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Competition Between Veridical and Perceived Location for Visuomotor Control

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Master Thesis

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Abstract

An influential proposal holds that our visual systems use different information for perception and action. Though numerous studies utilized visual illusions, in which veridical and perceptual properties of objects differ, the evidence was inconclusive and no consensus was reached. In response priming, some evidence suggests that only physical attributes of the prime stimuli control motor responses. Across two experiments, we examined the contributions of physical and consciously perceived location to response priming, using a well-known flash-lag illusion, in which a briefly flashed disk and the moving bars appearing at the same location are perceived as displaced. In all experiments, participants made speeded responses to the location of the target disk presented above or below the static bars. In the first experiment we kept the physical location of the prime disk constant; the disk and moving bars were presented at the same location. Responses to the target disk were consistently biased by the prime disk, demonstrating that rapid motor responses were primed by the illusory perception of the prime location. In the second experiment, we inverted the physical and perceived location of the prime. We estimated the size of illusion for each participant and then presented the prime disk either above or below the moving bars, so that perceived location was in alignment with the moving bars. Motor responses were moderated by the physical location of the disk, showing that visuomotor system used veridical prime location. Our experiments demonstrate that our visuomotor systems use both sources of information, veridical as well as consciously perceived location to guide behavior.

Introduction

In our everyday lives, we face different tasks and challenges, each with its intrinsic unique properties. It is conceivable that our brains process visual information differently for different tasks.

A popular proposal suggests that one major division is between vision for action and vision for perception (Milner & Goodale, 1992). There have been several definitions proposed for perception. To separate perception from consciousness, it has been suggested that perception involves extraction of perceptual information from a stimulus (Kanwisher, 2001). For example, when viewing the Rubin's vase ambiguous figure, the percept alternates between two states, yet the stimulus itself does not change. Perception means "the extraction of perceptual information (including perceptual constancies) that is represented at the personal or more broadly, organismal (individual) level and can be used for the control and guidance of action" (Persuh, 2018, p. 120). The rationale is that our perception summarizes our visual environment and represents the relationships between objects and between objects and environment. Actions, however seem to depend on knowing and representing veridical object properties. Early support for this hypothesis came from patient studies. Patients with visual agnosia, for example, are unable to perceive objects, yet can execute precise visuomotor guidance. On the other hand, patients with optical ataxia, show poor motor guidance but can nonetheless perceive and recognize objects. One popular approach to testing this hypothesis with normal human subjects is with visual illusions, which suggests that processing of visual information for perception and action can be dissociated. Although some data show a dissociation between vision for action and vision for perception (Goodale, 2007), other evidence is more equivocal (Franz, 2001).

The idea that non perceptual type of visual information guides motor activity has been developed for the phenomenon of response priming. Schmidt et al. (2011), proposed that response priming is independent of visual awareness and depends on the rapid feedforward stream of information processing, which extracts only basic, physical properties of the prime stimulus. In response priming, participants perform a faster response to a target stimulus that is preceded by a prime stimulus provoking either the same response as the target (congruent prime) or the opposite response (incongruent prime) (Schmidt et al, 2011). In other words, response priming, a presentation of one stimulus, the prime, affects the processing of a subsequent stimulus, the target. Also, Vorberg et al. (2003) suggest that congruent primes accelerate responses to the target while incongruent primes will slow down responses. For example, Schmidt and colleagues (Schmidt et al., 2010) asked participants to respond to targets that differed in brightness. Targets were preceded by flanking primes presented on a corrugated plaid, which creates illusory brightness differences. Responses to targets were affected by primes; however congruency effects were based on local prime contrast and not on perceived prime brightness. The authors concluded that priming is based on physical features that are rapidly extracted, whereas perceptual qualities that take longer time do not contribute to motor responses.

