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CLINICAL PSYCHOLOGY & NEUROPSYCHOLOGY | RESEARCH ARTICLE

Body mass index and flanker size: Does (over) weight modulate the Baldwin illusion?

M. Baskini^{1*}, P. Brugger^{2,3}, P. Fragkiadoulakis⁴, C. Keramydas⁵, D. Panagiotakos⁶ and H. Proios²

ABSTRACT: Visuospatial processing is a complex process that is vulnerable to bias. Line bisection paradigms are used to help detect the factors that balance left and right hemispatial attention that go beyond the domains of perception and action. For example, studies have indicated the “pseudoneglect” phenomenon in the bisection of horizontally presented lines in healthy subjects. Among the modified versions of the traditional line bisection task is the “Baldwin illusion”. In the Baldwin illusion, the subjective midpoint of a line flanked by squares of different sizes is displaced towards the small square. The goal of the study was two-fold. First, we wanted to investigate whether there is an asymmetry in the Baldwin effect depending on leftward or rightward arrangement of the small square and second whether obesity (as measured by body mass index—BMI) would affect bisection of Baldwin-like flanked lines.

Thirty-one healthy, right-handed female subjects (20 normal-weight and 11 overweight) had to repeatedly bisect a horizontal straight line using a series of Baldwin-type stimuli, including a photography of their own and the experimenter’s body.

As predicted, this displacement was larger when the small square was on the left end of the line ($M = -1.80$ mm, $SD = 2.71$ mm, $t = -10.48$, $p = <0.001$) than when it flanked the right end ($M = +0.71$ mm, $SD = 2.90$ mm; $t = 3.83$, $p = t = 4.35$, $p = <0.001$). Across all stimulus types (irrespective of the size or type of a flanker),



M. Baskini

ABOUT THE AUTHOR

Peter Brugger and Hariklia Proios started their collaboration about 20 years ago at the Neuropsychology Unit of the University Hospital in Zurich and continues today in the areas of visual neglect and visual-spatial processing as well as in the area of random number generation by healthy and neurologically impaired subjects.

PUBLIC INTEREST STATEMENT

Visuospatial processing is subject to various sources of bias. The bisection of horizontal lines can uncover many such biases. Healthy individuals systematically bisect a line to the left of the objective midpoint (“pseudoneglect”). This effect is due to the superiority of the right hemisphere for processing visuospatial information. Scientists have long used numerous modified versions of the line bisection task. One version requires the bisection of a line flanked by images of different sizes. In this paper, we explored, for the first time, whether a person’s body size would modulate the bisection of lines flanked by geometric figures or photographs of human bodies, including the subject’s own image. Our preliminary results indicate that, over all flanker types, overweight women deviated more to the left than women of normal weight. Body mass index appears to play a role in visuospatial processing, but this needs to be further investigated.

overweight subjects placed the subjective midpoint more leftward than the normal-weight subjects. In 13 out of 16 types the results differed significantly and in the remaining 3 types the tendency was clear ($0.074 < p < 0.13$).

Limitations were addressed. Our results confirmed our asymmetry hypothesis. Also, these preliminary results demonstrated an influence of BMI on line bisection performance, i.e. a larger pseudoneglect for the overweight/obese subjects.

Subjects: Psychological Science; Behavioral Neuroscience; Cognitive Neuroscience; Cognitive Neuroscience of Vision

Keywords: line bisection; pseudoneglect; Baldwin illusion; overweight

1. Introduction

When the German ophthalmologist Karl Theodor Paul Polykarpus Axenfeld introduced the line bisection task (Axenfeld, 1894), he could not have dared to anticipate its enormous development over the upcoming 100 years. What he proposed to be a “simple method to identify hemianopia”, soon advanced to a practical bedside test for unilateral spatial neglect (Albert, 1971). As such, the apparently trivial task to mark the midpoint of presented lines turned out to be determined not only by visual-perceptual but also by motor, attentional and intentional factors. Systematic investigations of the role of these factors in bisection performance used an almost bewildering variation of the original procedure and its applications. Most importantly, line bisection has long ceased to be a mere diagnostic tool for perceptual and attentional deficits after unilateral brain damage. It has advanced to an important method for delineating the top-down contributions, which balance healthy subjects’ spatial attention along the horizontal axis (Fischer, 2001, for a fascinating brief review). Emergent from the respective studies is the finding of a “pseudoneglect” in the bisection of horizontally presented lines, i.e. healthy volunteers’ placement of the subjective midpoint *leftward* of the objective midpoint (Bowers & Heilman, 1980; Jewell & McCourt, 2000; see also the Discussion section). Pseudoneglect is commonly viewed as the consequence of a right hemisphere superiority for spatial processing. Its magnitude depends on a number of factors, comprising of subjects’ age and handedness (younger subjects and right-handers show stronger pseudoneglect) and the response hand (stronger leftward deviation for the left hand). “Lines”, whose bisection demonstrate pseudoneglect, are not necessarily pencil-drawn, but can be represented by a blank space between two printed endpoints (McIntosh et al., 2004) or between two simultaneously touched points on the skin (Lenggenhager et al., 2015). They can also be pre-bisected, vertically or displaced, to invite an observer’s comparative judgment of length without any hand-motor involvement (Fink et al., 2000; see also the paradigm of “ocular bisection”, Rinaldi et al., 2018). Lines can be printed as arrays of characters, notably of digits and letters (Fischer, 1996). In the case of digital character lines, those made of the digits 1 or 2 enhance the pseudoneglect over that observed with a “neutral” line like “5555555555555555”, whereas lines of the digits 8 or 9 weaken it, demonstrating the biasing effect of a “mental number line”, which extends from left to right in cultures with a left-to-right oriented script. In the case of letter lines, pseudoneglect commonly holds for scrambled, meaningless sequences; as soon as the strings contain meaningful words, the bisection mark is shifted rightwards (Mohr & Leonards, 2007), possibly as a consequence of semantic processing activating the left hemisphere and inducing a transient right-ward orientation bias (see also Bultitude & Davies, 2006). Finally, “lines” do not need to be displayed visually; they can be rods to be haptically explored (Laeng et al., 1996), felt distances on body parts (Lenggenhager et al., 2015; Sposito et al., 2010) or defined by two tones in sequence which require choosing the “midpoint” of a temporal duration (Kopeck & Brody, 2010). “Number line bisections” require a subject to indicate the middle number between two auditorily presented stimulus numbers (Loftus et al., 2009). Interestingly, healthy subjects err towards too small numbers, corresponding to “pseudoneglect in number space” (Loetscher & Brugger, 2007), whose magnitude depends as much on higher cognitive functions and personality, as does pseudoneglect in physical space (Brugger et al., 2007).

Altogether, the rich methodology of line bisection paradigms developed since Axenfeld (1894) has helped to uncover those determinants of the balancing between left and right hemispatial attention that transcend the domains of perception and action and are better ascribed to higher cognitive functions and to trait-like measures of hemispheric balance as they underlie different personality types (see, e.g., Brugger & Graves, 1997; Brugger et al., 2007; Drake & Ulrich, 1992).

