# Enhanced visual perception near the hands

Bachelor thesis


Marina Meinert

(s0163430)


Supervisors:

1st supervisor: Prof. Dr. Ing. W. B. Verwey

2nd supervisor: Dr. M. L. Noordzij

External supervisor: Dr. N. Le Bigot (*IfADo*)


University of Twente

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## Abstract

Previous research has shown that the position of the hands can have an impact on the distribution of visual attention as well as on the visual sensitivity in the space near the hands. The aim of the present study was to examine whether the positions of the hands influence visual perception near the hands. The participants performed a visual discrimination task, during which they placed their hands in four different position configurations at a screen, either the left, the right, both or no hands. Further, the visual stimuli appeared at three different positions, either at the left or the right side or in the centre of the screen. Results show that the participants responded more accurately while having both or the right hand at the screen compared to the no hand condition. Such an advantage was not found when participants positioned the left hand at the screen. These findings specify the conditions in which visual perception is enhanced in the space near the hands.

## Introduction

In everyday life, we are surrounded by all kinds of objects. The objects near our body (in the peripersonal space) are mostly more important for us than objects further away from it because we can interact with them in a direct way. With our hands we can grasp, hold, or fend them off. Imagine someone throws an object at you. In this situation it is crucial that you use your hands to fend it off, otherwise it could hit and injure you. Thus, the peripersonal space plays an important role. Recent studies investigated that this space is represented in our brain in a different way than space further away from the body (Làdavas, di Pellegrino, Farnè, & Zeloni, 1998). Particularly, it is important that we process the visual information in peripersonal space in an effective way. We have to decide to which visual stimuli we will attend to. Due to the process of visual spatial attention we can select visual stimuli on the basis of their spatial location, simultaneously disregarding other stimuli (Vecera & Rizzo, 2003). Moreover, the position of our hands can help in the selection of the visual information (Reed, Garza, & Roberts, 2007). It can have an impact on the way we perceive objects in the space near the hands (Dufour & Touzalin, 2008).

Recent studies showed that the position of the hands can influence visual attention (Reed, Grubb, & Steele, 2006; Abrams, Davoli, Du, Knapp, & Paull, 2008; Reed, Garza, & Roberts, 2010; Pollux & Bourke, 2008; Davoli, Du, Montana, Garverick, & Abrams, 2010; di Pellegrino & Frassinetti, 2000). In their experiment, Reed et al. (2006) used a covert visual attention task (Posner, Walker, Friedrich, & Rafal, 1987) to examine whether the hand position has an impact on the distribution of attention in space near the hands (perihand space). The participants placed either only the left, only the right or no hand at the sides of a computer monitor. They were instructed to press a computer mouse button on the table with the other hand in order to indicate the presence of a target, responses should be as quickly and accurately as possible. The results showed that the reaction time (RT) to targets was shorter when the targets appeared near the hand, compared to targets which appeared away from the hand. Based on these results, Reed et al. (2006) concluded that hand presence affected attentional prioritization of space. Ensuring that this effect was due to the hand position, Reed et al. (2006) conducted a control experiment with the same task. However, a condition was added in which a board was positioned vertically at either the right or the left side of the screen, while the participants placed their hands on the legs. In order to create a visual input similar to that of hand, the boards were approximately the same size as the hand. The results showed that in the board condition RT was longer when the stimuli appeared near the board than when the participants had placed their hand at the screen and therefore, the stimuli appeared near the hands. Based on these findings, Reed et al. (2006) concluded that the attentional prioritization of space occurred due to the hand and not because of random visual objects like a board.