Location is considered a special feature. It is possible that location information in rapid motor responding is processed differently from other features. The current study investigated whether response priming is based on veridical or perceived location, using a flash-lag illusion. In this illusion, a briefly flashed disk presented at the same location with a moving stimulus is perceived as displaced (Nijhawan, 1994). We took advantage of this illusion to ask whether motor responses in priming are affected by the veridical or perceived location of the disk.

Experiment 1

Participants in Experiment 1 made speeded responses to a disk presented above or below stationary bars. The preceding prime consisted of moving bars and a briefly flashed disk presented at the same location (Figure 1). Note that the veridical location of the disk is always in the center, between the moving bars and therefore physically neutral with respect to the target location. Perceptually however, the disk is displaced. For example, when the bars are moving downward, the disk is perceived above the moving bars and is therefore perceptually congruent with the target disk presented above the stationary bars and incongruent with the target disk presented below the stationary bars. If response priming depends on veridical disk location, no priming would be expected. If, however, rapid motor responses depend on perceptual information, responses to targets should be affected by the perceived location of the prime. To ensure that moving bars by themselves are not affecting motor responses we included a control condition in which we omitted the prime disk and presented only moving bars by themselves. We presented the stimuli in the upper visual field (UVF) for half of the participants and in lower visual field (LVF) for the other half of participants.

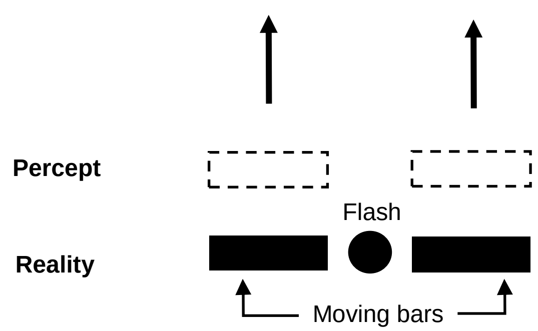

Figure 1. The prime presented in Experiment 1, consisted of two moving bars and a disk flashed at the same location (in the center).

Method

Participants. Twenty participants, 12 females, ages 18-23 (M = 19) were recruited from the pool of the City College of New York undergraduate psychology students. All students had normal or corrected to normal vision and participated after signing the informed consent form.

Stimuli and Apparatus. Stimuli were presented on a 19", Dell M991 CRT monitor, set at 60 Hz refresh rate. Stimuli were presented on a uniform gray background. The fixation cross, subtending 0.29^o, was presented at the center of the screen. The prime consisted of two horizontal bars, subtending 1^o x 0.36^o and separated by 0.71^o. Bars were moving either upwards or downwards with the speed of 0.07^o/s. The prime disk, subtending 0.36^o, was presented between the two bars for one frame (16 ms). For the stimuli in the UVF or LVF, the prime disk was presented 1.43^o above or below the fixation point, respectively. The target consisted of two stationary bars, subtending 0.20^o x 2.14^o and presented at 1.43^o above or below the fixation cross for the UVF and LVF and a disk, subtending 0.20^o and presented 0.36^o above or below the bars.

Procedure. Participants were seated in a dimly lit room. Their head position was fixed with a chinrest positioned 57 cm away from the monitor. In the center of the screen a cross sign was presented and the subjects were asked to look at the cross sign continuously throughout the experiment. Participants were to make speeded responses to targets, a black disk that was presented either above or below the two black bars (Figure 2). The response assignments were counterbalanced between the subjects, with half of the subjects using the left key on the keyboard to indicate the disk above the two black bars and the right key on the keyboard to indicate the disk below the two black bars and the other half of the subjects using the right key on the keyboard to indicate the disk above the two black bars and the left key on the keyboard to indicate the disk below the two black bars. Two types of trials were included. Trials with no prime served as a control condition which presented only moving bars by themselves. The second type of trial consisted of a prime disk presented in the center to see if responses to the target disk were consistently biased by the prime disk, thereby allowing for rapid motor responses to be primed by the illusory perception of the prime location. The two types of trial were presented in random order. Each participant performed 260 blocks of trials with a break after 40 trials. Participants were instructed to respond as quickly and accurately as they could.