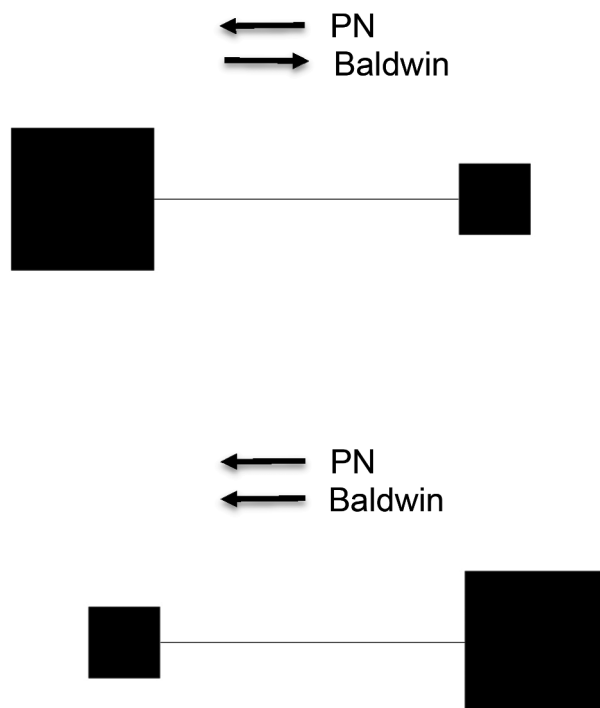
One modification of the traditional bisection task involves the placement of flankers on one or both sides of the line (Chieffi et al., 2014; Milner et al., 1992). Generally, a letter cue placed on one end of the line “attracts” the subjective midpoint, i.e. the motor response is displaced towards the side of the cue. In the presence of bilaterally placed geometrical forms, however, flanker size is critical. This modification, especially relevant to the present investigation, is famously known as the “Baldwin illusion”. It is named after the American philosopher and psychologist James Mark Baldwin, who first described it just one year after Axenfeld’s publication on the bisection of simple, unflanked lines (Baldwin, 1895). In the Baldwin illusion, the subjective midpoint of a line flanked by a large square on one side and a small square on the other is displaced toward the small square.¹ Although low-level perceptual and contextual factors that determine the size of the Baldwin illusion have been studied in detail (e.g., Chieffi & Ricci, 2002; Clavadetscher & Anderson, 1977; Pressey & Smith, 1986), top-down influences have been neglected. It is highly probable, however, that bisection performance in a Baldwin context depends as much on higher cognitive factors and personality variables as does the bisection of unflanked lines. Evidence for this assumption comes from demonstrations of Baldwin-type illusions in the auditory modality (Brigner, 1987), in the supramodal judgments of numerical distances (Bonato et al., 2008) and in the bisection of temporal intervals (Brigner, 1989).

The rationale of the present investigation was two-fold. First, we wondered whether pseudoneglect would manifest itself also in bisections of Baldwin type lines, i.e. lines flanked with identical shapes of differing size at the two ends. More specifically, we expected an asymmetry of the Baldwin effect not previously described in the literature. If the effect of pseudoneglect (leftward displacement of bisection mark) and the Baldwin effect (smaller flanker attracts bisection mark) were additive, lines with a flanker arrangement left-small and right-large (□—□) should lead to a larger bisection error (to the left) than lines with the reversed flanker assignment (□—□). According to the Attentional Repulsion Effect when subjects are presented with horizontal pre-bisected lines with vertical marks near the center, observers misjudge the center as a result of whether the line is preceded by a cue lateralized to right or left orientation (Suzuki & Cavanagh, 1997). Figure 1 illustrates this hypothesis.

A second goal of the present study was inspired by Fischer (2001), who emphasized that bisection tasks still have some unrecognized potential in that they might have diagnostic applications beyond those in patients with hemianopia or neglect. We thus set out to explore whether obesity would affect the bisection of Baldwin type lines. Since size is a critical and delicate cue in overweight people and visual body size adaptation aftereffects were found to be strongly correlated to an observer’s body mass index (BMI; Ambroziak et al., 2019, Exp. 3) we predicted a more pronounced size susceptibility and, hence, a larger Baldwin effect in obese compared to normally weighted participants. Such prediction might also be based on the theory that obesity is accompanied by a generally exaggerated response to external stimuli (Schachter & Rodin, 1974), although, over the past decades, controversies have emerged about the validity of this notion (see Section Discussion). In order to accommodate the observation that women’s side-dependent distortions of visually perceived size were different for objects, other persons’ bodies and the observer’s own body (Mohr et al., 2007), we selected pictures of all these categories to be used as flankers, in addition to the square boxes traditionally used in studies of the Baldwin illusion.

Figure 1. Visualization of the hypothesis tested in the present study (part 1).

While the Baldwin effect predicts displacement of the subjective center of a line toward the small square, pseudoneglect consists in a flanker-independent shift of this center towards the left. Hence, the two phenomena should be additive in the small left/LARGE right flanker placement (bottom), but counteract one another in the LARGE left/small right placement (top). PN: pseudoneglect, Baldwin: Baldwin effect.



2. Materials and methods

2.1. Study design

This study used a computerized stimulus presentation of Baldwin-type lines to bisect. Each trial was composed of a line segment flanked by various pairs of images that differed from each other in size, by two equal sized squares or an unflanked line. In the first part, we used a within-subject design with neurologically healthy right-handed women to test the hypothesized additivity of pseudoneglect and the Baldwin effect.

In the second part, we used the same data for preliminary analyses in a between-subject design. Specifically, we classified our sample as “normal-weight participants” or “overweight participants” according to published cut off points for BMI (Weir & Jan, 2019). Normal-weight individuals are defined as those with BMI smaller than or equal to 18.5 to 24.9 kg/m², overweight as those with BMI from 25.0 to 29.9 and obese as those with BMI greater than 30. For the present study, we pooled overweight and obese subjects into one “overweight participants” group.




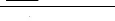



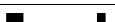






2.2. Participants

Thirty-three subjects were initially recruited for this study. According to the World Health Organization (2020), 39% of adults worldwide are overweight or even obese. We thus hoped to have a sufficiently large number of subjects with a relatively high BMI for our preliminary analyses of BMI as a potential modulator of bisecting Baldwin-type stimulus lines.

Two participants were excluded on the basis of their scores of +4, indicating ambidexterity, on the FLANDERS Handedness inventory (see below). There were thus 31 healthy right-handed women (ages: 29.9±12.4 years), 20 of normal weight (NW group) and 11 overweight (OW group).

Subjects were recruited from the community through flyers posted in University, bank and local industry centers. Inclusion criteria comprised normal vision (either without or with correction) and no history of psychiatric or neurological disorders or metabolic disease (assessment with a semi-

Table 1. Mean (M) and standard deviation (SD) of the subjective midpoint displacement (in mm) for the different flanker types and arrangements used in the experiment (n = 31 neurologically healthy women). The direction of the displacement (L = leftward, R = rightward) and the results (t-values and two-tailed p-values and degrees of freedom) of the one-sample t-test comparing subjective and objective midpoint are also provided

Flanker type	m (± SD)	Direction of displacement	t(df)	p
	-0.53 (2.44)	L	-3.43(247)	0.001
	-0.65 (2.66)	L	-3.83(247)	<0.001
	-1.80 (2.71)	L	-10.48(247)	<0.001
	+0.71 (2.90)	R	3.83(247)	<0.001
	-0.20 (2.84)	Center	-1.12(247)	0.263
	-0.38 (3.05)	L	-1.98(247)	0.048
	-0.18 (2.85)	Center	-0.97(247)	0.331
	-1.33 (2.53)	L	-8.26(247)	<0.001
	+0.25 (2.62)	Center	1.48(247)	0.140
	-1.38 (2.54)	L	-8.57(247)	<0.001
	-0.04 (2.54)	Center	-0.24(247)	0.809
	-0.32 (3.12)	Center	-1.62(247)	0.106
	+0.90 (2.77)	R	5.12(247)	<0.001
	-1.75 (2.61)	L	-10.56(247)	<0.001
Individual subject's own body (small/LARGE)	+0.71 (3.28)	R	3.39(247)	0.001
Individual subject's own body (LARGE/small)	-1.74 (2.87)	L	-9.54(247)	<0.001

structured interview; questions provided in the Appendix). Subjects were informed that this was an investigation on the bisection of various different lines. They were asked to wear close-fitting dark clothes (instructions as in Mohr et al., 2007). They provided written informed consent to participate in the study conducted in accordance with the ethical principles of the Declaration of Helsinki. Subjects did not get any reimbursement for participation. The experiment took place in two different sessions. Table 1 shows the demographic and clinical data of our sample, including BMI and handedness scores.

2.3. Procedure

Subjects were individually tested in two sessions. In session 1, handedness and body mass relevant data were collected and a picture of the subject was taken. This served as an individual stimulus in the Baldwin task to be administered in session 2.