Abrams et al. (2008) pointed out another influence of the hand position on visual attention. In their experiments they used three visual attention tasks (visual search, inhibition of return, and attentional blink) to investigate whether nearness of the hands modifies visual processing. During the experiments the participants were instructed to place either both hands vertically at the sides of a computer screen or both hands on their legs. For example, the first experiment used a visual search paradigm. The task was to search for target letters appearing between a specific number of non-target letters, displayed at randomly locations on a computer screen. The participants responded as fast as possible by pressing a button with their hands, to indicate which target letter appeared on the screen. The results showed that the participants took longer to identify a target letter when the hands were placed at the screen than on the legs. The researchers suggested that they shifted their attention more slowly when they appeared in perihand space. Ensuring that this effect occurred due to the sheer presence of the hand and not because of answering with the hand, Abrams et al. (2008) conducted another visual search task similarly to the first one, but participants responded with their feet and not with their hands: the results were the same as in the first experiment, suggesting that the effect arose due to the mere presence of the hand. Further, like Reed et al. (2006), Abrams et al. (2008) tested a control condition in which the participants could not view their hands. The results showed that for enhanced processing viewing the hands was not necessary. Abrams et al. (2008) concluded that the effect of hands on adjacent targets may be a stronger focus of attention that inhibits the shift of attention from target to target, leading to longer performance time.

Besides these studies, Reed et al. (2010) considered possible differences between the back side and palm side of the hand, these two sides have a different functional meaning when grasping objects. In their experiment, participants directed a stretched hand towards the centre of a computer screen while the stimuli appeared either on the back side of their hand or at the palm side (grasping space). Results showed that objects which appeared in the grasping space were detected faster than objects which appeared on the back side of the hand. Based on these results, Reed et al. (2010) concluded that the functional capabilities of the grasping hand biased attention.

The mentioned studies indicated that the hand position can alter the prioritization and the shifting of attention. The objects near the hands were prioritized, and the shifting of attention between the objects was slower in perihand space. Further, recent studies showed that the visual perception is modified in perihand space (Dufour & Touzalin, 2008; Cosman & Vecera, 2010). Using a visual detection task, Dufour and Touzalin (2008) investigated in which way visual sensitivity is altered in space near the hands. In their experiment three light-emitting diodes (LEDs) were installed on a table. One LED was placed in the centre of the table, used as fixation point. The two target LEDs were installed at the left and right side of the fixation LED. The participants were instructed to place either the left or the right hand on the table, in each case placing the opposite hand under the table. With this setup near- and far-hand conditions were created. The task was to respond as fast and accurately as possible by pressing a button with the hand under the table when the right or left target LED flashed with the fixation LED at the same time. The results showed that there were no significant differences in RT between near- and far-conditions, but a greater accuracy in the near-hand condition. Ensuring that this effect occurred due to the hand presence and not because of other influencing factors, Dufour and Touzalin (2008) alternately changed different aspects of the experiment. They first replaced the hands by a piece of wood. Results showed no differences in RT and accuracy between near- and far-conditions, consistent with previous findings of Reed et al. (2006). Secondly, the experiment was conducted in darkness in order that the participants were not able to view their hands, also showing no difference in RT and accuracy between near- and far-conditions. Dufour and Touzalin (2008) concluded that for an improved visual processing viewing the hands was required. These results were not consistent with previous findings which indicated that enhanced visual processing was not related to viewing the hand (Reed et al., 2006; Abrams et al., 2008). At last, a further LED and hand position was added vertically in front of the fixation LED, closer to the participants' bodies. These results were similar to the first experiment, a greater accuracy in the near-hand conditions compared with the far-hand conditions. Based on these findings, Dufour and Touzalin (2008) concluded that visual sensitivity is enhanced in the space near the hands due to viewing the hand, independently of the hand position in space.

