

## Comparing motion induction in lateral motion and motion in depth

**Julie M. Harris<sup>1\*</sup> and Katie J. German<sup>2</sup>**

1. School of Psychology, University of St. Andrews, St. Mary's College, St. Andrews, KY16 9JP Scotland, UK.

2. School of Biology and Psychology, University of Newcastle upon Tyne, Henry Wellcome Building, Framlington Place, Newcastle, NE1 4HH UK.

Corresponding author, email: [jh81@st-andrews.ac.uk](mailto:jh81@st-andrews.ac.uk)

### Abstract

Induced motion, the apparent motion of an object when a nearby object moves, has been shown to occur in a variety of different conditions, including motion in depth. Here we explore whether similar patterns of induced motion result from induction in a lateral direction (frontoparallel motion) or induction in depth. We measured the magnitude of induced motion in a stationary target for: (a) binocularly viewed lateral motion of a pair of inducers, where the angular motion is in the same direction for the two eyes, and (b) binocularly viewed motion in depth of inducers, where the angular motions in the two eyes are opposite to each other, but the same magnitude as for the lateral motion. We found that induced motion is of similar magnitude for the two viewing conditions. This suggests a common mechanism for motion induction by both lateral motion and motion in depth, and is consistent with the idea that the visual signals responsible for induced motion are established before angular information is scaled to obtain metric motion in depth.

## Introduction

Induced motion (sometimes called the Duncker illusion) is the perceived motion of an object in a direction opposite to the physical motion of a background or other object. A naturalistic example of this phenomenon is when the moon appears to drift in the opposite direction to the clouds on a windy day. Induced motion has been formally studied by vision scientists since Duncker (1929), or even earlier (Porterfield, 1759, cited in Wade & Swanston, 1987). Duncker asked why a stationary spot appears to move in the opposite direction when a surrounding frame is moved. Mack (1986) extensively reviewed the conditions under which it appears (see also Reinhardt-Rutland, 1988). The phenomenon is important because it illustrates that motion perception involves much more than sensing motion from the retina of the eye. Its exploration gets at the heart of the problem of how the visual system assigns a reference frame against which other motion is measured. The key is to decide what is moving relative to what. Our aim in this manuscript is to compare motion induction for lateral motion and motion in depth. We wanted to explore whether the mechanisms involved in delivering the perception of induced motion operate on angular motions, or on visual information that has been scaled to obtain Euclidean distance and motion in three dimensional (3-D) space.

To explain induced motion, considerations have been made of how the brain decides what moves and what is stationary, as well as how retinal and extra-retinal information (information the brain has about how our eyes/head/body are oriented) are combined. The main flavours of explanation have historically been described in terms of subject-relative effects and object-relative effects. Object-relative accounts suggest that induction arises from changes in the perceived relative position (Duncker, 1929; Nakayama and Tyler, 1978; Mack, 1986) or motion (Smeets and Brenner, 1995) of objects within a scene. The assertion is that relative motion (motion of objects in relation to other objects) is correctly perceived but not absolute motion (motion of objects relative to the observer). A key issue of interest is what is perceived as the stationary frame (if any), and what as moving. Duncker (and others) suggested that larger, or surrounding, areas of a scene act as a frame of reference for the smaller or central areas. Thus, a surrounded area would likely be seen as moving, whereas a surrounding area would likely be seen as stationary. Similarly, small or more central areas are proposed to be more likely to be seen as moving than large or surrounding areas (e.g. see Mack, 1986). In other, currently fashionable terminology, we can think of this as an expectation (sometimes called a 'prior') on the part of the visual system that large and/or surrounding parts of a scene will be stationary relative to the body.

While object-relative accounts consider only motion of objects relative to each other, subject-relative accounts consider motions relative to some head- or body-centred frame of reference. Motion at the retina can correspond to external object motion, but also to body/head-motion, or eye-motion. Conversely, a moving object can result in no retinal motion if the eyes move to follow that object. How the visual system combines retinal and extra-retinal information to achieve motion perception is a question that has been puzzled over for a long time. A classic subject-relative illusion is the Roelofs effect: if a large frame is positioned off-centre it is perceived as though shifted in the direction opposite the offset. Recent explanations propose that the apparent body-midline is biased by the frame (e.g. Dassonville et al, 2004). Subject-relative accounts of induced motion similarly propose that background object motion alters the observer's perception of their own head or body midline (where motions are considered with respect to a fixed frame for which there may not be any visual markers, the body itself). Other proposals suggest that inducer motion causes mis-registration of eye movement signals and that subsequent errors in the perception of

motion or location occur as a consequence of errors in these extra-retinal signals (e.g. Bridgeman and Klassen, 1983; Brosgole, 1968; Post and Heckmann, 1986). In other words, the visual system has an expectation that large parts of a scene should be stable, and this leads to a recalibration of extra-retinal signals, and that recalibration can lead to the misperception of motion of other objects in the scene.

