Human Vection Perception Using Inertial Nulling and Certainty Estimation: The Effect of Migraine History

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ABSTRACT

Vection is an illusory perception of motion that may occur when a moving visual stimulus fills the majority of the visual field [1]. The ambiguity of self- vs external-motion arises because the labyrinth cannot always provide reliable self-motion information, such as during long, constant velocity motion [2-5], making the correct interpretation of visual motion as external or as self-motion important.

Several studies have attempted to quantify vection, primarily with magnitude estimation, where the subject assigns a subjective numeric value to their perception [6-11]. This technique is simple to implement, however due to the subjective nature of the reporting it is difficult to determine if differences in subject responses are due to differences in underlying perception or to differences in the interpretation of the stimulus in relation to the reporting scale [12-14].

The goal of the current study is to determine the effect of visual stimulus duration on the perception of vection and the origin of the substantial between-subject variation in vection perception.

Preliminary results of this study suggested that subjects endorsing migraine symptoms had stronger perception of vection. We then prospectively enrolled subjects with a history of migraine and control subjects screened for no migraine history to explore the hypothesis that a diagnosis of migraine may be an important confounding variable in vection studies.

METHODOLOGIES AND MATERIALS

Subjects:

Three separate cohorts of subjects were recruited. In the first experiment, subjects were post-hoc assessed for migraine history. In the second and third experiments, subjects were separated by migraine status, and reported vection using CE and IN for VFM durations of 1, 4, 8, and 16s. Subjects from experiment three are shown in Table 1.

Design and Methods:

Study measurements were performed with a six-degrees of freedom Hexapod Motion Platform (HMP) connected to a visual display. Visual star-field stimuli consistent with either looming or receding motion were presented for 1 to 16s. Subjects reported the perceived direction of self-motion during the final 1s of the stimulus.

Additional methods included using an inertial nulling (IN) and a certainty estimation (CE) technique to determine the point of subjective equality (PSE) at which forward or backward responses were equally likely. For the CE trials the same range of VFM was used but without inertial motion and subjects rated their certainty of motion on a scale of 0-100.

RESULTS

Point of Subjective Equality Trials

The PSE was determined for 1s, 4s, 8s, and 16s stimuli, and individual data is shown in Figure 1. Migraine subjects required a greater velocity to null their perception of motion in the 8s stimulus (mean difference in PSE = 1.48 cm/s, student t-test, p=0.04), as well as in the 16s stimulus (mean difference in PSE = 1.18 ± 0.51 cm/s, p<0.01). See Figure 2.

Certainty Estimate Trials

Certainty estimates were determined for 1s, 4s, 8s, and 16s stimuli. Diagnosis of migraine was associated with significantly increased perception of self-motion by CE across 1s, 4s and 8s VFM studies (Two-way ANOVA, F(1,101) = 4.251, p = .04), as well as the 16s VFM study (p<0.001).

Point of Subject Equality vs Certainty Estimate Trials

Pearson’s correlation coefficient was obtained for each trial and for all trials collectively. The 8s PSE and CE looming and receding VFM studies had a strong correlation of r=0.48 and r=-0.58, respectively.

DISCUSSION

The current study examined vection induced by the same VFM stimulus using two different measures. We demonstrated a strong correlation between vection measured using the CE and IN at 8s duration.

One important consideration for the observed variation in vection among studies may be the lack of screening for migraine diagnosis. A major finding of this study is that migraine subjects demonstrated larger vection measurements in both the CE and IN trials.

Given that the prevalence of migraine in the population is almost 18% in females, it is likely that other studies of vection perception included some individuals with migraine [15].

The diagnosis of migraine did not uniformly affect results, as some migraine subjects had minimal vection using one or both measurement techniques. It is difficult to determine the cause of this variation. Variations in migraine presentation (aura vs no aura), severity or frequency, and location may find making a homogenous migraine population difficult. Much larger studies would be needed to compare migraine by these subcategories.

CONCLUSIONS

Our data demonstrate a strong correlation between vection measured by CE and IN methods. Point-of-subjective equality through inertial nulling is a novel technique that may enhance the study of vection by minimizing the subjective nature of reporting, and allowing for intra- and inter-subject analysis. Using both tools, we demonstrated that migraine subjects tended to have an enhanced vection that may account for some of the variability in vection perception. Migraine should be appropriately screened for and noted in future studies of vection.

REFERENCES