2.3.1. Session 1

Handedness was assessed with the FLANDERS inventory (Nicholls et al., 2013), which had been translated into Greek by bilingual personnel from the department of education of the University of Macedonia (with two-fold back translation). Each subject's height and weight were then measured in order to calculate their BMI. Finally, a picture of each subject's body was taken in order to be used as a stimulus flanker in the Baldwin task to be administered in the second experimental session. Picture specifications were taken from Mohr et al. (2007). In brief, the picture was taken by iPhone7 (1334 x 750 pixels, resolution at 326 dpi) in portrait orientation without automatic flash setting to avoid red eyes.

2.3.2. Flanker preparations

The second experimental session took place within two weeks from the first. In between the two sessions, each participant's picture was rescaled and uploaded in the computer software running the experiment. The original images were rescaled both upwardly and downwardly using Adobe Photoshop CC (2018). The two resulting images differed from each other by 50% in width (height remained constant). To "fatten" the original image, width was increased by 1/3 and to "thin" it we reduced its width by 1/3. This way the fatter image (referred to as "large image") was two times larger than the slender one (referred to as "small image"). The same small/large ratios were obtained for all other images used in the experiment except the 3D body figures from Mutale et al. (2016), which represented a slender and a fat figure corresponding to a BMI of 16.55 kg/m² and 30.15 kg/m², respectively. All flanker photographs (i.e. standard 3D figure, experimenter's and participants' images) were approximately 600 pixels wide x 2000 pixels high and the ratio of body to head ranged between 12.5% and 14%. All images including that of the water bottle were desaturated in greyscale and presented against a white background. All geometrical shapes (squares, rectangles and circles) were black on white background.















2.3.3. Session 2

At the second experimental session, a computerized Baldwin task was administered. We refer to the task as "Baldwin task" despite the fact that we included various types of lines, flanked with squares (the original Baldwin stimuli) and other geometrical forms (rectangles and circles) and pictures of female bodies (the own, the experimenter's and an anonymous female person's body). The picture of an object (water bottle) was also used as flanker, as were unflanked stimulus lines. Flankers were always of the same picture type, but presented in two variants: either the small version was left and the large right (small/LARGE) or vice versa (LARGE/small). All stimuli used in this modified Baldwin task are displayed in Tables 1 and 2.

The bisection task was run on a computer (Hewlett Packard, Folio 9470 m). Participants sat comfortably on a chair and viewed the 36 cm height monitor from a 18 cm distance (LG monitor size 27", 1920x1080 pixels). A chinrest was used for head stability. The computer program was designed in such a way that after the participant located the midpoint of a line by mouse click, she pressed a "next" button in order to proceed to the next trial (a trial could be repeated by pressing a "repeat" key in case a mouse response had been elicited unintentionally). If no response was provided within 60 seconds after stimulus exposure, the computer would automatically turn into a "pause" mode. To continue, the participant had to press the "repeat" button and the timer would be restarted. Each subject thus responded to 128 trials (preceded by three practice trials that were not analyzed). The task lasted approx. 20 minutes.

The horizontal line segment was always presented in the center of the computer screen, black on white background. Its length was 434 pixels (~ = 11.5 cm). Flankers were positioned at the line ends without any gap. A small vertical black line bisected the horizontal line and was used as a tracker to locate the subjective midpoint. The tracker stood out 1 mm above and 1 mm below the line (tracker height: 4 pixels, ~1.5 mm and tracker width: 1 pixel). Tracker movement was only possible along the line. Below the tracker, on the line, there was a cross, which indicated the mouse's location. The use of a mouse had advantages over the use of a touch screen as the size of the tracker line was much smaller compared to a human finger and localization accuracy accordingly higher.

Table 2. Mean (M) and standard deviation (SD) of the subjective midpoint displacement (in mm) for the different flanker types and arrangements used in the experiment and for the two subject groups (NW = normal weight, n=20; OW = overweight, n=11) separately. The direction of the group difference as well as t-values, degrees of freedom and p-values (two-tailed) of the difference assessed by an independent-samples t-test are also provided. L = left, R = right

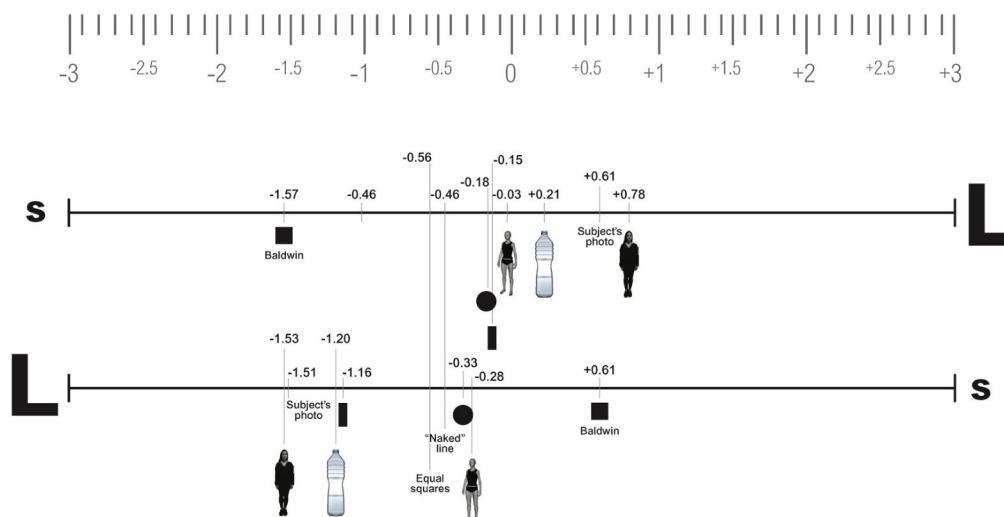
Flanker type	NW subjects (n = 20) m (± SD)	OW subjects (n = 11) m (± SD)	Statistical parameter t(df),p	Group difference
	-0.29 (2.62)	-0.97 (2.00)	2.30(221),0.022	OW more L
	-0.22 (2.56)	-1.42 (2.66)	3.45(174), 0.001	OW more L
	-1.38 (2.66)	-2.56 (2.64)	3.35(180),0.001	OW more L
	+1.14 (3.01)	-0.09 (2.51)	3.45(208), 0.001	OW more L
	+0.11 (2.73)	-0.76 (2.97)	2.26(167), 0.025	OW more L
	-0.07 (2.97)	-0.95 (3.12)	2.16(172), 0.032	OW more L
	+0.14 (3.01)	-0.76 (3.11)	2.28(157), 0.024	OW more L
	-1.04 (2.47)	-1.85 (2.56)	2.39(174), 0.018	OW more L
	+0.54 (2.58)	-0.29 (2.63)	2.39(177), 0.018	OW more L
	-0.83 (2.59)	-2.39 (2.12)	5.09(211), <0.001	OW more L
	+0.44 (2.61)	-0.91 (2.15)	4.38(210), <0.001	OW more L
	-0.07 (3.37)	-0.77 (2.57)	1.84(221), 0.068	OW tendentially more L
	+1.13 (2.76)	+0.48 (2.75)	1.79(180), 0.074	OW tendentially more L
	-1.47 (2.48)	-2.26 (2.78)	2.21(163), 0.029	OW more L
Individual subject's own body (small/LARGE)	+0.94 (3.31)	+0.28 (3.19)	1.54(185), 0.126	OW tendentially more L
Individual subject's own body (LARGE/small)	-1.45 (2.85)	-2.26 (2.85)	2.13(179), 0.035	OW more L

Each stimulus was presented 8 times at random positions in the 128-trial sequence (see Fortenbaugh et al., 2015; Toba et al., 2011). As eye scanning at the begin of a trial can have an impact on bisections (Jewell & McCourt, 2000), we controlled for visual scanning habits by randomly positioning cursor and tracker in either the left or the right lower corner of the screen. We used pseudorandomization that guaranteed an equal number of left (and right) cursor positions for each stimulus type.

