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Monocular vision:

Occupational limitations and current standards

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Defence R&D Canada

Technical Report

DRDC Toronto TR 2010-166

March 2011

Canada

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Abstract

At the request of the Canadian Forces (CF) Health Services Group, Defence Research and Development Canada (DRDC) - Toronto conducted a literature review on the occupational limitations of monocular vision including recommendations for further work if required. The current CF vision standard for new recruits covers only near and far visual acuity and colour vision. The general entry standard for far visual acuity is a minimum of 6/9 corrected in the better eye and 6/60 corrected in the other eye. Based on that standard, anyone with monocular vision would be excluded automatically. Recently, this policy has been challenged on the grounds that not all military occupational categories require binocular vision. A review of the basic and applied literature and other standards indicated that monocular vision could impact performance on critical military tasks requiring good spatial vision, especially under low illumination and low contrast conditions. However, most of the research compared the performance of people with good visual acuity or contrast sensitivity in both eyes against the same people wearing an eye patch. Research using people with monocular vision finds smaller differences, and in the case of people enucleated early in life, equivalent performance. Possibly more importantly, none of the research has compared people meeting the minimum visual acuity standards for entry into the CF to monocular controls. It is recommended that the performance of people in these two populations should be compared on critical occupational tasks, under low illumination and low contrast conditions. Some of the difficulties in carrying out these recommendations are identified.

Résumé

À la demande du Groupe des services de santé des FC, Recherche et développement pour la défense Canada (RDDC) – Toronto a procédé à une analyse documentaire des restrictions professionnelles touchant la vision monoculaire, en plus de formuler des recommandations quant aux études plus poussées qui pourraient s'imposer. La norme applicable aux recrues des Forces canadiennes (FC) ne porte que sur l'acuité en vision de près et de loin et que sur la perception des couleurs. La norme générale d'admissibilité en ce qui concerne l'acuité en vision de loin est d'au moins 6/9 avec correction dans l'œil le plus fort et 6/60 avec correction dans l'autre œil. Selon cette norme, une personne dont la vision est monoculaire serait exclue automatiquement. Dernièrement, cette politique a été contestée du fait que les catégories professionnelles militaires n'exigent pas toutes une vision binoculaire. Selon un examen de la recherche fondamentale et appliquée et d'autres normes en vigueur, la vision monoculaire pourrait avoir une incidence sur la qualité de l'exécution de tâches militaires essentielles qui exigent une bonne vision spatiale, particulièrement lorsque l'éclairement lumineux est faible et que les contrastes sont faibles. Cependant, la majorité des chercheurs ont comparé le rendement de personnes dotées d'une bonne acuité visuelle ou d'une bonne sensibilité différentielle dans les deux yeux, à celui des mêmes personnes portant un cache-œil. Les études faisant intervenir des sujets dotés d'une vision monoculaire ont relevé de plus faibles écarts, et même un rendement équivalent dans le cas des sujets énucléés tôt dans leur vie. Un facteur pourrait être encore plus important : aucune des études ne compare des groupes témoins monoculaires et des sujets qui atteignent la norme minimale d'acuité visuelle établie pour l'admissibilité dans les FC. On recommande de comparer le rendement de ces deux groupes durant l'exécution de tâches militaires essentielles, lorsque l’éclairement lumineux est faible et que les contrastes sont faibles. Certaines des difficultés inhérentes à l’application de ces recommandations sont mentionnées.

Executive summary

Monocular vision: Occupational limitations and current standards

[Sharon M. McFadden; Justin G. Hollands]; DRDC Toronto TR 2010-166; Defence R&D Canada – Toronto; March 2011.

Introduction or background: The vision standard in the Canadian Forces (CF) medical standard for new recruits only covers near and far visual acuity and colour vision. The general entry standard for far visual acuity is a minimum of 6/9 corrected in the better eye and 6/60 corrected in the other eye. Based on that standard, anyone with monocular vision (i.e., no vision in one eye) would be excluded automatically. Recently, this policy has been challenged on the grounds that not all military occupational categories require binocular vision (i.e., at least some vision in both eyes). At the request of the CF Health Services Group, Defence Research and Development Canada (DRDC) - Toronto conducted a literature review on the occupational limitations of monocular vision including recommendations for further work if required. The review was to cover the available basic and applied literature on the relative visual capabilities of monocular and binocular individuals, the current standards in Canada and its allies, and existing analyses of visual capabilities required to carry out critical tasks in the military.

Results: Our results indicated that monocular vision could potentially impact performance on tasks requiring good spatial vision, depth perception, motion perception or a wide field of view. However, based on relevance and existing entrance standards, monocular vision will most likely impact performance on critical military tasks requiring good spatial vision, especially under low illumination and low contrast conditions. An important caveat is that most of the research compared the performance of people with good visual acuity or contrast sensitivity in both eyes against the same people wearing an eye patch. Research using people with monocular vision finds smaller differences and, in the case of people enucleated early in life, equivalent performance on spatial vision tasks.

Significance: Based on the existing literature, it is not possible to show unequivocally that people with monocular vision would do worse on the standard occupational tasks than people that meet the minimum entrance standard. Further research is required to determine the relative capabilities of people who meet the minimum far visual acuity standard (stated above) and people with monocular vision.

Recommendations: It is recommended that a study should be carried out to measure performance, on simulated versions of relevant occupational tasks, of representative military personnel with one eye corrected to 6/9 and the second eye corrected to either 6/9 or poorer. Each individual would be tested with the poorer eye corrected to 6/9 through 6/60 or viewing a featureless field of equivalent luminance (to simulate monocular vision). If possible, people with monocular vision should be tested as well. All tasks should be carried out under both normal and low illumination and contrast conditions.

Sommaire

Vision monoculaire : Restrictions professionnelles et normes en vigueur

[Sharon M. McFadden; Justin G. Hollands]; RDDC Toronto TR 2010-166; R & D pour la défense Canada – Toronto; mars 2011.

Introduction ou contexte : La norme de vision établie dans les exigences médicales applicables aux recrues des Forces canadiennes (FC) ne porte que sur l'acuité en vision de près et de loin et que sur la perception des couleurs. La norme générale d'admissibilité en ce qui concerne l'acuité en vision de loin est d'au moins 6/9 avec correction dans l'œil le plus fort et 6/60 avec correction dans l'autre œil. Selon cette norme, une personne dont la vision est monoculaire (c'est-à-dire qui ne voit pas d'un œil) serait exclue automatiquement. Dernièrement, cette politique a été contestée du fait que les catégories professionnelles militaires n'exigent pas toutes une vision binoculaire (c.-à-d. au moins une vision partielle dans chaque œil). À la demande du Groupe des services de santé des FC, Recherche et développement pour la défense Canada (RDDC) – Toronto a procédé à une analyse documentaire des restrictions professionnelles touchant la vision monoculaire, en plus de formuler des recommandations quant aux études plus poussées qui pourraient s'imposer. L'analyse devait porter sur les publications accessibles en recherche fondamentale et en recherche appliquée concernant les capacités visuelles relatives des personnes qui sont monoculaires et binoculaires, les normes en vigueur au Canada et dans les pays alliés, ainsi que les analyses à ce jour des capacités visuelles requises pour accomplir des tâches militaires essentielles.

