Exploring body holistic processing investigated with composite illusion

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Abstract

The aim of the present study was to explore the holistic processing of the human body shape. Composite illusion is used as a marker to demonstrate face holistic processing. Previous studies showed that adults find it difficult to name the top half of a familiar face when it has been aligned with the bottom half of a different face compared with misaligned condition. The current study aimed to explore body shape processing using composite effect. In our study body stimuli were generated by a computer program. Body shapes varied by BMI having a thinner and a fatter version as well. Face composite illusion was also investigated as a control. Composite illusion was observed for faces as reaction time was significantly faster and performance was better for misaligned faces compared to aligned faces. For human body shapes composite illusion was observed nevertheless merely inverted bodies. Participants performed superiorly for inverted misaligned bodies compared with inverted aligned bodies.

Keywords: composite illusion; holistic processing; body perception; face perception; configural processing

Face and body shape processing

Compared to face perception processing, body shape perception is a less studied area, although perception of face and body share many processes. Both have abstract configural properties, as bodies and faces consist of parts (eye, mouth, arm, leg, etc.), which characterize all faces and bodies. The configural processing involves spatial positions of individual parts, which are permanent to distinguish individual bodies and faces (Slaughter, Stone and Reed, 2004). On the other hand, people perceive both stimuli together and quite frequently, so they become experts in face and body processing. In the literature configural and holistic processing are usually considered as synonymous terms, whereas these two processing types can be well distinguished. However, there is no consensus about the definition of holistic and configural processing, and how we can distinguish them based on their functions. The configural processing continuum is from feature-based to holistic processing. According to the feature-based processing, objects are recognized via local feature information, such as houses. Objects recognized holistically as undifferentiated wholes such as faces, are on the other end of the continuum called holistic processing (Reed et al., 2006). The configural processing can be divided into two mechanisms using first- and second-order relational information, which refers to the spatial position of the individual features of parts. The first-order relational information means the relative positions of the individual elements, such as the nose is above the mouth. Using this information, we are able to identify a stimulus as a face, a house, or a car. Second-order relational information refers to the spatial and metric relations between the internal elements (e.g. distance between the eyes). Based on this information we can recognize the individual exemplars. The first-order relational information helps us to recognize that we perceive a face, whereas the second-order relational information helps us to identify whose face we perceive (Reed et al., 2006).

The conception of first- and second-order relational information comes from Maurer, Le Grand and Mondloch (2002). Contrary to the continuum theory, their hypothesis consists of three types of processing; the first-and second-order relational information, and the third one is the holistic processing, which derives from the first-order relational information. When the first-order relations are detected, it is harder to collect individual features, thus we tend to process the stimulus as a Gestalt. We perceive faces as a unique Gestalt instead of the combination of single features.

The specific marker of the holistic processing is the composite face effect which was demonstrated by Young, Hellawell and Hay (1987). This perceptual illusion was originally described as naming the top half of a familiar face is more difficult when it is aligned with the bottom part of another face than when the two face parts are misaligned (the face cut halved horizontally under the eyes). Performance on the same trials is poorer in the aligned condition than in the misaligned condition, with longer response times and worse accuracy. In upright aligned condition the face is processed holistically, thus the identification of the top half becomes problematic compared with misaligned condition. When faces are inverted, the composite effect either disappears or is decreased. The composite face illusion can be observed even with faces that are not biologically possible and whose first-order relations were disrupted (de Heering, Wallis and Maurer, 2012; Rossion and Boremanse, 2008).

Inversion effect

Inversion effect was first studied for faces, but then it was extended to bodies. The inverted picture of a body or a face impaired the recognition with increasing the reaction time compared to the upright presented stimuli (Tanaka and Farah, 1993; Reed et al., 2003; Reed et al., 2006). These findings have been supported by brain imaging studies (Reed et al., 2003). Additionally, the effect was supported for several body postures, but only for biomechanically possible poses. Some studies found that the body inversion effect appears merely for the whole body, whereas no inversion effect occurs for isolated body parts and for horizontally cut half bodies (Reed et al, 2006). Findings suggest better performance for body part recognition in the context of the whole body than when they are in isolation.