On the basis of these findings, the present study used another approach whether visual perception is enhanced in perihand space. In the previous research, a visual discrimination task has not yet been used to investigate the effects of different hand positions on visual processing. In the most recent experiments (Reed et al., 2006; Reed et al., 2007; Reed et al., 2010; Abrams et al, 2008), RT served as the primary dependent measure, i.e. participants responded as fast and as accurately as possible. In the present study, the quality of visual perception was of primary interest. Therefore, accuracy served as the only dependent measure (Moore and Egeth, 1998). Moreover, the participants were encouraged to take as much time as they needed to respond, in order to avoid a possible bias due to the participants aiming to be faster. Unlike other experiments studying a hand effect, the present research involved four different hand conditions in the same experiment. In earlier studies, comparisons were made either between one or no hand (Reed et al., 2006; Dufour and Touzalin, 2008), or between two or no hands (Abrams et al, 2008). In the present experiment, these different hand positions are combined, so that comparisons can be made between the left, the right, both and no hands in the same test. Moreover, most previous experiments used visual information either at the left or right side of the screen (Reed et al., 2006; Reed et al., 2007; Reed et al., 2010), or only in the centre (Abrams et al., 2008), but not yet in a combination of all three different positions in the same experiment. Similar to the research of Dufour and Touzalin (2008), stimuli were shown on the left or right side as well as in a central position. Compared with the experiments of Dufour and Touzalin in the present experiment the hand was not positioned near the stimulus in the central position and the distance between the stimulus positions was smaller.

On the basis of previous findings it is hypothesised that the visual sensitivity is increased in the space near the hands. A greater accuracy should be found in the both-hand condition compared with the no-hand condition (Abrams et al., 2008). Further, there should be a greater accuracy in the right-hand condition as well as in the left-hand condition compared with the no-hand condition (Reed et al., 2006; Dufour and Touzalin, 2008). Based on previous results (Reed et al., 2006; Dufour and Touzalin, 2008), there should be a greater accuracy when the stimuli appear on the same side as the participants place their hand on the screen , i.e. when the participants have their right hand at the screen and the stimuli appear within the right square next to the right hand, or when the participants have their left hand at the screen and the stimuli appear within the left square, thus in space near the left hand.

## Method

**Participants**. Thirty volunteers (17 females, 13 males, mean age = 24.5 years) participated, optional for money or course credit. Twenty-five of the participants were right-handed and five were ambidextrous, as indicated by the Edinburgh Handedness Inventory

(Oldfield, 1970). All participants had normal or corrected to normal vision and signed a written informed consent.

**Stimuli and apparatus**. Stimuli were presented on a 19 inch monitor with the refresh rate set at 100 Hz. The viewing distance from the eyes to the monitor was 50 cm, kept constant using a chin rest. In some conditions during the experiment, the participants were instructed to put their hands at the left and / or right screen border. For this purpose they placed their arms on one of two separated braces which were wooden boxes adjustable in height. The participants were presented with a central empty square (0.56°), flanked by two other empty squares (1.68°) located 15° to either side. The stimuli presented within the squares were either an ‘x’ or a ‘+’. All these objects were grey on black background. After presenting these stimuli, they were masked by a random dot pattern within the same square. The masking consisted of 75% black and 25% white points (see Figure 1).

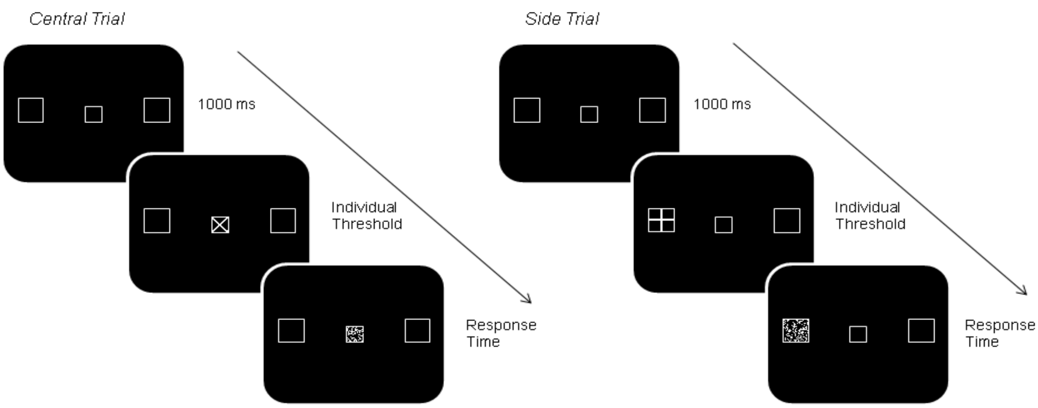


*Figure 1*. Progression of trials in the visual discrimination task. Each trial began with three empty squares for 1000 ms. Next, either the target stimulus x or the non-target stimulus + appeared as long as the individual threshold (which was determined in the adaptive procedure). For central trials, the target appeared within the central square. For side trials, the target appeared either within the left or within the right square randomly. Following the target, a visual masking appeared until the experimenter responded.

