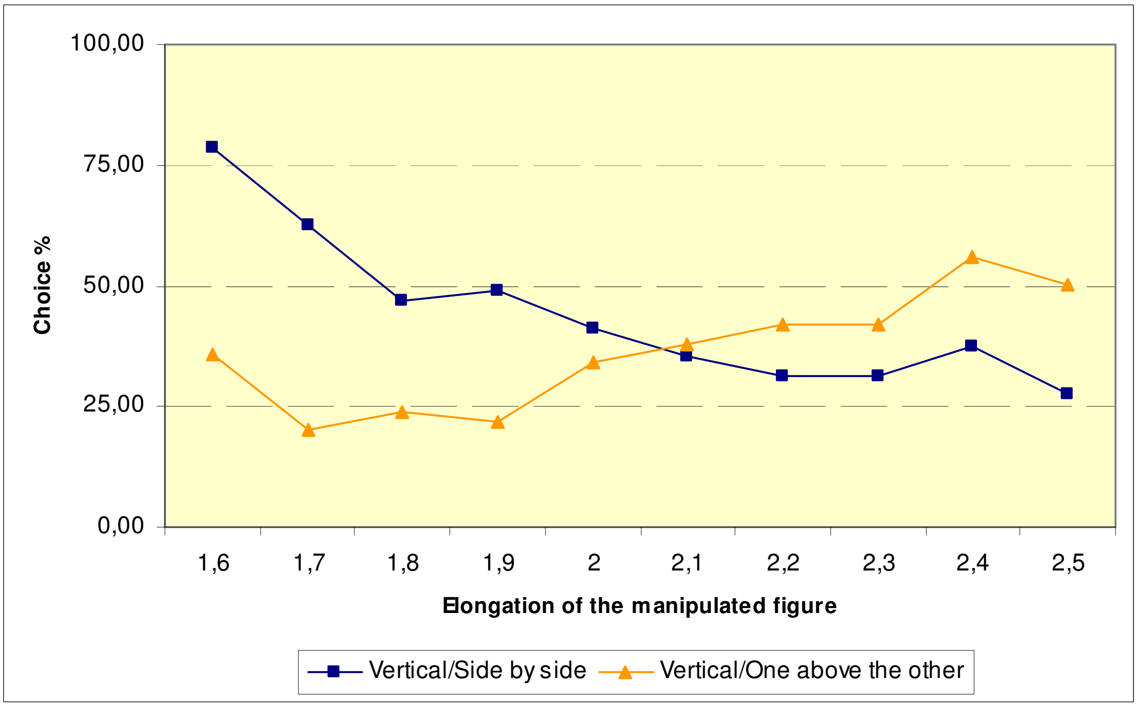


Figure 1: Choice Shares for the more Elongated Figure for Studies 1 and 3 (EL_{BF}=1.5)

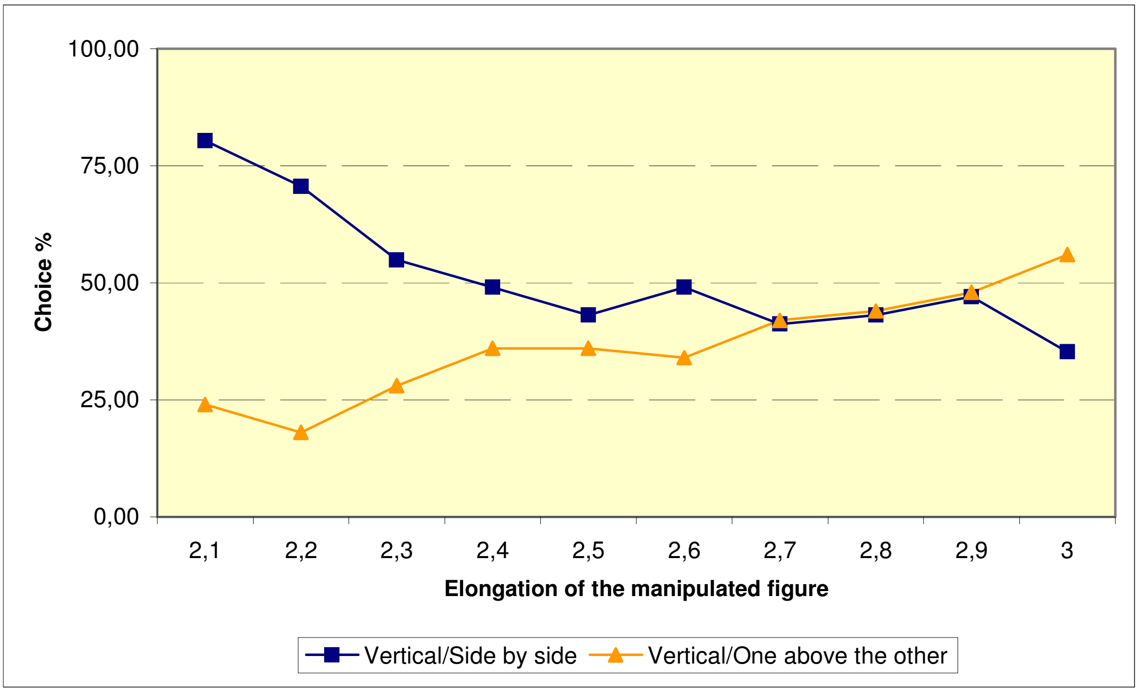


Figure 2: Choice Shares for the more Elongated Figure for Studies 1 and 3 (EL_{BF}=2)

4.3 Discussion

As illustrated in Figures 1 and 2, these results provide evidence for the existence of an interaction between elongation level and spatial disposition in choice for the bigger object. At low levels of elongation difference between the two figures, the less elongated one is perceived as bigger, when they are presented one above the other, which confirms H3. When baseline elongation is 1.5, choice shares for the manipulated figure with elongation 1.7, 1.8, and 1.9 were 20%, 24%, and 22%, therefore being significantly higher than 50%. In addition, when baseline elongation is 2, choice shares for the manipulated figures with elongation 2.1, 2.2 and 2.3 are 24%, 18%, and 28%, respectively, which are also significantly higher than 50%.

At low levels of elongation difference between the two figures, the more elongated one is perceived as bigger when the figures are presented side by side than one above the other. When comparing study 3 and study 1 results, it appears that the choice shares of the same figures considerably change at low levels of elongation difference. When spatial disposition changes from side by side to one above the other presentation, choice for the more elongated figure significantly drops by 42.43%, 42.72%, and 27.02% at manipulated figures elongation levels 1.6, 1.7, and 1.9, respectively, when baseline elongation level is 1.5. Similarly, when baseline elongation level is 2, choice for the more elongated figure significantly drops by 56.39%, 52.59%, and 26.90% at manipulated figures elongation levels 2.1, 2.2, and 2.3, respectively. These results confirm H4.

On the other hand, at high levels of elongation difference between the two figures, the choice share for the more elongated one was not significantly different than when one above the other presentation is adopted, which does not confirm H5. Also, at high levels of elongation difference between the two figures, the more elongated one is not significantly perceived as bigger when the figures are presented one above the other than side by side. Although these results do not confirm H6, they are in the expected direction, as illustrated in figures 1 and 2. At the highest level of manipulated figure elongation, there is a difference in choice share for the more elongated figure of 22.55% when baseline elongation is 1.5 and of 20.71% when baseline elongation is 2 depending on whether the figures were presented side by side or one above the other. These results show how spatial disposition of figures influence size perception when elongation varies. In both baseline elongation levels, an elongation bias was not present in any manipulated figure level. This finding adds to the existing literature on the elongation bias (Raghubir and Krishna, 1999; Wansink and Van Ittersum, 2003, Yang and Raghubir 2005) and size assessment and comparison (Krider, Raghubir, and Krishna 2001) by showing that the manner in which objects are displayed influence the elongation effect. Although Krider, Raghubir, and Krishna's (2001) dimension salience argument partially explains the results obtained at lower levels of elongation difference by stating that the width dimension is more salient due to vertical presentation, no existing model explains the disappearance of this bias at higher levels of elongation difference.

Chapter 5: Study 4: Does the Effect of Spatial Disposition Occur when Objects' Cardinal Orientation is Modified?

The same perceptual mechanism hypothesized when objects are presented one above the other (H3, H4, H5, and H6) is likely to occur, where the less elongated is perceived as bigger at low levels of difference in elongation but it is seen as smaller when there are high levels of difference in elongation between the figures. Given that the more elongated figure when the longer dimension was parallel to the vertical axis becomes the less elongated one when it is rotated by 90 degrees so that the longer dimension is parallel to the horizontal axis, a drastic shift in the choice share for the same figure is expected to occur when it is rotated. The hypothesized relationships described in study 3 (H3, H4, H5, and H6) are expected to be replicated. When figures are presented one above the other, the more elongated figure is expected to be perceived as smaller at low levels of elongation difference with the baseline due to assimilation/contrast and bigger at higher levels of elongation difference due to the proposed spatial disposition bias. On the other hand, spatial disposition is expected to have an impact on size perception such that the more elongated figure is perceived as 1) bigger at low levels of elongation difference with the baseline and as 2) smaller at high levels of elongation difference with the baseline when the objects are presented side by side compared to when they are presented one above the other. Given the 90 degrees rotation, width salience at low elongation difference and one above the other presentation makes choice shares for the same figure shift (compared to study 3 where figures were presented without the rotation) although the hypothesized relationships remain the same. Similarly, the spatial disposition bias is expected to trigger a change in choice share for the same figure across studies 3 and 4.