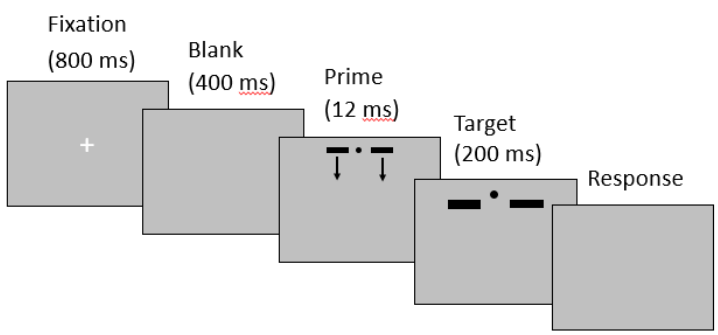

Figure 2. A diagram of trial sequence. The prime is always presented in the same location (in the center). The participants have to make speeded responses to targets as either above or below the two bars. For the stimuli in the upper visual field, the prime disk was presented above the fixation point.

Results and discussion

Overall accuracy for trials with the prime disk was 90%. Reaction times for correct trials only were analyzed with mixed measures ANOVA with congruency (2) and bar direction (2) as within-subject and visual field (2) as between-subject factors (Figure 3). Reaction times for congruent trials were significantly faster than reaction times for incongruent trials $F(1, 18) = 58.83$, $p < .001$. No other main effects or interactions were significant, except for the direction x visual field interaction, F (1, 18) = 9.57, p = .006. (Figure 3). Figure 3 indicates a pattern, in which bar movement away from the fovea seems to increase priming, although this effect was non-significant. There was no significant difference between the congruent and incongruent trials in the control condition, showing that the movement of bars alone does not contribute to a priming effect. Figure 4 shows individual priming results; all participants except one, showed priming. The analysis of accuracy confirmed these results (Figure 5). Participants made significantly more mistakes in incongruent trials, F (1, 18) = 34.54, p < .001, whereas there was no significant difference in accuracy between congruent and incongruent trials in the control condition.

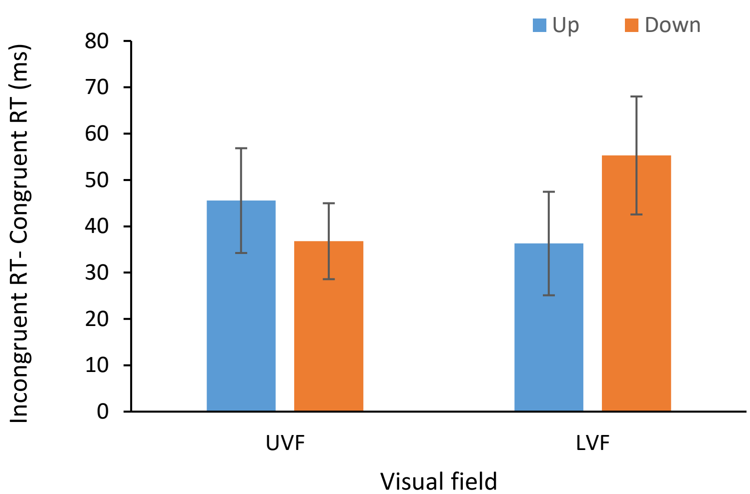

Figure 3. Priming based on reaction times. Data are presented for the UVF and LVF and direction of bar movement (up or down). Error bars represent ±1 SEM.