All of the above-cited work describes accounts of induced motion in terms of retinal motion (which can be expressed as a change in visual angle over time) and angular extra-retinal information. One group has pointed out that the simple dichotomy proposed above is not adequate to develop a full understanding of induced motion and that consideration must be made of the fact that we have two eyes that move in a head that moves, and so on. Wade and Swanston (1993; see also Wade & Swanston, 1987; Swanston, Wade & Day, 1987) describe a framework in which induced motion (and indeed the perception of motion in general) is to be understood in terms of frames of reference. Five possible frames of reference are identified: patterncentric (considering the relational motions within a display) and retinocentric (motion with respect to the eye) together combine with information from eye movement signals to describe motion with reference to the eye's orbit (orbitocentric). Information from the two orbitocentric frames can be combined to describe motion with respect to an egocentric frame (with respect to the head, in their formulation). Finally, the angular measures of motion described so far must be understood in terms of motion in three dimensions in the outside world. To convert to this geocentric frame, account must be taken of the distance to the scene and the observer's self-motion. As the authors themselves point out, most studies of induced motion have been concerned only with the first two or three frames. Further, the above theory has not been extended to consider the different roles of lateral motion (where each eye receives the same visual signal, and eye movements are yoked) and motion in depth, where the eyes receive potentially very different motion signals, and where disconjugate vergence eye movements also occur.

In this manuscript, we are interested in induced motion in depth and specifically whether induced motion in depth can be described using only patterncentric, retinocentric and orbitocentric frames of reference. The extant literature on induction of motion in depth is hard to interpret because no studies have objectively quantified whether the same magnitude of induction occurs for the same amount of motion laterally or in depth, for the same retinal stimulation. This is important because the same magnitude of motion in the world can correspond to very different retinal motion when objects move laterally or in depth.

When objects move in depth they can deliver different motion signals to each eye. For example, when equal, approximately horizontal, motions of the same magnitude and direction are presented to the two eyes, lateral motion (we will define this as X-motion) is perceived and when the motion direction is reversed in one eye, motion in depth (Z-motion) is perceived. The equations below show that these equal retinal motions can correspond to very different motions in the real world. For small motions near the midline, both X- and Z-components of motion in the world can be defined in terms of motion components at the eyes. Expressions for motion in the world ( $V_x$ ,  $V_z$ ), in terms of motion at the eye ( $v_l$ ,  $v_r$ ) are given by:

$$(1)$$

$$(2)$$

where D is the viewing distance and I the inter-ocular separation (see Sumnall & Harris 2000). For convenience, let positive  $v_l$ ,  $v_r$  represent rightward motion at the

retina, then positive  $V_x$  corresponds to leftwards motion in the world and positive  $V_z$  corresponds to motion towards the observer.

Notice (from equations (1) and (2) above) that the same retinal motions for  $V_x$  and  $V_z$  can correspond to very different inducer motion magnitude when expressed in Euclidean world-based units. If induced 3-D motion required consideration in a geocentric frame of reference, where the visual system dealt with motions as scaled motions in space (rather than in angular units, as at the retina), the magnitude of induced motion might be very different for  $V_x$  and  $V_z$ . For example, if  $D=2\text{m}$  and  $|v_l| = |v_r| = 6.5 \text{ min arc s}^{-1}$ , then for  $v_l = v_r$  we have  $V_x \approx 0.4 \text{ cm s}^{-1}$ , and for  $v_l = -v_r$  we have  $V_z \approx 24 \text{ cm s}^{-1}$ , a much larger magnitude of motion. Such large differences would be expected to result in big differences in the extent of motion induction. On the other hand, a patterncentric or orbitocentric frame would operate on the raw angular information ( $v_l, v_r$ ) and the same extent of motion induction would then be expected.