Body holistic processing

A previous study (Soria Bauser, Suchan and Daum, 2011) intended to explore whether body shape is processed holistically, like faces or feature-based processing. The human body and face have similarities (Reed et al., 2006), but it is still unclear which type of processing is involved in body shape perception. Face holistic processing is studied by inversion effect (Tanaka and Farah, 1993; Reed et al., 2003; Reed et al., 2006) and composite illusion (Hellawell and Hay, 1987; de Heering, Wallis and Maurer, 2012; Rossion and Boremanse, 2008). Inversion effect was also tested for body shapes (Reed et al., 2003; Reed et al., 2006), but composite illusion has been so far used once to investigate body holistic processing (Soria Bauser, Suchan and Daum, 2011). In this study black and white photographs of 15 women and 15 men were used, with the faces masked and same clothes being worn in each picture. However, the T-shirts were the same in all photographs and the jeans were different with all with all the models. All the stimuli were halved horizontally and were presented aligned, or misaligned, upright, or inverted. The same procedure was used for faces. The pictures were presented in same-different task. Reaction times, accuracy and efficiency scores were examined. The study revealed composite illusion in face, because the participants were faster, more accurate, and more efficient in misaligned faces compared to aligned faces, but no composite illusion was found in bodies. This means face process is holistic; we could not perceive it as separate parts, but according to these findings, bodies show no integration between top (waist up) and bottom (waist down) halves as a whole. A recent study (Robbins and Coltheart; 2012) used the same-different version of composite illusion method for body but not only with horizontal but also vertical body split. They found body composite effect, but it was stronger for left and right halves compared to top and bottom halves, and the effects were weaker than for faces. Instead of using identity-based approach toward body processing, posture-based approach was conducted in another study (Willems et al., 2014) to investigate human body perception. In contrast to the studies mentioned above, (Soria Bauser, Suchan and Daum, 2011; Robbins and Coltheart, 2012), computer-generated model was used with the same identity, but with different postures. Results suggest the evidence that human body posture configuration is processed in a holistic way. In the present study we intended to use the same experiment design as Soria Bauser, Suchan and Daum (2011). Our aim was to explore body shape processing using composite effect. Previous identity-based studies (Soria Bauser, Suchan and Daum, 2011; Robbins and Coltheart, 2012) where the stimuli were pictures of humans wore more or less the same clothes. Their hairstyle differentiated (Soria Bauser, Suchan and Daum, 2011), thus it could affect the results, because participant had to tell whether the top half of the first and second pictures were identical or different. However in the study of Robbins and Coltheart (2012), the five individuals were clothed in the same garments with a swimming cap. Additionally, there were other effects which could have affected the results, like wearing clothes or the lengths of the t-shirts. In summary, it can be stated that it was not only the shape of the body that affected the processing of the body shapes, but also the appearance. The aim of our experiment was to create stimuli which are controlled and where merely the shape of the body affects the participants' responses. Our experiment is a revised identity-based study, where the related stimulus bodies have the same identity, but different body shape. The computer-generated model makes it possible to create the same identity with a different body shape. We used only the classic horizontal composite effect because, previous identity-based body composite effect studies (Soria Bauser, Suchan and Daum, 2011; Robbins and Coltheart, 2012), have mixed results. Our aim was to clarify whether body is processed holistically like faces. Furthermore, we used body stimuli with heads, because body processing uses first-order configural information, so it is clear, that heads are above shoulders, thus bodies without heads would be an unnatural stimulus.

Method

Participants Altogether 41 persons participated in the experiment, 10 men and 32 women, all of them were right handed. Mean age was 23.7 years SD=5.1, the age range varied from 20 to 49 years old. Four subjects were excluded from the experiment because their error rate was greater than 50% or the RTs were 3 SD greater than the mean of other subjects, thus there were 37 participants.

Stimuli

The bodies that we used in our experiment were generated by an internet based program (www.modelmydiet.com/). The program allows generating all kinds of bodies, with different gender, face, clothes, hair style, and BMI, thus each part of the body could have been under control. Varying the BMI allow us to create models with different shapes. We created ten identities with different hairstyle, and bikinis. Only female bodies were made. Their faces were masked and they wore bikinis thus clothes did not affect the participant perception. By using this program there was a chance to generate models, and varying their

BMI thus the body shape was the merely variable that could affected the participants' responses. Each identity had a thinner (BMI 19) and fatter (BMI 26) version. Altogether 20 bodies were made. The same identity model different versions (thinner or fatter) were paired together; either the fatter version was on the top, or the thinner one. Taking together 40 body stimulus were made, which were all aligned and upright. The aligned version of the body was made by cutting it half horizontally across the waist by a white thin line. The misaligned version of the body was made by shifting the lower part of the body right. All the aligned version stimuli had a misaligned version. Plus all the aligned and misaligned stimulus had an inverted version, thus 120 body stimulus were made (Fig. 1). Upright and inverted conditions were separated.