**Task**. The participants’ task was to indicate if a target stimulus appeared for a short moment of time within the squares. They were instructed to answer orally “ja” (yes) when the target stimulus x appeared within one of the squares and “nein” (no) when the non-target stimulus + appeared. The experimenter entered these oral responses into the computer by pressing the respective mouse button. Participants were instructed to fixate the central square and to respond as accurately as possible. The participants placed their hands in four different positions (see Figure 2). Grey fields indicated where they should place their hands. In the left-hand condition, the participants placed their left hand vertically at the left screen border with the middle finger at the level of a grey field, and the right hand vertically on the right side of the right brace. The second condition was the right-hand condition, where the hands were placed opposite to the left-hand condition. In the both-hand condition, the participants placed both the left and right hand vertically at each screen border with each middle finger on the shown grey field. Both hands were placed vertically on the sides of the braces in the no-hand condition.

*Figure 2.* Four different hand positions during the task. The participants had either the left, the right, both or no hand at the screen, supported by a brace in front of the screen.

Because accuracy served as dependent measure, it was important that the task was neither too easy nor too difficult. Since task difficulty is related to the duration of stimulus presentation, an adaptive psychophysical procedure was conducted to determine for each participant the stimulus duration that gave an average of 80% correct responses. For this purpose, a staircase procedure following a three-down, one-up algorithm was used (Leek, 2001). In this adaptive procedure, the stimulus duration begins above threshold duration and decreases after three sequential positive responses. After one negative response the level increases again. The median value of the last five responses is the threshold duration used in the subsequent experimental blocks (see Figure 3). During the adaptive procedure the participants were instructed to put their hands on the legs. The task was the same as in the experiment.

Because there is a difference in perceiving a stimulus within the central square (foveal vision) or within one of the side squares (peripheral vision), two different thresholds for each participant were needed. On the one hand, a threshold was determined only for the central square, and on the other hand a threshold was determined for the left and right square together. In previous tests performed in our laboratory, difficulties occurred when the two different thresholds were measured in the same block by presenting the stimuli in the three positions at the same time. As a consequence, in the present experiment the two thresholds were measured separately, so that there were two stimulus presentation conditions. First, a central stimulus presentation condition in which the stimuli only appeared within the central square. Second, a peripheral stimulus presentation condition in which the stimuli appeared either within the left or within the right square randomly. Thus, after the adaptive procedure for each participant, an individual threshold duration was available for both the central and the peripheral stimulus presentation condition. The order of the conditions was counterbalanced in a way that each participant performed both conditions, half of them began with the central condition and half with the peripheral condition.