Résultats : Nos résultats indiquent qu'une vision monoculaire pourrait influer sur la qualité de l'exécution de tâches qui exigent une bonne vision spatiale, une perception de la profondeur, une perception du mouvement ou un grand champ de vision. Cependant, selon la pertinence des données et les normes d'enrôlement existantes, la vision monoculaire influencera fort probablement l'accomplissement de tâches militaires essentielles qui exigent une bonne vision spatiale, particulièrement lorsque l'éclairement lumineux est faible et que les contrastes sont faibles. Il faut toutefois faire une mise en garde importante : la plupart des chercheurs ont comparé le rendement de personnes dotées d'une bonne acuité visuelle ou d'une bonne sensibilité différentielle dans les deux yeux, à celui des mêmes personnes portant un cache-œil. Les études faisant intervenir des sujets monoculaires ont relevé de plus faibles écarts, et dans le cas des sujets énucléés tôt dans leur vie, elles ont relevé un rendement équivalent pour l'exécution de tâches exigeant une vision spatiale.

Importance : Selon la documentation publiée, il est impossible de prouver sans équivoque que les personnes dont la vision est monoculaire réussiraient moins bien les tâches professionnelles standard que celles qui répondent à la norme minimale établie pour l'admissibilité dans les FC. Il faudra réaliser d'autres études afin de déterminer les capacités relatives des personnes qui atteignent la norme minimale d'acuité en vision de loin (indiquée ci-dessus) et celles des personnes ayant une vision monoculaire.

Recommandations : Il est recommandé de mener une étude afin d'évaluer, à l'aide de simulations de tâches pertinentes, le rendement de militaires représentatifs dont la vision dans un œil serait corrigée à 6/9 et la vision dans l'autre œil, à 6/9 ou à un degré plus faible. On ferait

subir à chaque participant un examen de la vue avec une correction allant de 6/9 à 6/60 dans l'œil le plus faible ou avec un champ sans relief de luminance équivalente (pour simuler la vision monoculaire). Si possible, on devrait aussi faire participer des sujets monoculaires à de tels examens. Toutes les tâches devraient être exécutées dans un éclairement lumineux normal et faible et en présence de contrastes normaux et faibles.

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Introduction

Currently, the vision standards in Canadian Forces Publication (CFP) 154 (Canadian Forces Health Services 2009) only cover near and far visual acuity and colour vision. The general entry standard for far visual acuity is a minimum of 6/9[1] corrected in the better eye and 6/60 corrected in the other eye. Based on that standard, anyone with monocular vision (i.e., no vision in one eye) would automatically be excluded. Recently, this policy has been challenged on the grounds that, for some Military Occupational Structure Identifications (MOSIDs), all of the specified duties could be carried out by an individual with monocular vision.

The current method for assessing the acceptability of a vision standard is to demonstrate that an applicant requires a certain level of visual capability to meet the bona fide occupational requirements (BFOR) of the job. A BFOR is a standard or rule that is integral to carrying out the functions of a specific position (Canadian Human Rights Commission 2004). The process (Casson 1995) for establishing the BFOR for a job includes:

1. Identification of the essential tasks which make up the requirements of the job;

2. Identification of the skills and capabilities required to perform the essential tasks of the job;

3. Methods which evaluate the ability of the individual to carry out the essential tasks of the job by any reasonable method; and

4. Standards which do not exceed the minimum requirements of the job.

Although a BFOR process has been carried out to assess the visual acuity requirement for several MOSIDs in the Canadian Forces (CF) (Casson et al. 1998a; b; c; d; Kumagai et al. 2006; Williams et al. 2003), the process has not been used to assess the requirements for the current entrance standard for visual acuity. However, employability and deployability requirements applicable to all CF recruits do exist. Several requirements, for example, performing a high or low crawl and evacuating a casualty across country in hostile terrain, in unpredictable working conditions, and under extreme climatic conditions, would seem to require the ability to visually perceive the environment.

As a first step in determining if the current vision standard is justifiable, the Canadian Forces Health Services Group (CF H Svcs Gp) tasked Defence Research and Development Canada – Toronto (DRDC Toronto) to conduct a literature review on the occupational limitations of monocular vision, including recommendations for further work if required. The review was to cover the available basic and applied literature on the relative visual capabilities of monocular and binocular individuals, the current standards in Canada and its allies, and existing analyses of visual capabilities required to carry out critical tasks in the military. For the purposes of this review, monocular vision is defined as having no vision in one eye and binocular vision is defined as having some vision in both eyes. In most of the studies reviewed, binocular individuals had corrected visual acuity of at least 6/9 in both eyes.

[1] This number is a measure of visual acuity using an eye chart such as the Snellen chart. The numerator refers to the distance in metres between an individual reading an eye chart and the actual chart. The denominator is the distance in metres at which the components of the letters on the 6/9 line of an eye chart subtend a visual angle of 1 minute of arc.

The visual performance of monocular individuals has been widely studied, either to compare monocular and binocular visual capability or to determine what happens to vision in the remaining eye in order to compensate for the loss of binocularity. However, most, if not all, of the research examines the effect of monocular vision on a specific visual capability as opposed to its effect on overall visual performance. The loss of one eye has been shown to affect depth perception, field of view (FOV), spatial vision, and motion perception. In turn, these visual capabilities can affect performance on a range of militarily critical tasks (Casson et al. 1998a; b; c; d; Kumagai et al. 2005). For this reason, it was decided to examine the direct impact of monocular vision on those capabilities. For each capability, current standards and existing research were reviewed and the relevance of this information to performance on militarily critical tasks examined. Based on the results of this review and analysis, gaps in our existing knowledge base are identified and recommendations are provided.

Visual capabilities and monocular vision

Depth perception

Description

Depth perception involves the ability to estimate the distance of an object from the observer or to estimate the relative distance of two or more objects in the environment. Depth information can be acquired using both monocular and binocular cues. The primary binocular cue for depth perception is stereopsis or stereoacuity. Stereopsis is based on a comparison of how the image information in the two eyes differs due to retinal disparity or the lateral separation of the two eyes. Stereoacuity is the difference in depth of two objects at which an individual, viewing with two eyes, can correctly identify that the objects are not in the same plane. As with all acuity measures, the critical difference varies with absolute distance. Thus, the minimum distance is usually expressed in visual angle or minutes of arc. Under optimal conditions, skilled observers are able to produce thresholds of 3 - 5 seconds of arc (Casson 1995). Monocular depth cues include static cues such as object overlap, shading and shadow, relative size, texture gradient, linear perspective and aerial or atmospheric perspective. Monocular cues can be dynamic such as accommodation and convergence, motion parallax (faster relative motion for near objects) and deletion and accretion (the rate at which, in passing, a close object covers or reveals a more distant surface) (González et al. 1989).

