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The effects of drift and displacement motion on Dynamic Visual Acuity

J.Antonio Aznar-Casanova[†*]; Lluïsa Quevedo[‡] and Scott Sinnett[†]

[†] Universitat de Barcelona. [‡] Universitat Politècnica de Catalunya (Spain)

Dynamic Visual Acuity (DVA) can be measured from two types of equivalently considered movement referred to as drifting-motion and displacement-motion. Displacement motion can be best described as the horizontal displacement of a stimulus, thus implying pursuit eye movements, and involves moving the stimulus from the fixation point of gaze towards the periphery. The drifting motion of a Gabor patch, for example, avoids pursuit eye movements, since the gaze is fixed in a point of the patch. Our data shows that in both types of movement visual acuity (VA), expressed in terms of spatial frequency, diminished as the velocity of the target increased. However, the slope of the regression equation indicated that this impairment is more than two-fold in the case of drifting-motion when compared to displacement motion. As the greater impairment took place when pursuit eye movements did not exist, our data suggests that these two types of motions correct differently for retinal slip. Retinal slip appears to be less efficiently compensated for in the case of drifting motion having adverse consequences on VA, while retinal slip has a higher tolerance in the case of displacement motion exhibited by the performance in VA.

Detecting the movement of an object is essential, and at times, even a life or death matter. For instance, many animals must be able to rapidly detect movement or otherwise risk being prey. It is important to be able to estimate the velocity, direction, and if possible, identify all types of approaching stimuli, especially in situations when such stimuli are quickly approaching and may be dangerous. Thus, identifying the shape and other details of stimuli is essential in order to avoid imminent dangers. However, little effort has been spent emphasizing the relationship among spatial and temporal frequency, velocity, types of movement and eye movements. In this paper we investigate resolution acuity, sometimes called the "minimum separable" acuity, for two types of moving stimuli.

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Acuity is defined as the ability to detect a separation or gap between small details. Visual Acuity (VA) is a measure of the smallest detail (highest spatial frequency) that the visual system can resolve. In our case, VA is measured by the spatial frequency of the sine wave contained in a Gabor patch. However, when acuity relates to moving targets it is referred to as Dynamic Visual Acuity (DVA) in order to distinguish it from acuity measures with stationary targets (SVA). It has been known [see Hoffman, Rouse and Ryan (1981) for a review] that VA for a moving target diminishes as target velocity increases (Ludvigh and Miller, 1958; Miller, 1958; Morrison, 1980; Prestrude, 1987; Long and Zavod,, 2002).

Nevertheless, agreement has yet to be achieved regarding factors that explain this relationship. Murphy (1978) pointed out that when our eyes do manage to keep up with a moving target, visual resolution is not impaired. Ludvigh and Miller (1958) verified that DVA can be improved by practice, although, there were important individual differences of this capability. However, it is possible that this improvement reflects the fitting of the speed of pursuit eye movements to the speed of the target's movement. Also, Mayyasi, Beals, Templeton, and Hale (1971) and Brown (1972) reported that as the contrast of the stimulus decreased, DVA deteriorated. From another point of view, and based on Miller's research (1958), DVA appears to degrade similarly when stationary observers viewed vertically or horizontally moving stimuli.

Spatial acuity, defined as the highest visible spatial frequency one can distinguish, is roughly 40-50 cycles/deg for human foveal vision with gratings of high contrast (Bruce, Green, and Georgeson, 1996). Temporal acuity, defined as the fastest distinguishable visible flicker rate, is around 40-50 Hz for human vision. Also, Robson (1966) and Kelly (1979) have shown that contrast sensitivity for grating depends on both spatial and temporal frequency. They found that sensitivity is greatest at roughly 5 c/deg and 5 Hz respectively. Kelly (1983, 1984), more accurately controlling the temporal frequencies by means of a modern retinal stabilization technique, found similar values. In brief, as temporal frequency increases, sensitivity to high spatial frequencies slightly decreases (a low-pass filter), while sensitivity to low spatial frequencies increases (a band-pass filter). On the other hand, at very low temporal frequencies the low spatial frequency attenuation is greater.

Research performed during the last few decades includes using several types of moving stimuli in order to investigate motion vision; such as d*rifting grating, flickering, flashing* and *displacement patches*. These stimuli require the use of many different discrimination tasks: direction of motion, speed of motion, rate of flicker, spatial frequency discrimination, and others. Researchers choose which form of moving stimuli to utilize depending on their experimental objectives. As the aim of this study was to investigate DVA, drifting-motion and displacement-motion appear to be the most suitable stimuli.