Farne (1970, 1972) has investigated induced motion-in-depth, but using monocular viewing conditions. His set-up consisted of a pair of lines on a stationary sheet of glass that appeared to move in depth when a background surface oscillated in depth about a vertical axis. Likova and Tyler (2003) studied Cyclopean induced motion in depth, for a stimulus that did not have consistent monocular lateral motion components. Gogel and Griffin (1982) studied induced motion in depth, using 3-point displays where the central target moved up/down (Y-direction) and the outer inducing targets moved either left/right (X-direction) or towards/away (via stereoscopic presentation, Z-direction). Their observers rotated a rod to indicate the direction of motion either in the X-Y plane or the Y-Z plane. Large amounts of induction were found for both conditions. The authors acknowledge that they were not able to directly compare X- and Z-motion induction, because in their stimuli neither the retinal nor real-world motions were equivalent between the two conditions. Wade and Swanston (1993) showed that induced motion in depth can result from induction in just one eye (when the stationary target is visible to both eyes). But they did not study induced motion for inducers moving in depth, nor did they quantify the induced motion in depth that they observed. Recent work from our own lab is exploring how eye movements affect induced motion for stimuli moving in depth with depth defined by both looming and disparity information (Nefs & Harris, 2007a).

The aim of the work we present here is to compare induced motion for binocularly viewed lateral motion and for binocularly viewed motion in depth. We compared (1) standard induced motion in the X-direction, using a pair of moving inducing dots located above and below a central target dot, with (2) induced motion in the Z-direction. We measured the induced motion in depth produced in the physically stationary target dot. This study compares induced motion perception using inducing stimuli with X-motion and Z-motion that have equivalent retinal magnitudes. Induced motion for X-motion and Z-motion were compared for several different experimental conditions: as a function of the speed of inducing motion for fixed amplitude, for fixed frequency (speed and amplitude varied) as a function of frequency for fixed speed, and for a variety of target-inducer separations. We predict that, if induced motion occurs at a level where the representation is unscaled for distance (consistent with the pattern- or retino-centric frame of reference) then the amount of induced motion should be similar for lateral and motion in depth with the same angular motions, but different if those motions are expressed in scaled metric units.

## Methods

Stimuli were generated using a Dell Dimension XPS M200s PC, containing a Genuine Pentium 199 MHz processor, and a NVIDIA Vanta 3D Graphics Accelerator. Stimuli were presented on a Sony GDM-F400T9 18-inch monitor. A six button game pad connected to the computer's game port was used for making experimental responses when required.

To create the perception of three-dimensional (3D) motion while using a two dimensional (2D) CRT monitor, observers wore a pair of StereoGraphics CrystalEyes II LCD shutter goggles. The goggles and associated hardware allow each eye to see separate left and right eye images, presented in alternate video frames. The refresh rate of the monitor was 120 Hz, thus the image in each eye was refreshed at a rate of 60 Hz.

The stimuli consisted of three vertically aligned dots of equal luminance ( $21 \text{ cd/m}^2$ ) presented in the centre of the screen. Each dot was  $4 \times 4$  pixels in size, subtending  $2.58 \text{ arcmin}$  at the viewing distance of 2 m. Vertical dot separation was  $7.5 \text{ cm}$  ( $2.2 \text{ deg}$ ), except for condition 4 (see table 1). The top and bottom dots will be described as the inducing dots, and the central dot as the target dot. The dots were presented on a black background (screen luminance  $0.03 \text{ cd/m}^2$ ) in an otherwise dark room. The target dot was positioned half way between them and observers were asked to fixate on the target. The only visible elements of the display were the dots. The screen and its edges were not visible. The heads of the observers were rested on a chin-rest to reduce head movements.

Equivalent stimulus motions, in terms of retinal magnitude, were used to generate X- and Z-motion. To obtain X-motion, we set  $v_l = v_r = v$ ; to obtain Z-motion, we set  $v_l = v$  and  $v_r = -v$ . It is these retinal motions that are referred to when specifying the triangle wave form of motion (constant retinal speed) and the oscillation frequencies. Clearly, the real world motions corresponding to these retinal motions do not follow the same pattern. For example, constant speed at the retina does not scale into constant speed of motion in the world. For condition 1, both X- and Z-motion, inducing motion amplitude was held constant at  $6.5 \text{ arcmin}$  on each retina, corresponding to approximately  $0.38 \text{ cm}$  of X-motion in the world, and to Z-motion in the world of  $23.7 \text{ cm}$  in front of the fixation plane and  $26.9 \text{ cm}$  behind. The inducing dots oscillated with triangle wave motion (constant speed) at frequencies of 0.3, 0.6, 0.7, 1.5 or 2.9 Hz (speeds of 3.9, 7.7, 9.7, 19.3 or  $38.7 \text{ arcmin/s}$ ), and amplitude  $6.5 \text{ arcmin}$ . The target dot also began by oscillating with one of four possible motions, with amplitude 0, 1.3, 2.6 or  $3.9 \text{ arcmin}$ , drawn randomly on each trial, either in phase or  $180 \text{ degrees}$  out of phase with the inducer motion (thus target and inducers oscillated at the same frequency). Total presentation time was dictated by the observer, who was asked to null the induced motion by altering the target motion amplitude until the target appeared to be stationary.