Current standards

Among Air and Space Interoperability Council (ASIC) nations, all but Australia test for stereoacuity (Air Standardization Coordinating Committee 2003). Canada tests for stereoacuity in pilots using the Titmus Stereo test, but does not specify a cut-off point. Among other ASIC nations (United States (US) and United Kingdom (UK)), the acceptable level ranges from 25 to 120 seconds of arc. In the US, the stereoacuity standard only applies to pilots. A similar situation exists in industry. A recent review by Beard et al. (2002) found that those industrial occupations that require "normal binocular vision" often fail to specify a test procedure or a criterion. Where a criterion is specified, it is often stated in terms of the eyes' muscular balance and the eyes' ability to work together. One possible reason for lack of testing is that a large percentage of the human population is unable to make use of the normal range of disparity cues (Richards 1971).

Research

Since stereopsis cannot occur with monocular vision, most of the relevant research on the impact of monocular vision on depth perception concerns stereopsis. As stated above, stereopsis occurs because a slightly different image falls on the two retinae. Since the difference between the two images is greater the nearer the object, stereopsis is most useful for discriminating differences in depth for objects that are relatively close (Hovis 2000). Even at these distances, relative depth judgements can be made using monocular cues such as motion parallax as well as stereopsis. González et al. (1989) found that monocular depth perception improved to within a factor of 2[2] of binocular depth perception for adult participants when they were instructed to move their heads laterally while trying to align two plates in depth. Without head movements, the judgements were

[2] E.g., 44 seconds of arc as opposed to 22 seconds of arc with binocular vision.

poorer by a factor of 8. As well, a study by Marotta et al. (1995) found some evidence that the type of compensatory head movement changes as a function of time since the eye was removed (enucleation). They compared the compensatory head movements made by adults enucleated between 2 weeks and 35 years prior to the study. Although the frequency of head movements did not vary as a function of post enucleation time, they did find an increase in the ratio of lateral (x-axis) and vertical (y-axis) to forward (z-axis) head movements. They concluded that the extent of the head movements was less than expected and suggested that training might be helpful.

Most studies examining the role of stereopsis in depth perception focus on depth discrimination and/or only use relatively short distances of 1 to 2 metres. It is assumed that depth estimation beyond about 6 metres is based on monocular cues alone. However, recent research by Allison et al. (2009) showed that stereopsis contributed to estimates of relative depth at distances up to 9 metres even in an enriched environment. They had observers estimate the difference in depth of two sets of lights at distances of 4.5 and 9 metres, respectively, in either a dark room or an illuminated room populated by regularly spaced desks and chairs. With monocular vision, gain in perceived depth with increase in true depth was minimal and did not improve in the illuminated environment. In the binocular condition, the proportion increase in perceived depth with increase in real depth was greater in the illuminated condition and in both situations, it was significantly greater than in the monocular condition. In addition to presenting their own results, they cited several other studies that showed binocular enhancement in judgements of depth intervals at distances up to 30 to 50 metres.

Relevance

Outside the laboratory, it has proven difficult to determine the importance of stereoacuity in depth perception. For example, a recent review by Beard et al. (2002) found little systematic evidence for the occupational importance of stereoacuity in depth perception. Casson (1995) suggested that stereoacuity may only be relevant for specialized jobs that require the use of stereograms. One possible reason for this might be the fact that many people with otherwise normal binocular vision have deficiencies in the processing of disparity cues (Richards 1971).

Military pilots, interviewed by Kumagai et al. (2005), noted the importance of depth perception when landing an aircraft adjacent to obstacles and determining the distance to those obstacles. For example, helicopter pilots must perceive the clearance afforded from the helicopter rotor blades to surrounding buildings or trees. Based on the work of Allison et al. (2009), stereopsis should be useful for the clearance task since the distance to the tip of the blades would be less than 50 metres. However, for many aviation tasks, such as landing an aircraft or estimating the distance between two aircraft, the distances would be much greater and judgements would be made using monocular cues. For the infantry, Casson et al. (1998a) reported that depth perception was important in judging distance for accurate firing of weapons, surveillance, and reporting locations, but that the ranges for judging distance were typically 50 to 400 metres. At those distances, judgements would be made using monocular rather than binocular cues. However, with the growth in urban operations, ranges can be considerably shorter and stereopsis might provide some advantage. Casson et al. (1998c) did find a benefit to stereopsis for avionics technicians when engaged in a soldering task using a stereo microscope. Participants were judged on their ability to carry out the task of soldering circuit boards monocularly and binocularly. Quality scores went from 87% when the task was carried out binocularly to 70% when it was carried out monocularly. Although monocular performance might have improved with extended practice, these results suggest that individuals lacking stereopsis would find this type of task difficult to learn.

Spatial vision

Description

Spatial vision refers to the ability to resolve or discriminate spatially defined objects. The two basic measures of spatial vision are acuity and contrast sensitivity. Acuity is a measure of the ability to resolve fine detail, usually in a centrally-fixated, high-contrast, stationary object. Both near and far acuity are measured. Far acuity is measured using high contrast letters positioned at a distance of six metres (20 feet) while near acuity is measured at about 40 centimetres (16 inches) using printed text. Acuity is usually measured monocularly.

Contrast sensitivity is a measure of the ability to discriminate an object from its background as a function of the luminance difference between them. It is computed across a range of spatial frequencies and is typically measured using either low contrast letters or sinusoidal luminance gratings that are varied in both spatial frequency and contrast (Kumagai et al. 2005). Again, contrast sensitivity is usually measured monocularly.

Current Standards

The general entry standard in the CF for far visual acuity is 6/9 corrected in the better eye and at least 6/60 corrected in the other eye. However for some occupations, entrance criteria are more stringent (Canadian Forces Health Services 2009). Currently contrast sensitivity is not assessed. As stated earlier, based on any of these acuity standards, candidates with monocular vision would not qualify.

Research

Using the small letter contrast sensitivity charts, Rabin (1995) found a 40% improvement on average for binocular contrast sensitivity as compared to monocular and about a 10% increase for binocular acuity. Using more practical tasks involving spatial vision, Johnson (2008), Jones and Lee (1981), and Home (1977) all found a binocular advantage. Johnson measured the ability of drawbridge operators to detect pedestrians standing on the bridge on a foggy day as a function of visual acuity (simulated with lenses) with one eye or two. There was a 15 to 20% improvement in detection distance with two eyes at all but the poorest acuity level. Jones and Lee measured monocular and binocular performance on a letter identification task, a detection task, and a colour discrimination task. On all three tasks, performance was superior in the binocular condition, particularly under dim lighting conditions. Home compared monocular and binocular performance on three tasks - contrast detection, acuity (Landolt C) and recognition - at background luminances between .1 and 4.7 X 10^{-5} Candelas/metre^2 (Cd/m^2). For all three tasks, the binocular thresholds were lower.