5.1 Method

Fifty North American consumers participated in a fifteen minute online experiment. They were members of an existing consumer panel to which an invitation to participate in the study was distributed. In this study, the same rectangle pairs used in study 2 were presented to participants, one above the other (see Exhibit 4). The same procedure used in the previous studies was adopted. Participants' average age was 38 years (range 20 – 49 years). Thirty-six participants were female (72%) and fourteen were male (28%). Forty participants (80%) were right-handed, nine (18%) were left-handed, and one (2%) was ambidextrous. The composition of this sample was very similar to study 1, 2, and 3 samples.

Exhibit 4: Examples of Identically-Sized Rectangles Used in Study 4

Figure 1 : EL=1.6 versus Figure 2 : EL= 1.5

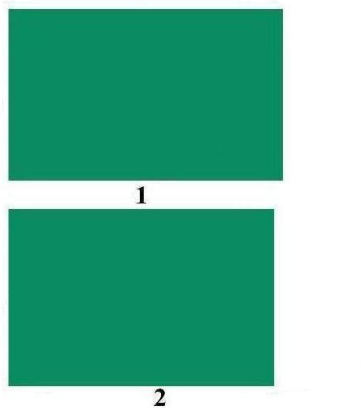


Figure 1 : EL= 2.5 versus Figure 2 : EL=1.5

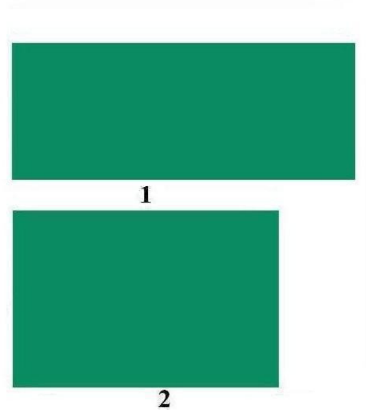


Figure 1 : EL= 2.1 versus Figure 2 : EL=2

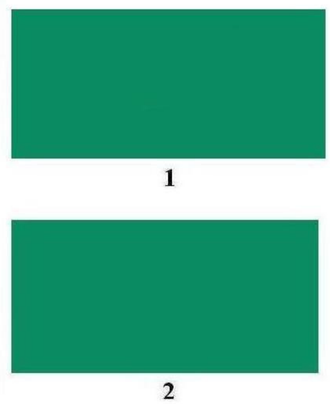
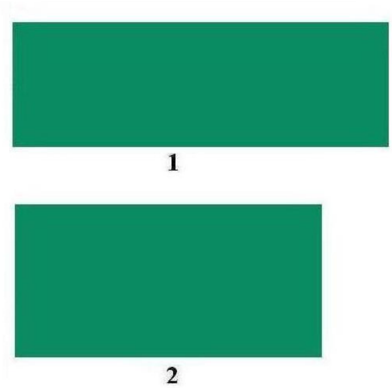


Figure 1 : EL= 3 versus Figure 2 : EL=2



5.2 Results

5.2.1 Elongation Effect when Rotated Objects are Presented One above the Other

Baseline figure elongation 1/1.5 (see Figure 3): At the highest level of its elongation (EL_{MF}=1/1.6), the less elongated figure's choice share was significantly higher than 50% (CS_{MF}=72%, Z=3.11, p=.04). The elongation effect was therefore reversed, which supports H3. Afterwards, there was a series of elongation levels where no significant difference with 50% was found and thus, no elongation effect. As expected, the choice share for the less elongated figure (i.e., the manipulated figure) fell significantly below 50% when the manipulated figure elongation was equal to 1/2, 1/2.2 (i.e., .45) and 1/2.5 (i.e., .4) (respectively CS_{MF}=30%, *Z*=-2.83, p=.05, CS_{MF}=28%, *Z*=-3.11, p=.03 and CS_{MF}=28%, *Z*=-3.11, p=.03). Thus, elongation positive effect came back at those higher levels of elongation of the manipulated figure thus confirming H5 (see Table 11). Cochran Q test result shows a significant difference between choice shares for the less elongated figure across manipulated figures elongation levels (Cochran Q (9)=58.73, p<.01). A McNemar test shows that the choice share for the more elongated figure (i.e., the baseline) was significantly lower when EL_{MF}=1/1.6 than when EL_{MF}=1/2.5 ($CS_{1/1.6}$=28, $CS_{1/2.5}$=72, $\chi^2(1)$=16.13, p<0.01). As shown in Table 12, twenty six participants (i.e., 52%) who selected the more elongated figure as the bigger when EL_{MF}=1/1.6 opted for the less elongated one when EL_{MF}=1/2.5. Only four participants (8%) did the opposite. Overall, these results provide strong support for both H3 and H5.

Baseline figure elongation 1/2 (see Figure 4): For all elongation levels of the manipulated (and less elongated) figure except for the lower level of elongation (EL_{MF}=1/3), there was no difference between its choice shares and 50% and therefore no reversal of the elongation bias. These results do not support H3. When EL_{MF} became 1/3, choice share for the less elongated figure became significantly lower than 50% (CS_{MF}=24%, *Z*=-3.68, p<.01), and therefore the positive effect of elongation was then present, which supports H5 (see Table 11). Cochran Q test result shows a significant difference between choice shares for the less elongated figure across manipulated figures elongation levels (Cochran Q (9)=28.99, p=.001). A McNemar test shows that the choice share for the more elongated figure (i.e., the baseline) was significantly lower when EL_{MF}=1/2.1 than when EL_{MF}=1/3 ($CS_{1/2.1}$=46, $CS_{1/3}$=76, $\chi^2(1)=9$, p=.004). As shown in Table 13, twenty participants (i.e., 40%) who selected the more elongated figure as the bigger when EL_{MF}=1/2.1 opted for the less elongated one when EL_{MF}=1/3. Only five participants (10%) did the opposite. Overall, these results provide support for H3 and H5.

Table 11: Choice Shares for the Manipulated Figures and the Baseline Figures (the more Elongated) when Objects are Presented Horizontally and One above the Other

Elongation Level for the manipulated figure	Choice share (in%) for the manipulated figure	Choice share (in%) for the baseline figure	Z-test (p-value) compared to 50%	Holm-Bonferroni corrected p-value
Baseline=1/1.5				
1/1.6	**72***	**28**	**3.11 (p=.003)**	**.03**
1/1.7	62	38	1.70 (p=.12)	.48
1/1.8	46	54	-0.57 (p=.67)	1
1/1.9	42	58	-1.13 (p=.32)	1
1/2	**30**	**70**	**-2.83 (p=.007)**	**.049**
1/2.1	34	66	-2.26 (p=.03)	.15
1/2.2	**28**	**72**	**-3.11 (p=.003)**	**.03**
1/2.3	32	68	-2.55 (p=.02)	.12
1/2.4	38	62	-1.70 (p=.12)	.48
1/2.5	**28**	**72**	**-3.11 (p=.003)**	**.03**
Baseline=1/2				
1/2.1	54	46	0.57 (p=.67)	1
1/2.2	58	42	1.13 (p=.32)	1
1/2.3	54	46	0.57 (p=.67)	1
1/2.4	36	64	-1.98 (p=.06)	.42
1/2.5	40	60	-1.41 (p=.20)	1
1/2.6	40	60	-1.41 (p=.20)	1
1/2.7	42	58	-1.13 (p=.32)	1
1/2.8	34	66	-2.26 (p=.03)	.27
1/2.9	34	66	-2.26 (p=.03)	.27
1/3	**24**	**76**	**-3.68 (p<.01)**	**<.01**

* Each significant result at 95% is presented in bold

Table 12: McNemar Crosstabs for Baseline Elongation 1/1.5

Baseline=1/1.5 Manipulated figure=1/1.6	Baseline=1/1.5 Manipulated figure=1/2.5	
	Choice for the less elongated	**Choice for the more elongated**
Choice for the less elongated	10	26
Choice for the more elongated	4	10

Table 13: McNemar Crosstabs for Baseline Elongation 1/2

Baseline=1/2 Manipulated figure=1/2.1	Baseline=1/2 Manipulated figure=1/3	
	Choice for the less elongated	**Choice for the more elongated**
Choice for the less elongated	7	20
Choice for the more elongated	5	18

5.2.2 Elongation Level and Spatial Disposition

Baseline figure elongation 1/1.5 (see Figure 3): Results of the choice shares comparison for the more elongated figure between the side by side and the one above the other objects' presentations are presented in Table 14. For elongation levels EL_{MF}=1/1.6 and EL_{MF}=1/1.7, there was a significant difference between choice share for baseline figure EL_{BF}=1/1.5 depending on spatial disposition (side by side CS_{MF}=63.46%, one above the other CS_{MF}=28%, $\chi^2(1)=12.90$, $p<.01$, and side by side CS_{MF}=75%, one above the other CS_{MF}=38%, $\chi^2(1)=14.22$, $p<.01$, respectively), the more elongated figure (i.e., the baseline figure) being more often reported as bigger when presented next to the manipulated figure than below it. These results support H4. Afterwards, for elongation levels $EL_{MF}=1/1.8$ and $EL_{MF}=1/1.9$, there was no significant difference between the choice shares for the more elongated figure. Finally, a reversal of the effect was found from $EL_{MF}=1/2$ to $EL_{MF}=1/2.5$, the more elongated figure (i.e., the manipulated figure) being perceived as smaller when presented next to the baseline figure than above it. The detailed statistics for these five elongation levels are presented in Table 14.