Table 1 shows how different stimulus parameters were used for condition 1: fixed inducer amplitude, condition 2: fixed frequency, condition 3: fixed speed, condition 4: variable vertical separation. Conditions were run using the same eight observers, but in separate, non-interleaved sessions.

### **Measurement of induced motion**

Using buttons on a game-pad, observers either increased or decreased the amplitude of target motion until the target appeared stationary, thus cancelling out the induced motion. There was no time limit for performing the task. Once satisfied that the target dot was stationary, observers pressed another button to accept the trial. A grey screen then appeared to prevent dark adaptation ( $3.6 \text{ cd/m}^2$ ). Observers then pressed another button to start the next trial, in their own time. The amount of

real motion required to cancel the perceived induced motion was recorded on every trial.

A total of 160 trials were run for each observer for each set of X- and Z- conditions presented. Trials were blocked across motion conditions (X- or Z-motion), randomised across speed, (figures 1-3), frequency (figure 4) or vertical separation (figure 5) and run over 4 sessions per condition. Each session consisted of 5 blocks of 8 trials. Each observer performed a set of 6 practice trials prior to commencing the experimental trials.

Observers were instructed to null the motion: that is, they were given the same instruction for X- and Z-motion conditions. We were confident that observers actually saw motion in depth in the Z-motion condition and lateral motion in the X-motion condition. No observers complained that they did not perceive it, nor did they report inability to fuse the stimuli. Our confidence is backed up by data from a different experiment, where observers were asked to point to the start and end locations of the motion for the same stimulus conditions as used here (presented in preliminary form in Harris and German, 2006). The difference between start and end points always contained both X- and Z-components, but these were predominantly X-direction for X-motion, and Z-direction for Z-motion (except for one observer, who showed rather small Z-components for Z-motion).

The amplitude of real motion (expressed as distance moved during one half cycle of the oscillation) required to null the apparent motion of the target was taken as a measure of the induced motion perceived (see Levi and Schor, 1984; and Day, 1981; for earlier use of a nulling method to measure induction). This was then expressed as a percentage of the total distance the inducers moved during half an oscillation, to give an estimate of the proportion of motion induction. The average setting for each observer was always in phase with the inducing motion.

### **Observers**

Eight observers participated in the experiments, five had taken part in psychophysical experiments before, three were totally naïve. All had normal, or corrected to normal, vision and their stereovision was verified using the Randot stereo test. Observers gave informed consent and their participation was with the consent of the Newcastle University Psychology Ethics Committee.

### **Results**

Figure 1 presents the percentage of induced motion perceived as a function of the speed of the inducing dots, for each observer. Speed is expressed in terms of arcmin/s at each retina, to enable us to easily compare X- and Z-motion. Only one observer showed a systematic difference between conditions (ELV) although her performance was more variable than the other observers.

Overall, there was no systematic difference between observer behaviour between X-motion and Z-motion. Although individuals showed idiosyncratic differences, there was no significant difference found between conditions (ANOVA,  $F_{1,7}=1.96$ ,  $p=0.21$ ). This is demonstrated in figure 2a, where we plot average data across all observers. Notice that the close overlap of data occurs when the speed is expressed in terms of motion at each retina. If the same data are re-plotted (Figure 2b) as a function of inducer speed in the world (see equations 1 and 2): there is much less overlap when

comparing X-motion and Z-motion. Similar motion in the world, results in larger motion induction for Z-motion, than for X-motion.

We went on to consider a wider range of conditions. In condition 2, we held the frequency of oscillation constant at either 0.5 Hz or 0.67 Hz, whilst using the same range of speeds as before (now, amplitude varied along with speed, see table 1). Figure 3 shows average data, across the same 8 observers. Induction still falls as a function of speed (or amplitude), but again there is very little difference between the induced motion for X- and Z-motion. No significant differences were found between X- and Z for either the 0.5Hz condition ( $F_{1,7} = 0.28$ ,  $p=0.62$ ), or the 0.67Hz condition ( $F_{1,7} = 1.09$ ,  $p=0.33$ ).

Figure 4 shows data for condition 3, where the speed of motion was fixed at 7.7 or 9.7 arcmin/sec and frequency varied between 0.2Hz and 1Hz. For 7.7 arcmin/s there was no significant effect of X- or Z-condition ( $F_{1,7}=0.79$ ,  $p=0.4$ ), nor frequency ( $F_{4,28}=2$ ,  $p=0.12$ ). For 9.7 arcmin/s, X- and Z- were not significantly different, although frequency was ( $F_{4,28}=8.72$ ,  $p=0.01$ ). There is a hint of a separation in performance between X- and Z-motion at the smallest frequencies, but the interaction was not significant.

