# Chapter 7

# **Motion**

#### **Chapter Outline:**

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#### Motion

You attempt to cross a street. A baseball player moves easily to catch a fly ball. A car driver slams on the brakes to avoid hitting the car to the front. All of these behaviors require the perception of motion. While covering the topic of motion, the nature of what is being discussed changes. Motion is not a simple experience. Not only do the cars we are watching and the ball we want to catch move, but we move. We walk and we ride in cars that move us around the world. We move our heads and eyes. [DEVELOP THIS INTRODUCTION WHAT CAN I ANTICIPATE]

#### What is Motion

Simply defined motion is a change in position over time. If I were brave and wanted to put this statement into an equation: Motion = (change in position)/time. If you look carefully you can see how the sentence and the equation say literally the same thing. From physics you have heard that all motion is relative. Does the sun revolve around the Earth or the Earth revolve around the sun? In some respects, physics says, both or either are true. It depends. Of course, it is simplest to think of the Earth revolving around the sun so that is the usual perspective, but it is a perspective. That point is very important in understanding motion. To be able to measure, judge or even perceive motion, the motion of the object must be compared to a context. This context is called a **frame of reference** [to glossary]. This context can be the background which is perceived to be still. If we think the Earth is spinning around the sun, then the sun is the frame of reference for the Earth. Let us try another example: a car moving down a road. In this case the Earth forms the frame of reference for the perception of the motion of the car. The Earth is moving rapidly through space: rotating, traveling around the sun, and traveling around the galaxy with the sun. But to perceive the motion of the car, the earth is taken to be still and it forms the frame of reference. To judge the speed of a car, we measure the motion relative to the earth and have no need to pay attention to the motions of the Earth relative to the sun, for example. Since the perceptual systems of animals exist in the physical world, the problem of a frame of reference remains a factor of motion that has to be solved by our visual system. Moreover, how the frame of reference is determined is adaptive and the solution can change depending upon the context.

Open Interactive Illustration 7.x, Frame of Reference [link to media], which will illustrate how frames of reference are important in motion perception. When you open the interactivity, you will see a wheel with spokes in about the middle of the screen. On the wheel is a red dot. To best do this activity, you will need to have a piece of paper you can write on. Get one out before you go on. Press the **Start** button at the bottom of the screen to start the wheel rolling to the right. When the wheel gets to the end of the screen, it will return on the left side of the screen. Notice motion of the red dot. Draw on your paper how the motion of the red dot appears to you. When you have what you think is an accurate representation of the red dot, you can click on the **Show Wheel** checkbox at the bottom of the screen to remove the wheel but leave the dot moving as it had before. Does the red dot appear to move as it appeared to you before or even as you drew its motion? Most people find that the motion of the red dot without the wheel appears much differently that the red dot appears to move with the wheel. The size and speed of the wheel can be adjusted using the sliders at the bottom of the screen.

In a way, this illustration is not an illusion. Since there is not any such thing as absolute motion, the motion of the red dot can be perceived in different ways and each of the perceptions is valid. If the computer screen is taken as the frame of reference, the motion of the dot is always the motion seen when the wheel is absent, that strongly elliptical-like path called a cycloid (Duncker, 1929, Vision Research Graphics, 1990). However, when the wheel is present, the center of the wheel can be taken as a frame of reference and the motion of the dot relative to the wheel is far more circular than the motion of the dot relative to the screen on your computer. So in some sense, both perceptions are correct and what is being revealed is the flexible way that our visual system operates to determine the frame of reference to judge motion.

So, just as in the physical world motion needs to be measured relative to a frame of reference, our perceptual system also needs to be measured relative to a frame of reference (Mack, Heuer, Fendrich, Vilardi, Chamers, 1985; Wallach, Becklen, Nitzberg, 1985). Moreover, our sensory system will develop more than one frame of reference. In this one example, the visual system used two different frames of reference. Given this complexity, our perception of motion requires a sophistication in processing that is not possible in the retina and, in addition, requires information from beyond the retina and even beyond the