Performance accuracy was measured as midpoint deviation from the true line center. Positive values indicate a rightward shift and negative values a leftward shift.

Figure 2. Schematic representation of subjective midpoint location in neurologically healthy right-handed females (n = 31) for Baldwin illusion and its variants in the small left/LARGE right and LARGE left/small right conditions.

L: indicates the large-size flanker variant, s: indicates the small-size flanker variant.



After completion of the Baldwin task, participants were administered the Body Dissatisfaction Scale (BDS- Mutale et al., 2016) to rule out that the degree of body dissatisfaction would account for the different results in the two different weight groups. We used this scale because it is gender-specific and has good validity and reliability. In addition, BDS is life-like in appearance and not in a sketch format and thus creates a more realistic presentation. BDS score is derived by the difference between a subject's actual body size (the image that he/she thinks best suits his/her own current size) and his/her ideal body size (the image that he/she thinks best suits the size he/she wants to be) (Mutale et al., 2016).

3. Results

3.1. Pseudoneglect and Baldwin effect

Table 1 lists means and SDs of the displacement of subjective from objective midpoints (in mm) for all stimuli used (see Figure 2 for a graphical display). The direction of the displacement (left or right) and whether it is significant by two-tailed one-sample t-test is indicated in Table 1. For the symmetric lines (without flankers and with equally sized squares) there was a significant pseudoneglect. The Baldwin effect showed up for the original Baldwin-type stimulus lines with squares as flankers; the subjective midpoint was systematically displaced towards the small squares. As predicted, this displacement was larger when the small square was on the left end of the line ($M = 1.80$ mm, $SD = 2.71$ mm) than when it flanked the right end ($M = 0.71$ mm, $SD = 2.90$ mm; $t(492) = +4.35$, $p < 0.001$). For the lines with non-square geometrical forms (circles and rectangles) there was no Baldwin effect, but a left-sided displacement (pseudoneglect) irrespective of flanker size arrangement. This pseudoneglect was significant for both circles and rectangles with the large size flanker on the left, in contradiction to the Baldwin effect. Likewise, an inverse Baldwin effect was also found for the object flanker (the water bottle) and for all pictures of a female body (significant for the experimenter's and the subject's own body, as a tendency for the schematic female body). Pooled over both flanker arrangements (small/LARGE and LARGE/small), there was a significant pseudoneglect, i.e. leftward midpoint displacement, for the combined non-body flankers ($M = 0.54$ mm, $SD = 2.88$ mm, $t(1983) = -8.37$, $p < 0.001$) as well as for the combined body-flankers ($M = 0.37$ mm, $SD = 3.06$ mm, $t(1487) = -4.72$, $p < 0.001$). The reason for the high degrees of freedom is that each subject contributed with eight trials per scenario to the overall experimentation and we aggregated all trials for a given scenario. For example, this means that, when we aim to test a hypothesis for the total group of the 31 subjects, we have a total sample of 248 trials or $31 \times 8 = 248$ degrees of freedom. When mixing more than one scenarios, as for example when pooling over the alternative geometric stimuli and the two flanker size arrangements (mixing

Figure 3. Schematic representation of subjective midpoint location in neurologically healthy right-handed normal-weight (n = 20) and overweight/obese (n = 11) females for Baldwin illusion and its variants in the small left/LARGE right condition.

s: indicates the small-size flanker variant, L: indicates the large-size flanker variant
 NW: normal weight subjects, OW: overweight/obese subjects.

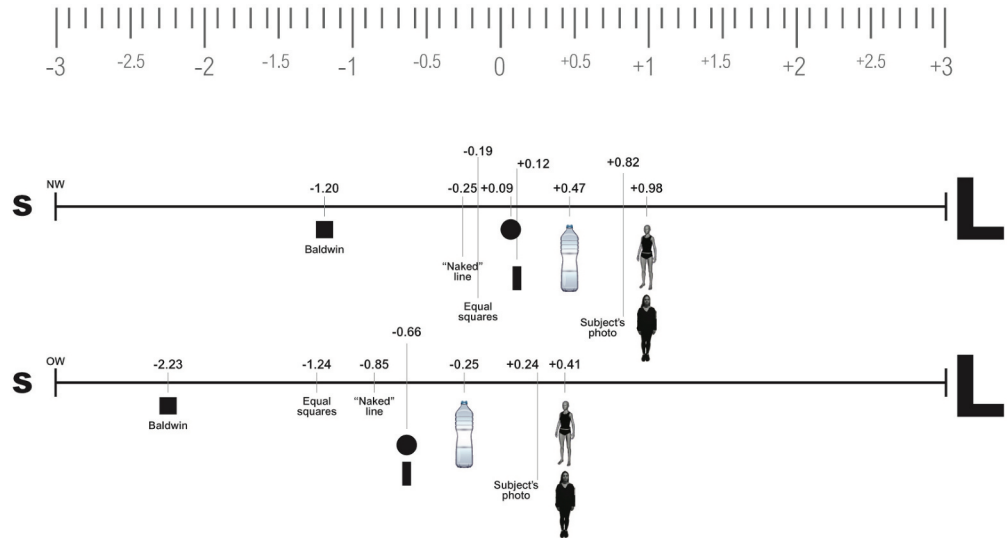
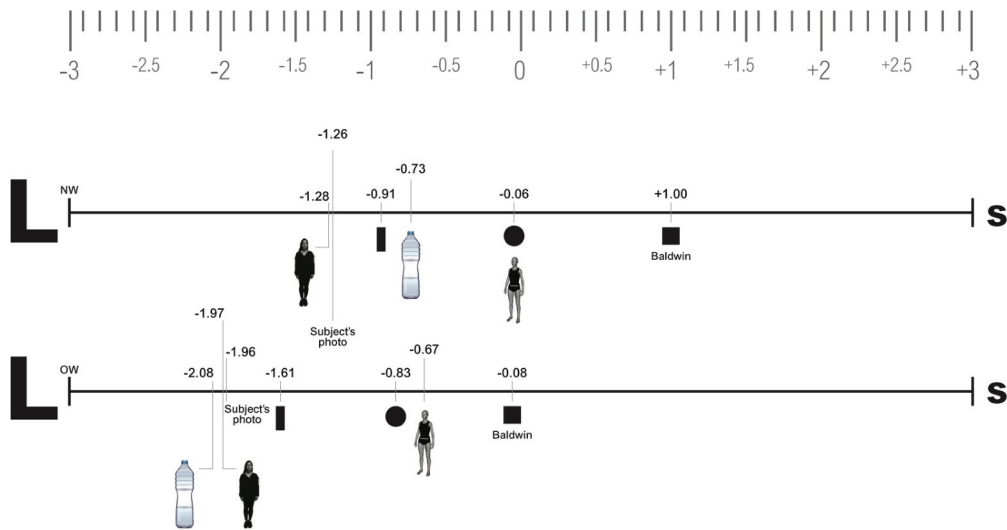


Figure 4. Schematic representation of subjective midpoint location in neurologically healthy R-handed normal-weight (n = 20) and overweight/obese (n = 11) females for Baldwin illusion and its variants in the LARGE left/small right conditions.

L: indicates the large-size flanker variant, s: indicates the small-size flanker variant.
 NW: normal weight subjects, OW: overweight/obese subjects.



eight scenarios), we reach the maximum of $8 \times 8 \times 31 = 1984$ degrees of freedom. Since the number of trials is exactly the same for each subject, there seems to be no bias in terms of subjects and their contribution to the overall experimentation.