Finally, in condition 4, we explored how the magnitude of induced motion changed as the separation between inducers increased. The vertical separation between inducers was varied between X and Y deg and induced motion measured for speed X, frequency X and so on. Figure 5 shows average performance for induced motion as a function of the inducers vertical separation. Although there is a trend towards induction falling off more quickly for Z-motion than for X-motion as vertical separation was increased, this trend was not significant ( $F_{1,7}=2.48$ ,  $p=0.16$ ).

All in all, there is very little suggestion that induced motion is very different between X- and Z-motion for a whole range of conditions where retinal motions were the same magnitude.

## **Discussion**

Although induced motion in depth has been demonstrated in several previous studies (e.g. Farne, 1970, 1972; Gogel & Griffin, 1982; Likova & Tyler, 2003), previous experiments have not compared the perception of induced motion for lateral motion and motion in depth for the same range of retinal motions. Those were the conditions we tested here. For all the conditions we studied, induced X- and Z-motion were not significantly different from one another, when the same ranges of motion amplitude, speed and frequency were used, in other words when the same angular sizes and motion of raw retinal signals were applied.

### Frames of reference

These results have clear implications for considering the simplest frame of reference that can be used to account for the data. As already described, when the same magnitude of left and right eye motions are used to deliver X-direction motion (when the motions applied to each eye are in the same direction) or Z-motion (when the left and right eye components have opposite direction), these correspond to very different X- and Z-motions in the world, when expressed in Euclidean units (metres and metres per second). If the data are plotted as a function of inducer motion in such units, the amount of motion induced in the static target no longer overlaps for the two conditions (see figure 2). The results therefore suggest that induced motion occurs early, before motions are differentially scaled by distance to represent real-world motions. This is consistent with what we know about the processing of real motion in depth. For the same angular motion magnitudes on the two retinae,

physically altering the viewing distance (and hence the real-world motion magnitude) has little effect on the detection of 3-D motion (Harris & Sumnall, 2000). This suggests that the limiting factors in detecting 3-D motion operate at a level before that of a scaled 3-D representation. Here we have thus extended this finding to the phenomenon of induced motion.

None of our experimental manipulations resulted in 100% induced motion amplitude. This pattern of data can be considered in terms of the reference frames used for interpreting the motion. If induced motion in our study had occurred due to use of a solely pattern-centric frame of reference, then, by definition, the inducing dots would have provided that frame of reference and one would expect 100% motion induction in the stationary target. The less than 100% induction found (typical of many induced motion studies) suggest that more than a single frame of reference must be considered. For example in the retino-centric frame the retina itself is defined as the fixed reference frame. The stationary target does not move in that frame of reference. A combination of motion processing with respect to these two frames can account for the data.

#### *Possible use of eye movement information*

Information from these two frames (retinal and pattern) will feed to the next frame in the hierarchy: the orbito-centric frame, where visual information must be combined with extra-retinal information about how the eyes move. The models set out by Swanston and colleagues (Swanston, Wade & Day, 1987; Wade and Swanston, 1987, 1993) do not lay out clearly how, or exactly at what stage, angular information should be converted to Euclidean units. They consider the problem of how to combine left and right eye information for lateral motion, and conjugate version eye movements. They do not explicitly consider how information may need to be differently combined for motion in depth, which requires a differencing of right and left eye information, and a consideration of vergence eye movements (disconjugate eye movements).

It is therefore very difficult to fit our results into that hierarchy. Further, we did not measure eye movements here and do not know whether observers successfully fixated the central stationary target dot.

Though there is a large literature on how pursuit eye movements affect perceived lateral motion and position (e.g. Schlag & Schlag-Rey, 2002, Freeman & Banks, 1998) very little work has considered how vergence interacts with motion in depth. Regan et al (1986) and Erkelens & Collewijn (1985a, b) showed that motion in depth is hard to detect when specified by a change in absolute disparity that did drive vergence. One study (Nefs and Harris, 2007b) has measured interactions between vergence and motion in depth, showing that targets followed with the eyes are perceived as moving slightly slower than when the eyes fixate a stationary reference. In related work (Nefs and Harris, 2007a), we have shown that eye movements can have a big impact on the magnitude of induced motion in depth, with much larger induced motion occurring when the eyes move. Further studies are needed, and a clearer theoretical framework, before we can predict what differences between X- and Z-motion might be expected due to eye movements.