visual system. A few examples will suffice to illustrate this point. First, consider a person staring at an object: say a fixation mark, straight ahead. If another object, say a ball, is moved, the image of that ball will move across the retina. In this circumstance, the ball will be perceived as moving. Now have the person track that ball. While keeping the head still, have the person use smooth pursuit eye movements to follow the ball. Now the image of the ball is still on the retina but the ball is still perceived as moving. In both examples, the ball is perceived to be moving but the retinal image for the two perceptions is very different. Somehow the brain, to perceive the ball moving in both situations, has to know what the eye is doing. Try a second example, in this case it will be an experiment where you will participate. First, look back and forth across the room you are in. Does anything appear to move? Now, gently take your forefinger and place is on the evelid of one of your eves and close the other eve. Press, again gently, your open eye back and forth through the eyelid. In this case did anything or perhaps everything appear to move? In the first condition, the world appeared still, and in the second, the world appeared to move. Yet, in both situations, the retinal image of the world moves back and forth across your retina and it fact it moves moves across the retina when you looked around the room than when you gently pressed your eye. This simple experiment demonstrates that your visual system uses information about your eye movement (at least eve movement executed in a more normal fashion) to determine if the movement of the retinal image of the world on your retina should mean that the world is moving or stable. [DO I WANT TO INTRODUCE THE TERM CORROLARY DISCHARGE?] This information arises from outside the visual system and in the motor system. The visual system will need to keep up with more than the eye movements, but also the movement of the head and body.

As can be seen, the visual system has a complex job determining if something is moving. – where am I going here?

#### **Basic Studies of Motion Perception**

#### Motion Thresholds

#### **Motion Perception Across the Retina**

Recall, from Chapter 4, that our visual acuity falls off very rapidly in the periphery. Motion thresholds also increase out into the periphery but much less than acuity does. If the fovea can be considered to be equally sensitive to motion and acuity, then the periphery is much more sensitive to motion than acuity. You can demonstrate this by opening **Experiment 7.x, Motion Sensitivity and Retinal Location [link to media]**. This experiment is very similar to the experiments from Chapter 4, where you could measure acuity and vernier acuity across the periphery. The difference is that in this experiment, you will run the acuity experiment twice. The first time doing this experiment, you will determine your motion threshold at three positions across your retina. The second time doing this experiment, you determine your visual acuity using the checkerboard stimulus in the same three locations. When you first open the experiment, you will see the stimulus setup page. Here you can pick the two stimuli, you will use in the two drop down menus near the top of the screen. They are the **First** 

**Stimulus Type** and **Second Stimulus Type** menus. Below those menus you can select the number of positions in the periphery to set, using the **Number of Positions** menu. The default is three positions across the screen. Finally, you can select the largest stimuli to be tested separately for each stimulus by setting the two **Upper Limit** values. For now, leave the experiment in the default settings and press the **Done** button at the bottom of the screen. You will now be able to change the settings of the method of limits. The default method of limits here is the staircase method, as was the case with the other acuity experiments. Again, leave the method with the default settings and press the **Done** button at the bottom of the screen.

On the next screen, you will see a fixation mark at the left side of the screen. Again position yourself x times the width of the screen from the front of the screen. In this first condition, you will measure your motion threshold. The stimulus is a grating, and your task is to determine if you can see it move. If you can, press the **Yes** button at the bottom of the screen, or the z key. If you cannot see the grating move, press the **No** button at the bottom of the screen, or the *I* key. As this is a staircase method, if you can see it, the motion will get slower on the next trial. If you report you cannot see the motion of the grating, it will get faster. After you have completed the staircase for the grating in the first location, the

grating will move to the next location and the procedure will start over. When you have completed the task for all three locations of the moving stimulus, the calibration screen for the background of the checkerboard will be presented. Follow the same procedure as the calibration for the acuity experiments. Your goal to is make the grating disappear. Look to the middle of the screen while you are doing this calibration. You can adjust the background brightness using the **Background Brightness** slider at the bottom of the screen. When you have a match in the brightness of the background and the grating, press the **Done** button. The acuity test for the checkerboard will be run. This test runs basically the same way as the test for the motion threshold but you are now reporting whether you can make out the checks of the checkerboard. When you have completed these three runs, your data will be presented.