All of the above studies compared the performance of binocular individuals viewing binocularly and monocularly. In the monocular condition, participants usually wore an eye patch. Based on recent research with individuals enucleated at a young age, the applicability of the above finding to individuals with actual monocular vision is questionable (Steeves et al. 2008). Unilaterally enucleated observers have been shown to have better letter recognition, vernier acuity, and global pattern recognition than binocular observers viewing monocularly at high and low contrast levels. Moreover, their performance on these tasks is equivalent to that found with binocular viewing (Steeves et al. 2008). In fact, Nicholas et al. (1996) found that the contrast sensitivity of unilaterally enucleated adults was equivalent to binocular contrast sensitivity for spatial frequencies between .58 and 32 cycles per degree, at least for individuals undergoing enucleation by the age of 13 years. In addition, they found an enhancement in contrast sensitivity at 4 cycles per degree for those enucleated prior to the age of 2 years. At least three kinds of processes may lie behind the superior performance of enucleated observers in certain visual tasks: (a) monocular practice since time of enucleation, (b) recruitment of the resources (possibly cortical) normally assigned to the missing eye, and (c) the absence of binocular inhibitory interactions as a result of the removal of one eye (Steinbach and González 2006). We did not find any study that used a participant who lost vision in one eye later in life. Thus, it is unclear whether or not such an individual would also show unimpaired or superior performance on spatial vision tasks.

Just as the lack of binocular rivalry may be partially responsible for the superior performance of enucleates on spatial tasks, its presence may prove a disadvantage for binocular individuals wearing an eye patch. Steeves et al. (2004) compared global shape discrimination of enucleated individuals with binocular participants viewing binocularly, wearing an eye patch (monocular), or with one eye viewing a luminance-matched grey field (dichoptic viewing). Performance was measured on both high and low contrast shapes. Performance of the enucleated individuals was similar to that of the binocular viewing controls. Performance in the dichoptic condition was midway between the binocular and the eye patch conditions. The implication of this is that experimental comparisons of binocular vision to monocular viewing using an eye patch may show a monocular disadvantage that enucleates would not show, at least for spatial vision tasks, and that dichoptic viewing offers a better control.

Relevance

The importance of acuity and contrast sensitivity for performance on visual tasks having military or industrial relevance has been widely documented and the effect of degraded acuity has been demonstrated for many of those tasks (Casson et al. 1998a; b; c; d; Johnson 2008; Kumagai et al. 2006). However, in most cases, the studies have focused on a decrement in binocular acuity, i.e., visual acuity was adjusted to be the same in both eyes despite the fact that most standards require good acuity in only one eye. Moreover, in those studies, the changes in acuity that produce a performance decrement were larger than the 10 - 15% difference that is found between monocular and binocular acuity. To the best of our knowledge, there have not been any studies conducted, either basic or applied, that have examined the performance of people with poor acuity in one eye and relatively good acuity in the other eye.

Most assessments (Evans and Ginsburg 1985; Ginsburg et al. 1982; Kumagai et al. 2006) of the impact of contrast sensitivity have not systematically manipulated the participants' contrast sensitivity (other than as a by-product of manipulating visual acuity). They primarily show a correlation between task performance and performance on a contrast sensitivity test as opposed to defining the level of contrast sensitivity associated with a significant decrement in task performance. To do so would require knowledge of the spatial frequencies being used in the task and the ability to systematically degrade those frequencies.

Based on the literature cited above, it is not clear that one can artificially replicate the capabilities of monocular individuals. Thus, the legitimacy of any assessment of the impact of monocular vision on tasks requiring good visual acuity or contrast sensitivity is questionable. In the study by Nicholas et al. (1996), participants enucleated in their early teens had poorer contrast sensitivity than those enucleated in the first two years of life, but it was not significantly different from the contrast sensitivity of binocular individuals. Unfortunately, none of the studies reviewed to date used individuals enucleated as adults. In addition, the results of Steeves et al. (2004) indicate that some of the performance decrement with binocular individuals viewing monocularly may be due to the use of an eye patch.

Motion Perception

Description

Motion perception involves the assessment of the direction and rate of movement of objects in space relative to the observer. As with static depth perception, both monocular and binocular cues can be used. One example is motion in depth (objects moving towards or away from the observer). As an object moves towards the observer, the two retinal images move in opposite directions and its perceived size increases. The change in relative direction is a binocular cue and the change in size is a monocular cue.

Current standards

There is no standard or clinically accepted test for measuring motion perception. One relatively simple method is to measure visual acuity for motion-defined letters (Regan and Hong 1990). Another method, used in both the laboratory and in the field, is time to collision (TTC). Participants are asked to judge the time at which an object will reach a specific location or collide with another object or the observer (Kumagai et al. 2005). Research by Regan and colleagues (Hong and Regan 1989; Regan et al. 1979; Regan et al. 1986) has shown that some individuals with normal frontal plane motion perception and normal static stereo acuity may be blind to motion in depth in some parts of their visual field.

Research

Gray and Regan (1998) examined the relative importance of monocular and binocular cues in estimating TTC. They found that when both binocular (change in retinal disparity) and monocular (change in size) cues were available and large targets (.7° of visual angle at the initial distance) were used, errors ranged from 1.3 to 2.7%. This compared to 5.8 to 12% when only monocular information was available. With the smaller target, TTC could not be reliably estimated with only monocular information. As with stereoacuity, these results would apply to relatively small distances from the observer.

Unlike spatial vision, the performance of people enucleated early in life on tasks such as discrimination of relative motion, motion coherence, direction discrimination, motion-defined letter detection and discrimination, and motion in depth (TTC) is either equivalent or poorer than that of binocular individuals viewing monocularly (Steeves et al. 2008). For example, Steeves et al. (2000) found that enucleated observers had equivalent or poorer TTC estimates than binocular controls using only monocular information. Errors in estimating TTC were about 10% for enucleated observers compared to less than 3% for binocular observers found in the study by Gray and Regan (1998). They noted that these results were at odds with the ability of monocular individuals to carry out tasks successfully in the real world that required accurate estimation of TTC. They suggested that monocular individuals have learned to use other optical variables such as perceived distance and perceived size. In a familiar environment, these types of cues could be used reliably. However, they could produce degraded performance in an unfamiliar environment. This effect has been observed with binocular pilots who must operate in unfamiliar terrain (e.g., populated by small bushes rather than large trees) and discover they are flying closer to the ground than they thought. For binocular individuals, this type of error is restricted to large distances as encountered in flight. With monocular individuals, it could occur at relatively short distances as encountered in an urban environment. A study by Cavallo and Laurent (1988) provides some supporting evidence. They looked at estimates of TTC under actual driving conditions as a function of experience, speed, restricted FOV, and monocular versus binocular vision. They found that the binocular performance of both inexperienced and experienced drivers was superior to their monocular performance with targets between 25 and 75 metres in distance from the vehicle.