3.2. Preliminary analyses respecting the variable body mass index

Table 2 lists means and SDs of the displacement of subjective from objective midpoints for all stimuli used for the two weight groups separately (see Figures 3 and 4 for a graphical display for small/LARGE and LARGE/small flanker positions, respectively). Also indicated in Table 2 is the direction and significance of the group difference for each stimulus type as established by two-tailed t-test for two independent samples. Across all stimulus types, subjects of the OW group placed the subjective midpoint more leftward than the subjects of the NW group, in 13 out of 16 types significantly so, in the remaining three types as a tendency ($0.074 < p < 0.126$). The OW group did not show a Baldwin effect for the classical squares as flankers when the small square was on the right side of the line. In that case, the OW group misplaced the subjective midpoint

towards the large square in the left ($M = 0.09$ mm $SD = 2.51$ mm), while their NW peers towards the small square on the right ($M = 1.14$ mm, $SD = 3.01$ mm, $t(208) = 3.45$, $p = 0.001$). What is specific to the stimuli using realistic pictures of subjects' bodies (photographs of the own and the experimenter's body) is that for both weight groups there is, numerically, a reverse Baldwin effect, i.e. both OW and NW group misplaced the subjective midpoint away from the small realistic pictures of female bodies and towards the large picture (own body: $M = 1.27$ mm $SD = 3.18$ mm, $t(175) = 5.30$, $p < 0.001$ for the OW subjects, $M = 1.20$ mm $SD = 3.10$ mm, $t(319) = 6.91$, $p < 0.001$ for the NW subjects; experimenter's body: $M = 1.37$ mm $SD = 2.90$ mm, $t(175) = 6.26$, $p < 0.001$ for the OW subjects, $M = 1.30$ mm $SD = 2.63$ mm, $t(319) = 8.88$, $p < 0.001$ for the NW subjects). Pooled over these body-flanker stimuli and the two flanker size arrangements, subjects of the OW group showed a stronger pseudoneglect than subjects of the NW group ($t(1137) = 5.10$, $p = 0.001$). Pooled over the stimuli with more classical Baldwin-type flankers (i.e. geometric forms) and their arrangement a stronger pseudoneglect for the subjects of the OW group was found as well ($t(1436) = 7.72$, $p < 0.001$).

The BDS score between the two weight groups did not differ significantly ($M = 1.50$ $SD = 1.40$ for the NW group, $M = 3.00$, $SD = 1.00$ for the OW group, $t(26.7) = 2.50$, $p = 0.125$). However, over the entire sample BMI was positively correlated to BDS scores ($r(31) = 0.63$, $p < 0.001$).

4. Discussion

The present study set out to answer two questions, both concerned with known biases in the bisection of lines. First, we wondered whether two phenomena investigated in quite disparate literatures, pseudoneglect and Baldwin type flanker effects, might interact with one another. Second, we explored whether flanker size, known to systematically influence the bisection of a line (the "Baldwin illusion") could be a cue critically interacting with the bisecting person's body mass. We proceed to a discussion of these two questions in turn.

4.1. The Baldwin illusion and pseudoneglect

In a sample of 31 right-handed women without a neurological or psychiatric history, we replicated the classical Baldwin effect. Baldwin (1895) described an illusion of length by placing squares at both ends of a horizontally presented line. A line flanked by large squares would consistently be judged as shorter than a line of equal length, flanked by small squares. This contrast illusion may be conceptually related to various other illusions of length induced by different flanker types, such as arrows, wings or fins (the Müller-Lyer, Judd or Ebbinghaus illusions, see Clavdetscher & Anderson, 1977; Pressey & Martin, 1990; Rinaldi et al., 2018). To quantify the illusion, observers are often presented with lines flanked by squares of different sizes and asked to bisect the line (e.g., Chieffi, 2016; Wilson & Pressey, 1988). Observers would systematically displace the subjective midpoint toward the smaller square. For pure reasons of balance, the large square would once be positioned to the left and the small to the right of the line and once the opposite placement would be used (see Figure 1). Since at Baldwin's times line bisection paradigms were not popular and confined to the use as a diagnostic tool in brain-damaged patients (Axenfeld, 1894), differences in illusion strength between the two flanker arrangements were of no theoretical interest and either escaped a researcher's attention or could not be explained if incidentally observed (e.g., Chieffi & Ricci, 2002). In particular, the phenomenon of pseudoneglect, i.e. healthy subjects' robust and nowadays well-established leftward displacement of the subjective from the objective midpoint of a line, had not been described (Jewell & McCourt, 2000). From today's stance, we would expect that, if pseudoneglect also holds for the bisection of flanked lines, the Baldwin effect should be stronger for the small/LARGE (□—□) compared to the LARGE/small (□—□) flanker arrangement, because the leftward bisection bias due to pseudoneglect and the attraction of the perceived midpoint by the smaller square would be additive (Figure 1). To the best of our knowledge, the present study is the first to test this asymmetry in the Baldwin effect.

Not only did we replicate the Baldwin effect but we also found our asymmetry hypothesis confirmed: the small/LARGE positioning of the two squares evoked a significantly larger

displacement than did the LARGE/small positioning. The question emerges why such an asymmetry, apparently robust as it showed up in our relatively small sample of only 31 healthy women, had escaped prior investigators. As noted above, if an effect is not actively looked for, the chances are high that it will not be found. In some instances, the asymmetry of flanker position was deliberately pooled and an average Baldwin effect was reported (e.g., Holland et al., 1990). We thus do not know whether the asymmetry had not been noticed in the first line, or whether it was noted, but its discussion avoided because of the lack of a conceptual background. Likewise, Chieffi (1996; Exp. 1) noted both the observation of pseudoneglect and of the Baldwin illusion, but did not comment on the interaction of the two. Finally, inspection of Figure 2 (top left) in Chieffi and Ricci (2002) suggests the presence of an at least numerical asymmetry of the type tested here. The authors do, however, not discuss this asymmetry.

A consistent pseudoneglect was observed for unflanked lines and the lines with equally sized flankers. This is in agreement with what is known from the large literature on line bisection (see, e.g., the meta-analysis in Jewell & McCourt, 2000). In the absence of any discussion of the phenomenon in the literature on the Baldwin illusion, we can only speculate about the potential impact of pseudoneglect on the subjective midpoint in the various non-traditional Baldwin variants we have used here. While we replicated the Baldwin illusion with the classical flanker-type, i.e. squares, we could not demonstrate it with other geometrical forms, nor with pictures of an object or body parts. This may surprise, as the *size* (or better: the relative *size difference*) of any object would seem to be the illusion-critical cue. It seems as if pseudoneglect was overriding any illusion tendency in the non-square flanker variants. In fact, our hypothesis of a significant interaction of pseudoneglect and (traditional) Baldwin effect may also hold for other flanker types. At least as judged from the sign of the bisection mark (minus corresponding to a leftward displacement, plus to a right-ward displacement; see Table 1) our data suggest that the large, rather than the small flanker had attracted more attention, leading to a numerically inverse Baldwin illusion in some flanker types, which could be interpreted as the consequence of an exaggerated pseudoneglect. Such effect would appear compatible with one effect described in the literature on line bisection, that is, the “attentional repulsion effect” (ARE; Suzuki & Cavanagh, 1997; Wardak et al., 2011). The phenomenon of ARE shows an overrepresentation of space around a (peripheral) locus of attention. It makes healthy subjects’ estimated center of a line to be displaced towards the more salient flanker (Wardak et al., 2011), which, in a Baldwin context, would be the *larger* of two otherwise identical flankers. Wardak et al. (2011, pp. 542–543) discuss the potential interactions between pseudoneglect and the ARE in line bisection and think that the former complicates interpretation of the ARE as bisections are most frequently performed with the hand. To avoid the hand-motor component of hemi-inattention to either side (Sapir et al., 2007) they propose the use of ocular bisections. We agree with this proposal and think that future experimentation referring to the Baldwin illusion should also apply eye-movement methodology (see Rinaldi et al., 2018, in the context of the Judd illusion; Toba et al., 2011 for interactions between ARE and pseudoneglect compatible with the one found in the present study).