The type of motion labelled *drifting gratings* consists of a temporal change in the phase of every pixel of a pattern. The rate that the spatial phase changes specifies drift velocity. The effect of such a variation is that the perceived pattern (the bars of the grating) appears to move continuously in a certain direction through an aperture. Hence, here we will use the expression, drift motion, to indicate a particular type of drifting, that is, to refer to the drift of the grating contained inside the Gabor patch. (aperture).

On the other hand, the d*isplacement* motion of an object consists of a continuous change in the spatial position of the object through time. An example of displacement motion could be a stimulus moving in a horizontal path along a fronto-parallel plane. The goal of our research was to verify if these two movements (drifting motion and displacement motion) are equivalent when measuring DVA, or, on the contrary, produce different results.

Currently, it is not clear as to which factors produce diminishments in VA, or for what reasons they operate in this way. In fact, it is known that as a consequence of the temporal integration that occurs in vision (Barlow, 1958; Legge, 1978; Gorea and Tyler, 1983; Georgeson, 1987), moving stimuli should appear more blurred than stationary stimuli.

As previously mentioned, *drifting-motion* and *displacement motion* will be used for our investigation of DVA. Using *drifting-motion* as a moving stimulus offers the researcher an advantage in that pursuit eye and head movements, which are difficult to control for, are not likely to occur (Tatler and Wade, 2003). However, it is possible that this motion promotes *retinal slip*. The idea of retinal slip will be further discussed below. Moreover, if fixation is maintained on a point in the centre of the Gabor patch, a resulting stimulus moving with afferent motion occurs. On the other hand, with *displacement motion*, the entire Gabor patch moves across a stationary background, promoting pursuit eye movements (Rashbass, 1961 and Robinson, 1965). By smooth pursuit eye movement keeping the moving target relatively stable on the fovea we are able to discriminate and thus obtain high visual acuities. For instance, Rashbass, (1961) and Robinson (1965) found that for targets moving at constant velocities of less than 30 deg/sec, eye movements are able to pursue the target successfully through the use of pursuit eye movements. That is, adjusting the gain, or ratio, between eye velocity and target velocity, to a value close to one.

The function of the vestibulo-ocular reflex (VOR) is to stabilize the retinal image by making eye rotations that counterbalance head rotations. When VOR fails, the image slips over the retina during head rotation, that is, a *retinal slip* is produced. The oculomotor system is characterized by the interaction between peripheral reflexes and central motor commands of visual origin. The neural control of gaze in natural conditions requires the interaction between different strategies of oculomotor control e.g., Krauzlis, 2004). According to De Brouwer, Missal and Lefèvre (2001) the visual tracking of moving targets requires the combination of smooth pursuit eye movements with catch-up saccades. Pursuit eye movements attempt to minimize retinal image motion or retinal slip (e.g., Krauzlis and Lisberger, 1994). In order to track a moving target, the visual system uses two sources of information, one about position error of the target while the other would be *retinal slip*. However, when we use drift motion the Gabor patch is stationary (only the inner grating is moving), therefore it is not necessary to verify the position of the patch on the screen..

As the two types of motion we use differ in their movement, differing in the displacement or the immobility of the patch, it is important to investigate what possible effects they will have on measurements of DVA. Certainly, in both displacement and drift motion retinal slip is produced, but in the first (displacement), an additional positional error could contribute to diminish VA to greater levels than in the second (drift motion).

METHOD

Participants. Four participants (APH, LQJ, SCS and JAA), three of which were authors and the other a naïve student, participated in the experiment. All subjects had normal or corrected to normal visual acuity and also a normal sensitivity to contrast.

Equipment: hardware and software. Motion visual stimuli were presented on a Sony GDM-F520 television monitor. Stimuli were controlled by a Cambridge Research System VSG 2/5 graphic board with a spatial resolution of 1024x768 pixels (dot pitch = 0.22 mm) and a frame rate of 120 Hz non-interlaced.

The stimuli, Gabor patches differing in spatial frequency, temporal frequency and contrast, were generated by VSG Software Library (VSL) version 6.1. The programs (software) used to obtain measurements (DVA) and manage the experimental sequence were written in Delphi language (Borland).

Gamma correction was performed independently for each colour (RGB) by ColorCal (CRS) and the mean luminance of the stimuli was measured by a Minolta LS100 luminometer. A CB6 response box (CRS) was used to register responses producing a tone from an internal buzzer informing the participant that a response had been made. A chin-rest was used in order to ensure the distance between the participant and the monitor.

Stimuli. Gabor patches were used in two different tests. The Gabor patches varied in both spatial frequency and velocity (or temporal frequency). Figure 1 shows an example of a Gabor patch (orientation 135 deg) and its luminance profile. In the first test the Gabor patch was displaced in a unidirectional horizontal path (left to right), varying the velocity (displacement-motion). Meanwhile, in the second test the Gabor patch was shown in the centre of the screen with a pre-determined drift velocity (drifting-motion) also presented in only one direction (aperture).