The faces were chosen from the University of Pécs Institute of Psychology computer's database 10 faces were used, which ones were cut over therefore merely the inner parts of the face could be seen. Similar like Soria Bauser, Suchan and Daum (2011) study, the faces were not cut half, but under the nose. The aligned faces were created by separating the lower face halves by a white line from the upper face halves. The misaligned version of the faces created by shifting the lower part of the face right. The faces were presented aligned or misaligned, upright or inverted. Upright and inverted conditions were separated.

All stimuli were presented either upright aligned, upright misaligned, inverted aligned, inverted misaligned, together 120 body, and 120 face stimuli were made. The stimuli were gray-scaled. (See Fig. 1. and Fig. 2.)

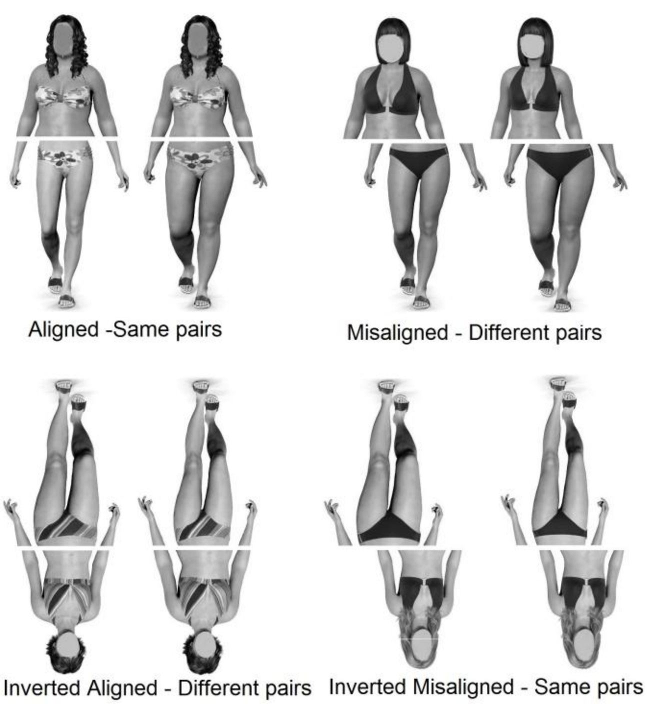

Figure 1: Illustration of the body stimuli

Design and Procedure

Subjects were participated in a computer assisted experiment. They were seated in front of a 20" monitor, and they could give their response by using two keyboard bottoms. The program was designed with DmDx. The subjects participated in four trials in random order; body upright, body inverted, face upright, face inverted. They were instructed to use the central as a fixation point. Halved bodies or a faces were seen for 400ms, after a scrambled mask for 200ms, and following a halved body or face. The participants' task was to response whether the two pictures' top halves were same or different. If it was same they pressed L, if it was different they pressed A. The procedure could be seen in Fig. 3.