Baseline figure elongation 1/2 (see Figure 4): A comparable pattern of results was found when baseline figure elongation was 1/2 (presented in Table 14). When $EL_{MF}=1/2.1$, $EL_{MF}=1/2.2$ and $EL_{MF}=1/2.3$, the difference between choice share for the more elongated figure when presented next to the baseline figure and when presented above it was in the expected direction, although non significant. Next, for elongation levels $EL_{MF}=1/2.4$ and $EL_{MF}=1/2.5$, a shift in the choice shares depending on spatial disposition is occurring but is still not significant. Starting at level $EL_{MF}=1/2.6$ and until $EL_{MF}=1/3$, the effect was reversed, the more elongated figure (i.e., the manipulated figure) being perceived as smaller when presented next to the baseline figure than above it. The detailed statistics for these four elongation levels are presented in Table 14.

Table 14: Choice Shares for the More Elongated Figure (i.e., the baseline figure) when Horizontally-Oriented Figures are Presented Side by Side versus One above the Other

Elongation level for the manipulated figure	Choice share (in%) for the side by side presentation	Choice share (in%) for the one above the other presentation	χ^2 (p-value)	Holm-Bonferroni corrected p-value
Baseline=1/1.5				
1/1.6	**63.46**	**28**	**12.90 (p<.01)**	**<.01**
1/1.7	**75**	**38**	**14.22 (p<.01)**	**<.01**
1/1.8	63.46	54	.94 (p=.33)	.66
1/1.9	50	58	.66 (p=.42)	.42
1/2	48.08	70	5.06 (p=.025)	.07
1/2.1	34.62	66	10.04 (p=.002)	.008
1/2.2	**40.38**	**72**	**10.33 (p=.001)**	**.005**
1/2.3	**32.69**	**68**	**12.71 (p<.01)**	**<.01**
1/2.4	**26.92**	**62**	**12.72 (p<.01)**	**<.01**
1/2.5	**32.69**	**72**	**15.78 (p<.01)**	**<.01**
Baseline=1/2				
1/2.1	65.38	46	3.88 (p=.049)	.20
1/2.2	61.54	42	3.89 (p=.048)	.24
1/2.3	63.46	46	3.14 (p=.08)	.24
1/2.4	51.92	64	1.52 (p=.22)	.22
1/2.5	44.23	60	2.54 (p=.11)	.22
1/2.6	34.62	60	6.59 (p=.01)	.06
1/2.7	**30.77**	**58**	**7.76 (p=.006)**	**.04**
1/2.8	**30.77**	**66**	**12.67 (p<.01)**	**<.01**
1/2.9	**32.69**	**66**	**11.32 (p=.001)**	**.008**
1/3	**34.62**	**76**	**17.73 (p<.01)**	**<.01**

* Each significant result at 95% is presented in bold

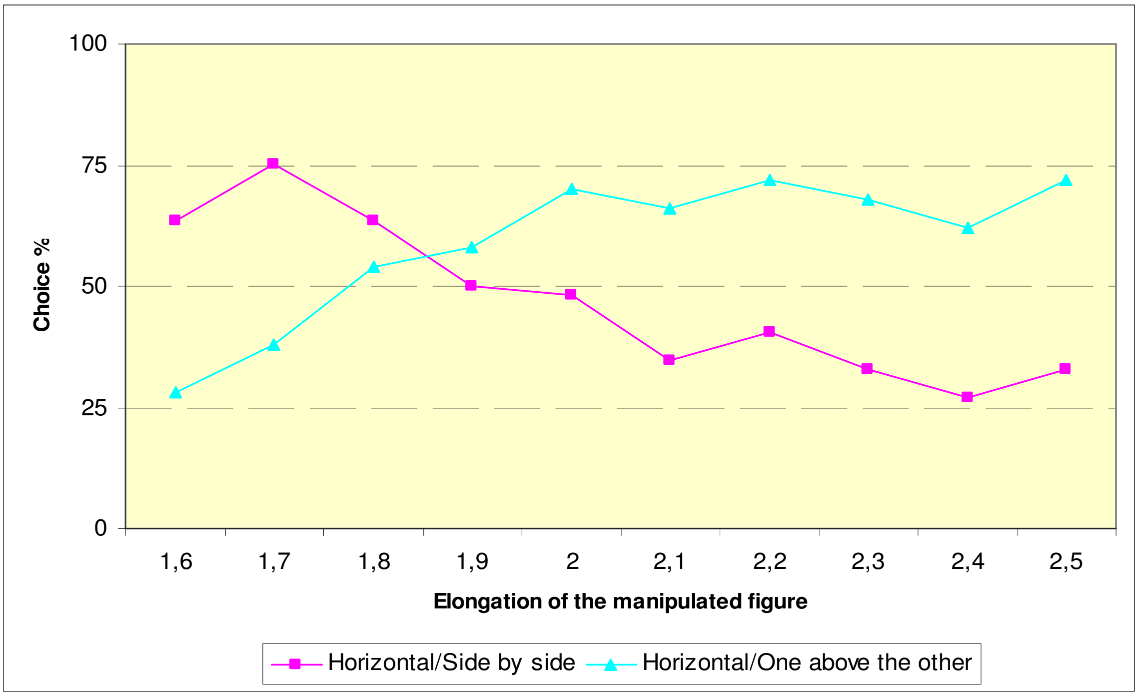


Figure 3: Choice Shares for the more Elongated Figure for Studies 2 and 4 (EL_{BF}=1/1.5)

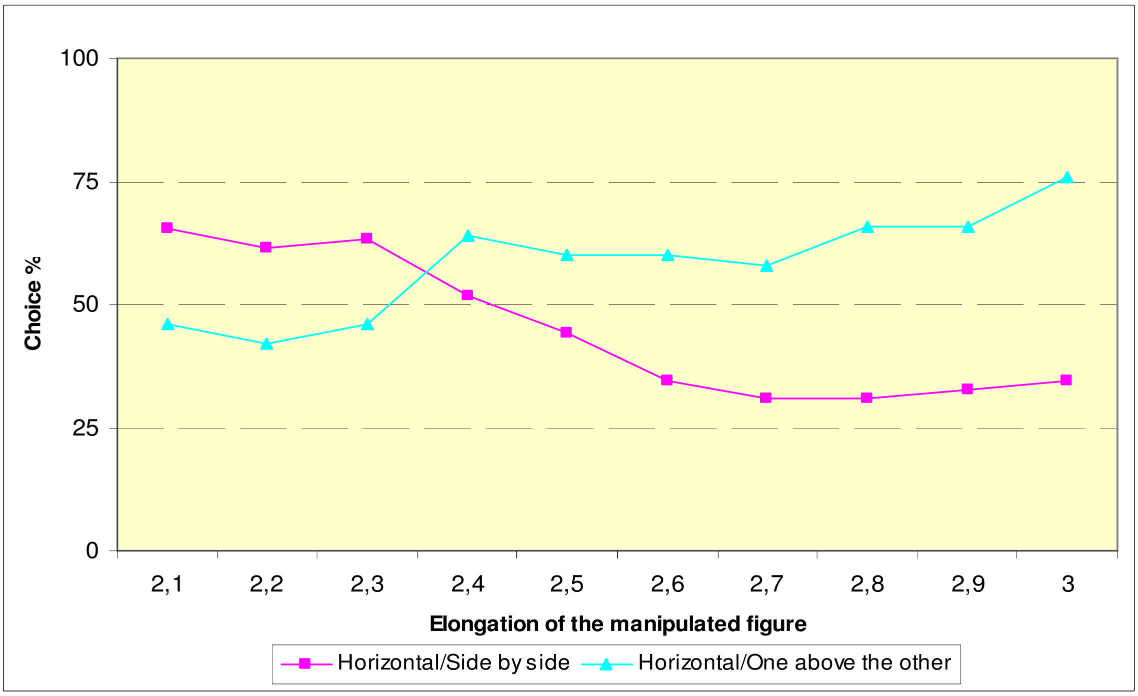


Figure 4: Choice Shares for the more Elongated Figure for Studies 2 and 4 (EL_{BF}=1/2)

5.3 Discussion

This study strongly supports the hypothesis of an existing interaction between elongation level and spatial disposition. Study 4 results show that at lower levels of elongation difference between objects, elongation has a negative effect on size perception when objects are presented one above the other, which confirms hypothesis 3. For baseline elongation 1/1.5, (i.e., EL_{BF}=0.67), choice share for the baseline figure when the manipulated figure was elongation 1/1.6 (i.e., EL_{MF}=0.625) was 28% which is significantly lower than 50%. When baseline elongation is 1/2 (i.e., EL_{BF}=0.5), choice share for the baseline figure when the elongation of the manipulated figure was 1/2.1 (EL_{MF}=0.48) is not significant, but it is in the expected direction (CS_{BF}=46%). Furthermore, when the results of study 2 and study 4 are compared, it appears that the choice shares of the same figures considerably change at low levels of elongation difference when spatial disposition varies. When spatial disposition changes from side by side to one above the other presentation, choice for the more elongated figure significantly decreases by 35.46% and 37% at manipulated figures elongation levels 1/1.6 and 1/1.7, respectively, when baseline elongation level is 1/1.5. When baseline elongation level is 1/2, choice for the more elongated figure is not significantly different depending on spatial disposition of the figures, but the result is in the expected direction (decrease of 19.38%) at manipulated figure's elongation level 1/2.1. Similar to studies 1 and 3 results comparison, these findings overall confirm H4.