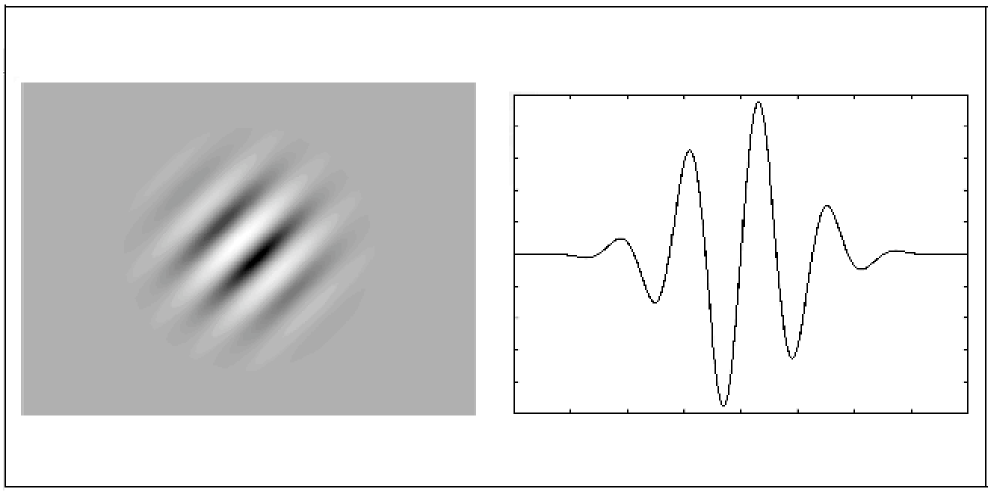

FIGURE 1. An illustration of the Gabor patch used as a stimulus with an orientation of 135 degrees. The luminance of the background is equal to the mean luminance of the Gabor function. Left panel: grey level representation of the 2-D Gabor function. Central panel: profile of the luminance corresponding to a line orthogonal to the variation of luminance of the Gabor function. Right panel: an isometrical 3-D representation of the 2-D Gabor function.

In the first test visual acuity was measured for a wide range of velocities (0.5, 1, 2, 5, 10, 20, 30, 40, 50 deg/sec) in addition to stationary visual acuity (SVA). With such a variation in velocities we adapted the test to four different viewing distances (6 m for SVA; 3 m for velocities of less than 5 deg/sec; 2 m for velocities of 10 and 20 deg/sec and 1.2 m for velocities of 30, 40 and 50 deg/sec). According to the viewing distance, the visual angle (0.57 deg) subtended for the Gabor patch was kept constant. For this reason, the size of the Gabor patch was adapted for each distance. DVA was measured using three different levels of contrasts, low (m= 0.20; minimum luminance or Lmin= 10.4 cd/m^2 and maximum luminance or Lmax= 15.6 cd/m^2), middle (m= 0.50; Lmin= 16.25 cd/m^2; Lmax= 48.75 cd/m^2) and high (m= 0.80; Lmin= 10.4 cd/m^2; Lmax= 93.6 cd/m^2). The luminance of the screen background was equal to the mean luminance of the Gabor function used in each trial. Displacement-motion was implemented by using X and Y motion vector tables. In each trial the Gabor patch was moved to the specified (XPos, YPos) in the table on the next video frame. This algorithm works by scanning through two arrays of positions, one for the X axis and one for Y axis. Nevertheless, as there was only a horizontal movement the Y value was kept constant. For each frame, the data for the next item was read from the two arrays, thus repositioning the video region accordingly. The value of horizontal displacement was varied in order to control the speed with which the system moves through the X table. A value of *n* will cause the system to advance by *n* pixels every video refresh.

In the second test the spatial frequencies tested were approximately the upper limits of discrimination determined in the first test (displacement-motion) for different velocities. Only a middle contrast was fixated (Lmean= 32.5 cd/m^2) from a viewing distance of 2 meters. Orientations of the pattern of the Gabor patch could be 45 or 135 degrees. In this test we used Gabor patches with a size of 90 pixels (diameter of patch) and a deviation of 15 pixels which subtended a visual angle of 0.57 deg. The patches were presented in the middle of the screen (coordinates: 0, 0). The luminance of the screen background was also the mean luminance of the Gabor function used in each trial.

The spatial phase of the Gabor patch was increased at a particular rate in order to vary the drift velocity. The effect of such a variation consists of the pattern seemingly moving continually. The rate of change of the spatial phase controller was measured in cycles of spatial waveforms per second (c/sec), that is to say, drift velocity was the temporal frequency. In brief, this parameter allowed us to move (drift) the pattern (grating) contained in the Gabor patch at a particular velocity. However, the upper limit in temporal frequency that can be presented depends on the frame rate of the graphic system (120 Hz in our case) and the size of the envelope gaussian of the Gabor patch. Therefore, as we have fixed the patch for the second test with a size of 90 pixels, and given that the inner grating (in the Gabor patch) is a periodic stimulus, then drift velocities (temporal frequencies) higher than 30 c/sec would be constant. Thus implying that we can not use, in this test, temporal frequencies above 30 c/sec.