Relevance

Motion perception is important in a wide range of tasks (Kumagai et al. 2005), but Casson et al. (1998a; b; c; d) did not find it to be critical in any of the tasks for the occupations they reviewed. Moreover, as stated above, it is not clear that the limitations imposed by monocular vision hamper the performance of every-day tasks. In addition, many binocular individuals lack stereo motion perception in certain parts of the visual field (Hong and Regan 1989; Steeves et al. 2000).

Visual field of view (FOV)

Description

FOV is a measure of the spatial extent of vision without head movements or the degree of peripheral vision. Individuals with normal binocular vision typically have a horizontal FOV of greater than 200° as compared to less than 160° for individuals with monocular vision[3]. However, both of these depend on the fixation position of the eyes (Good et al. 2005). The decrement with monocular vision occurs because the nose blocks almost all of the nasal visual field. If the point of fixation is nasalward (as would happen with eye movements to compensate for monocularity), the horizontal extent of the visual field can be less than 120° in each eye.

Current standards

CFP 154 does not specify a minimum FOV. However, an ASIC report on vision standards for aircrew (Air Standardization Coordinating Committee 2003) states that a loss of peripheral vision (due to eye disease or scotoma) would be grounds for rejection of a pilot in the CF. In the US Army, any restriction in visual field due to disease of the eye or central nervous system, or trauma is disqualifying (Medical Services 2008). The US Air Force (Air Force Medical Operation Agency 2006) and the US Navy (Bureau of Medicine and Surgery 2005) have similar requirements.

Research

The relationship between restricted visual fields and driving performance has been examined extensively. Johnson and Keltner (1983), in a large scale study, found that people with binocular visual field defects had accident and violation rates more than double those of age- and sex-matched control participants. However, there was no difference between monocular drivers and the control group. The findings for evaluations of driving performance are similar. For example,

[3] Most perimetry tests only assess peripheral vision up to 75°. This would result in an estimate of 150° binocular FOV and a 105° monocular FOV.

Wood and Troutbeck (1992) found that the loss of visual field associated with monocular vision had only a minor impact on driving performance, at least for young drivers under good illumination. Decrements in driving performance typically only occurred when the visual field was reduced binocularly to less than 40°.

Casson et al. (1995; 1998a; b; c; d) investigated the role of peripheral vision in performing a range of simulated tasks in four MOSID categories. Detection performance was assessed with FOVs of full, 120, 60, and 30°. None of the studies looked at monocular vision. In most cases, performance was significantly poorer if the visual field was degraded to 60° or less, especially in situations where two objects were presented simultaneously. However, in the boatswain MOSID (Casson et al. 1998b), performance was significantly degraded even with a 120° FOV, and the ability to detect two events simultaneously fell to 20%. The simulated boatswain task was to detect hazardous events while maintaining tension on a rope being heaved in or checked away on a ship.

The usefulness of head movements to compensate for a limited FOV has been studied by Good et al. (2005) and Lövsund et al. (1991). Good et al. had binocular participants detect which of eight lights, equally spaced in a 360° arc around them, had flashed. On each trial, a light was flashed for either .1 or .8 seconds, .5, .75 or 1 second after the onset of a warning tone. Participants carried out the task monocularly and binocularly and could make eye, head, or body movements. Detection performance was significantly poorer in the monocular condition despite the fact that their head movements were not restricted. However, the results could be attributed to lack of experience. Lövsund et al. compared the detection performance of people with and without visual defects (including monocular vision) in a driving simulator. Among the three monocular participants, one performed normally, the second showed prolonged reaction times on the blind side for medium and small stimuli, and the third showed prolonged reaction times for all sizes of stimuli on the blind side, although head movements were not restricted. Among the participants with visual field defects other than monocular vision, the participant that compensated best had a significantly different search scanning pattern than the participant with the poorest detection performance.

Standard FOV or perimetry tests assess the participant’s ability to detect a flash of light at different eccentricities. More recently, researchers and clinicians have started to assess the useful field of view (UFOV). Ball et al. (1988) defined the UFOV as the total visual field area in which useful information can be acquired without head and eye movements. Studies with older drivers (Ball et al. 1988; Scialfa et al. 1987) have found that the UFOV is a better predictor of visual performance than the perimetry tests used in clinical assessments of FOV (Beard et al. 2002). In a follow-up to their 1992 study, Wood et al. (1993) examined the correlation between driving performance and functional field tests. A significant correlation was found between driving performance and functional visual fields for a high cognitive load. Participants with artificial monocular vision typically performed similar to participants without artificial visual impairment on the UFOV test at all eccentricities (out to 23°) as well as on the driving performance tests. However, they did perform significantly poorer on the Humphrey field-analyser which assesses performance out to 75° eccentricity.

Relevance

Peripheral vision has been identified as a critical function for a wide range of military tasks. (Casson et al. 1998a; b; c; d; Kumagai et al. 2005). For infantry, it was considered to be critical during driving, patrolling, surveillance, and firing a weapon. For boatswains, critical tasks requiring peripheral vision included manipulating hawsers and the anchor chain and operating and loading cranes and davits. For the aircraft mechanic, it was required for detecting problems on the flight line, while for mobile support equipment operators, it was considered to be critical for refuelling aircraft, operating heavy equipment, and teaching. Pilots identified it as critical in detecting warning lights inside the cockpit, birds and other aircraft outside the cockpit, and in ascertaining where the aircraft is relative to the horizon. The latter aspect is particularly critical for shipboard landings.

While peripheral vision is clearly important, restriction of the visual field associated with monocular vision does not seem to have a demonstrable effect – unlike reducing the visual field binocularly. However, as with the research on other visual capabilities, most of the studies have investigated performance of people during daylight, using relatively simple tasks and or familiar environments. Under conditions of high cognitive load or where the observer must monitor different parts of the visual field simultaneously, small decrements in the visual field have been shown to be important. The requirement to function in unfamiliar terrain and under low levels of illumination may also create a sufficiently high cognitive load to degrade the performance of people with monocular vision on tasks requiring peripheral vision.