In previous studies in which Baldwin-like stimuli were exploited, rectangles were used to elicit the illusion (Chieffi, 1996). However, size was varied in the dimension perpendicular to the line, whose length had to be judged. Since we were concerned about the horizontal rather than the vertical extension (in connection with an observer’s body *width*, rather than height) we had varied the former in all our flanker types. Nevertheless, the absence of a Baldwin effect for circles is still puzzling. It may be that flankers must contain both horizontal and vertical lines of equal length (hence, a square; see Clavadetscher & Anderson, 1977). The use of circles is in fact avoided in the Baldwin illusion, even if the rule in the related Ebbinghaus illusion (see discussion in Clavadetscher & Anderson, 1977). The fact that an inverse Baldwin effect was found in the case of flankers depicting a human figure is discussed in the context of the second question of the present study, to which we now proceed.

4.2. Body mass and flanker size

Our prediction that overweight subjects would show a stronger Baldwin effect than their normal-weight peer if flankers were lean and fat bodies, respectively, was not born out. Intriguingly, if the flankers were photographs of the (female) experimenter or of the subject herself, an *inverse* Baldwin effect was observed, that is, the bisection mark was significantly displaced toward the *larger* body. Why would larger squares pull the bisection mark away (the classic Baldwin effect), but larger-size bodies would attract it? Research on BMI-related biases in attention to own-body stimuli may provide an answer. Roefs et al. (2008) had observers of differing BMI view pictures of the own and a foreign person's body and rate the attractiveness of all pictures. The authors found that with increasing BMI, participants attended relatively more to own-body pictures than to pictures of the foreign person, especially if they had rated themselves unattractive. This would suggest an *increased* attention to the larger body and explain why the traditional Baldwin effect would have been overridden specifically in overweight and obese subjects for photographs of the own body. This explanation, however, can offer only half the story, because a similar anti-Baldwin to own-body and experimenter's body flankers was also found for the subjects, whose BMI was in the normal range. In this normal-weight group (but not in the overweight subjects) it even showed up for the non-body objects. Thus, our experiment has provided some evidence for the specificity of body flankers, and perhaps some tentative evidence for an exaggerated attention to the larger of two own-body flankers in persons, who are concerned about their weight.

Our original hypothesis of a stronger Baldwin effect—for any flanker, but perhaps especially for (own) body stimuli—was also shaped by the influential theory that obesity is accompanied by an exaggerated attention toward outside stimuli and, at the same time, a lowered monitoring of interoceptive cues (“externality theory of obesity”, Schachter, 1971; Schachter & Rodin, 1974). This would explain the kind of vicious circle, obesity brings about: while low interoceptive sensitivity facilitates binge eating and may thus increase BMI (Gaudio et al., 2018), this automatically leads to an enhanced dissatisfaction with one's own-body image, which is still boosted by the exaggerated tendency to pay attention to external stimuli, specifically other persons' body, whose appearance is typically idealized. While our own finding of a positive correlation between BMI and scores on the BDS (Mutale et al., 2016) is in line with this view, the notion of a *generally* increased attention to external stimuli has been questioned over the past decades. First, behavioral experimentation could not support the theory (Meyers & Stunkard, 1980) and second, more recent neuroimaging studies described obesity-related structural abnormalities in brain networks responsible for (external) visual attention (Stillman et al., 2017). The most parsimonious conclusion is that the present findings from a Baldwin paradigm can probably not contribute to the discussion of the validity of an external visual-perceptual hypersensitivity in obese people. Our findings are compatible, however, with those from a quite different paradigm, i.e. visual body size adaptation. Ambroziak et al. (2019) studied aftereffects of adaptation to thin and fat bodies. After viewing either extreme body size, observers' judgment of both own and others' body sizes were biased away from the adapting stimulus, indicating that body size adaptation affects body representation in a generic way, i.e. not specific to the own-body image. This is in accordance with our observation that (inverse) Baldwin effects were found for both flankers showing the own and flankers showing another person's body. Interestingly, in Ambroziak et al. (2019; Exp. 3), observers' BMI correlated strongly with the size of the adaptation effects. Unfortunately, our sample was too small that correlations between an individual's BMI and the size of the Baldwin effect in the different stimulus conditions would have yielded enough statistical power.

The most consistent result of our experiment was the larger pseudoneglect in the group of overweight observers. This effect was least pronounced for flankers showing a female body, but evident for 8 out of 8 flanker types showing an object or a geometric figure, including the original Baldwin box. Importantly, also in the case of lines with equally sized squares on both line ends and bare, unflanked lines overweight subjects placed the subjective midpoint significantly more left than normal-weight subjects did. On first consideration, this stronger pseudoneglect in association with an observer's overweight contradicts the view that obesity is linked to right hemisphere dysfunction, as such

dysfunction would be associated with a neglect-like pattern rather than the converse (Hach & Schütz-Bosbach, 2014; Mohr et al., 2007). A trait-like relative overactivation of the right hemisphere in obesity is also incompatible with studies on conjugate lateral eye movements, which rather point to an underactivation of the right hemisphere (Rodin & Singer, 1976; Weisz & Adam, 1993; Weisz et al., 1990). However, neuropsychological models of pseudoneglect not only consider activation differences between the two hemispheres (Bultitude & Davies, 2006), but also structural and functional differences in interhemispheric connectivity. For instance, Siman-Tov et al. (2007) demonstrated an asymmetry in the strength of connections between the left and right intraparietal sulci in favor of right-to-left connections. They made this asymmetry responsible for the phenomenon of pseudoneglect. It is possible that connectivity differences between overweight and obese subjects on the one hand and lean control subjects on the other hand (Luo et al., 2018) are responsible for an enhanced pseudoneglect in the former groups. Luo et al. (2018) described these interhemispheric connectivity differences between homotopic areas mediating not only sensorimotor but also visual and visual-attentional functions and their subjects were all neurologically healthy individuals. Of further relevance is a study on obesity-related functional hemispheric differences in cognitive abilities. Kuo et al. (2006) found that overweight participants outperformed normal-weight controls in visual-spatial functions mediated by the right hemisphere, but not in left-hemisphere typical functions of verbal learning and memory. This cognitive asymmetry, although its causative role for the genesis of obesity is unclear, would be compatible with an increased pseudoneglect in people with a high BMI. In how far structural (gray matter; Stillman et al., 2017) or functional (Restivo et al., 2016; Tsai et al., 2017) obesity-related deficits in attention-relevant brain regions and tasks may play a role for the performance in bisection paradigms as used here must be determined by future empirical research.

We summarize the major findings of the present investigation by first pointing out some clear limitations. First of all, sample size, especially that of the overweight group, was small. We have attempted to be cautious, therefore, in our interpretation and reiterate it here: while the evidence for the predicted interactions between Baldwin illusion and pseudoneglect is quite unequivocal—there is an important asymmetry in flanker placement in Baldwin paradigms—the impact of an observer's body mass on the magnitude on the Baldwin illusion must remain an open issue. Nevertheless, some trends could be noted in the application of unconventional flanker types such as photographs of bodies including the observer's own body: here, an *inverse* Baldwin illusion was observed. The factors determining this inverse Baldwin effect admittedly remain unknown. We have tried to offer some speculations and can only hope that our investigation will stimulate further empirical research on body-mass-related visual-attentional functions. What we hope to have achieved, even with the small sample tested here, is to have sparked researchers' attention to the fascinating opportunities line bisection paradigms still offer more than 125 years after their first introduction.

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Note

1. Sometimes the illusion is also formulated in comparative terms: a line spanning the distance between two large squares appears shorter than a line of identical length between two smaller squares. To avoid confusion, we will refer to the Baldwin illusion as it manifests itself in a bisection paradigm as the « Baldwin effect ».

Declaration of interest statement

The authors declare that there is no conflict of interest.

Data availability statement

Raw data were generated at the University of Macedonia. They are available by the corresponding author, Maria Baskini, upon request.