The data from the motion threshold test and the acuity test have different dependent measures. The motion threshold is in terms of the speed of the grating and the acuity value is in terms of the size of the checkerboard. Still, we want to compare the results of the two experiments and the differences in the dependent variables confuse the issue. Actually, it turns out that the absolute values of the two data sets are not important to us. We do not need the absolute changes in the thresholds, but the relative changes. We are more interested in questions of this sort: If the acuity in the second location is twice as large in the first location, is the motion threshold also twice as large in the second location than the first? What we want to know is the relative change in the threshold values across location, not the absolute change. Towards this end, the two sets of data are scaled so that thresholds for the motion threshold has a value of one, so that all of the data are relative to that maximum. The red line is for the motion thresholds, and the green line is for the checkerboard acuities. Typically, the slope of the checkerboard acuities is steeper than that for the motion sensitivities, which by comparison is much flatter. Acuity falls off far faster into the periphery than does our motion threshold.

This observation gives some insight into the function of the periphery of the visual system. Most of the functions of the visual system discussed so far have been true mostly about the region of the visual field near and around the fovea. So color and much of the discussion of form relate to our fovea and near it. Yet motion is a function that does very well in the periphery. It is tempting to think of our peripheral vision as merely poor vision, or a poor version of how vision operates in the fovea. However, that would be a mistake. Vision in the periphery is not so much poorer as different. The relative importance of acuity and motion in the fovea and the periphery gives some insight into this different. A moving stimulus in the periphery seems to grab the attention, and may even direct our fovea over to this stimulus. While we do not function well with this type of vision, a visual system that relies primarily on motion can be very effective. Cats have very poor acuity, which as tested, uses still stimuli. Yet, feline grace and agility, which is visually guided, is to be envied, not excused.

#### Motion Phenomena (These are in no order at the moment)

#### Apparent Motion

Motion in the world is created by the continual change in position of an object relative to some frame of reference. However, we are fortunate that in our visual system, it is possible to create a very real experience of motion using a sequence of still images. This phenomenon is known as **Apparent Motion [to glossary]**. If apparent motion were not possible, neither would be film, television, or most methods of creating motion. Every moving example that has been used or will be used in this text will be created with apparent motion.

At this point, it is good to remember that apparent motion is different from Critical Fusion Frequency (CFF). Recall that the CFF is the rate at which a light goes on and off so that it is perceived to be continuously on. Open **Interactive Illustration 7.x**, **Flicker Motion [link to media]** which is a repeat of a figure from Chapter 4. If you adjust the **Speed** slider at the top of the screen, you can make the wheel clearly move while clearly flickering. In other words, the stimulus is flickering below the CFF but above the rate necessary to achieve apparent motion. It is possible to adjust the quality of the perception of motion by using the **Flicker Rate** slider at the bottom of the screen. This slider controls how long the wheel is on and off. The wheel is on as long as it is off, so the two times are the same. If you slow down the flickering, you will eventually find a speed where even when you see the wheel's spokes in a new location, there does not appear to be any motion. It is sometimes easier to see this speed by turning on the red dot, using the **Show Dot** button at the top of the screen.

In this demonstration, the stimulus will always obviously flicker no matter what settings you use. It is quite probable that the flicker of this wheel is rather irritating, especially if viewed for a long time. You would not want to sit through a 30 minute sitcom or a 2 hour movie, let alone all three *Lord of the Rings* films with this type of flicker. So, in movies and television, it is necessary to achieve both apparent motion and flash the images at a rate higher than the CFF. Yet, the more images that need to be shot in a second, the more expensive the process will become. In film, the camera only captures an image 24 times a second. If the film was presented only 24 times a second, the screen would flicker quite intolerably. To avoid flicker, each frame of the film is flashed on the screen two or three times. This method balances the need to both generate apparent motion and to exceed the CFF. Standard television takes a similar approach, but it is more complicated.

Open Interactive Illustration 7.x: Apparent Motion [link to media]. This figure is an expanded version of a figure used in Chapter 1. When the figure is first opened, a circle is seen flickering on and off in two positions on the screen. At the bottom of the screen are several parameters that can be adjusted to change the nature of this flickering. These parameters include: the **ISI** or time when the dot is off before the dot is drawn again in its new position, **Dot Duration** or time that the dot is one,

**Separation** or how far apart the two flashes are, **Dot Size**, and **Contrast** or how much brighter the dot is than the background. With these variables, there are a number of apparent motion phenomena that can be explored.