Procedure. We measured DVA of the participants in two tests, each of them based on a different type of motion. Test one was designed to measure DVA in terms of determining the upper spatial frequency that participants could successfully discriminate for different velocities of Gabor patches. Test two was designed to measure DVA for a narrow range of spatial frequencies (6, 7, 8, 9, 10, 12, 14, 16, 18 c/sec.) in terms of the upper temporal frequency for a particular spatial frequency that participants could successfully discriminate the orientation of that pattern. Both tests were conducted in the darkness, so that only light coming from the screen (background and patch) was used.

Test One: In order to measure the highest spatial frequency that can be seen for a particular velocity (DVA), in the first test (displacement-motion) we varied (by increasing or decreasing) the spatial frequency from trial to trial in small steps (0.5 c/deg) according to six interleaved staircases. Ten blocks (sessions), each for a particular velocity (0, 0.5, 1, 2, 5, 10, 20, 30, 40, 50 deg/sec) were given to the participants. We used two of these staircases for each particular contrast (0.20, 0.50 and 0.80), one according to an ascending series and another according to a descending series. The upper limit for each staircase was determined from the mean of the last eight (of ten) reversal points of that staircase (at which the observers' responses changed). The first two reversals were considered as training. The upper limit of spatial frequency for each of these velocities and contrasts was estimated by averaging the two upper limits in spatial frequencies obtained in the two corresponding staircases. Participants had to indicate the orientation of the Gabor patch (45 or 135 deg.) by pressing one of two buttons on a response box. Feedback was not given.

The orientation of the Gabor patch was randomly generated for each trial. Participants were instructed not to guess the orientation; rather, a third response key was available for occasions when the orientation was not confidently known (3 AFC paradigm). Two successive failures or successes were required in order to reverse the direction of the staircase in a run, that is, to decrease or increase the spatial frequency in 0.5 c/deg steps for the next trial. Therefore, the duration for each session depended on the responses by the participant. On average a session lasted approximately eight minutes. Therefore, as DVA was measured for ten velocities, ten blocks were given to each participant distributed over three sessions.

Each trial began with a tone (1000 Hz, 100 msec), indicating the onset of the trial, followed by a moving Gabor patch which crossed the screen with a unidirectional horizontal movement. Each patch had a particular velocity (depending on the block), specific spatial frequency (controlled by the staircase procedure) and contrast (according to a particular staircase), and a random orientation of pattern (45 or 135 deg). The moving stimulus crossed the screen only once, covering a distance of 390 mm. Therefore, as the horizontal spatial resolution of the screen was 1024 pixels and the frame rate was 120 Hz, the minimum time needed to cross the screen was 274 msec (highest velocity) and the maximum was 14.8 seconds (slowest velocity). However, participants could respond before the trial was completed, that is, when they had discriminated the orientation of the pattern.

Test Two: The second test explored the effects of drift motion on DVA. In order to measure DVA in this test (drift-motion) for a particular spatial frequency (with the upper limits found in the first test) we varied (by increasing or decreasing) the temporal frequency (drift velocity) from trial to trial in small steps (0.25 Hz) according to two interleaved staircases composing each session. It is important to note that in this case the Gabor patch did not move in the horizontal direction, rather, it remained in the centre of the computer screen 'drifting' as previously described. Only a middle contrast (m = 0.50; Michelson) was used in this test as we did not want to surpass the maximum temporal frequency that could be applied. The range of spatial frequencies studied here in order to obtain the highest temporal frequency was 6, 7, 8, 9, 10, 12, 14, 16, and 18 c/degree. Equivalent to the first test, participants also had to indicate the orientation, randomly generated, of the Gabor patch (45 or 135 deg) by pressing one of three buttons on the response box, once again, without trying to guess the response (the same third response key was available for occasions of uncertainty). Stimulus presentation was limited to 700 msec for each trial. All other details for the staircase were identical to those described above (test one).

The value of the upper limit of temporal frequencies obtained for each spatial frequency was used to calculate the velocity (in deg/sec) of the drifting Gabor patch. As $v = ft / fs$ (where v is velocity, fs is spatial frequency and ft is temporal frequency) we can derive a new measure for velocity from the rate of ft / fs. In this way, the visual acuity (upper limit in spatial frequency) for a narrow range of velocities (less than 5 deg/sec) was obtained. In other words another measurement of DVA from drifting-motion was generated in order to compare with values obtained from displacement motion (test one).