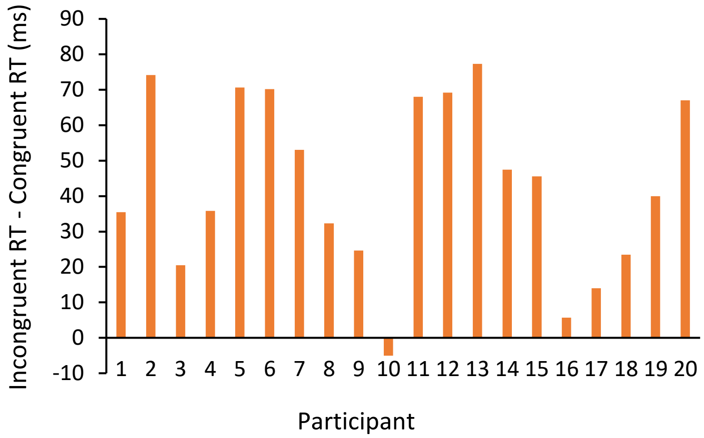

Figure 4. The priming effects (incongruent minus congruent RT's) measured for each participant.

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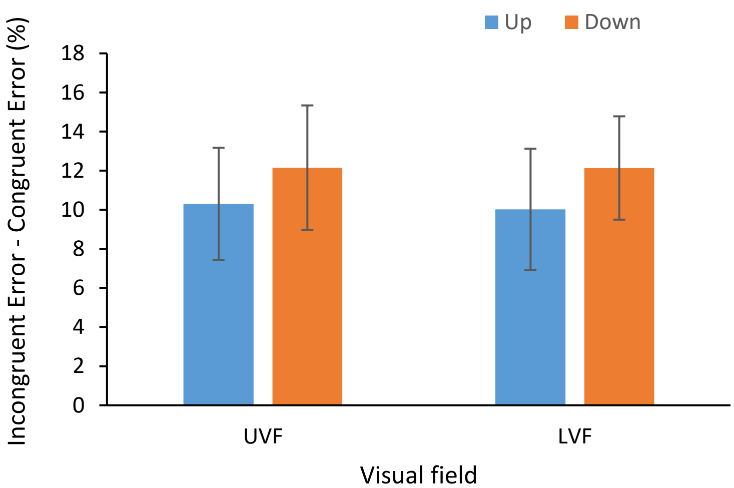

Figure 5. Priming based on error rates. Data are presented for the UVF and LVF and direction of bar movement (up or down). Error bars represent ±1 SEM.

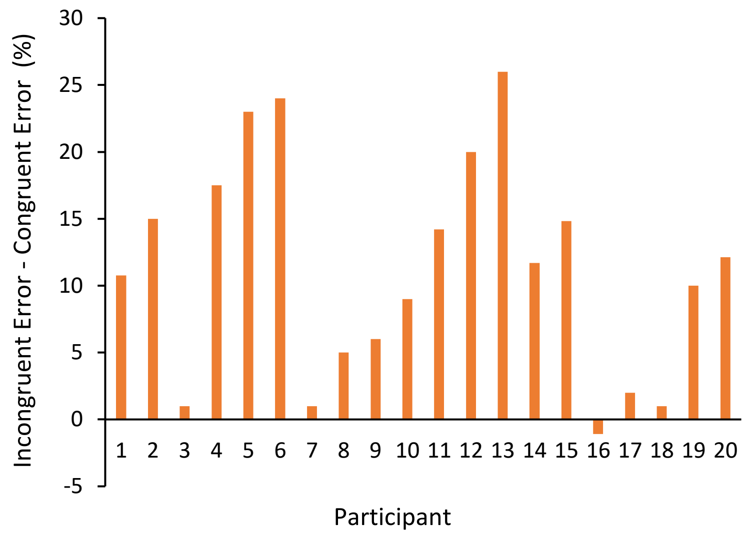

Figure 6. The priming effects based on error rates (incongruent error minus congruent error RT's) measured for each participant.

Results of Experiment 1 show that priming based on location is strongly affected by the perceived location of the prime. It would be however premature to conclude that response priming is exclusively based on perception, since the veridical prime location was not manipulated. In Experiment 2, we directly examined this possibility.