On the other hand, at high levels of elongation difference between the two figures, the more elongated one is perceived as bigger, when objects are presented one above the other. These results confirm H5 and show the spatial disposition bias. At elongation baseline level 1/1.5 (i.e., EL_{BF}=0.67), baseline figure choice shares are 70%, 72%, and 72% when the manipulated figure elongation is 1/2, 1/2.2, and 1/2.5, respectively, are significantly higher than 50%. At elongation baseline level 1/2, the choice share for elongation 1/3 (i.e., EL_{MF}=0.33) is 76%, which is also significantly higher than 50%.

Again, when these results are compared with those of study 2, choice shares are significantly different depending on spatial disposition. The positive direction of the effect at high elongation difference levels contrasts with its negative direction at low elongation difference levels, therefore highlighting the interaction between spatial disposition and elongation level. When spatial disposition changes from side by side to one above the other presentation, choice for the more elongated figure significantly increases by 31.62% to 39.31% at manipulated figures elongation levels 1/2.2 to 1/2.5, when baseline elongation level is 1/1.5. Also, when baseline elongation level is 1/2, choice for the more elongated figure significantly increases by 27.33% to 41.38% at manipulated figures elongation levels 1/2.7 to 1/3. These results provide strong support for H6.

In sum, as hypothesized, the elongation effect is reversed at lower levels of elongation difference between figures while the effect is observed at higher levels of elongation. Contrary to when figures are presented side by side (see figures 3 and 4), choice for the more elongated one is drastically enhanced when elongation increases in a one above the other presentation context. Choice share for the more elongated figure (i.e., baseline figure) significantly increases from 28% and 46% to for the lowest manipulated figure elongation level to 72% and 76% for the highest elongation level, when baseline elongation levels are 1/1.5 and 1/2, respectively.

Moreover, the results pattern is in line with study 3 findings, thus highlighting the influence of spatial disposition on choice for the bigger object. Similar to what has been reported in study 2, these findings also emphasize the role of both assimilation/contrast and spatial disposition bias as the main drivers of size perception. At baseline elongation 1.5 (study 3) and 1/1.5 (study 4), the choice shares for the same manipulated figure with elongation 1.6 and 1/1.6 are 36% and 72%, respectively. On the other hand, at these baseline elongation levels, the choice shares for the same manipulated figure with elongation 2.5 and 1/2.5 are 50% and 28%, respectively. Therefore, choice share for the same object can vary significantly depending on whether objects are presented along a vertical or a horizontal axis of elongation. In sum, this study provides additional support for H3, H4, H5, and H6. It consolidates the evidence for the use of both assimilation and constrast processes and spatial disposition bias proposed in this research. The demonstration of the elongation effect boundaries and the underlying process at different elongation levels add to both the cognitive psychology and consumer behaviour literatures.

Studies 1 to 4 have demonstrated how figure size comparison and assessment is undertaken for rectangles. Shapes derived from rectangles are among the most widely adopted in the marketplace (Greenleaf and Raghubir 2008). The question remains, however if elongation of more complex shape resembles that of rectangles. Does the elongation effect have the same boundaries for more complex shapes? Study 5 explores this question.

Chapter 6: Study 5: Does the Spatial Disposition Bias Appear More Rapidly for a More Complex Shape?

According to Greenleaf and Raghubir's (2008) integrative conceptual model of consumer response to geometry, complexity is a basic geometric property that can influence consumer perception and therefore has important marketing mix implications. Studies 1 and 2 show a consistent elongation bias at levels of elongation close to the baseline, which reverses at higher levels of elongation. In the marketplace, more complex shapes also exist and it is unknown whether the elongation effect extends to those shapes. It is expected that, due to increased shape complexity, the spatial disposition bias will occur more rapidly due to the lowered ability to visually compare the geometric dimensions.

H7: When a more complex shape is evaluated, spatial disposition bias will occur at lower levels of elongation than when a simpler shape is assessed.

6.1 Method

Fifty North American consumers participated in a fifteen minute online experiment. They were members of an existing consumer panel to which an invitation to participate in the study was distributed. In this study, participants were presented with 20 pairs of images of shampoo bottles of identical size, displayed in random order (see Exhibit 5). The same data collection procedure used in previous studies was adopted. This study adopted the same elongation levels of baseline and manipulated figures used in study 1. A shampoo bottle, which is symmetric along the vertical axis, was used so that only figure complexity, but not figure symmetry, varied (see Greenleaf and Raghubir 2008). A vertical axis of symmetry was adopted to favour assimilation and contrast at lower levels of elongation to avoid symmetry effects that would favour the use of the hypothesized spatial disposition bias.

The average age of the participants was 38 years (range 21 – 50 years). Twenty-eight participants were female (56%) and twenty-two were male (44%). Thirty-five participants (70%) were right-handed, ten (20%) were left-handed, and five (10%) were ambidextrous. The composition of this sample was similar to studies 1, 2, 3 and 4 samples.

6.2 Results

Baseline figure elongation 1.5 (see Figure 5): The positive effect of elongation on size perception was supported: when EL_{MF}=1.6, the more elongated figure's choice share (CS) was significantly higher than 50% (CS_{MF}=72%, *Z*=-3.11, p<.05). When those levels of elongation were exceeded at EL_{BF}=1.5, no effect of elongation on size perception is found given that choice share for each manipulated figure was not significantly different from 50%. As expected, this effect reverse more rapidly than with rectangles (starting EL_{MF}=2: CS_{MF}=18%, *Z*=4.52, p<0.01) (see Table 15). Cochran Q test result shows a significant difference between choice shares for the less elongated figure across manipulated figures elongation levels (Cochran Q (9)= 82.78, p<.01). A McNemar test demonstrates that the choice share for the more elongated figure (i.e., the baseline) was significantly higher when EL_{MF}=1.6 than when EL_{MF}=2.5 ($CS_{1.6}$=72, $CS_{2.5}$=24,

$\chi^2(1)=20.57$, $p<.01$). As shown in Table 16, 26 participants (i.e., 52%) who selected the more elongated figure as the bigger when $EL_{MF}=1.6$ opted for the less elongated one when $EL_{MF}=2.5$. Only two (4%) of them did the opposite.

Baseline figure elongation 2 (see Figure 6): No positive effect of elongation on size perception was found for levels of manipulated figure elongation close to the baseline shampoo bottle figure. Starting $EL_{MF}=2.7$, the more elongated figure's choice share (CS) was significantly lower than 50% ($EL_{MF}=2.7$: $CS_{MF}=$ 18%, $Z=4.52$, $p<.01$) (see Table 15). Cochran Q test result shows a significant difference between choice shares for the less elongated figure across manipulated figures elongation levels (Cochran Q (9)=42.72, $p<.01$). A McNemar test shows that the choice share for the more elongated figure (i.e., the baseline) was significantly higher when $EL_{MF}=2.1$ than when $EL_{MF}=3$ ($CS_{2.1}=56$, $CS_3=26$, $\chi^2(1)=10.71$, $p=.001$). As shown in Table 17, 18 participants (i.e., 36%) who selected the more elongated figure as the bigger when $EL_{MF}=1.6$ opted for the less elongated one when $EL_{MF}=2.5$. Only three (6%) of them did the opposite.

Table 15: Choice Shares for the Manipulated Figures (More Elongated) and the Baseline Figures when Shampoo Bottle Shapes are Presented Vertically and Side by Side

Elongation Level for the manipulated figure	Choice share (in%) for the manipulated figure	Choice share (in%) for the baseline figure	Z-test (p-value) Compared to 50%	Holm-Bonferroni corrected p-value
Baseline=1.5				
1.6	**72***	**28**	**-3.11 (p=.003)**	**.018**
1.7	52	48	-.28 (p=.89)	1
1.8	44	56	.85 (p=.48)	.96
1.9	36	64	1.98 (p=.06)	.18
2	**18**	**82**	**4.52 (p<.01)**	**<.01**
2.1	**28**	**72**	**3.11 (p=.003)**	**.018**
2.2	**28**	**72**	**3.11 (p=.003)**	**.018**
2.3	**20**	**80**	**4.24 (p<.01)**	**<.01**
2.4	**18**	**82**	**4.52 (p<.01)**	**<.01**
2.5	**24**	**76**	**3.67 (p<.01)**	**<.01**
Baseline=2				
2.1	56	44	-.85 (p=.48)	1
2.2	44	56	-.85 (p=.48)	1
2.3	50	50	0 (p=1)	1
2.4	32	68	2.54 (p=.015)	.09
2.5	40	60	1.41 (p=.20)	.80
2.6	32	68	2.54 (p=.015)	.09
2.7	**18**	**82**	**4.52 (p<.01)**	**<.01**
2.8	**24**	**76**	**3.68 (p<.01)**	**<.01**
2.9	**26**	**74**	**3.39 (p<.01)**	**<.01**
3	**26**	**74**	**3.39 (p<.01)**	**<.01**