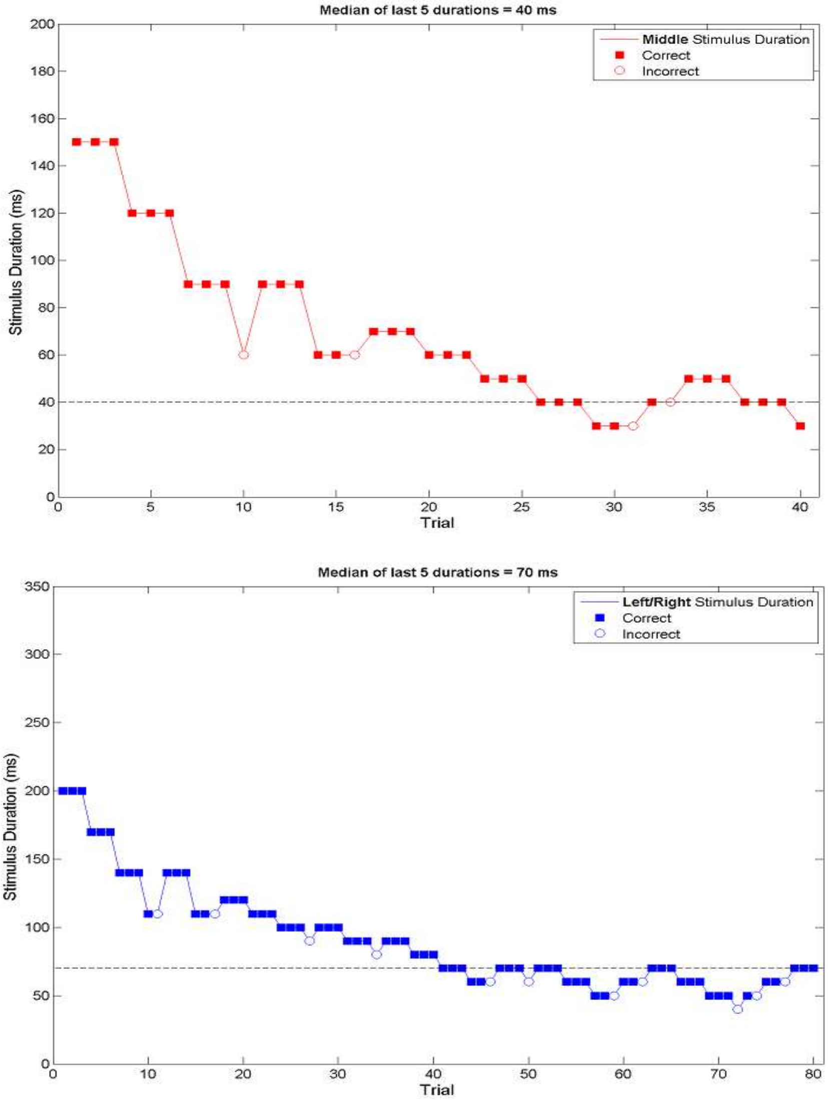


*Figure 3*. Threshold duration measurement for the central stimulus presentation condition (*top panel*) and for the peripheral stimulus presentation condition (*bottom panel*). The stimulus level began above threshold and decreased after three sequential positive responses; after one negative response the level increased. The median value of the last five responses was the stimulus duration value for how long the targets appeared within the squares in the respective condition.

**Procedure**. Before the experiments started, each participant adopted a comfortable position by setting the chair, the chin rest and the armrests in a suitable height. Then, the experimenter explained the task using a demo which constituted examples of the progression of the trials. In a random half of the trials in each block the target x appeared, and in the other half the non-target + appeared. Participants completed four 30-trial blocks, during which the stimuli appeared in the central square, and four 60-trial blocks, during which the stimuli appeared in the peripheral squares. Each trial began with a presentation of three empty squares for 1000 ms. Then, the individual threshold duration was used. Following the target, a visual masking appeared until the participant responded and the experimenter pressed the respective button.

Both stimulus presentation conditions started with the adaptive procedure. During this adaptive procedure there were 40 trials in the central stimuli presentation condition and 80 trials in the peripheral stimuli presentation condition. After 40 trials a 15 s. break was made in the peripheral stimuli presentation condition. During the experimental block, there were 30 trials in the central stimuli presentation condition and 60 trials in the peripheral stimuli presentation condition. After 30 trials a 15 s. break was made.

Before each block, grey fields displayed at the monitor indicated the participants where to place the hands exactly. The order of the hand conditions was counterbalanced using a Latin Square design. Following each block, the participants got feedback indicating the percentage of correct responses. We attempted to motivate the participants by informing the experimenter about this value and that they should try to improve.