To start with, the effect of time between the two flashes or **ISI** which is short for interstimulus interval **[to glossary]** will be explored. Start by putting the **ISI** slider to its maximum value (1000 msec or one second). There is, approximately, 1 second of blank screen between the drawing of dots. In this case, the dots appear unconnected. They are said to appear successively but without any appearance of motion. Sliding the ISI slider to its fastest setting, however, will give a very good appearance of apparent motion. The dot appears to move back and forth between the two locations. This is known as **Beta or Optimal Motion [to glossary]**. This is the type that is thought of when apparent motion is discussed. It is beta motion that movies and television aim to reproduce. If you look carefully, the dot appears to cover the space between the two locations where it is flashed. In other words, the motion looks real and is indistinguishable from real motion.

As you gradually increase the **ISI** value on the **ISI** slider, you will see that the quality of motion changes. Before the perception of motion is lost, there comes an ISI value where motion is still perceived, but the dot clearly flickers on and off and does not appear to move. In other words, motion is seen from one dot location to the next, but the dot does not appear to move between the two dot locations. Unlike beta motion, the dot does not appear to move across the space between, but there is still the clear perception of motion between the two dots. This is the **Phi Motion [to glossary]**, that was mentioned in Chapter 1 as being so important for the development of Gestalt Psychology [LOOK UP REFERENCE TO MAGNI PHI AND GET THEIR REFERENCES]. LINK TO HYPER PHI?

The rate at which a new image needs to be presented to generate good apparent motion depends upon many factors. You can manipulate a few of them with the sliders at the bottom of the screen. To illustrate how apparent motion depends upon these factors, set the **ISI** slider to 50 msec. At this setting of the **ISI** you will get a good perception of beta motion. From this setting, you can manipulate the other variables to see how they alter this perception of beta motion. Get a good sense of what this motion looks like. First, use the **Separation** slider and move the dots apart. As the dots move farther apart, first the motion becomes phi-like and then, eventually, the perception of motion breaks down altogether. You can use the **Reset** button at the top of the screen to reset all of the values to their default setting. The duration of the dot, or more properly the entire duration, from the beginning of one dot to the beginning of the next dot can also alter our perception. This time from the beginning of one dot to the beginning of the next is made up of the **Dot Duration** and the **ISI**. Reduce both the **Dot Duration** and the **ISI** to their minimal values without altering the distance between the two dots. In this situation, you will have the dot being drawn in one place and then immediately on the next refresh of the screen in the next place. Exactly how long the dot will be on depends on your monitor and computer. Understand that the two dots are never on at the same time. Many people report that the two dots appear to be one at the same time or nearly at the same time. From this example we can conclude that if you are fast enough you can appear to be in two places at the same time. Despite all the ways variables can affect the perception of apparent motion, some

generalities can be made. Basically, beta motion will be better with shorter distances and shorter periods of time. However, if the time between stimuli is too short, the perception might be of simultaneity, not motion. Play around with the other variables and see how they affect the perception of motion. Try adding a barrier between the two dots. What does that barrier do the perception of motion? Is the effect of the barrier the same for both beta and phi motion?

[THINK ABOUT A DISCUSSION OF CONTRAST AND MAKE IT DIFFERENT FROM FROM]

#### **Induced Motion**

This chapter started with a discussion of the idea that all motion is relative and one result of that point is that motion perception is also relative. Our motion perception system needs to define a frame of reference, and sometimes the motion perception system can select a frame of reference that does not accurately reflect the motions that are most useful to us. For example, in some circumstances the motion of one object, relative to us or the Earth, is perceived as the motion of the another object. Open **Interactive Illustration 7.x, Induced Motion** to see an example of this situation. The interactivity defaults to the most commonly research stimulus arrangement when it first comes up. There is a central dot and a square frame around the dot. [THIS DISCUSSION IS FOR THE CURRENT CONTROLS. I AM NOT SURE I WANT TO KEEP TO THESE.] The most important control is the checkbox at the bottom right of the screen labeled **Move**. This control moves the frame around the dot. On this screen, only the frame will move. Click the **Move** checkbox and watch the center dot. Most people report seeing the dot move to a small extent in the opposite direction to the frame. You can adjust the **Step Size**, the **Square Size**, and the **Dot Size** using the controls across the bottom. Manipulate these variables and see how they alter your perception of the size of the motion of the dot.