* Each significant result at 95% confidence level is presented in bold

Table 16: McNemar Crosstabs for Baseline Elongation 1.5

Baseline=1.5 Manipulated figure=1.6	Baseline=1.5 Manipulated figure=2.5	
	Choice for the less elongated	Choice for the more elongated
Choice for the less elongated	12	2
Choice for the more elongated	26	10

Table 17: McNemar Crosstabs for Baseline Elongation 2

Baseline=2 Manipulated figure=2.1	Baseline=2 Manipulated figure=3	
	Choice for the less elongated	Choice for the more elongated
Choice for the less elongated	19	3
Choice for the more elongated	18	10

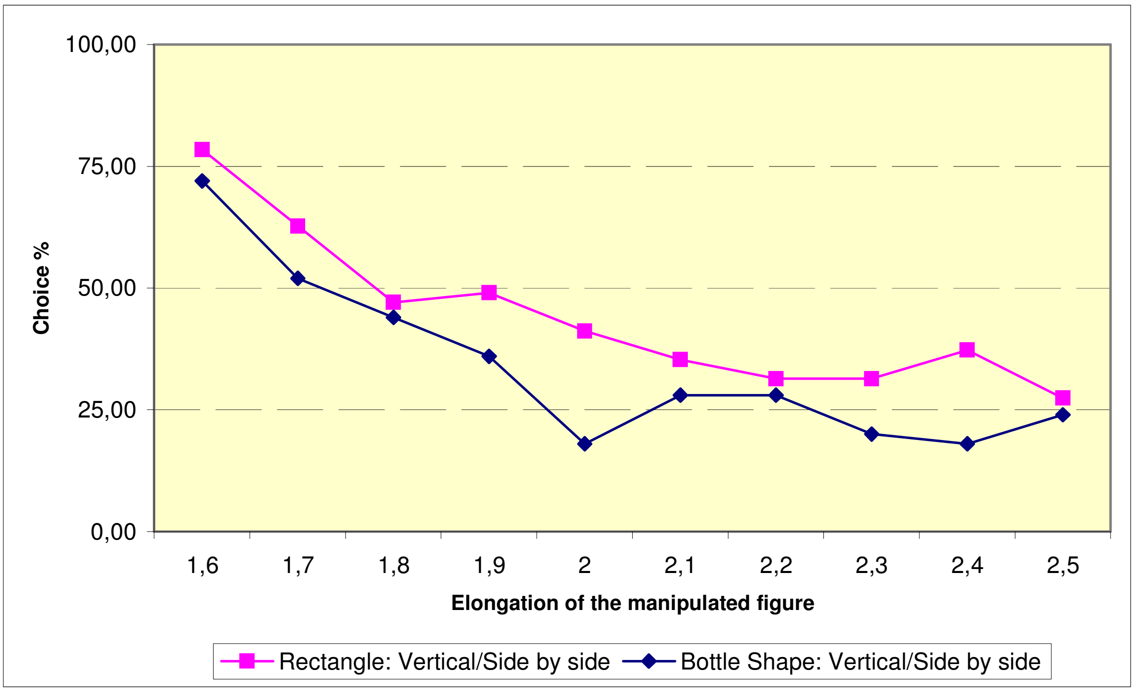


Figure 5: Choice Shares for the more Elongated Figure for Studies 1 and 5 (EL_{BF}=1.5)

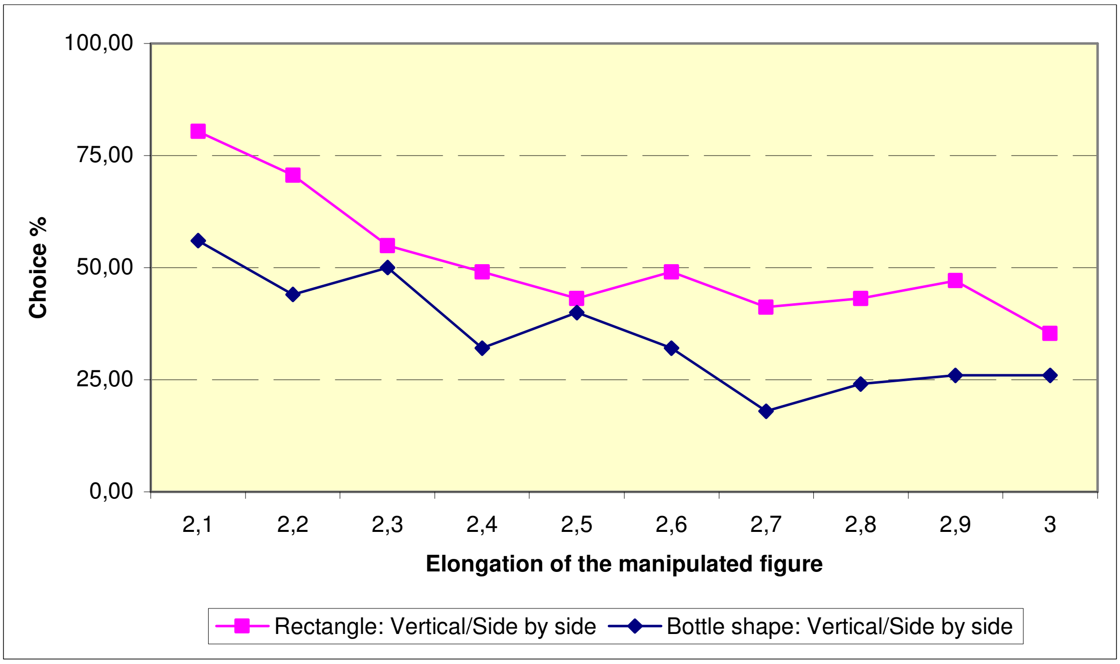


Figure 6: Choice Shares for the more Elongated Figure for Studies 1 and 5 (EL_{BF}=2)

Exhibit 5: Examples of Shampoo Bottle Figures Used in Study 5

Figure 1 : EL=1.6 versus Figure 2 : EL= 1.5

Figure 1 : EL= 2.5 versus Figure EL=1.5

Figure 1 : EL= 2.1 versus Figure 2 : EL=2

Figure 1 : EL= 3 versus Figure 2 : EL=2

6.3 Discussion

When study 5 results are compared with those obtained in study 1, a similar pattern of results is found. When there is a small difference between the manipulated and the baseline figure's elongation, the more elongated figure is perceived as bigger. For instance, choice share for the manipulated figure which EL_{MF}=1.6 when EL_{BF}=1.5 is 78.43% (when compared with 50% share, Z=-4.06, p<.01) for rectangles and 72% (when compared with 50% share, Z=-3.11, p<.01) for shampoo shape bottles. On the other hand, choice share for the manipulated figure with EL_{MF}=2.5 when EL_{BF}=1.5 is 27.45% (when compared with 50% share, Z=3.22, p<.01) for rectangles and 24% (when compared with 50% share, Z=3.67, p<.01) for shampoo shape bottles. However, as illustrated in Figures 5 and 6, the elongation effect reverses more rapidly for shampoo bottle shapes than for rectangles. When EL_{BF}=1.5, the reversal starts at EL_{MF}=2 for shampoo bottle shapes with a choice share of 18% (when compared with 50% share, Z=4.52, p<.01) while it starts only at EL_{MF}=2.5 for rectangles with a choice share of 27.45% (when compared with 50% share, Z=3.22, p<.01). Also, when EL_{BF}=2, there is no elongation effect at lower levels and the spatial disposition effect started at EL_{MF}=2.7 for shampoo bottle shapes with a choice share of 18% (when compared with 50% share, Z=4.52, p<.01) while no such significant effect is found at EL_{MF}=3 for rectangles with a choice share of 35.29% (when compared with 50% share, Z=2.1, p=.40). Hypothesis 7 is therefore supported: when a more complex shape is evaluated, the spatial disposition bias occurs at lower levels of elongation compared to a simpler shape.

Chapter 7: Study 6: Are Elongation Effect and its Reversal Automatic or Driven by Cognition?

In Raghubir and Krishna's (1999) research, elongation effect on size estimation was not moderated by motivation or by cognitive load. Consequently, the authors suggested that elongation bias was a partially automatic mechanism. It is however unknown whether automaticity occurs at low levels only, due to ease of comparison in the assimilation/contrast process or whether the spatial disposition bias that occurs at higher levels of elongation discrepancy between the figures is also automatic. An automatic process is expected to occur in context where low cognitive resources are available (Raghubir and Krishna 1996). By definition, an automatic process is effortless (Bargh 1989) and difficult to modify (Schneider and Shiffrin 1977). Both the assimilation/contrast and the spatial disposition bias are expected to be automatic. In other words, increasing the cognitive load should not alter consumer's choice.

H8: Across elongation levels, there is no difference in choice share for the bigger figure between low and high cognitive load consumers.