#### *Relation to dichoptic induced motion*

An issue that has been considered in the literature is whether the motion signals responsible for the perception of induced motion are derived before or after binocular combination. A standard methodology applied to test this issue is to compare monocular and dichoptic stimulation, using the logic that if binocular combination occurs before the signals are derived then one should find the same effects under



both monocular or dichoptic conditions. When this has been measured, dichoptic stimulation has delivered weak induced motion (Levi & Schor, 1984; Over & Lovegrove, 1973). Swanston et al (1993) found that induced motion was perceived as frequently when inducers were monocular or dichoptic. Though this suggests that the signals for induced motion could occur after binocular combination, the authors argued that their results were also consistent with probability summation in separate monocular mechanisms. They further demonstrated that induced motion in depth can be observed in a physically stationary binocular target when inducing motion is present in only one eye. This is what would be expected if motion induction before binocular combination. Induced motion would occur in one eye and be binocularly combined with zero motion in the other eye, resulting in a 3D trajectory towards or away from the eye whose image contained neither real nor induced motion. If binocular combination occurred first, the same percept of laterally induced motion should occur for dichoptic or binocular inducers. Our data here do not directly address this issue. What they do suggest is that if binocular combination were to occur after motion induction has been achieved, the combination is not a simple averaging of monocular signals. If it were then there would be no induced motion for the Z-motion condition where the average of the inducer motion is zero.

In sum, we have found no evidence that induced motion in depth relies on the scaled three dimensional motion signal that would be required for induction due to an ego-centric frame of reference. Instead, the data can be explained using a combination of relational signals within the visual scene and motion with respect to the retina.

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**Table 1**

Condition	Vertical Separation (deg)	Amplitude (min, per retina)	Frequency (Hz)	Speed (min/sec, per retina)
1	2.2	6.5	0.15 – 1.49	3.9 – 38.7
2	2.2	7.8-77.4 or 5.8-57.8	0.5 or 0.67	3.9 – 38.7
3	2.2	3.9 – 19.3	2 – 0.4	7.7 or 9.7
4	0.5 – 7.5	6.5	1.49	9.7

**Figure legends**

**Figure 1**

Percent motion induction as a function of inducer speed (arcmin / sec) for 8 individual observers. Black diamonds show data for the X-motion condition and open squares data for the Z-motion condition. Error bars show standard error of the mean.

**Figure 2**

Percent motion induction as a function of inducer speed expressed in arcmin / sec (a) and m / sec (b), averaged across all 8 observers. Error bars show standard error of the mean.

**Figure 3**

Percent motion induction as a function of inducer speed (arcmin / sec), averaged across 8 observers for stimuli moving at 0.5Hz (a) or 0.67 Hz (b). Error bars show standard error of the mean.

**Figure 4**

Percent motion induction as a function of inducer frequency, averaged across 8 observers. Speed was fixed at either 7.7 arcmin/sec (a) or 9.7 arcmin/sec (b). Error bars show standard error of the mean.

**Figure 5**

Percent motion induction as a function of inducer vertical separation, averaged across 8 observers. Error bars show standard error of the mean.