RESULTS

All results are expressed in terms of the upper limit in spatial frequency that participants could successfully discriminate the orientation of the Gabor patch for each particular velocity. Similarly, previous research has measured DVA in unities of Visual Acuity (VA), that is, as a fraction expressing the inverse of the visual angle (in min. arc) resolved by subjects. We prefer to use cycles/degree as units as areas in V1, V2 and V3 also analyse the stimuli in terms of spatial frequency (Maffei and Fiorentini, 1973).

Figure 2 shows the results in DVA obtained in test 1 (displacement motion) for each participant. The data (upper limit of spatial frequencies) are plotted as a function of the velocity of the target (DVA) separately for each participant. All data corresponds to a contrast of m= 0.80 (Michelson terms) in the inner pattern of the Gabor patch. This measurement confirmed that the highest discriminable spatial frequency used in a stationary Gabor patch (SVA) diminished dramatically until the target moved at a velocity around 20 deg/sec. For the highest velocities (until 50 deg/sec) this upper limit continued to diminish until it had been reduced in half. In other words, from a spatial frequency of 16-18 c/deg, in the case of stationary VA, the value of DVA progressively decreased as the velocity increased. This trend was especially evident for velocities greater than 20 deg/sec. For instance, a velocity of 50 deg/sec yielded values of 7-8 c/deg. It is important to highlight that nearly half of the impairment in VA occurred in the range of velocities between 0.5 and 20 deg/sec. For velocities more than 30 deg/sec VA appears to stabilize.

Figure 3 shows the same values of upper limit in spatial frequency for two participants (APH and LQJ) as a function of the contrast of the Gabor patch separately for each velocity. This graph shows that as contrast increases, a slight increment in DVA can be seen, indicating that contrast is a relevant factor in the measurement of VA. Data from the other two participants follow a similar pattern of results with regard to the relationship between DVA, velocity and contrast. Additionally, this figure tells us how contrast can modulate VA capability for each particular velocity in an independent way. In other terms, contrast and velocity do not interact on VA, but, on the contrary, have an additive effect on VA.

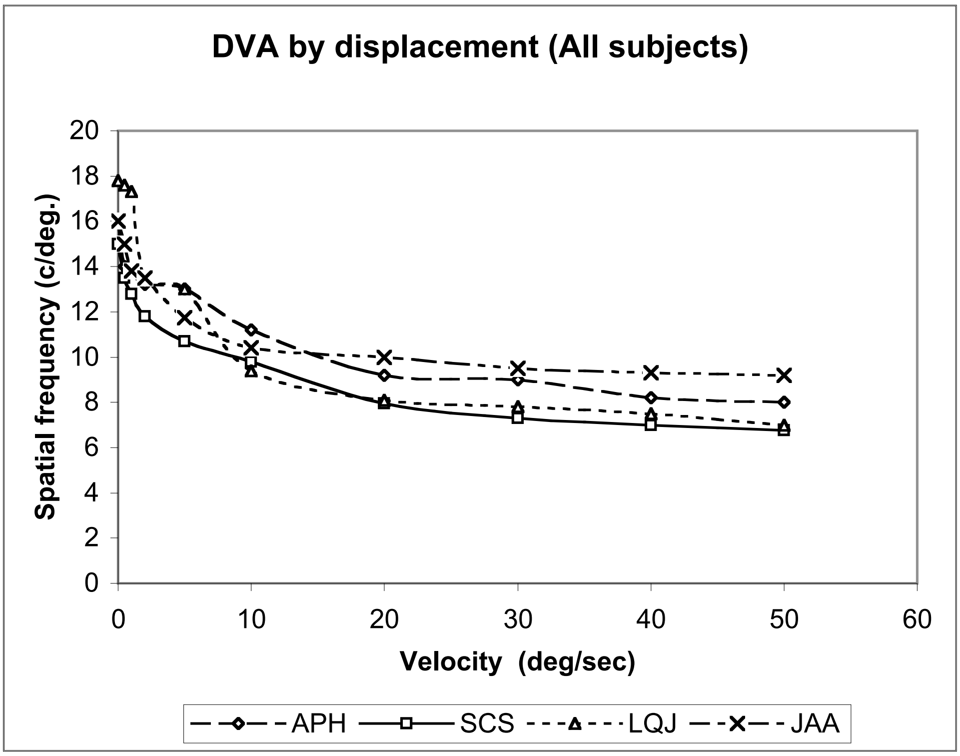

FIGURE 2. The relationship between the upper limit of spatial frequencies perceived by the subjects and the velocities of the displacement-motion of the Gabor patch. Each curve represents the DVA (Dynamic Visual Acuity) for each subject (APH, SCS, LQJ & JAA).