Discussion

Spatial vision

Based on relevance and existing standards, the most important visual capability potentially impacted by monocular vision is spatial vision. The CFP 154 requires at least some vision in both eyes. The preponderance of research indicates that binocular spatial vision is superior to monocular spatial vision especially under low illumination and/or low contrast conditions. The benefit is often attributed to binocular concordance or the flow of similar optical information to the two eyes. However, there are several caveats to this conclusion. Most of this research compares binocular individuals viewing binocularly or with one eye occluded by an eye patch. Recent research (Nicholas et al. 1996; Steeves et al. 2008) comparing binocular individuals with monocular individuals enucleated at a young age finds that the performance of the enucleated individuals is equivalent, and in some cases even superior, to binocular controls. However, not all monocular applicants to the CF will fall into this group. Unfortunately, very little data have been collected on individuals enucleated later in life. What is available suggests that the spatial capabilities of late enucleates is poorer than binocular controls. A second issue is the use of an eye patch when evaluating monocular vision. Some researchers (Steeves et al. 2004; Steinbach and González 2006) suggest that the poor performance by people using an eye patch is due in part to binocular rivalry induced by the eye patch. They recommended replacing the eye patch with a featureless field of equivalent brightness.

A further limitation with many of the studies, including those carried out on early enucleates, is that they have been carried out under normal illumination conditions. The limited research available on performance in low illumination (Home 1977; Johnson 2008; Jones and Lee 1981) suggests that performance was poorest when participants carried out tasks monocularly under dim illumination. However, all of those studies employed binocular controls using an eye patch. A review of the generic tasks, (e.g., the requirement to carry out a high crawl and a low crawl, and to evacuate personnel during a fire on board a ship or across open country under a wide range of climatic and illumination conditions) indicates that data are required on the performance of enucleated individuals under low illumination and low contrast conditions. However, based on a study by Rabin (1994), visual acuity can decrease by a factor of three when luminance is decreased from 100 to 0.1 Cd/m^2.

If the main benefit of two eyes is due to binocular concordance, what happens as the spatial vision capabilities of the two eyes become less similar? The literature does not appear to answer this question. Most visual standards, including the CF entrance standard, allow substantive differences in the visual acuity of the two eyes. However, when the impact of performance on visual acuity is assessed, both eyes are degraded equally. Thus, it is not known if there are significant differences in performance among individuals with 6/9 corrected in both eyes, 6/60 corrected in their weaker eye (and by definition, legally blind in that eye (Vargo 2010)) and monocular individuals.

Other visual capabilities

Monocular vision can also affect depth perception, motion perception, and FOV. While the effects are measurable, it is less likely that the reduction in these capabilities could readily be used to reject people with monocular vision. The utility of binocular vision in depth and motion perception is limited to short distances. Thus, while it may be critical for a few trades, there is little evidence that a lack of stereopsis and/or stereo motion perception would limit performance on the majority of critical tasks. A possibly more compelling argument is the fact that there is no standard for either capability. In addition, as stated earlier, a significant portion of binocular individuals with good visual acuity have degraded stereopsis or stereo motion. Testing for either could have unintended consequences.

The findings for FOV are similar. Very few studies on monocular vision have found it to have a significant effect on tasks requiring peripheral vision. Population studies draw a similar conclusion. However, as with other visual functions, very little of the research has looked at performance under low luminance levels or high cognitive load. Based on the existing literature, it would be difficult to reject people with monocular vision on the basis of a limited FOV.

Other issues

One issue that the literature on monocular vision does not seem to consider is redundancy. In the military, redundancy has been used to justify the requirement for personnel to have a higher level of visual capability than may be justifiable in civilian occupations (G. Gray, personal communication, November 2010). Military personnel are routinely exposed to extremely hazardous working conditions that could result in temporary or permanent loss of vision in one eye during the execution of a mission. In such a situation, binocular individuals would still have sufficient visual capability to extract themselves from the hazardous situation. If the loss occurred in the good eye, individuals with monocular vision would now be completely blind. However, as discussed above, individuals with 6/60 corrected in the undamaged eye might be at equivalent risk especially if corrective lenses were damaged or lost.

Conclusion and recommendations

Based on the literature surveyed, it is likely that the performance of some individuals with monocular vision will be inferior on some tasks to that of binocular individuals with good visual acuity in both eyes, especially under low illumination and low contrast conditions. However, it is not possible to state unequivocally that people with monocular vision would perform more poorly than people that just meet the minimum entrance standards for visual acuity. The research to answer that question does not appear to exist. For that reason, it is recommended that the CF conduct a study to establish the BFOR for the general visual acuity standard for new recruits.

Since generic task statements exist (Canadian Forces Health Services 2009), they should serve as a good starting point for developing suitable tasks for evaluating performance of people with different visual acuity in their two eyes. In addition, the generic task statements indicate that applicants must be able to complete the tasks under a wide range of climatic conditions which would include low luminance and low contrast. Once suitable tasks have been selected, the participants would be required to carry out these tasks with both eyes corrected to 6/9 or with one eye corrected to 6/9 and the other eye corrected to 6/18, 6/36, 6/60 or 6/∞ (monocular). These levels are based on previous work conducted by Casson et al. (1998a; b; c; d). Pilot testing may allow the number of levels to be reduced. For the monocular condition, dichoptic viewing (a luminance matched grey field) should be used to minimize the effects of binocular rivalry. If at all possible, participants with monocular vision should be recruited to carry out these tasks as well. The tasks should be carried out under normal and low illumination, and normal and low contrast conditions. The papers by Home (1977) and Johnson (2008) should provide useful guidance on this aspect of the study.

References

Air Force Medical Operation Agency (2006), Medical examinations and standards Volume 3 - Flying and special operational duty, (Air Force Instruction 48-123V3), Air Force Medical Operation Agency, Aerospace Medicine Directorate, Bolling AFB.

Air Standardization Coordinating Committee (2003), Pilot entry vision standards, (INFO PUB 61/115/11D), Air Standardization Coordinating Committee.

Allison, R. S., Gillam, B. J., and Vecellio, E. (2009), Binocular depth discrimination and estimation beyond interaction space. *Journal of Vision*, 9 (1), 10.1-14.

Ball, K., Beard, B. L., Roenker, D. L., Miller, R. L., and Griggs, D. S. (1988), Age and visual search: expanding the useful field of view. *Journal of the Optical Society of America A*, 5 (12), 2210- 2219.

Beard, B. L., Hisle, W. A., and Ahumada Jr., A. J. (2002), Occupational vision standards: A review, (Report for FAA AAR-100), NASA Ames Research Center, Moffett Field, CA.

Bureau of Medicine and Surgery (2005), Physical examinations and standards for enlistment, commission, and special duty, In *Manual of the Medical Department*, Washington, DC: U.S. Navy Bureau of Medicine and Surgery.

Canadian Forces Health Services, (2009), Medical standards (Online), Canadian Forces Health Services, http://www.forces.gc.ca/health-sante/pd/cfp-pfc-154/default-eng.asp (19 October 2010).