This phenomenon is simply the laboratory version of an experience that you might have noticed. If, during a moonlight night, the clouds are thin, cover much of the sky, and move quickly, it often appears that the moon is moving. To see a version of this demonstration that is more similar to that situation, click on the drop down menu that now has the word **Frame** in it in the lower right hand corner of the screen. Select the **Grating** option and then click the **Move** checkbox. This action will cause the grating to move. As the grating moves many people report that the dot appears to move in the opposite direction. The controls at the bottom of the screen have changed to reflect the change in the stimulus setup from a frame to a grating. **Step Size** has changed to **Grating Speed** and **Square Size** has changed to **Grating Speed** speed specifies the specifies t

#### Grating Bar Size.

Generally, the perceived movement of the dot is greater when the frame is larger and more in the periphery. In addition, reducing the size of the dot will also increase the perceived motion of the dot (Ref). These findings suggest that the periphery is important for induced motion. As was discussed above, the importance of motion to the way our visual system works in the periphery may play a role here. It is also supposed by some researchers that there is a general conservation of motion in this illustration. By conservation of motion, the authors are arguing that the perceived relative motion between the dot and the frame stays the same. What is changed is the perceived absolute motions of the dot and the frame. The perceived motion of the dot takes away from the perceived motion of the frame or grating. So the perceived motion of the frame is lessened by the exact degree of the perceived motion of the dot.

#### Motion Recruitment

Open Interactive Illustration 7.x, Motion Recruitment [link to media]. You will see a background sine wave grating with a random collection of black dots on it. Click the **Move** checkbox on the bottom of the screen, and the grating will move back and forth horizontally. Each time the grating moves, a new random collection of dots will be drawn on the screen. Let us consider the situation of any one dot from one movement of the grating to the next. From the flickering motion demonstration, the idea was put forth that the perceived motion in apparent motion depends upon matching up a stimulus with the closest identical stimulus in the next frame. This phenomenon allowed for the perception of the wheel to move backwards. Now, since the placements of the dots are random in each frame, the closest dot on the next frame will be randomly located. It might be up, down, left, right or any angle. Across, the screen different dots in the first frame will pair up with dots in different directions because of the random placement of the dots. As a result, the perception of motion from one set of dots to the next should also be

random; some up, some down, some at any number of angles. Yet most people report seeing most of the dots move horizontally and in the same direction as the grating (REF). This phenomenon is called **motion recruitment** [to glossary], because the motion of the grating influences or recruits the perceived motion of the dots. To see that it is the motion of the grating that leads to this perception and not some bias, click the **Update Dots Only** checkbox, next to the **Move** checkbox. Now, motion in many different directions will be perceived.[ADD some explanation]

#### **Biological Motion**

#### Self-Motion and Vection

Many people report the following type of situation. They are stopped at a light, and suddenly they feel that their car is moving and they might even step on the breaks harder. When they look around, they realize that it was the next car or cars that was moving, often slowly. One of the objects that we need to be able to perceive to be moving is ourselves. Vision is just one of the senses involved in determining our self motion, but vision plays a very powerful role in the determination of our motion, as shown by this illustration (REFS). Just as the determination of the motion of objects outside of ourselves is a complex task determined by the overall relativity of motion, so is the determination of our own motion. As a result, there can be illusions of self motion. The illusion of self motion is called **vection [to glossary].** In the laboratory, vection is often studied by putting the participant on a chair in the center of a circular screen that totally covers the field of view. There is a grating on the screen. The grating is moved, and in time the participant comes to perceive that the grating is still and that they are what is moving. They perceive their motion to be in the opposite direction of the actual motion of the grating (REF).

To generate the perception of vection, it is usually necessary to use a large stimulus, filling up a large portion of the field of view. Usually the larger the better, though small motions can work as shown by Anderson (or Andersen?) (REF). Again, vection suggests the powerful role of the periphery in motion perception.