In figure 4 we compare DVA levels for each participant with both types of movement studied (drifting and displacement) as a function of the velocity of the target. Due to the size of the Gabor patch used (90 pixels), moreover, its periodicity, and as the frame rate of the monitor (120 Hz) restricted the temporal frequency of presentation, it was not possible for drifting motion to have velocities above 5 deg/sec. Nevertheless, the narrow range of temporal frequencies that we have assessed allowed us to verify that VA deteriorated more rapidly with drifting movement than the equivalent displacement motion. All participants exhibited similar patterns as can be seen in this graph. That is, the reduction in VA was more accelerated for drifting motion, while this diminishment is smoother in the case of displacement motion.

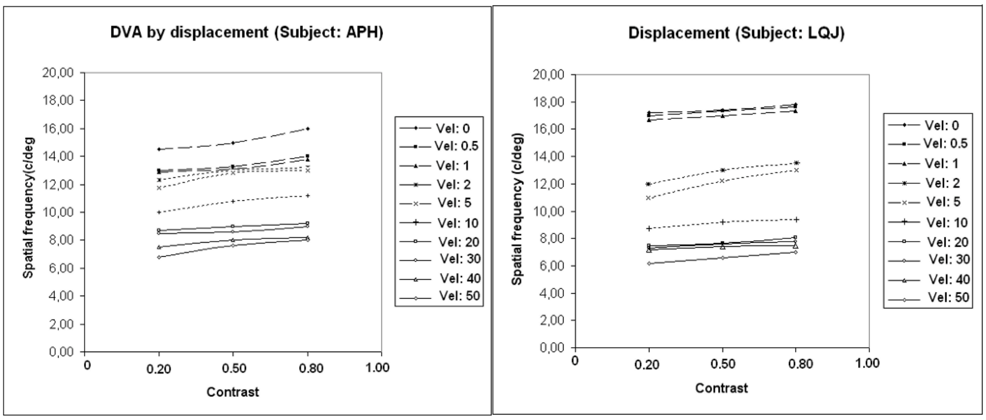

FIGURE 3. According to the displacement-motion test of the Gabor patch, the highest spatial frequency that two subjects (APH an LQJ) were able to resolve in the different velocities studied as a function of the contrast in the Gabor patch.

Finally, figure 5 shows the DVA of all participants as a function of the velocities between 0 and 5 deg/sec. These velocities are directly comparable between both tests (both types of movement). As a good linear fit between spatial frequency and velocity was found, the line of regression was separately estimated for each participant in both types of movement studied. As can be seen in the graphs, the slope (*b* parameter) of the regression line in the case of drifting motion has a value around 2.5 (for APH *b*= -2.47; for JAA *b*= -2.58; for SCS *b*= -2.46) or almost 3 (for LQJ *b*= -2.98), while the slope, in the case of displacement motion, is roughly equal to 1 (for APH *b*= -0.93; for LQJ *b*= -1.11; for JAA *b*= -0.7; and for SCS *b*= -0.91). Obviously, the constant (*a* parameter or intersection with Y-axis) is a factor related with the stationary VA of each participant.

DISCUSSION

DVA it is not only a relevant visual ability necessary for the survival of a species, but also provides us with an important means of investigating the relationships among important factors of spatial vision: spatial frequency, temporal frequency, velocity, types of motion, eye movements, and so on. In this paper we have explored DVA in two experimental conditions with the aim of studying the consequences of the type of motion of the target on VA. The two types of motion studied were drifting and displacement, which typically have been considered as equivalent. However, our data reveal that, in some sense, they are not similar, since we have found differences in their effects on VA. Can these differences shown in DVA from the two types of motion tell us something about the way the visual system encodes spatial frequency, temporal frequency and velocity? Or, perhaps, those differences could have been stated in previous steps, for example, retinal sampling or eye movements? Possible sources to these differences will be discussed.