Experiment 2

Experiment 2 consisted of two parts. In the first part we estimated the size of the flash-lag illusion for each participant. In the second part we used the estimated illusion size to place the prime disk either below or above the moving bars, so that the disk was perceived as aligned with the moving bars. In that way the prime disk was perceptually neutral with the target, whereas in reality it was physically congruent or incongruent (Figure 7). Note that this is the opposite of the design in Experiment 1, in which physical location was neutral. If priming is based only on perceived location, no priming should be occurring, because perceptually the prime disk was neutral with respect to the target. Because that would be a negative result, we also included a condition with the prime in the center as a positive control. If priming is also based on veridical location, priming would be expected in both conditions. A no-prime control was also included as in Experiment 1.

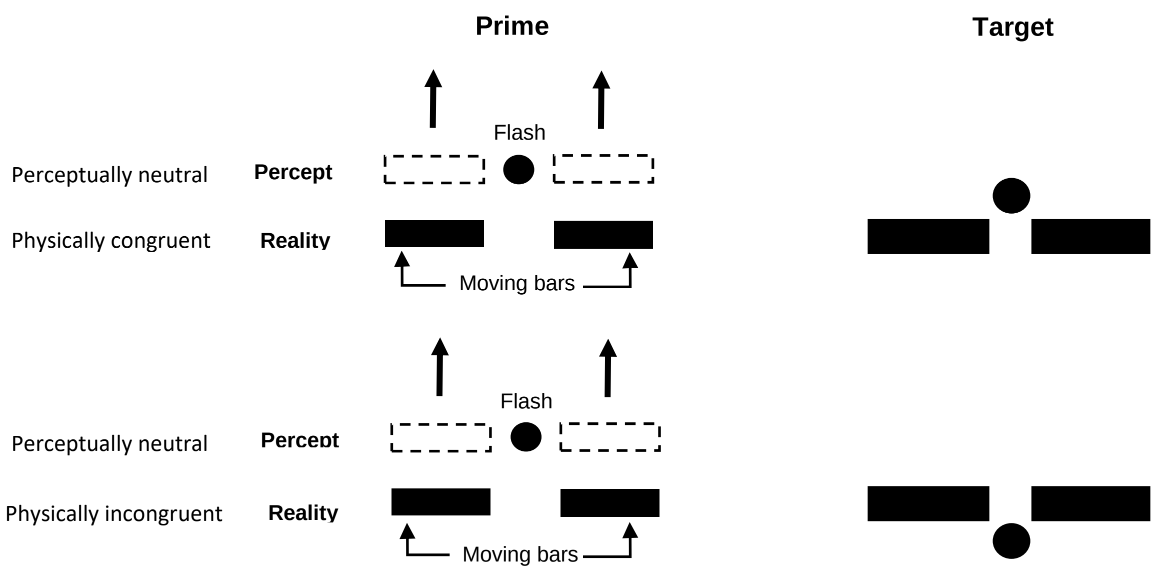

Figure 7. An example of a congruent and incongruent trials in Experiment 2. The estimated illusion size was used to place the prime disk either below or above the moving bars, so that the disk was perceived as aligned with the moving bars. In that way prime disk was perceptually neutral with the target, whereas it was physically congruent or incongruent.

Method

Participants. Twenty participants, 8 females, ages 18-27 (M= 20) were recruited from the pool of the City College of New York undergraduate psychology students. All students had normal or corrected to normal vision and participated after signing the informed consent form.

Stimuli and Apparatus. Stimuli were the same as in Experiment 1.

Procedure. In the first part of the experiment, we used an interleaved staircase procedure to estimate illusion sizes, which were then used in the second part of the experiment. For each staircase procedure, participants were presented with prime stimulus alone and reported whether the disk was perceived above or below the bars. The staircase consisted of two interleaved sequences with the starting position for the prime disk above and below the central position for the up and down staircase, respectively. After each response, disk position was adjusted by the 0.07^{o}, until the first reversal, after which the adjustment was 0.036^{o}. The procedure was terminated after ten reversals. The illusion size was calculated as the average of the last six reversals for each staircase and the two values were averaged to obtain the illusion size. Two staircase procedures per participant were used to estimate individually the illusion sizes for upward and downward bar movements.