7.1 Method

Fifty-one North American consumers participated in a fifteen minute online experiment. They were members of an existing consumer panel to which an invitation to participate in the study was distributed. This study uses the same stimuli as study 1 (i.e., vertically aligned rectangles, presented side-by-side). A 2 (elongation baseline: 1.5, 2) x

10 (levels of elongation of the manipulated figure: elongation increments of .1 starting at the baseline level) x 2 (cognitive load: low, high) mixed-factorial design was adopted, with cognitive load manipulated between participants, and elongation baseline and elongation level manipulated within participants. Twenty-five participants were randomly assigned to the low cognitive load condition while the twenty-four others were randomly assigned to the high cognitive load condition. Participants average age was 35 years (range 21 - 49 years). Thirty-seven participants were female (74%) and thirteen were male (26%). Forty-six participants (92%) were right-handed, three (6%) were left-handed, and one (2%) was ambidextrous. The composition of this sample was very similar to the previous studies samples. The same data collection procedure used in previous studies was adopted. In order to manipulate cognitive load, participants were presented with the stimuli developed by Silverman and Eals (1992) and used by Silverman, Choi, and Peters (2007) to measure an individual's object location memory. A task based on the memorization of visual stimuli was adopted due to its effective manipulation of visual/cognitive load (see Krishna 2006), which is more relevant to the purpose of the present experiment (i.e., visually-based volume assessment) and the process of visual search and products comparison in a store than a numbers memorization task (e.g., Patrick, Macinnis, and Park 2007) or memorizing a list of product features (e.g., Kramer and Block 2008). Participants assigned to the high cognitive load condition were asked to perform the object location memory task originally developed by Silverman and Eals (1992). They were required to memorize as many items as they could from an array of 27 familiar objects and animals (see Exhibit 6) that appeared for 90 seconds). They were specifically instructed to keep these objects in mind during the next

task (i.e., the size assessment task) because after its completion, they would be asked about which of the objects were moved to a different location. After the initial memory task, the size assessment task started. In this task, pair of rectangles were presented side by side, in random order. After the size assessment task was completed, the array of objects reappeared with some of the objects having exchanged position with other objects (see Exhibit 7) and participants had to indicate with a mouse click which objects had moved. In the low cognitive load condition, participants were also presented with the two arrays of objects. However, they only had to memorize the location of the cat. After the size assessment task, they indicated whether the cat image was at the same or a different location. Following Raghubir and Krishna's (1999) manipulation check, participants in both conditions were asked to rate the difficulty of the location memory task on a seven-points semantic differential scale ranging from 1 (very easy) to 7 (very difficult).

7.2 Results

Manipulation check: The object location memory task is rated significantly more difficult by participants in the high visual cognitive load condition ($M_{\text{High visual cognitive load}}$ = 4.33) than those in the low load condition ($M_{\text{Low visual cognitive load}}$ = 2.88; $t(1,47) = 4.00$; $p < .01$), which suggests that the manipulation of cognitive load is successful.

Choice shares comparisons: As illustrated in Table 18, no significant difference is found between choice shares for the manipulated figure under low versus high visual cognitive load for both baseline figure levels. This finding supports H8.

Table 18: Choice Shares for the Manipulated Figures (More Elongated) under Low versus High Cognitive Load when Objects are Presented Vertically and Side by Side

Elongation level for the manipulated figure	Choice share (in%) for the manipulated figure in low cognitive load	Choice share (in%) for the manipulated figure in high cognitive load	Z-test (p-value) Low vs high cognitive load	Holm-Bonferroni corrected p-value
Baseline=1.5				
1.6	84	76	.50 (p=.48)	1
1.7	56	56	0 (p=1)	1
1.8	48	56	.32 (p=.57)	1
1.9	48	44	.08 (p=.78)	1
2	48	52	.08 (p=.78)	1
2.1	28	32	.09 (p=.76)	1
2.2	32	24	.40 (p=.53)	1
2.3	36	36	0 (p=1)	1
2.4	28	28	0 (p=1)	1
2.5	28	32	.95 (p=.76)	1
Baseline=2				
2.1	88	84	.17 (p=.68)	1
2.2	76	76	0 (p=1)	1
2.3	76	52	3.12 (p=.08)	.72
2.4	52	56	.08 (p=.78)	1
2.5	40	40	0 (p=1)	1
2.6	44	40	.08 (p=.78)	1
2.7	32	60	3.95 (p=.05)	.50
2.8	40	36	.08 (p=.78)	1
2.9	36	32	.09 (p=.77)	1
3	36	52	1.30 (p=.25)	1

Exhibit 6: Object Location Memory Stimulus Seen Prior to the Size Assessment Task

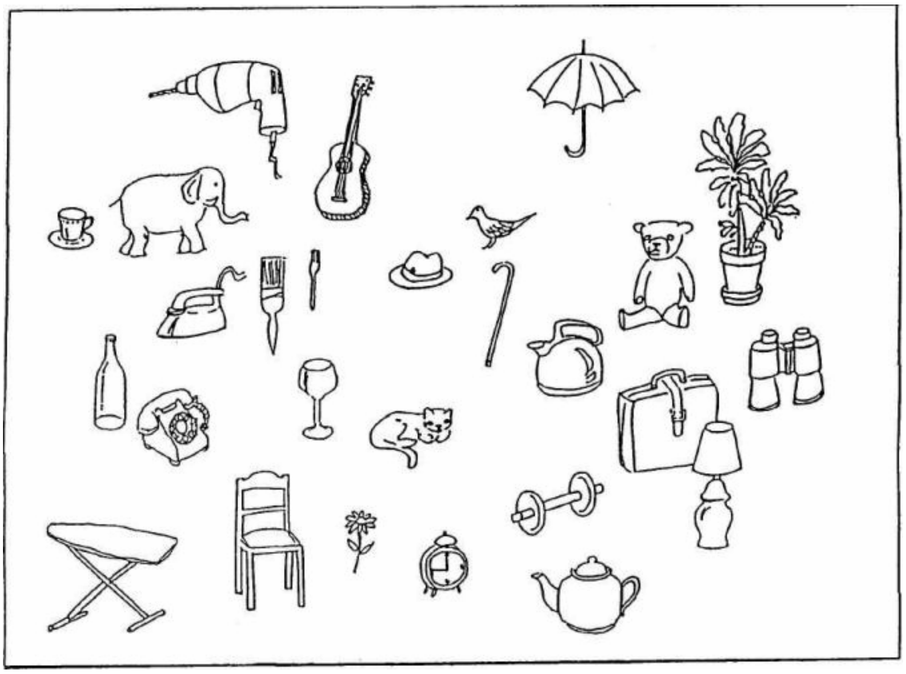
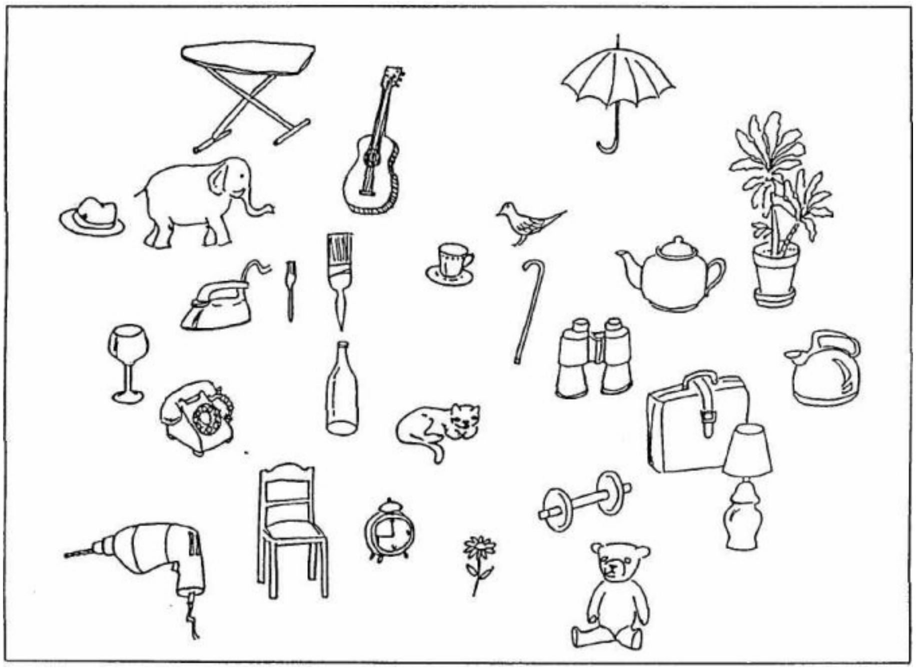


Exhibit 7: Object Location Memory Stimulus Seen After the Size Assessment Task



7.3 Discussion

Study 5 findings confirm H8, which states that across elongation levels, no difference in choice share for the bigger figure should be found between low and high cognitive load individuals. The results thus support that the elongation effect and its reversal are automatic rather than due to cognitive processing. The results obtained at high and low cognitive load are very similar to those obtained in study 1 where the more elongated object was selected as the bigger when its elongation was slightly different from the baseline elongation and the opposite result is found at high difference between their elongations. This pattern of results as well as the absence of difference between low and high cognitive load conditions was found for both baseline elongation levels 1.5 and 2. These results replicate and extend Raghubir and Krishna's (1999) finding that the elongation effect is automatic. The present research shows not only that the elongation bias is automatic, but also that its disappearance and its reversal are too. In other words, both the assimilation/contrast processes that drive the elongation effect at low levels of elongation difference and the spatial disposition bias at high levels of elongation difference influence size assessment in an automatic manner and are not influenced by cognition.

Chapter 8: General Discussion

This dissertation has identified and demonstrated the boundaries and contextual dependence of the elongation bias. The current results demonstrate that consumer perceptions of object size are influenced by 1) the elongation level of an object compared to a reference, 2) the physical position (i.e., side by side versus one above the other) of the object compared to a reference, and 3) the cardinal orientation (horizontal or vertical) of the object.