Canadian Human Rights Commission, (2004), Preventing Discrimination, Tools and Resources, Boan Fide Occupational Requirements (Online), Canadian Human Rights Commission, www.chrc-ccdp.ca/preventing_discrimination/page4-eng.aspx (19 October 2010).

Casson, E. J. (1995), Report on the feasibility of developing task-oriented visual standards for the Canadian Forces, (DDS #08SV.W8477-4-SC07), Ottawa University Eye Institute, Ottawa, ON.

Casson, E. J., McGinnis, J., Gibbs, G. G., and Cameron, B. (1998a), Vision requirements for job tasks of CF infantry trade (MOC 031), (Technical Report prepared for D. Med. Services, DND), BC Research Inc., Vancouver, BC.

Casson, E. J., McGinnis, J., Gibbs, G. G., and Cameron, B. (1998b), Final report for development of entry level visual standards for Boatswains (MOC 181), (Technical Report prepared for D. Med. Services, DND), BC Research Inc., Vancouver, BC.

Casson, E. J., McGinnis, J., Gibbs, G. G., and Cameron, B. (1998c), Final report for development of entry level vision standards for Avionics Technicians (MOC 526), (Technical Report prepared for D. Med. Services, DND), BC Research Inc., Vancouver, BC.

Casson, E. J., McGinnis, J., Gibbs, G. G., and Cameron, B. (1998d), Final report for MSE Operators(MOC 935), (Technical Report prepared for D. Med. Services, DND), BC Research Inc., Vancouver, BC.

Cavallo, V. and Laurent, M. (1988), Visual information and skill level in time-to-collision estimation. *Perception*, 17 (5), 623-632.

Evans, D. W. and Ginsburg, A. P. (1985), Contrast sensitivity predicts age-related differences in highway-sign discriminability. *Human Factors*, 26 (6), 637-642.

Ginsburg, A. P., Evans, D. W., Sekuler, R., and Harp, S. A. (1982), Contrast sensitivity predicts pilots' performance in aircraft simulators. *American Journal of Optometry and Physiological Optics*, 59 (1), 105-109.

González, E. G., Steinbach, M. J., Ono, H., and Wolf, M. E. (1989), Depth perception in children enucleated at an early age. *Clinical Vision Science*, 4 (2), 173-177.

Good, G. W., Fogt, N., Daum, K. M., and Mitchell, G. L. (2005), Dynamic visual fields of one-eyed observers. *Optometry*, 76 (5), 285-292.

Gray, R. and Regan, D. (1998), Accuracy of estimating time to collision using binocular and monocular information. *Vision Research*, 38 (4), 499-512.

Home, R. (1977), Experimental assessment of monocular and binocular vision, (RARDE Technical Report 2/77), Royal Armament Research and Development Establishment, Fort Halstead, Kent, U.K.

Hong, X. and Regan, D. (1989), Visual field defects for unidirectional and oscillatory motion in depth. *Vision Research*, 29 (7), 809-819.

Hovis, J. K. (2000), Establishing a Bona Fide Occupational Requirement and validated standards for vision: A review, In N. Gledhill, J. Bonneau, and A. Salmon (Eds.), *Proceedings of the consensus forum on establishing Bona Fide requirements for physically demanding occupations*, 123-133, Toronto, ON.

Johnson, C. A. and Keltner, J. (1983), Incidence of visual field loss in 20,000 eyes and its relationship to driving performance. *Archives of Ophthalmology*, 101.

Johnson, C. A. (2008), Occupational psychophysics to establish vision requirements. *Optometry And Vision Science*, 85 (10), 910-923.

Jones, R. K. and Lee, D. N. (1981), Why two eyes are better than one: The two views of binocular vision. *Journal of Experimental Psychology: Human Perception and Performance*, 7 (1), 30-40.

Kumagai, J. K., Williams, S., and Kline, D. (2005), Vision standards for aircrew: Visual acuity for pilots, (DRDC-TORONTO-CR-2005-142), Greenley and Associate Inc., Ottawa.

Kumagai, J. K., Kline, D., Tryan, J. L., Shorten, J. A., and Jung, G. H. (2006), Far and near visual acuity standards for Canadian Forces aircrew, (DRDC-TORONTO-CR-2006-255), Greenley and Associate Inc., Ottawa.

Lövsund, P., Hedin, A., and Törnros, J. (1991), Effects on driving performance of visual field defects: a driving simulator study. *Accident; Analysis and Prevention*, 23 (4), 331-342.

Marotta, J. J., Perrot, T. S., Nicolle, D., and Goodale, M. A. (1995), The development of adaptive head movements following enucleation. *Eye*, 9, 333-336.

Medical Services (2008), Standards of medical fitness, (Army Regulation 40-501), Medical Services, Department of the Army, Washington, D.C.

Nicholas, J. J., Heywood, C. A., and Cowey, A. (1996), Contrast sensitivity in one-eyed subjects. *Vision Research*, 36 (1), 175-180.

Rabin, J. (1994), Luminance effects on visualacuity and small letter contrast sensitivity. *Optometry and Vision Science*, 71 (11), 685-688.

Rabin, J. (1995), Two eyes are better than one: binocular enhancement in the contrast domain. *Ophthalmology and Physiological Optics*, 15 (1), 45-48.

Regan, D., Beverley, K., and Cynader, M. (1979), The visual perception of motion in depth. *Scientific American*, 241, 136-151.

Regan, D., Erkelens, C. J., and Collewijn, H. (1986), Visual field defects for vergence eye movements and for stereomotion perception. *Investigative Ophthalmology and Visual Science*, 27, 806-819.

Regan, D. and Hong, X. H. (1990), Visual acuity for optotypes made visible by relative motion. *Optometry and Vision Science*, 67, 49-55.

Richards, W. (1971), Anomalous Stereoscopic Depth Perception. *Journal of the Optical Society of America*, 61 (3), 410-414.

Scialfa, C. T., Kline, D. W., and Lyman, B. J. (1987), Age differences in target identification as a function of retinal location and noise level: examination of the useful field of view. *Psychology and Aging*, 2 (1), 14-19.

Steeves, J. K. E., Gray, R., Steinbach, M. J., and Regan, D. (2000), Accuracy of estimating time to collision using only monocular information in unilaterally enucleated observers and monocularly viewing normal controls. *Vision Research*, 40, 3783-3789.

Steeves, J. K. E., Wilkinson, F., González, E. G., Wilson, H., and Steinbach, M. J. (2004), Global shape discrimination at reduced contrast in enucleated observers. *Vision Research*, 44, 943-949.

Steeves, J. K. E., González, E. G., and Steinbach, M. J. (2008), Vision with one eye: a review of visual function following unilateral enucleation. *Spatial Vision*, 21 (6), 509-529.

Steinbach, M. J. and González, E. G. (2006), Visual development with one eye, In M. R. M. Jenkin and L. R. Harris (Eds.), *Seeing Spatial Form*, 385-404, NY, USA: Oxford University Press.