In the second part of the experiment participants made speeded responses to targets. Three types of trials were included. Trials with no prime served as a negative control. Trials with prime disk presented in the center served as a positive control. The third type of trial consisted of the prime disk presented above or below the moving bars; the position of the disk for each participant was based on the estimated illusion size. The three types of trial were presented in random order. Each participant performed 360 blocks of trials with a break after 40 trials. Participants were instructed to respond as quickly and accurately as they could.

Results and discussion

Experiment 2 was divided into two parts. In the first part of the experiment, an interleaved double staircase procedure was used to estimate the illusion size separately for upward and downward moving bars for the UVF and the LVF (Figure 8.). There was a significant visual field x direction interaction, $F(1, 18) = 9.38$, $p = .007$, demonstrating a stronger illusion for the movement towards fovea (down for UVF and up for LVF).

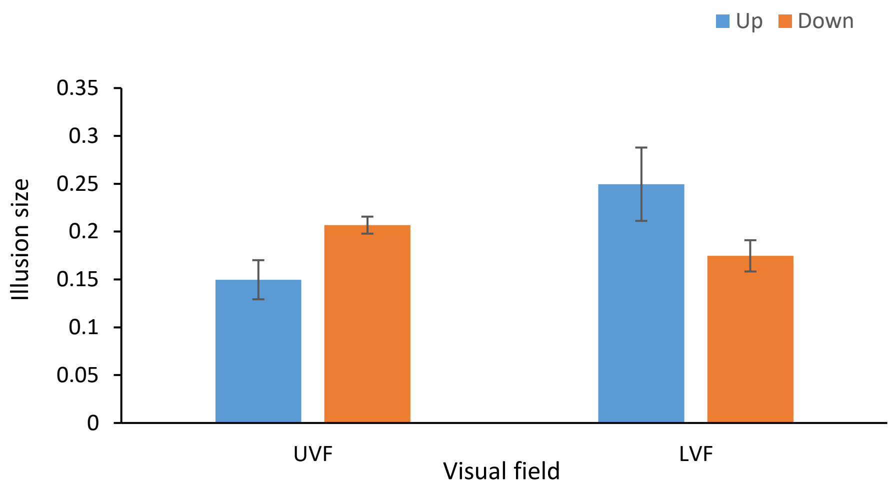

Figure 8. Illusion sizes presented for the UVF and LVF and direction of bar movement (up or down).

In the second part of the experiment, participants made speeded responses to targets. Accuracy in condition with prime in the center was 90.5%. Reaction times for congruent trials were significantly faster than reaction times for incongruent trials, replicating results of Experiment 1, $F(1, 18) = 18.43$, $p < .001$. These results also confirm that priming is based on perceived location of the prime disk. Participants also made significantly more errors in incongruent trials, $F(1, 18) = 11.38$, $p = .003$. Reaction times for congruent and incongruent trials in the no prime condition were not significantly different from each other, again replicating results from Experiment 1 and showing that moving bars alone had no effect on priming.

The crucial new manipulation was the introduction of trials in which the size of the illusion was used to place the prime disk either below or above the moving bars. Congruency in these trials was defined with respect to the physical location of the target. Accuracy was 91.3%. Reaction times or congruent trials were significantly faster than reaction times for incongruent trials (Figure 9.), demonstrating that priming occurred due to the physical, veridical location of the prime disk, F (1, 18) = 9.03, p = .008. No other effects were significant. Error analyses confirmed reaction time data (Figure 10.), participants made significantly more errors in incongruent trials, F (1, 18) = 4.8, p = .042; thus there was no speed-accuracy trade-off.