8.1 Summary of Findings

Results of six experimental studies with adult consumers shed light on how and to what extent the elongation bias operates. These findings show that, when comparing the perceived size of two identically-sized two-dimensional items, people first try to detect both their similar and differing geometrical dimensions. If there is no perceptible difference between the two figures on the length of the two dimensions (i.e., visual assimilation), individuals are expected to perceive them as identical. Nevertheless, when no noticeable difference appears on one dimension (e.g., width is the same and visual assimilation occurs) but a difference between the two figures on the length of another dimension (such as height) is perceptible (i.e., visual contrast), individuals base their size assessment only on the contrasting dimension. In addition, when both dimensions contrast, a "spatial disposition bias" occurs. It has been shown that this bias becomes stronger as differences between the dimensions of the two objects increase. Eventually, the object presenting the longer salient dimension is more often selected as the bigger one (i.e., the wider object in horizontal presentation and the taller object in vertical presentation). This leads to a reversal in choice share that is not explained in the marketing literature.

Specifically, the elongation bias holds only for levels close to the baseline object's elongation, when objects are presented side by side (study 1). This effect is reversed at higher levels of elongation due to the salience of width. When objects are rotated by 90 degrees in study 2, the more elongated object in study 1 became the less elongated one. Shifts in choice shares replicate the elongation bias and its boundaries demonstrated in study 1. When objects are presented one above the other (study 3), contrasting width led to a negative effect of elongation at lower levels of elongation, which disappeared at higher levels due to the absence of one contrasting dimension. These results were also found when objects were rotated by 90 degrees (study 4). The elongation bias and its reversal in a side by side presentation context were replicated with a more complex shape, where the effect reversal occurred more rapidly than with the rectangular shape (study 5). Finally, the automaticity of both elongation bias and its reversal were demonstrated in study 6 where low versus high cognitive load did not influence the elongation bias or its boundaries. These results are summarized in Table 19. Results of studies 1, 2, 3, and 4, using the same stimuli but varying spatial disposition (i.e., presentation side by side versus one above the other) and cardinal orientation (i.e., 90 degrees rotation) are presented in Figures 7 and 8.

Table 19: Summary of Results

Hypothesis	Result	
	Study 1	**Study 2**
H1: At low levels of elongation difference between two objects, the *more* elongated one is perceived as bigger, when the objects are presented side by side.	**EL_{BF}=1.5** Confirmed **EL_{BF}=2** Confirmed	**EL_{BF}=1/1.5** Confirmed **EL_{BF}=1/2** Not significant but in the expected direction.
H2: At high levels of elongation difference between two objects, the *less* elongated one is perceived as bigger, when the objects are presented side by side.	**EL_{BF}=1.5** Confirmed **EL_{BF}=2** Not significant but in the expected direction.	**EL_{BF}=1/1.5** Confirmed **EL_{BF}=1/2** Not significant but in the expected direction.
	Study 3	**Study 4**
H3: At low levels of elongation difference between two objects, the *less* elongated one is perceived as bigger, when the objects are presented one above the other.	**EL_{BF}=1.5** Confirmed **EL_{BF}=2** Confirmed	**EL_{BF}=1/1.5** Confirmed **EL_{BF}=1/2** Not significant but in the expected direction.
H4: At low levels of elongation difference between two objects, the *more* elongated one is perceived as bigger when the objects are presented side by side than one above the other.	**EL_{BF}=1.5** Confirmed **EL_{BF}=2** Confirmed	**EL_{BF}=1/1.5** Confirmed **EL_{BF}=1/2** Not significant but in the expected direction.

H5: At high levels of elongation difference between two objects, the *more* elongated one is perceived as bigger, when the objects are presented one above the other.	**EL_{BF}=1.5** Not significant but in the expected direction. **EL_{BF}=2** Not significant but in the expected direction.	**EL_{BF}=1/1.5** Confirmed **EL_{BF}=1/2** Confirmed
H6: At high levels of elongation difference between two objects, the *more* elongated one is perceived as bigger when the objects are presented one above the other than side by side.	**EL_{BF}=1.5** Not significant. **EL_{BF}=2** Not significant but in the expected direction.	**EL_{BF}=1/1.5** Confirmed **EL_{BF}=1/2** Confirmed
	Study 5	
H7: When a more complex shape is evaluated, spatial disposition bias will occur at lower levels of elongation than when a simpler shape is assessed.	**EL_{BF}=1.5** Confirmed **EL_{BF}=2** Confirmed	
	Study 6	
H8: Across elongation levels, there is no difference in choice share for the bigger figure between low and high cognitive load consumers.	**EL_{BF}=1.5** Confirmed **EL_{BF}=2** Confirmed	

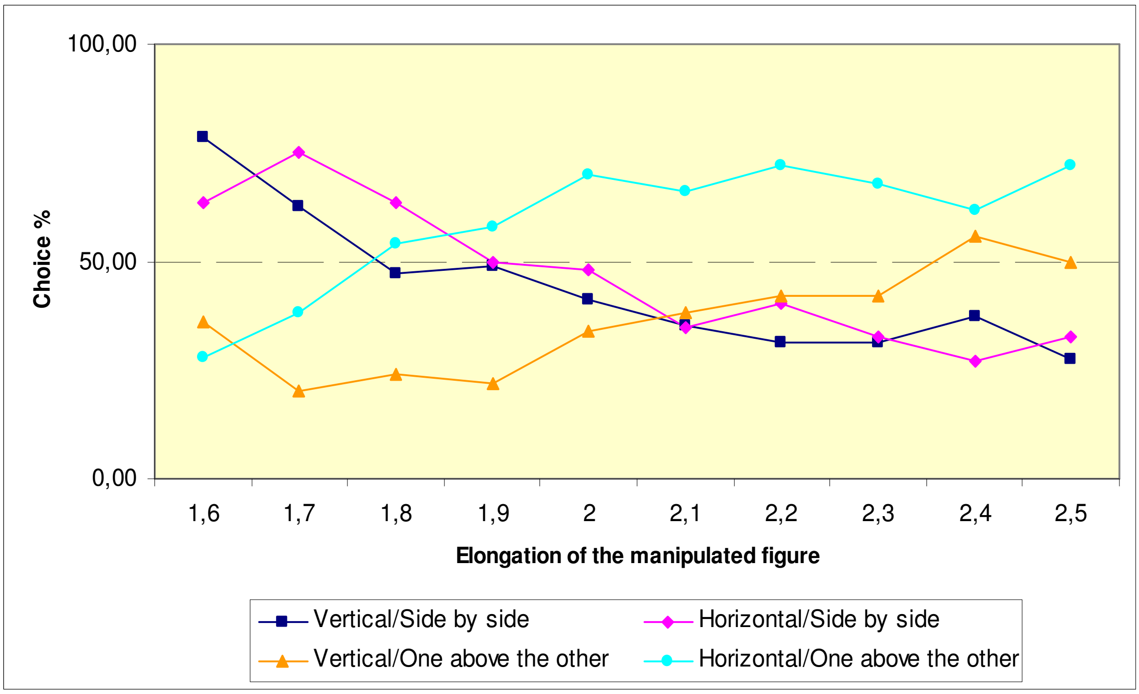


Figure 7: Choice Shares for the more Elongated Figure for Studies 1, 2, 3, and 4

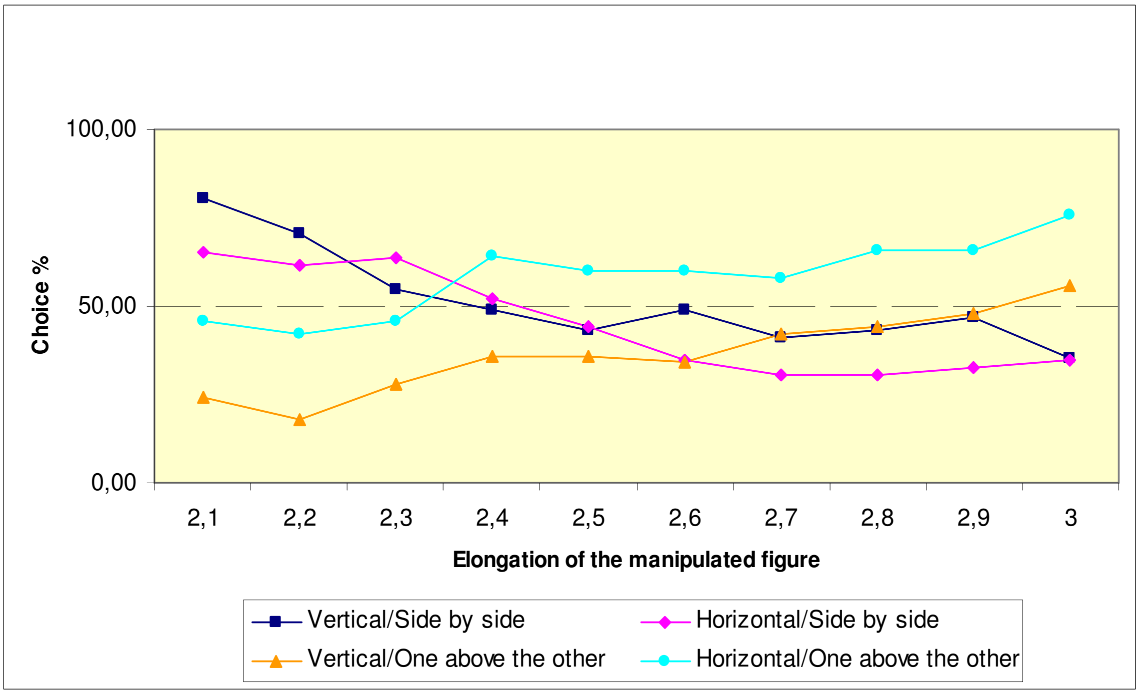


Figure 8: Choice Shares for the more Elongated Figure for Studies 1, 2, 3, and 4

8.2 Theoretical and Managerial Implications

From a theoretical perspective, this research innovates by determining the boundaries and the contextual factors necessary for the occurrence of the elongation bias. The findings of this research, in terms of elongation effect boundaries and objects' comparison process, add to both cognitive psychology and consumer behaviour literatures.