## Results

Mean percentage of correct responses for each target position relative to the hand position was calculated for each participant. Because in some cases the adaptive procedure did not work well, the threshold duration value was too easy or too difficult, so that participants were excluded when their mean calculation trials were four times outside a range of 55% - 95%. Consequently, six participants were excluded, leaving 24 participants (14 females, 10 males, mean age = 24.8, 21 right-handed and 3 ambidextrous) for the analysis. Percentage data were arcsine transformed prior to statistical analysis (Winer, Brown, & Michels, 1991).

To determine whether visual sensitivity was enhanced in perihand space, a 4 (hand position: both, left, right or no) x 3 (hand position: left, middle or right) within-subject design was used. Furthermore, a repeated measures analysis of variance (ANOVA) was conducted. On average, the participants conducted the central trial with a stimulus duration of 35.0 ms (*SD* = 11.8, range: 20-70) and the peripheral trial with a stimulus duration of 176.7 ms (*SD* = 109.5, range: 30-530). A main effect of hand position was found, $F(3, 69) = 6.45$, $MSE = .013$, $p < .002$. As expected, a planned comparison showed that the participants responded more accurately with both hands ($M = .848$, $SD = .103$) than with no hands ($M = .800$, $SD = .120$), [$F(1, 23) = 11.58$, $MSE = .009$, $p < .002$]. Further, they responded more accurately with the right hand ($M = .841$, $SD = .110$) than with no hands ($M = .800$, $SE = .120$), [$F(1, 23) = 12.42$, $MSE = .007$, $p < .003$]. However, no significant difference in accuracy was found when the participants responded with the left hand ($M = .814$, $SD = .107$) than with no hands ($M = .800$, $SE = .120$) [F < 1] (see Figure 4).

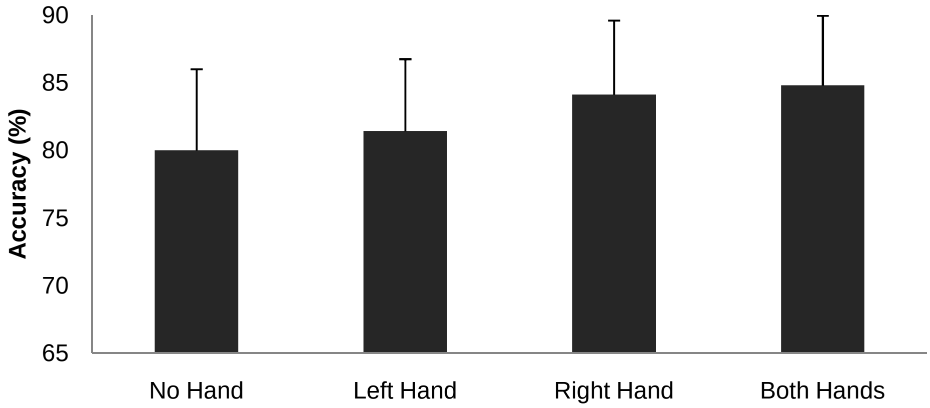


*Figure 4*. Mean accuracy (in percent) of the four hand conditions. Error bars represent the SD. The participants responded more accurately with the right or with both hands than with the left or no hand.

No significant main effect of stimulus position was found, $F(2, 46) = 2.93$, $MSE = .06$, $p = .08$. Further, the results pointed out no interaction effect between hand position and stimulus position, $F < 1$ (see Table 1).

*Table 1.* Mean accuracy and SD (in percent) of the hand positions in relation to the stimulus positions

| | Stimulus Left | Stimulus Central | Stimulus Right |
|---|---|---|---|
| No Hand | 76,8 (12,9) | 81,3 (12,9) | 81,9 (10,3) |
| Left Hand | 77,8 (11,6) | 84,6 (10,5) | 81,9 (9,9) |
| Right Hand | 80,4 (11,3) | 87,4 (8,6) | 84,4 (13,0) |
| Both Hands | 81,1 (11,3) | 86,1 (10,0) | 87,2 (9,5) |

## Discussion

The aim of the present study was to investigate whether the hand position has an impact on the visual perception in space near the hands. For this purpose, a visual discrimination task was used, where accuracy served as dependent measure. During the task, the participants adopted four different hand position configurations. They alternately positioned the left, the right, both or no hands at the computer screen. It was hypothesised that the participants would respond more accurately when they had their hands at the screen than when they had no hands at the screen. Moreover, it was hypothesised that the participants would answer more accurately when the stimulus appeared on the same side as the participants had placed their hand on the screen, thus near one of their hands.