References

- Albert, M. L. (1971). A simple test of visual neglect. *Neurology*, 23(6), 658–664. <https://doi.org/10.1212/WNL.23.6.658>
- Ambroziak, K. B., Azanon, B., & Longo, M. R. (2019). Body size adaptation alters perception of test stimuli, not internal body image. *Frontiers in Psychology*, 10, 1–10. <https://doi.org/10.3389/fpsyg.2019.02598>
- Axenfeld, D. (1894). Eine einfache M Hemianopise zu constataren. *Neurologisches Centralblatt*, 13, 437–438.
- Baldwin, J. M. (1895). The effect of size-contrast upon judgments of position in the retinal field. *Psychological Review*, 2(3), 244–259. <https://doi.org/10.1037/h0064681>
- Bonato, M., Priftis, K., Marenzi, R., & Zorzi, M. (2008). Modulation of hemispatial neglect by directional and numerical cues in the line bisection task. *Neuropsychologia*, 46(2), 426–433. <https://doi.org/10.1016/j.neuropsychologia.2007.08.019>
- Bowers, D., & Heilman, K. M. (1980). Pseudoneglect: Effects of hemispace on a tactile line bisection task. *Neuropsychologia*, 18(4–5), 491–498. [https://doi.org/10.1016/0028-3932\(80\)90151-7](https://doi.org/10.1016/0028-3932(80)90151-7)
- Brigner, W. L. (1987). Auditory illusion analogous to the Baldwin figure in vision. *Perceptual and Motor Skills*, 65(2), 527–530. <https://doi.org/10.2466/pms.1987.65.2.527>
- Brigner, W. L. (1989). Auditory illusion analogous to Baldwin illusion redux. *Perceptual and Motor Skills*, 68(3_suppl), 1065–1066. <https://doi.org/10.2466/pms.1989.68.3c.1065>
- Brugger, P., & Graves, R. E. (1997). Right hemispatial inattention and magical ideation. *European Archives of Psychiatry and Clinical Neuroscience*, 247(1), 55–57. <https://doi.org/10.1007/BF02916254>
- Brugger, P., Loetscher, T., Graves, R. E., & Knoch, D. (2007). Semantic, perceptual and number space: Relations between category width and spatial processing. *Neuroscience Letters*, 418(2), 133–137. <https://doi.org/10.1016/j.neulet.2007.03.012>
- Bultitude, J. H., & Davies, A. M. A. (2006). Putting attention on the line: Investigating the activation-orientation hypothesis of pseudoneglect. *Neuropsychologia*, 44(10), 1849–1858. <https://doi.org/10.1016/j.neuropsychologia.2006.03.001>
- Chieffi, S. (1996). Effects of stimulus asymmetry on line bisection. *Neurology*, 47(4), 1004–1008. <https://doi.org/10.1212/WNL.47.4.1004>
- Chieffi, S. (2016). Visual illusion and line bisection: A bias hypothesis revisited. *Experimental Brain Research*, 234(6), 1451–1458. <https://doi.org/10.1007/s00221-015-4550-z>
- Chieffi, S., Iachini, T., Iavarone, A., Messina, G., Viggiano, A., & Monda, M. (2014). Flanker interference effects in a line bisection task. *Experimental Brain Research*, 232(4), 1327–1334. <https://doi.org/10.1007/s00221-014-3851-y>
- Chieffi, S., & Ricci, M. (2002). Influence of contextual stimuli on line bisection. *Perceptual Motor Skills*, 95(3), 868–874. <https://doi.org/10.2466/pms.2002.95.3.868>
- Clavadetscher, J. E., & Anderson, N. H. (1977). Comparative judgment: Tests of two theories using the Baldwin figure. *Journal of Experimental Psychology: Human Perception and Performance*, 3(1), 119–135. <https://doi.org/10.1037/0096-1523.3.1.119>
- Drake, R. A., & Ulrich, G. (1992). Line bisecting as a predictor of personal optimism and desirability of risky behaviors. *Acta psychologica*, 79(3), 219–226. [https://doi.org/10.1016/0001-6918\(92\)90058-L](https://doi.org/10.1016/0001-6918(92)90058-L)
- Fink, G. R., Marshall, J. C., Shah, N. J., Weiss, P. H., Halligan, P. W., Grosse-Ruyken, M., Ziemons, K., Zilles, K., & Freind, H. J. (2000). Line bisection judgments implicate right parietal cortex and cerebellum as assessed by fMRI. *Neurology*, 54(6), 1324–1331. <https://doi.org/10.1212/WNL.54.6.1324>
- Fischer, M. H. (1996). Bisection performance indicates spatial word representation. *Brain Research. Cognitive Brain Research*, 4(3), 163–170. DOI: 10.1016/S0926-6410(96)00029-8
- Fischer, M. H. (2001). Cognition in the bisection task. *Trends in Cognitive Sciences*, 5(11), 460–462. [https://doi.org/10.1016/S1364-6613\(00\)01790-3](https://doi.org/10.1016/S1364-6613(00)01790-3)
- Fortenbaugh, F. C., VanVleet, T. M., Silver, M. A., & Robertson, L. C. (2015). Spatial distortions in localization and midline estimation in hemianopia and normal vision. *Vision Research*, 111, 1–12. <https://doi.org/10.1016/j.visres.2015.03.022>
- Gaudio, S., Dakanalis, A., Fariello, G., & Riva, G. (2018). Neuroscience, brain imaging, and body image in eating and weight disorders: A guide to assessment, treatment, and prevention. In M. Cuzzolaro & S. Fassino (Eds.), *Body image, eating, and weight* (pp. 97–111). Springer. https://doi.org/10.1007/978-3-319-90817-5_7
- Hach, S., & Schütz-Bosbach, S. (2014). In (or outside of) your neck of the woods: Laterality in spatial body representation. *Frontiers in Psychology*, 19(5), 123. <https://doi.org/10.3389/fpsyg.2014.00123>
- Holland, M., Wilson, A. E., & Goddard, M. (1990). Lack of sex difference with the Baldwin illusion. *Perceptual and Motor Skills*, 71(1), 305–306. <https://doi.org/10.2466/pms.1990.71.1.305>
- Jewell, G., & McCourt, M. E. (2000). Pseudoneglect: A review and meta-analysis of performance factors in line bisection tasks. *Neuropsychologia*, 38(1), 93–110. [https://doi.org/10.1016/S0028-3932\(99\)00045-7](https://doi.org/10.1016/S0028-3932(99)00045-7)
- Kopec, C. D., & Brody, C. D. (2010). Human performance on the temporal bisection task. *Brain and Cognition*, 74, 262–272. doi:10.1016/j.bandc.2010.08.006
- Kuo, H.-K., Jones, R. N., Milberg, W. P., Tennstedt, S., Talbot, L., Morris, J. N., & Lipsitz, L. A. (2006). Cognitive function in normal-weight, overweight, and obese older adults: An analysis of the advanced cognitive training for independent and vital elderly cohort. *Journal of the American Geriatrics Society*, 54(1), 97–103. <https://doi.org/10.1111/j.1532-5415.2005.00522.x>
- Laeng, B., Buchtel, H. A., & Butter, C. M. (1996). Tactile rod bisection: Hemispheric activation and sex differences. *Neuropsychologia*, 34(11), 1115–1121. [https://doi.org/10.1016/0028-3932\(96\)00025-5](https://doi.org/10.1016/0028-3932(96)00025-5)
- Lenggenhager, B., Hiltl, L., & Brugger, P. (2015). Disturbed body integrity and the “Rubber Foot Illusion”. *Neuropsychology*, 29(2), 205. <https://doi.org/10.1037/neu0000143>