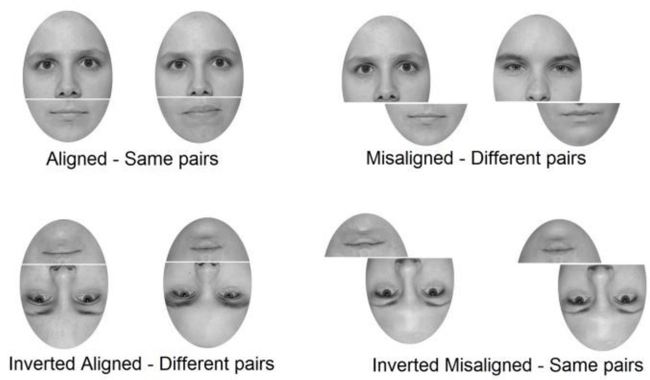

Figure 2: Illustration of the face stimuli

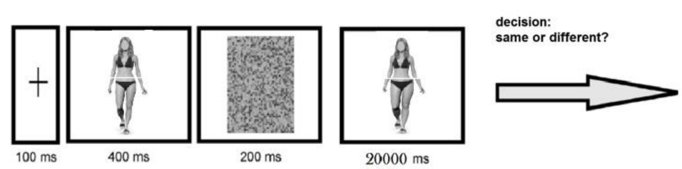

Figure 3: Experiment design

Results

In line with the other studies (e.g. Reed et al, 2003; Soria Bauser, Suchan, Daum, 2011), we analysed the performance differences for the orientation and alignment, in the same condition. Only correct response reaction times were used, and the median of the reaction times (RTs) were calculated. Furthermore, the mean proportions of correct responses were calculated for each condition. Using the previous approaches (Soria Bauser, Suchan and Daum, 2011), efficiency scores were also calculated to obtain an integrated performance score (mean RT divided by the proportion of correct responses). Low efficiency scores indicated better performance. For RT data, we analysed only trials for which the response was correct. Separate repeated measures of ANOVA were conducted (using Greenhouse-Geisser corrections) on median RTs data, proportion of correct responses and efficiency scores with two stimuli category (Body vs. Face) for 2 Orientation: upright vs. inverted) x 2 Alignment (Aligned vs. Misaligned) in accordance with previous studies (Soria Bauser, Suchan and Daum, 2011; Robbins and Coltheart, 2012; Willems et al., 2014; McKone et al., 2013). The results are presented in Fig. 4.

Face stimuli

Repeated measures ANOVA for reaction time yielded main effect of Alignment ($F(1, 36)=7.58$ $p<.01$). Reaction time was significantly faster for misaligned faces compared to aligned faces. There was interaction between Alignment and Orientation ($F(1,36)=7.88$ $p<.01$), which means participants were faster in case of upright misaligned faces, compared to upright aligned faces, whereas in case of inverted faces, this difference cannot be observed.

Analysis of accuracy yielded interaction of Alignment and Orientation ($F(1, 36)=6.6$ $p <.05$). Performance was better for misaligned faces compared to aligned faces when they were presented upright, while there was no difference in performance for inverted faces (aligned-misaligned).

Significant main effect of Alignment ($F(1,36)=3.8$ $p<.05$) was observed for efficiency scores, which means performance was better for misaligned faces compared with aligned faces. Additionally, there was interaction between Alignment and Orientation ($F(1,36)= 7,46$ $p<.01$), suggesting that participants were more efficient for upright misaligned faces, compared to aligned faces, although this difference disappears with inverted faces. None of the other analyses reached significance for faces stimuli.

Body stimuli

Repeated measures ANOVA for reaction time yielded main effect of Alignment ($F(1, 36)=13.6$; $p<.01$), and Orientation ($F(1,36)=4.25$; $p<.05$). Participants were faster in misaligned bodies compared to aligned bodies. Additionally, the effect was stronger for inverted bodies compared to upright bodies.

Analysis of accuracy yielded main effect of Alignment ($F(1, 36) = 6.02$; $p<.05$). Performance was more accurate for misaligned bodies compared to aligned bodies. Furthermore, we found significant interaction for Orientation and Alignment ($F(1, 36)= 5.7$ $p<.05$). Participants performed better for inverted misaligned bodies than inverted aligned bodies, whereas there was no difference in performance for upright aligned and upright misaligned bodies.

Efficiency scores analysis revealed main effect of Alignment ($F(1, 36)= 10.7$ $p<.01$). Performance was more accurate for misaligned bodies compared to aligned bodies. Furthermore, significant interaction for Orientation x Alignment ($F(1, 36)= 6.65$ $p<.05$) appeared. Performance was better for inverted misaligned bodies compared to inverted aligned bodies, whereas there was no difference in performance for upright misaligned bodies compared with upright aligned bodies. None of the other analyses reached significance for faces stimuli.

Discussion

In this study we explored holistic processing for bodies and for faces using composite effect. The evidence for body holistic processing is coming from inversion effect (Tanaka and Farah, 1993; Reed et al., 2003; Reed et al., 2006). Findings of previous studies using composite effect to explore body holistic processing are mixed (Soria Bauser, Suchan and Daum, 2011; Robbins and Coltheart, 2012). The holistic processing occurs when performance is better for misaligned stimuli, since in aligned condition it became difficult to separate the top half from the bottom half. In case of faces the result are clear; subjects are slower and less accurate in recognizing the top half of the face when it is aligned compared to misaligned condition when the bottom half of the face is created by shifting the lower part of the face right, thus faces perception is holistic (de Heering, Wallis and Maurer, 2012; Rossion and Boremanse, 2008). We meet faces and bodies frequently, therefore we become experts in body and face processing, and additionally we perceive them together (Reed et al., 2003). The aim was to investigate whether human body shape perception shares the same process used for face perception.