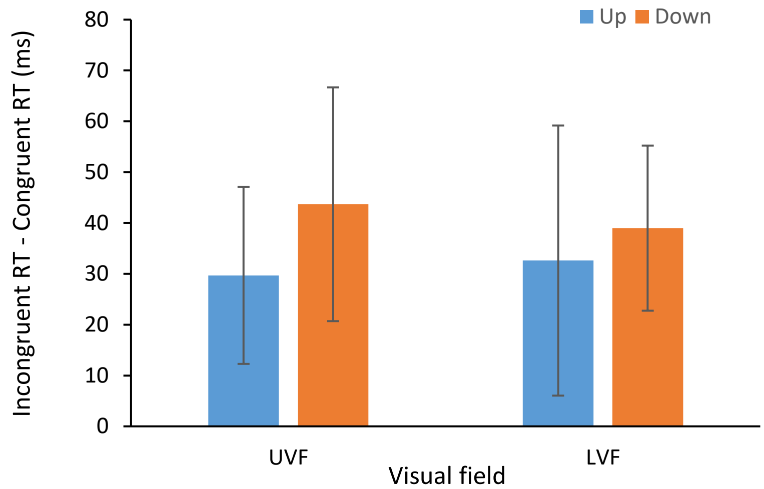

Figure 9. Priming based on reaction times. Data are presented for the UVF and LVF and direction of bar movement (up or down). Error bars represent ±1 SEM.

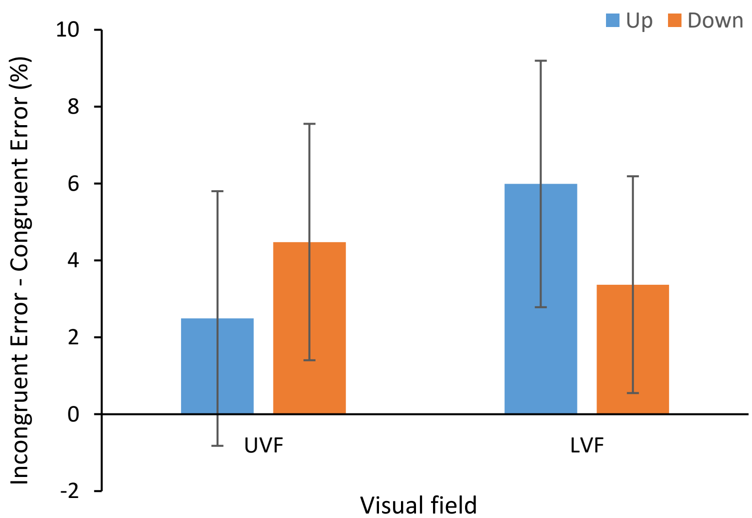

Figure 10. Priming based on error rates. Data are presented for the UVF and LVF and direction of bar movement (up or down). Error bars represent ±1 SEM.

Results of Experiment 2 demonstrate that our visuomotor systems use both, veridical as well as perceived, locations to guide motor responses.

General discussion

One of the most interesting questions in Psychology concerns the nature of visual information represented by our brains to guide behavior. A popular theory of vision for action and vision for perception proposes one such distinction. In our study we focused on response priming, using a flash-lag illusion, and explored whether veridical location or perceived location is used for speeded motor responses.

In Experiment 1, we demonstrated that location priming is based on perceived location of the prime disk displayed briefly at the center between the moving bars. Control trials without the prime disk showed that moving bars alone do not prime motor responses. These results are contrary to what has been proposed for response priming. It has been suggested that response priming is based on veridical aspects of the prime stimulus and not on its perceptual qualities. If that were the case, we would expect no priming in Experiment 1, because veridical prime location was constant on every trial. However, results of Experiment 1 do not exclude the possibility that priming is also based on veridical location. Experiment 1 is simply unable to answer this question, because the veridical prime location was not manipulated.

In Experiment 2 we addressed the possibility that veridical prime location contributes to priming as well. As control conditions, we included trials with prime in the center and no prime condition and replicated the results of Experiment 1. The crucial manipulation was the placement of prime above or below the moving bars, based on the illusion size estimated for each individual participant. Interestingly, we observed priming based on *veridical* location. The results of

Experiment 2 showed that our visuomotor systems use *both veridical and perceptual* information to guide behavior.