Figure 1

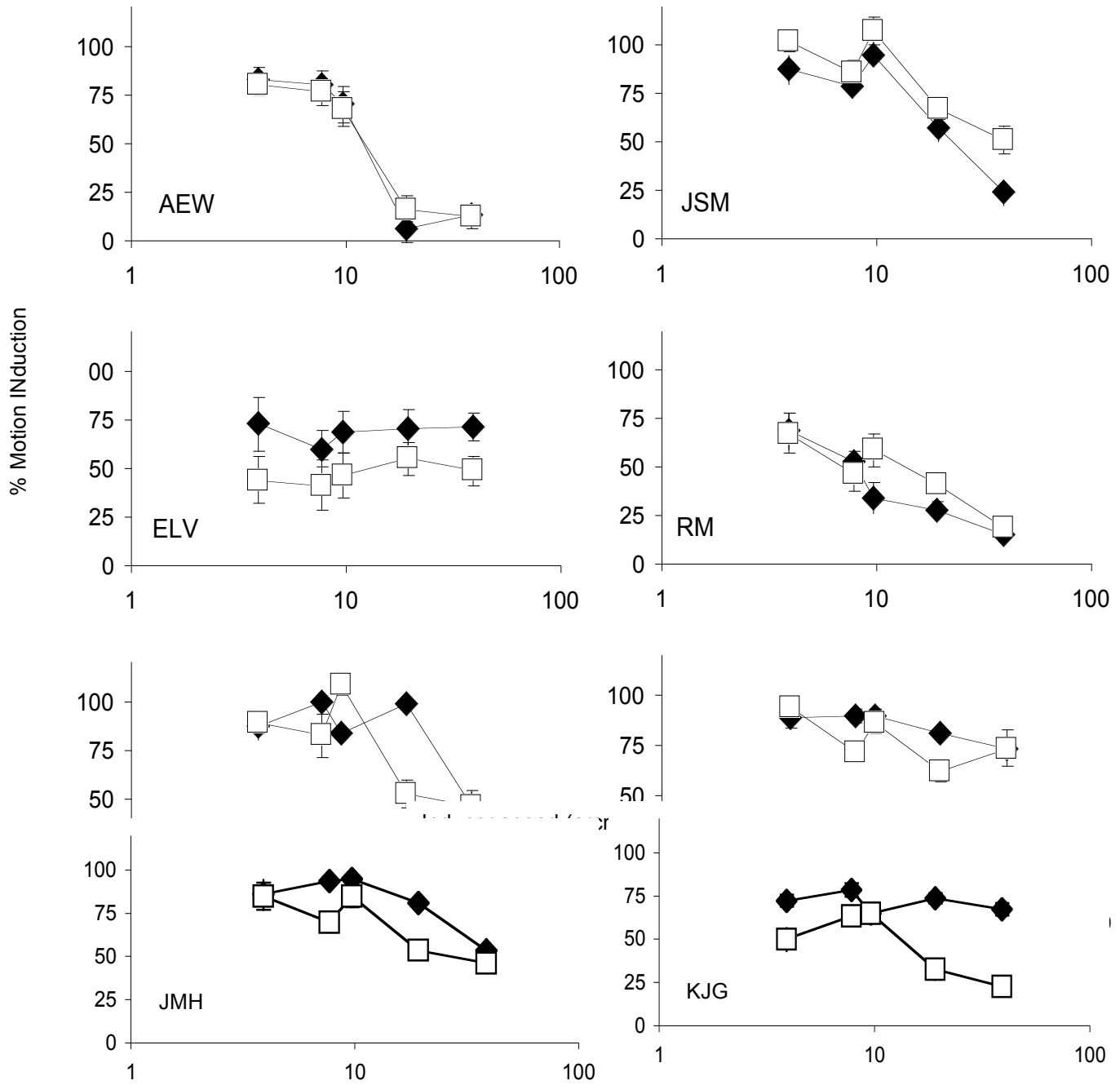
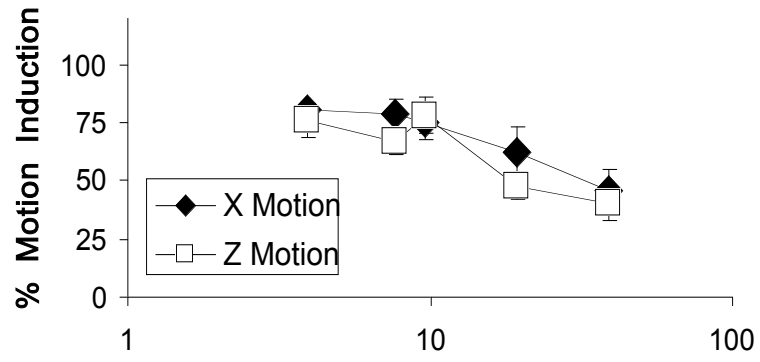


Figure 2

(a)



(b)

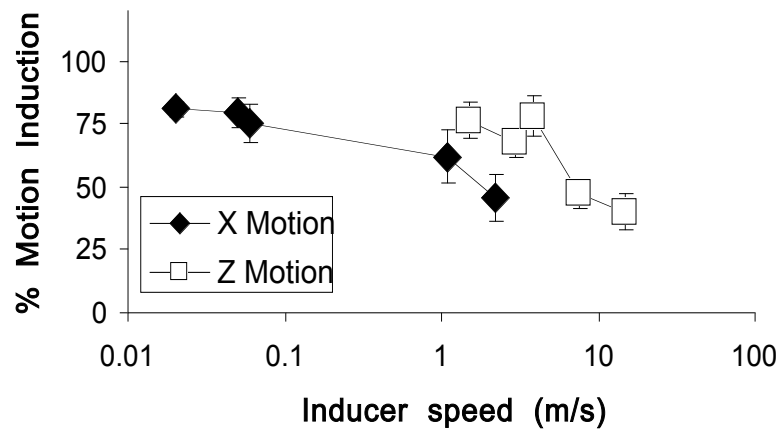
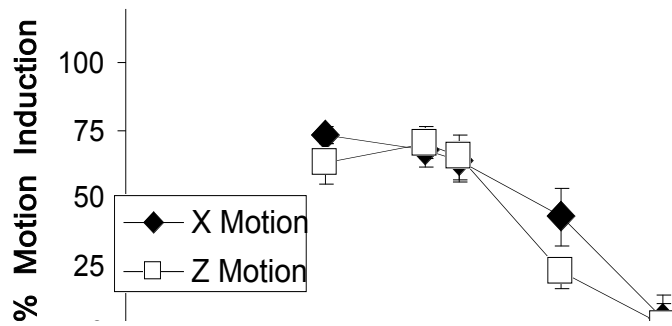