Consistent with previous results (Young, Hellawell and Hay, 1987; Rossion and Boremanse, 2008; Soria Bauser, Suchan and Daum, 2011; McKone et al., 2013), we observed composite illusion for faces as reaction time was significantly faster for upright misaligned faces compared to upright aligned faces. Also performance was better and more efficient for upright misaligned faces compared to upright aligned faces. In the case of inverted faces, there was no difference between misaligned and aligned stimuli. Our results confirm holistic processing for faces; we process face stimuli as a gestalt, thus for participants it was hard to name whose faces they saw when the top and the bottom half of the face were aligned. Nevertheless, misalignment made them faster and their performance better and more efficient. No composite effect was observed for inverted stimuli.

In a typical inverted face perception condition reaction time increases and performance decreases, which indicate the inversion effect (Tanaka and Farah, 1993; Reed et al., 2003; Reed et al., 2006). In our experiment, participants showed similar tendency, as they were slower when inverted faces were presented, but the effect could not be observed in their performance and efficiency scores.

Our results seem affirmative for body composite effect, however merely inverted. Participants were faster and had better performance and were more efficient for inverted misaligned bodies compared to inverted aligned bodies, which reveals composite illusion. In the case of upright bodies no composite illusion could be observed, since there was no difference in performance between upright aligned bodies and upright misaligned bodies. Results are contrary to Soria Bauser, Suchan and Daum (2011) findings, because they could not be observed difference between aligned and misaligned conditions. Our findings partly confirm Robbins and Coltheart's (2012) results, but they did not demonstrate