- Loetscher, T., & Brugger, P. (2007). Exploring number space by random digit generation. *Experimental Brain Research*, 180(4), 655–665. <https://doi.org/10.1007/s00221-007-0889-0>
- Loftus, A. M., Nicholls, M. E. R., Mattingley, J. B., Chapman, H. L., & Bradshaw, J. L. (2009). Pseudoneglect for the bisection of mental number lines. *The Quarterly Journal of Experimental Psychology*, 62(5), 925–945. <https://doi.org/10.1080/17470210802305318>
- Luo, X., Li, K., Jia, Y. L., Zeng, Q., Jiaerken, Y., Qiu, T., Huang, P., Xu, X., & Zhang, M. (2018). Abnormal of inter-hemispheric functional connectivity in elderly subjects with overweight/obesity. *Obesity Research & Clinical Practice*, 12(6), 555–561. <https://doi.org/10.1016/j.orcp.2018.01.003>
- McIntosh, R. D., McClements, K. I., Djikerman, H. D., & Milner, A. D. (2004). “Mind the Gap”: The size-distance dissociation in visual neglect is a cueing effect. *Cortex*, 40(2), 339–346. [https://doi.org/10.1016/S0010-9452\(08\)70129-1](https://doi.org/10.1016/S0010-9452(08)70129-1)
- Meyers, A. W., & Stunkard, A. J. (1980). Food accessibility and food choice. A test of Schachter’s externality hypothesis. *Archives of General Psychiatry*, 37(10), 1133–1135. <https://doi.org/10.1001/archpsyc.1980.01780230051007>
- Milner, A. D., Brechmann, M., & Pagliarini, L. (1992). To halve and to halve not: An analysis of line bisection judgements in normal subjects. *Neuropsychologia*, 30(6), 515–526. [https://doi.org/10.1016/0028-3932\(92\)90055-Q](https://doi.org/10.1016/0028-3932(92)90055-Q)
- Mohr, C., & Leonards, U. (2007). Rightward bisection errors for letter lines: The role of semantic information. *Neuropsychologia*, 45(2), 295–304. <https://doi.org/10.1016/j.neuropsychologia.2006.07.003>
- Mohr, C., Porter, G., & Benton, C. P. (2007). Psychophysics reveals a right hemispheric contribution to body image distortions in women but not men. *Neuropsychologia*, 45(13), 2942–2950. <https://doi.org/10.1016/j.neuropsychologia.2007.06.001>
- Mutale, G. J., Dunn, A., Stillier, J., & Larkin, R. (2016). Development of a body dissatisfaction scale assessment tool. *The New School Psychology Bulletin*, 13(2), 47–57. <http://nspb.net/index.php/nspb/article/view/249>
- Nicholls, M. E. R., Thomas, N. A., Loetscher, T., & Grimshaw, G. (2013). The flinders handedness survey (FLANDERS): A brief measure of skilled hand preference. *Cortex*, 49(10), 2914–2926. <https://doi.org/10.1016/j.cortex.2013.02.002>
- Pressey, A. W., & Martin, N. S. (1990). The effects of varying fins in Mueller-Lyer and Holding illusions. *Psychological Research*, 52(1), 46–53. <https://doi.org/10.1007/BF00867211>
- Pressey, A. W., & Smith, N. E. (1986). The effects of location, and cumulation of boxes in the Baldwin illusion. *Perception & Psychophysics*, 40(5), 344–350. <https://doi.org/10.3758/BF03203026>
- Restivo, M. R., McKinnon, M. C., Frey, B. N., Hall, G. B., & Taylor, V. H. (2016). Effect of obesity on cognition in adults with and without a mood disorder: Study design and methods. *British Medical Journal Open*, 6(2), e009347. <http://dx.doi.org/10.1136/bmjopen-2015-009347>
- Rinaldi, L., Bertolini, G., Bockisch, C. J., Maravita, A., Girelli, L., & Brugger, P. (2018). More far is more right: Manual and ocular line bisections, but not the Judd illusion, depend on radial space. *Brain and Cognition*, 122, 34–44. <https://doi.org/10.1016/j.bandc.2018.01.009>
- Rodin, J., & Singer, J. L. (1976). Eye-shift, thought, and obesity. *Journal of Personality*, 44(4), 594–610. <https://doi.org/10.1111/j.1467-6494.1976.tb00140.x>
- Roefs, A., Jansen, A., Moresi, S., Willems, P., van Grootel, S., & van der Borgh, A. (2008). Looking good. BMI, attractiveness bias and visual attention. *Appetite*, 51(3), 552–555. <https://doi.org/10.1016/j.appet.2008.04.008>
- Sapir, A., Kaplan, J. B., He, B. J., & Corbetta, M. (2007). Anatomical correlates of directional hypokinesia in patients with hemispatial neglect. *The Journal of Neuroscience*, 27(15), 4045–4051. <https://doi.org/10.1523/JNEUROSCI.0041-07.2007>
- Schachter, S. (1971). Some extraordinary facts about obese humans and rats. *American Psychologist*, 26(2), 129–144. <https://doi.org/10.1037/h0030817>
- Schachter, S., & Rodin, J. (1974). *Obese humans and rats*. Halsted.
- Siman-Tov, T., Mendelsohn, A., Schonberg, T., Avidan, G., Podlipsky, I., Pessoa, L., Gadoth, N., Ungerleider, L. G., & Hendler, T. (2007). Bihemispheric leftward bias in a visuospatial attention-related network. *Journal of Neuroscience*, 27(42), 11271–11278. <https://doi.org/10.1523/JNEUROSCI.0599-07.2007>
- Posposito, A. V., Bolognini, N., Vallar, G., Posteraro, L., & Maravita, A. (2010). The spatial encoding of body parts in patients with neglect and neurologically unimpaired participants. *Neuropsychologia*, 48(1), 334–340. <https://doi.org/10.1016/j.neuropsychologia.2009.09.026>
- Stillman, C. M., Weinstein, A. M., Marsland, A. L., Gianaros, P. J., & Erickson, K. I. (2017). Body-brain connections: The effects of obesity and behavioral interventions on neurocognitive aging. *Frontiers in Aging Neuroscience*, 9, 115. <https://doi.org/10.3389/fnagi.2017.00115>
- Suzuki, S., & Cavanagh, P. (1997). Focused attention distorts visual space: An attentional repulsion effect. *Journal of Experimental Psychology: Human Perception and Performance*, 23(2), 443–463. DOI:10.1037//0096-1523.23.2.443
- Toba, M. N., Cavanagh, P., & Bartolomeo, P. (2011). Attention biases the perceived midpoint of horizontal lines. *Neuropsychologia*, 49(2), 238–246. <https://doi.org/10.1016/j.neuropsychologia.2010.11.022>
- Tsai, C. L., Huang, T. H., & Tsai, M. C. (2017). Neurocognitive performances of visuospatial attention and the correlations with metabolic and inflammatory biomarkers in adults with obesity. *Experimental Physiology*, 102(12), 1683–1699. <https://doi.org/10.1113/EP086624>
- Wardak, C., Deneve, S., & Hamed, S. B. (2011). Focused visual attention distorts distance perception away from the attentional locus. *Neuropsychologia*, 49(3), 535–545. <https://doi.org/10.1016/j.neuropsychologia.2010.12.008>
- Weir, C. B., & Jan, A. (2019, January). *BMI classification percentile and cut off points*. [Updated December 7, 2019]. In: StatPearls [Internet]. StatPearls Publishing. <https://www.ncbi.nlm.nih.gov/books/NBK541070/>
- Weisz, J., & Adam, G. (1993). Hemispheric preference and lateral eye movements evoked by bilateral visual stimuli. *Neuropsychologia*, 31(12), 1299–1306. [https://doi.org/10.1016/0028-3932\(93\)90099-L](https://doi.org/10.1016/0028-3932(93)90099-L)
- Weisz, J., Balazs, L., & Adam, G. (1990). Hemispheric preference and obesity. *Neuropsychologia*, 28(8), 883–887. [https://doi.org/10.1016/0028-3932\(90\)90012-D](https://doi.org/10.1016/0028-3932(90)90012-D)
- Wilson, A. E., & Pressey, A. W. (1988). Contrast and Assimilation in the Baldwin Illusion. *Perceptual and Motor Skills*, 66(1), 195–204. <https://doi.org/10.2466/pms.1988.66.1.195>
- World Health Organization. (2020, April 1). *Obesity and overweight*. World Health Organization. Retrieved July 7, 2020, from <https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight>



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