[CAN I BUILD A VECTION DEMONSTRATION? TRY A FEW OPTIONS]

#### **Autokinetic Motion**

- need some research

#### Local vs. Global Motion

Open Interactive Illustration 7.x, Local Motion [link to media]. You will see a random pattern of dots. When you click on the **Move** button, the whole pattern will move either horizontally or vertically to a new location. The size of the movement is indicated by the **Step Size** slider at the bottom of the screen. When you first bring up the interactivity, the movement is very small, and you will probably see the whole pattern moving either up and down, or left and right (the direction is randomly selected by the program). You can verify the veracity of your perception by clicking on the **Reveal Direction** button at the bottom right hand corner of the screen. There is a perceptual ability here that is very remarkable, but is easy to miss, because of the ease with which the visual system accomplishes this task. The dots do not really move since this example is presented on a computer screen. The motion is apparent motion, with the dots first in one location and then in the next location. So the brain has to match up each dot from the first location of the pattern with the same dot in the next location. This ability is not as trivial as it sounds, as for any dot at Time A there are several identical dots that it could be matched to at Time B. Some of the dots are closer and some of the dots are farther away, but only one is the exact same dot. With the Interactive Illustration 7.x, Flicker Motion illustration from earlier in this chapter, we had a similar issue. When the update was ambiguous, the perceptual system chose the spoke after the blank period with the closest spoke it can find from before the blank period. This behavior of the visual system led to the wheel appearing to move backwards at certain speeds. However, that is not the case in the local motion figure. If you take some black dots, these dots are not paired with the closest black dot from after the blank period. No, the pairing is done so that each dot, white and black, is paired with another dot of the same color and at the same distance. As a result of this constricted pairing, only one direction of motion is seen, and the motion is perceived to be of rigid object. The overall all pattern of motion constrains the perception so that the pairings are done to give only one direction of motion. If the pairing is always done by matching the closest dot of the same color, there would not be any overall perceived direction of motion,

as the closest dot can be in any direction and will differ for the different dots on the screen. In this case, **global motion [to glossary]** supercedes the perception of **local motion [to glossary]**. The global motion is defined by the overall motion of the entire random dot field. The local motion is the motion defined by each dot pairing with the closest similar dot in the position of the pattern. The ability of global motion to be perceived and to be perceived so effortlessly represents a remarkable computational ability of the visual system to match each dot, and to do it based upon some larger general features, in this case the overall random pattern of dots.

The perception of global motion is limited in this example. Use the **Step Size** slider at the bottom of the screen and move it to the right very slowly, increasing the movement of the pattern from one update to the next. As you increase the step size between the updates of the random dot pattern, the perception of coherent motion of the pattern in one direction breaks down. Now there are lots of smaller motions. Local motion has taken over, and the perception of global motion can be lost entirely. To check this out, press the **New Direction** button in the lower right corner of the screen. This button will randomly select either a vertical or horizontal direction for the motion of the whole dot field. Try to guess the overall motion of the random dot field. Press the **Reveal Direction** button to see if you are correct. Try this task a few times, always pressing the **New Direction** button before the **Reveal Direction** button. If you are fairly successful, move the **Step Size** slider further to the right. Eventually, you should find a step size large enough where you should be no better than chance at guessing the direction motion of the random dot field.

#### Motion and Form Perception

It was discussed in Chapter 5 that contours can play an important role in form perception. The contours that were discussed in that chapter were contours made by changes in luminance. However, there are many ways that contours can be formed. Changes in color can form quite good contours. Relevant to the topic of this chapter, changes in motion can also form contours. Open Interactive Illustration 7.x, **Contour Motion** [link to media] to see an example of motion creating a contour in a very unusual way. When you open the illustration, all that you see is a random pattern of dots, generated anew each time the program opens. When you click the **Move** button, you will see an edge or contour moving down, and when it reaches the bottom of the random dots it reverses direction and moves up. However, what is happening in the image is that all the pixels in a row change to their opposite value. That is, a black pixel becomes white and a white pixel becomes black. So there is no overall change in the luminance, as on average there are the same number of white dots and black dots in each row of pixels. Also, note that you do not see an independent set of dots moving, but an edge. Stop the motion and consider the random dot stimulus. It is just a pattern of black and white dots. There is no perception of rows or columns. Going back to the Law of Proximity from Chapter 5, the dots are not overall closer to each other vertically than horizontally. The result of this fact is that there is not grouping of the dots into either rows or columns. Yet when the edge is moving, you clearly and easily see a contour. This contour rides on the motion alone and not on any of the luminance features of the stimulus. You can change the direction to left and right and back again by clicking the **Change Direction** button at the bottom of the screen. Also, when the edge is not moving, you can change the dot size using the **Dot Size (Pixels)** menu at the bottom right corner of the screen. [ARE THE ARE OTHER FEATURES I WANT TO CHANGE ON THIS FIGURE?]