Across the two experiments we showed that unlike previously suggested, our visuomotor system depends on veridical and perceptual information. This study explored location, which is frequently considered a special visual feature. Other visual features, such as color, motion and shape will be explored in future experiments to determine how general this phenomenon is.

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CITY UNIVERSITY OF NEW YORK

The City College of New York

Department of Psychology

CONSENT TO PARTICIPATE IN A RESEARCH PROJECT

Project Title: Competition between veridical and perceived location for visuomotor control

Principal Investigators (P.I.): Marjan Persuh, Fatemeh Alhabib, Robert Melara

City College of New York

160 convent Avenue Rm 7/230

New York, NY 10031

917-582-5535

Site where study is to be conducted: City College of New York, 160 convent Avenue Rm 7/230 New York, NY 10031

<u>Introduction/Purpose:</u> You are invited to participate in a research study conducted under the direction of Marjan Persuh at the City College of New York. The purpose if this research study is to investigate whether response priming is based on veridical or perceived location, using flash-lag illusion. In flash-lag illusion, a briefly flashed disk presented at the same location with the moving stimulus is perceived as displaced. We took advantage of this illusion to ask whether motor responses in priming are affected by the veridical or perceived location of the disk.

<u>Procedures:</u> Participants were sited in a dimly lit room. Their head position was fixed with a chinrest positioned 57 cm away from the monitor. In the center of the screen a cross sign was presented and the subjects were asked to look at the cross sign continuously throughout the experiment. Participants were to make speeded responses to targets, a black disk that was presented either above or below the two black bars. The response assignments were counterbalanced between the subjects, with half of the subjects using the left key on the keyboard to indicate the disk above the two black bars and the right key on the keyboard to indicate the disk below the two black bars and the other half of the subjects vice versa. Each participant performed 260 blocks of trials with a break after 40 trials. The time commitment of each participant is expected to be a total of 40 minutes.

<u>Possible Discomforts and Risks:</u> The experimental procedures pose no special risks to you. It is possible that you become bored. A researcher will be present when you are being tested at all times. If you are bothered in any way as a result of this study you should contact the primary research investigator, Fatemeh Alhabib, at 917-582-5535, or fatema_hbb@yahoo.com.

Benefits: There are no direct benefits for the participant. However, participating in this study will increase your knowledge in the field of cognitive psychology and research methods.

Voluntary Participation: Your participation in this study is voluntary, and you may decide not to participate without prejudice, penalty, or loss of benefits to which you are otherwise entitled. If you decide to leave the study, please contact the principal investigator, Fatemeh Alhabib, to inform her of your decision.

Confidentiality: We will keep your data and your identity completely confidential when analyzing and reporting results from the experiments in this project. The saved data will be coded and will not be identifiable. Only an arbitrary number will be associated with the data we collect from you. No personal identifying information will be stored with your responses. When publishing the results of this project, all data values, will be reported as group means; individual data are not expected to be reported. Should an individuals' data need to be reported for scientific reasons, only the participant number will identify individual respondents.

Contact Questions/Persons: If you have any questions about the research now or in the future, you should contact the Principal Investigator, Fatemeh Alhabib, at 917-582-5535 or fatema_hbb@yahoo.com.

Statement of Consent:

I have read the above description of this research and I understand it. I have been informed of the risks and benefits involved, and all my questions have been answered to my satisfaction. Furthermore, I have been assured that any future questions that I may have will also be answered by the principal investigator of the research study. I voluntary agree to participate in this study.
By signing this form, I have not waived any of my legal rights to which I would otherwise be entitled.
I will be given a copy of this statement.

______________________	______________________	______________________
Printed Name of Subject	Signature of Subject	Date Signed
______________________	______________________	______________________
Printed Name of Researcher	Signature of Researcher	Date Signed
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Printed Name of P.I.	Signature of P.I.	Date Signed