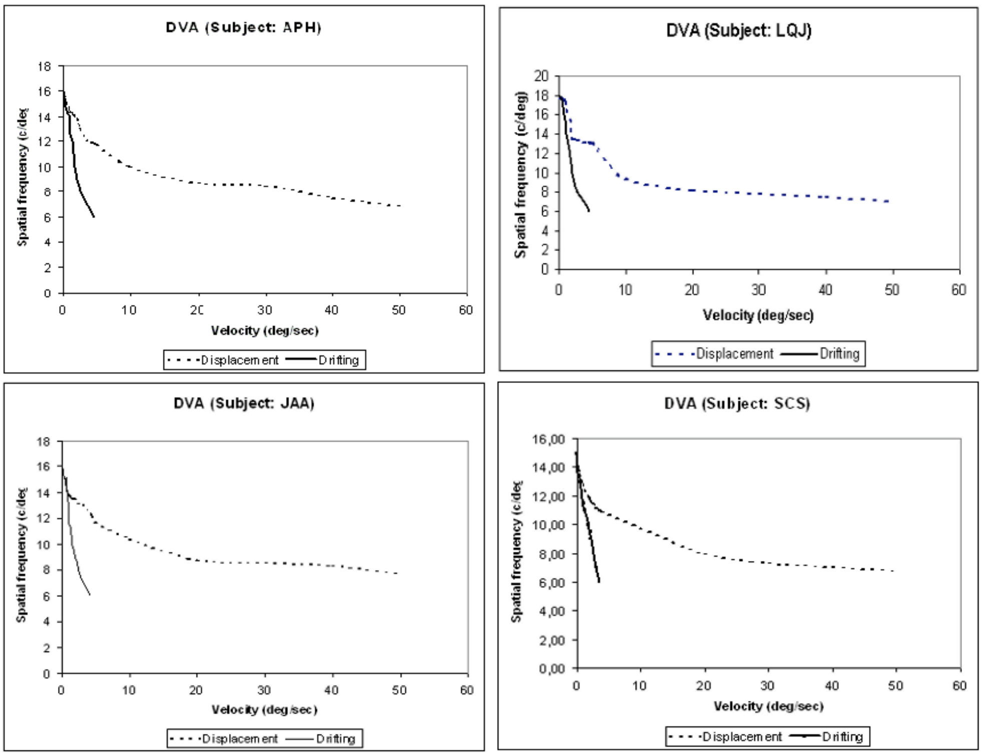

FIGURE 4. Measurement of the DVA as a function of the type of test used: a) Test 1, displacement motion; b) Test 2, drifting motion. Each graph corresponds to a subject.

By using two types of movement in our investigation, drifting and displacement, two independent measures of DVA have been obtained. Additionally, we measured the VA for the same stationary target (a Gabor patch) with the goal of obtaining a reference point (no motion or zero velocity). For displacement motion, we measured the upper limit in spatial frequency in a broad range of velocities which included very low (0.5, 1 deg/sec), low (2 and 5 deg/sec), middle (10 and 20 deg/sec) and fast (30, 40 and 50 deg/sec) velocities. A single unidirectional horizontal movement was used to study DVA with displacement motion. The results of this test verified that VA decreases as velocity increases, but not in a uniform way. Indeed, for very low and low velocities, VA diminished in an abrupt way, while for middle velocities this diminishing was much smoother, and finally, for the highest velocities DVA remained constant with a reduced VA value (approximately half of SVA) showing little variation. In addition to the effects of this type of motion on VA, contrast also produced different effects on VA. However, it is important to note that these effects occurred independently of velocity.

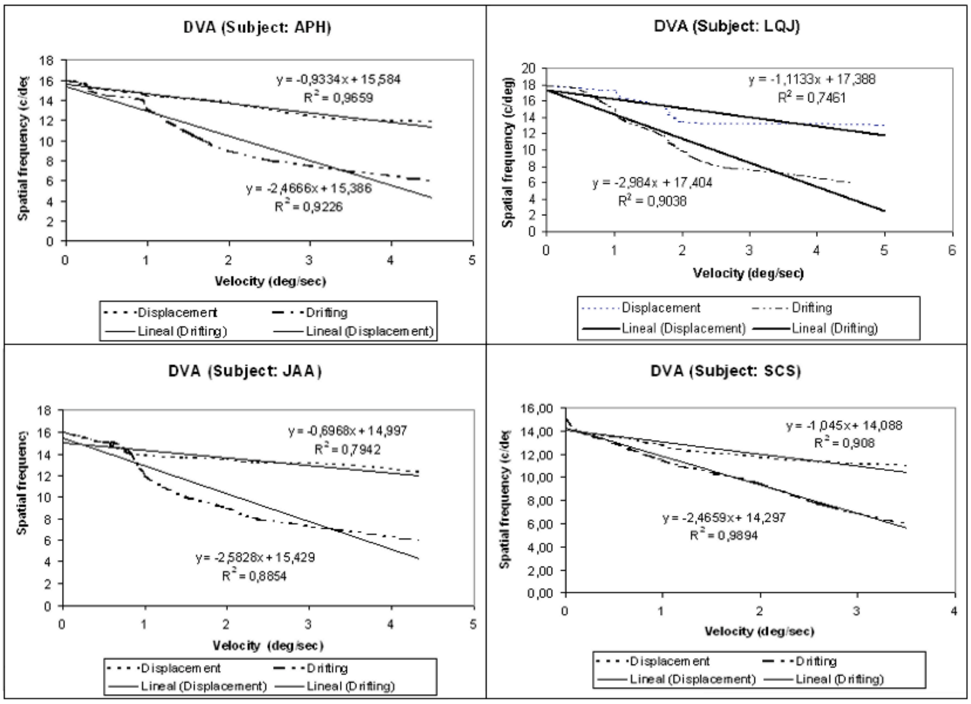

FIGURE 5. For every subject the two liniar regression equations corresponding to the two measurement conditions, test 1 (displacement) and test 2 (drifting). Only slow velocities have been compared in the two types of tests.