Motion can do more than generate a contour. Open Interactive Figure 7.x, Common Fate [link to media]. This is a copy of the figure from Chapter 5, illustrating one of the Gestalt laws of perception. In this law, Common Fate, the dots that move together are perceived as part of one solid object. The common motion is defining a form, and a rigid form at that. Open Interactive Illustration 7.x, Structure from Motion. When you first open this figure, all that you will see is a screen mostly covered with a random dot pattern. On that screen, there is a smaller square of dots that are actually drawn separately from the other random dots. But, since one set of random dots is imperceptible from any other set of random dots, you cannot see the smaller square. Now, click the **Move** checkbox in the lower right hand corner of the screen. The square will start moving for short periods of time over the screen. It will move randomly either up, down, left or right, stopping periodically. When the square is moving it will be clear, coherent, and even appear to be in front of the rest of the screen. When the square stops, it becomes invisible again. Here the motion, in this case the identical motion of all the dots of the square, works to make the square

figure become completely visible and seen as a figure, with the rest of the random dots becoming the ground.

# [DO I WANT TO ADD THE ABILITY TO MANIPULATE THE SPEED OF THE SQUARE? WHAT ABOUT THE SIZE OF THE SQUARE?]

To investigate this phenomenon more fully, use the menu on the lower left corner of the screen that now says **Static Dots**, and select **Dynamic Dots on Square**. Each time the square is in a new location, it has a new random selection of dots. While the edges of the square might not be as clear as they were when the dots did not change, they are still visible. The square can still be made out as a square. This suggests that motion, per se, is clearly vital to this perception. The difference between square and background can still be determined by the visual system. There is one final setting to try. What if both the background and the square change their spots at the same rate? Take a minute and see if you can make a prediction. Then go to the menu in the lower right corner of the screen and select **All Dots Dynamic**.

In this condition, only a portion of the screen has dots. This drawing of the background dots on a smaller portion of the screen is done for two reasons. First, but least important, is speed. To be able to redraw a new set of dots each time is time consuming, so doing less of the screen helps speed up the illustration. Second, and more important, is so you can see that there is still square. Sometimes the square will be drawn on the black background. In this situation, the square is clearly seen. However, there is a clear difference in luminance between the square which is half white and the background which is all black. It could be this luminance difference that allows you to see the square. When the square is over the background dots, it is invisible, just like the still square when the dots always remained the same. There is no consistent global motion to be picked out of this combined stimulus to support the form perception.

Since motion can generate a contour, and it was demonstrated in Chapter 5 that the presence of contours alone can cause us to see a shape, it can be expected that motion generating a series of contours could generate a shape. Try an experiment and see if that holds true. Open Interactive Illustration 7.x, Form from Moving Contours [link to media]. This experiment has a very similar layout to the Interactive Illustration 7.x, Contour Motion. The main difference is that when you click on the Move checkbox, instead of a single line moving across the screen, you get the moving edges of a square. The question here is not just, do you see the edges, but do you see and entire square moving? In other words, does the center seem to be moving as well as the square? If you recall the Criak-O'Brien-Cornsweet illusion from Chapter 5, you may recall that the strength of the effect depended upon the width of the edges. You can manipulate the edge size by using the Dot Size menu on the lower right hand corner of the screen. You can only change size of the dots when the square is not moving, so be sure to clear the Move checkbox to change the dot size. The default dot size is 8 pixels, and you can go up to 16 pixels and down to 1 pixel. Manipulate the dots' size and see what happens to your perception of the square as a whole. Can motion edges act in the same way as luminance edges?

Physiology of Motion Perception