Figure 3

(a)



(b)

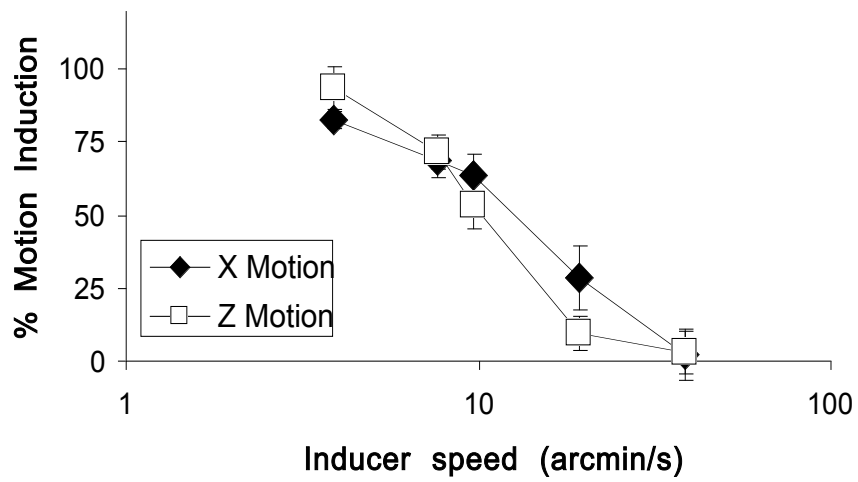
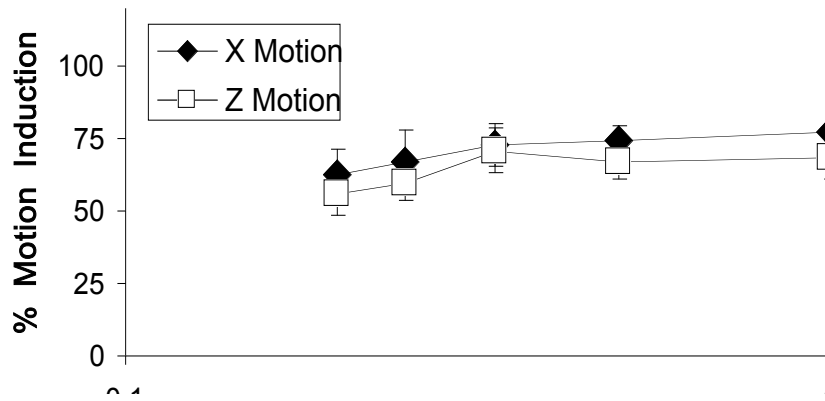


Figure 4

(a)



(b)

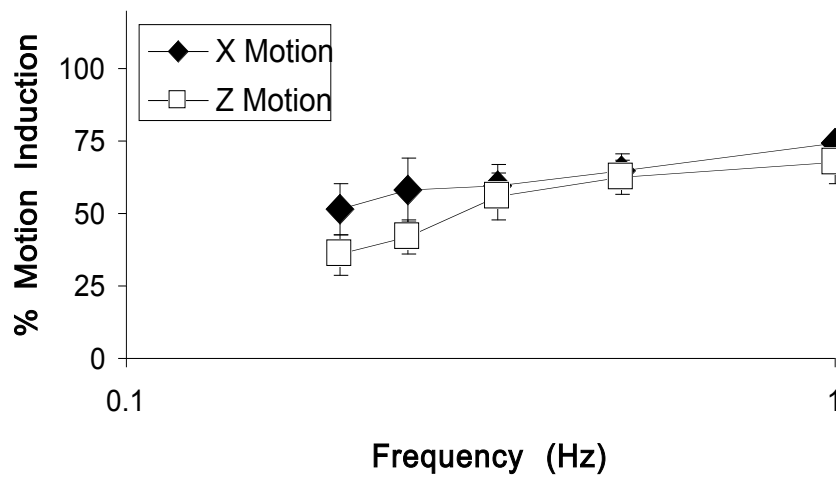




Figure 5