Prior research on the elongation effect (Krider, Raghubir, and Krishna 2001; Raghubir and Greenleaf 2006; Raghubir and Krishna 1999; Wansink and Van Ittersum 2003; Yang and Raghubir 2005) has established that elongation positively influence size perception across a variety of containers. As illustrated in Figures 7 and 8, this work demonstrates that when two objects are evaluated, the more elongated is selected as the bigger only when 1) objects are presented side by side and their difference in terms of elongation is low and 2) when objects are presented one above the other and their difference in terms of elongation is high. Existing size estimation or size comparison models, including Krider, Raghubir, and Krishna's (2001), cannot account for the choice share reversal when elongation increases and spatial disposition remains the same. This research shows, however, that reversal occurs across spatial disposition conditions, shapes, and cognitive load.

This research has critical managerial implications in terms of packaging, visual display merchandising, and positioning. This work shows that product and package dimensions should be determined (or adjusted) as a function of consumers' reference point in that specific category. Depending on whether a smaller or bigger shaped existing product is considered the target competitor, a new product would be slightly more or less elongated that the reference package. This raises important questions: from a consumer's standpoint, what is the reference package? Is it the package associated with the leading brand or with most brands in that category? Is there a prototypical elongation level for a given product category in consumers' minds? In the cognitive psychology literature, it has been proposed that the mental representation of a category is based on a prototypical exemplar (Posner and Keele 1968; Reed 1972). This theory has been corroborated by the marketing literature, mostly in a branding context (e.g., Mao and Krishnan 2006). The closer is a stimulus to the category prototype, the better exemplar of the category it is. Investigating the existence of such concept in package perception and categorization would be and to identify the criteria that must be met for a package to be perceived as a prototype in its category.

The spatial disposition results suggest that size perception does not only depend on product features but also on products' display at the point of purchase. This calls for a closer collaboration between manufacturers and retailers. Retailers can strategically place their private brand products and the products that provide the bigger profit margins so that they appear bigger or smaller than their national brand or than their less profitable counterparts. It is also important to emphasize that a bigger-looking packaging is not always desirable. For instance, in some product categories, product exclusivity is key to a luxurious image and small container size denotes such exclusivity (e.g., high-end anti-aging cosmetics, caviar) while in other categories technological advances are associated with smaller products (e.g., cell phones, iPods). In these cases, package or product elongation and shelves spatial disposition can be integrated to lead to smaller containers or products perception.

Although increasing product price is the typical strategy for augmenting product profit margin, a number of firms have adopted downsizing practices over the years. Downsizing consists of reducing product volume while keeping the price constant or even increasing it (Adams, Di Benedetto, and Chandran 1991). As increasing the price of a product is likely to generate negative consequences (e.g., consumers may decide to switch to a competitor brand), an increasing number of companies opt for downsizing, which corresponds to an "invisible" price increase (Gupta et al. 2007). This practice is popular in consumers branded items (Adams et al. 1991) and "hyper-competition" markets (Gupta et al. 2007). On the other hand, several cases of product upsizing (i.e., volume increase while keeping the price constant) have been undertaken for the sake of repositioning or category change (e.g., Carter 2003). Despite the wide use of these strategies and the increasing interest in downsizing by the media (e.g., Song 2003; Spors 2004), very little academic research has explored their actual impact on consumers' size perception and product evaluation. A reduction or increase in product volume is usually directly reflected in changes in packaging dimensions. The current research sheds light on visual biases when elongation changes while the actual size of objects remains the same. Given the results of this research, it is expected that downsizing perception would be reduced and upsizing perception strengthened by increasing package elongation at low package elongation difference between the downsized product and the reference product (e.g., the prior product version or leading brand's container) and by decreasing package elongation at high elongation differences, when products of the same category are presented side by side. The opposite results are expected when these products are presented one above the other: at low elongation difference with the reference product, reducing package elongation is likely to emphasize the upsizing and diminish the perception of downsizing, while at high elongation differences package elongation should be augmented to increase the effectiveness of both upsizing and downsizing strategies. Finally, as Nemati (2009) highlighted, building new theoretical frameworks is still much needed to progress towards a unified account of visual illusions. The current research is an important step in that direction.

Furthermore, the present results raise important public policy issues. Past studies showed that consumers spend minimal effort in reading price and volume labels. Echoing Dickson and Sawyer's (1990) findings, Cole and Balasubramanian (1990) found that consumers pay very little attention to information provided on the package. More recently, Yang and Raghubir (2005) reported that consumers use visual cues for volume assessment and do not rely on semantic indication on the product package. The current work confirms that consumers are likely to be subject to consistent visual biases triggered by both packaging and product display. From a public policy perspective, the findings of this research raise important questions about consumers' education and packaging regulations: Should standard norms for packaging volume (e.g., small size=250 grams, medium size=500 grams etc.) be imposed within a product category? Or, should products presenting better nutritional intake and lower calories be designed and displayed to favour selection by consumers? Should consumers be more informed about potential unethical practices that take advantage of automatic visual biases, and would this increased awareness of such biases increase consumers' propensity to read volume labels?

8.3 Limitations and Future Research

The main focus of this dissertation was to understand the process underlying elongation bias in size perception. Future research will pertain to the identification of the underlying individual characteristics that influence one's likelihood to be subject to biases in visual size estimation. It is still unknown what sensorial or cognitive skills produce individual differences in terms of propensity to overestimate or underestimate or accurately perceive objects size.

Given that participants in this research compared areas and not volumes, the present results are particularly relevant in a two-dimensional online visual merchandising context. They can also apply to in-store displays when packaging depth is constant across products within the category or when depth can be evaluated based on the shelf facing area (e.g., cylinders or cubes). According to the findings of this dissertation, managers may be motivated to use appropriate visual cues that make their product packaging look larger in order to increase consumers purchase propensity. However, the results of the current work should be used with caution in contexts other than those described above, as additional research is required to demonstrate that the perceptual mechanisms that operate in two-dimensional settings are also activated in three-dimensional ones. Moreover, in stores, consumers typically start with identifying the product visually and then they manipulate it haptically—even if it serves only to put the product into their shopping cart—prior to purchasing it. Tactile manipulation provides consumers with unique input that they would not obtain with visual examination only (Lindauer, Stergiou, and Penn 1986). It has been shown that consumers' confidence in their product judgment is influenced by whether or not they have the opportunity to integrate haptic information in their evaluation (Grohmann, Spangenberg, and Sprott 2007; Peck and Childers 2003). According to the theory of disappointed expectations (Ellis and Lederman 1999; Ross 1969), individuals form cognitive expectations about object weight based on its size. This expected weight (visually gauged) contrasts with perceived weight (haptically gauged) when visual and haptic input is inconsistent. This inconsistency leads people to perceive the larger sized object as lighter than the smaller sized object of identical weight. This phenomenon, known as the size-weight illusion (Charpentier 1891), has been consistently reported in a wide range of studies (Ellis and Lederman 1993). Moreover, Huang (1945) underlined that the size-weight illusion was not based on physical size (i.e., actual area or volume) but on apparent size (i.e., visually perceived area or volume). Consequently, the use of visual cues that induce a positive bias in terms of volume perception (e.g., elongation, color etc.) is likely to produce perception of larger apparent size and weight and is expected to contrast with haptic input. The psychology literature indicates that when sensory modalities produce conflicting input, vision dominates the other senses (Posner, Nissen, and Klein 1976). The size-weight illusion suggests that individuals incorporate visual input when assessing weight but do not completely disregard haptic information. Moreover, recent research shows that haptic information can modulate the appearance of visual illusions (Omori et al. 2007). Future research should explore the integration of both visual and haptic modalities and examining the influence of their interaction on producing or reducing the elongation bias, across elongation levels.

Most of the academic work on packaging (e.g., Folkes and Matta 2004; Raghubir and Krishna 1999; Wansink and Van Ittersum 2003; Yang and Raghubir 2005), including the current research, pertains to the study of the influence of product shape on consumers' judgment. Additional work is required in order to assess the influence of other visual information consumers may incorporate in their evaluation of a packaged product. Package color, for example, is a salient cue likely to instantiate inferences about product quantity. The Institute for Color Research estimates that color is the sole cue consumers use to assess between 62% and 90% of newly presented products (Singh 2006). However, while the impact of color has gained substantial interest in marketing practice, academic research in this area has almost exclusively focused on consumer reactions to colors in retail atmospherics (e.g., Bellizi and Hite 1992, Gorn et al. 2004).

In conclusion, this research highlights the need for a further investigation of packaging design and merchandising areas of research and calls for an integrative approach in their academic study and managerial implementation.

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