Vargo, F., (2010), Disabilities (Online), The Canadian Encyclopedia, http://www.thecanadianencyclopedia.com/index.cfm?PgNm=TCE&Params=A1ARTA0002310 (18 November, 2010).

Williams, S., Casson, E., Brooks, J., Greenley, M., and Nadeau, J. (2003), Visual acuity standard for divers, Greenley & Associates Incorporated, Ottawa, ON.

Wood, J. M. and Troutbeck, R. (1992), Effect of restriction of the binocular visual field on driving performance. *Ophthalmology and Physiological Optics*, 12 (3).

Wood, J. M., Dique, T., and Troutbeck, R. (1993), The effect of artificial visual impairment on functional visual fields and driving performance. *Clinical Vision Sciences*, 8 (6), 563-575.

List of symbols/abbreviations/acronyms/initialisms

ASIC	Air and Space Interoperability Council
BFOR	Bona Fide Occupational Requirements
Cd/m^2	Candela / $metre^2$: SI unit for luminance.
CF	Canadian Forces
CF H Svcs Gp	Canadian Forces Health Services Group
CFP	Canadian Forces Publication
DRDC	Defence Research and Development Canada
DRDKIM	Director Research and Development Knowledge and Information Management
FOV	Field of View
MOC	Military Occupational Category
MOSID	Military Occupational Structure Identification
TTC	Time to Collision
UFOV	Useful field of view
US	United States
UK	United Kingdom

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1. ORIGINATOR (The name and address of the organization preparing the document, Organizations for whom the document was prepared, e.g. Centre sponsoring a contractor's document, or tasking agency, are entered in section 8.) Publishing: DRDC Toronto Performing: DRDC Toronto Monitoring: Contracting:		2. SECURITY CLASSIFICATION (Overall security classification of the document including special warning terms if applicable.) UNCLASSIFIED
3. TITLE (The complete document title as indicated on the title page. Its classification is indicated by the appropriate abbreviation (S, C, R, or U) in parenthesis at the end of the title) Monocular vision: Occupational limitations and current standards (U) Vision monoculaire : Restrictions professionnelles et normes en vigueur (U)		
4. AUTHORS (First name, middle initial and last name. If military, show rank, e.g. Maj. John E. Doe.) Sharon M. McFadden; Justin G. Hollands		
5. DATE OF PUBLICATION (Month and year of publication of document.) March 2011	6a NO. OF PAGES (Total containing information, including Annexes, Appendices, etc.) 30	6b. NO. OF REFS (Total cited in document.) 46
7. DESCRIPTIVE NOTES (The category of the document, e.g. technical report, technical note or memorandum. If appropriate, enter the type of document, e.g. interim, progress, summary, annual or final. Give the inclusive dates when a specific reporting period is covered.) Technical Report		
8. SPONSORING ACTIVITY (The names of the department project office or laboratory sponsoring the research and development – include address.) Sponsoring: Tasking: Canadian Forces Health Services Group		
9a. PROJECT OR GRANT NO. (If appropriate, the applicable research and development project or grant under which the document was written. Please specify whether project or grant.)		9b. CONTRACT NO. (If appropriate, the applicable number under which the document was written.)
10a. ORIGINATOR'S DOCUMENT NUMBER (The official document number by which the document is identified by the originating activity. This number must be unique to this document) DRDC Toronto 2010–166		10b. OTHER DOCUMENT NO(s). (Any other numbers under which may be assigned this document either by the originator or by the sponsor.)
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(U) At the request of the Canadian Forces (CF) Health Services Group, Defence Research and Development Canada (DRDC) – Toronto conducted a literature review on the occupational limitations of monocular vision including recommendations for further work if required. The current CF vision standard for new recruits covers only near and far visual acuity and colour vision. The general entry standard for far visual acuity is a minimum of 6/9 corrected in the better eye and 6/60 corrected in the other eye. Based on that standard, anyone with monocular vision would be excluded automatically. Recently, this policy has been challenged on the grounds that not all military occupational categories require binocular vision. A review of the basic and applied literature and other standards indicated that monocular vision could impact performance on critical military tasks requiring good spatial vision, especially under low illumination and low contrast conditions. However, most of the research compared the performance of people with good visual acuity or contrast sensitivity in both eyes against the same people wearing an eye patch. Research using people with monocular vision finds smaller differences, and in the case of people enucleated early in life, equivalent performance. Possibly more importantly, none of the research has compared people meeting the minimum visual acuity standards for entry into the CF to monocular controls. It is recommended that the performance of people in these two populations should be compared on critical occupational tasks, under low illumination and low contrast conditions. Some of the difficulties in carrying out these recommendations are identified.

(U) À la demande du Groupe des services de santé des FC, Recherche et développement pour la défense Canada (RDDC) – Toronto a procédé à une analyse documentaire des restrictions professionnelles touchant la vision monoculaire, en plus de formuler des recommandations quant aux études plus poussées qui pourraient s’imposer. La norme applicable aux recrues des Forces canadiennes (FC) ne porte que sur l’acuité en vision de près et de loin et que sur la perception des couleurs. La norme générale d’admissibilité en ce qui concerne l’acuité en vision de loin est d’au moins 6/9 avec correction dans l’œil le plus fort et 6/60 avec correction dans l’autre œil. Selon cette norme, une personne dont la vision est monoculaire serait exclue automatiquement. Dernièrement, cette politique a été contestée du fait que les catégories professionnelles militaires n’exigent pas toutes une vision binoculaire. Selon un examen de la recherche fondamentale et appliquée et d’autres normes en vigueur, la vision monoculaire pourrait avoir une incidence sur la qualité de l’exécution de tâches militaires essentielles qui exigent une bonne vision spatiale, particulièrement lorsque l’éclairement lumineux est faible et que les contrastes sont faibles. Cependant, la majorité des chercheurs ont comparé le rendement de personnes dotées d’une bonne acuité visuelle ou d’une bonne sensibilité différentielle dans les deux yeux, à celui des mêmes personnes portant un cache−œil. Les études faisant intervenir des sujets dotés d’une vision monoculaire ont relevé de plus faibles écarts, et même un rendement équivalent dans le cas des sujets énucléés tôt dans leur vie. Un facteur pourrait être encore plus important : aucune des études ne compare des groupes témoins monoculaires et des sujets qui atteignent la norme minimale d’acuité visuelle établie pour l’admissibilité dans les FC. On recommande de comparer le rendement de ces deux groupes durant l’exécution de tâches militaires essentielles, lorsque l’éclairement lumineux est faible et que les contrastes sont faibles. Certaines des difficultés inhérentes à l’application de ces recommandations sont mentionnées.

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(U) Vision standards; monocular vision; binocular vision; stereoacuity; visual acuity; contrast sensitivity; depth perception; motion perception; field of view

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