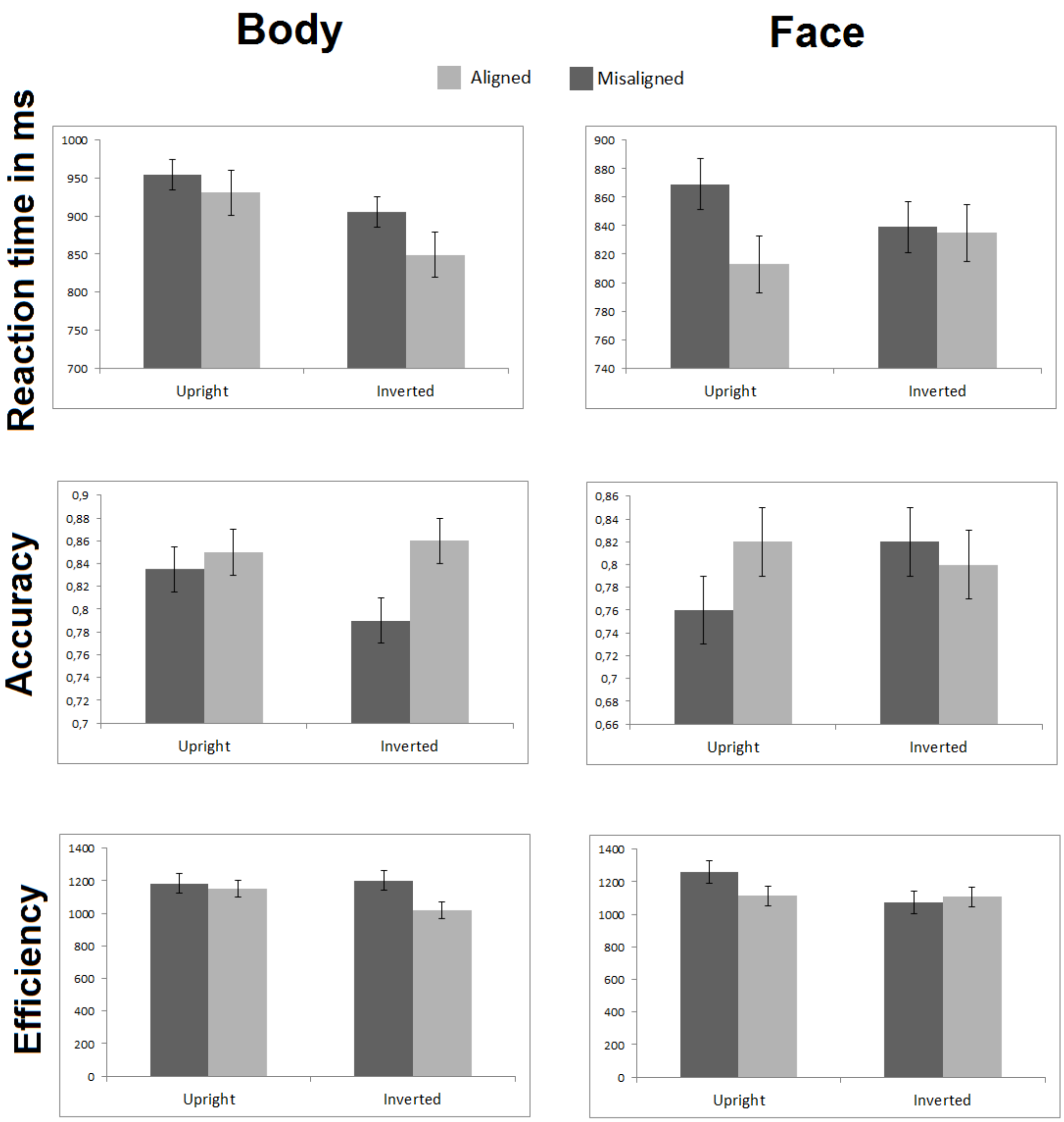

Figure 4: Results

composite effect inverted, when bodies were halved horizontally, although left and right halves showed inverted composite effect.

Two explanations could be interpreted, for inverted body composite effect, which are related to each other. One is that body processing is based on first-order relational information, which provides a spatial map among body parts and supported by inversion effect for several body postures (Reed et al, 2006). As seen in Fig. 1 in upright misaligned condition, the first-order relational information of the body is not compounded. This could influence that subjects performed the same for upright misaligned condition compared to upright aligned condition. In inverted condition, the body's configural spatial relations are disrupted by the inversion (Reed et al, 2006). In our study participants performed almost the same in accuracy and efficacy scores in inverted misaligned condition compared to upright aligned or misaligned conditions; additionally, their reaction times were slower for inverted bodies compared to upright bodies. Results support that inversion did not affect the performance, which reveals that the configural spatial relations were not disrupted by the inversion and the alignment. Thus, subjects performed significantly better for inverted misaligned condition compared to inverted aligned condition, which reveals composite illusion for inverted body shapes. The other possible explanation for inverted body composite effect is that we have learned how bodies look like because we meet them frequently, therefore we become experts (Reed et al., 2003). That is why in upright condition misalignment did not affect the result, because despite the gap between the two body halves and the misalignment, participants still perceived the stimuli holistically. The true composite effect could be observed with respect to inverted images. This is partly due to holistical processing and partly because of the fact that inversion disrupted perception; with both factors leading to worse performance in inverted aligned body, compared to inverted misaligned body. To support this hypothesis more information is needed. We suggest conducting the same study with children participants, since children may not be experts on body shapes, compared to adults like adults do.

This study is the first, as far as we are concerned, which investigated body composite effect using computer generalized bodies with different BMI. Previous studies used pictures of males or females (Soria Bauser, Suchan and Daum, 2011; Robbins and Coltheart, 2012) or Willems et al., (2014) used computer generalized bodies to investigate whether there is a composite effect for body postures. Using this method, perception was only affected by body shape, because the models that had to be compared had the same identity, merely their BMI differentiated.

Taken together, the subjects perceived the face holistically, that is why they were slower and less accurate and efficient in upright aligned condition. Furthermore, inverted presentation affected the holistic processing, and composite effect could not be observed for inverted faces. Body composite effect was revealed but merely for inverted stimuli. In upright condition there was no difference between misaligned and aligned conditions.

Conclusion

In this study the aim was to explore body holistic processing by composite illusion. There is little knowledge about human body shape processing. Additionally, this research is the first that studies body processing with computer generalized body shapes varying BMI. Body processing looks similar to face processing, thus there are similarities and differences as well (Slaughter, Stone and Reed, 2004). In our study composite illusion was supported for human body forms, but merely when they were presented in an invertedly. More research is needed in this field, because previous results are mixed, and our study has brought up even more questions.

Acknowledgments

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