In the case of drifting motion, the upper limit in temporal frequency that the orientation of the pattern (Gabor patch) could be discriminated was measured (test two) with a range of spatial frequencies between 6 and 18 cycles/deg. As a consequence of very high temporal frequencies presented with a particular spatial frequency, misperceptions occurred. In this case, therefore, the orientation of pattern could not be discriminated and the upper limit for a particular spatial frequency was found. Since $v = ft / fs$, this test allowed us to dispose of a new upper limit in spatial frequency for a narrow range of velocities (below of 5 deg/sec). Comparing the two measurements of DVA (drifting vs. displacement motion) in this range of low velocities it was observed that the impairment in VA was, at least, two and a half times faster in the case of drifting motion than in the case of displacement motion.

The use of drifting motion gives the advantage of enabling easy control of fixation, since the target stimulus is presented at an approximately fixed retinal position. Thus, we have a test of dynamic visual acuity which does not require pursuit movements of the eye, although, drifting motion also produce retinal slip. Conversely, the use of displacement motion to measure DVA requires pursuit eye movements, which can affect the VA of the participants.

The data demonstrates some dependence of the spatial frequency on the temporal frequency or, alternatively, on the velocity. These factors are not independent, but on the contrary, narrowly interlinked. Indeed, contrary to the relationship between contrast and velocity, which has been shown to modulate VA in independent ways, the relationship between spatial frequency and temporal frequency, in the case of lower velocities, depends on the type of motion. Certainly, in the case of drifting motion (test two) the consequences of increasing the temporal frequency was to produce higher levels of misperception of the Gabor patch than in the case of displacement motion (test one) at the same velocity. Therefore, our data reveal that the impairment in VA specifically occurs when pursuit eye movements did not occur.

In the case of displacement motion, our data is consistent with Demer, Honrubia and Baloh (1994). Demer et al. (1994) reported that human VA can tolerate retinal motion up to 2-4 deg/sec, but rapidly deteriorates for higher retinal slip velocities. Nevertheless, only displacement motion was used in order to clinically measure DVA. However, in the case of drift motion, VA tolerance begins to diminish from velocities as low as 0.5 deg/s. These data reveal that, for a stationary patch, retinal slip is not as efficient as in case of moving patch.

Grossman, Leigh, Bruce, Huebner and Lanska, (1989) found that retinal image slip was below 4 deg/sec while standing and walking, but about 9 deg/sec while running for targets at optical infinity. Hence, for observer movement, instead of object (patch) movement, the efficacy of the retinal slip grew as the velocity of the participants increased. Also, Crane and Demer (1997) reported that retinal slip for head rotations along the vertical axis is typically below 2 deg/sec for targets at 1 m. However, retinal slip could increase up to 5 deg/sec for temporal frequencies around 1.5 Hz when the moving target is as near as 20 cm.

Recently, Gielen, Gabel and Duysens (2004) have reported that participant performance improves in the visual perception of 3-D shape during active head movement when comparted to a passive condition (the stimulus moves, but participants are stationary). They suggest that the cause of the improvement (in gaze stabilization) is a compensation applied as a consequence of the retinal slip, which is considerably smaller for active observers than for passives ones.

When trying to explain the impairment on VA when pursuit eye movements are required, or not, that is, considering the two types of motion studied, we find surprising results. Indeed, the correction of position (of the moving patch) is a source of error only possible when pursuit eye movements are elicited for displacement motion. Therefore, we postulated that this additional source of error should be a responsible factor for the greater decrease in VA in the case of displacement motion. However, the data showed the contrary, that is, VA is more impaired in the case of drift, at least for velocities up to 5 deg/sec. How is it possible that the greater impairment in performance occurs precisely when pursuit eye movements are not elicited?

To summarize, the differences in DVA found between drift and displacement motion can be better interpreted as a result of a correction of the retinal slip, applied as a consequence of the eye movements; rather than as effects derived from the encoding of both frequencies (spatial and temporal) and velocity. Thus, this data suggests that these two types of motion promote different corrections of retinal slip, which impair VA to different levels. Drifting motion seems to cause a less efficient compensation of the retinal slip, with adverse consequences on VA, while for displacement motion, with its inherent pursuit eye movements, an increase in the tolerance of the retinal slip is seen, thus having less detrimental effects on VA.

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