The results document a main effect of hand position but no interaction effect between hand position and stimulus position. The participants answered more accurately when they placed both hands at the screen than no hands. Thus, the visual sensitivity is enhanced in space close to an object when both hands are placed near to it. This is consistent with earlier findings of Abrams et al. (2008) who pointed out a difference between either positioning both or no hands near an object. Based on their results, they suggested that with both hands the visual attention near the hands was altered in comparison with no hands. In the present study, the participants responded more accurately when they had placed their right hand than with no hand at the screen. Thus, it can be suggested that the visual sensitivity near an object is enhanced when the right hand is placed near to it. This finding is in line with the results of Dufour and Touzalin (2008) who indicated that the visual sensitivity is enhanced in space near the hands. Particularly in contrast to the hypothesis, in the present study no significant difference in accuracy was found when the participants had placed their left hand at the screen compared to no hand. The left hand alone failed to demonstrate an enhancement. It seems that the right hand had a crucial impact on the accuracy because the enhancement was better in conditions in which the right hand was involved at the screen. A possible explanation for this finding could be that no left-handers took part in the study. Except for three ambidextrous participants all were right-handers. Right-handers perform most actions with their right hand as for example writing, grasping, catching or holding objects. Thus, the main functions are performed mostly or sometimes exclusively with the right hand. Reed et al. (2010) showed that visual attention near a hand can particularly be enhanced on the inner (grasping) side of a hand. They suggested that because of the experience and the functional use of the hand, the space near the hand is biased. This could be a possible explanation for the present finding. Due to the functionality of the dominant hand for the most participants in the present study, the visual attention could be more biased at the right hand than at the left hand. For further research it would be interesting to observe if the same experiment with left-handers instead of right-handers would show the opposite effects. To sum up, the participants responded more accurately in conditions in which they had their right hand at the screen. It seems that the functionality of the right hand had an essential impact on the accuracy.

Further, it was presumed that the participants respond more accurately when the stimulus occurred on the same side where the hand was placed, e.g. when the stimulus occurred within the right (left) square while the participants had the right (left) hand at the screen. The results document no such interaction effect between hand and stimulus position. As already indicated the participants discriminated the targets more accurately when they had their hands at the screen compared to no hands, but this effect occurred independently of the stimulus position. This finding is contrary to the second hypothesis and is not consistent with recent findings. Based on their results, Dufour and Touzalin (2008) suggested that the smaller the distance between the visual stimuli and the hand, the greater the increase in visual sensitivity. In the present study instead, the distance between the visual stimuli and the hand does not have a significant impact on the visual perception in that space. For a possible explanation for these different results, a closer view on the experimental setups is needed. There, differences in the distances in the far-condition between the hands and the stimuli positions are noticeable. In the experiment of Dufour and Touzalin (2008), the greatest distance between hand and stimulus position was 80 cm. Contrary, the greatest distance between hand and stimulus position in the present experiment was 32 cm. Thus, the distances in the present study are remarkably smaller than in the experiment of Dufour and Touzalin. Taking this in consideration, a possible explanation could be that the smaller distances between hand and stimulus positions in the present experiment are not sufficient to measure a significant interaction effect. To sum up, the second hypothesis is not confirmed. The visual perception near the hands is enhanced regardless of the stimulus position in that space.

As a conclusion, it is shown that the visual perception is enhanced in space near the hands. In the present experiment, the stimulus position had no impact on it. Further, no significant difference was found when the participants had either the left or no hand at the screen. However, the participants responded more accurately with both or the right hand positioned at the screen than no hand. It seems that the right hand had a crucial impact on the enhancement. Further research is needed to confirm these findings.

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