WELCOME...

to the annual Airprox Magazine 2018

Welcome to the Airprox Magazine for 2018. This, our sixth edition, builds on previous years by focusing on the ins-and-outs of lookout and how the eye works.

Most people know the eye's an imperfect tool in aviation, so we have to work hard to overcome its deficiencies. Although ATC and electronic systems can provide vital situational awareness, in the end the pilot needs to see what he or she is avoiding.

While some material might be familiar, it does no harm to review strategies both for visual scanning and prioritising cockpit activities. If you want to find out more about lookout there's a really good study titled The Limitations of the See-And-Avoid Principle by Alan Hobbs of the Australian Transport Safety Bureau in April 1991 which you can link to by clicking here or simply searching for the title on the internet.

I've also included a section on the Airprox statistics for 2017. Hopefully it will also provide food for thought — how can you maximise the protection offered by mid-air collision safety barriers? The increasingly affordable collision warning systems seem to be a quick-win. The bottom-line is that it's clear that the majority of Airprox could be avoided if only the pilots had known the other aircraft was there.

Suffering an Airprox doesn't make anyone a bad pilot, but failing to report one means that everyone loses the opportunity to learn from the incident. I'm deeply grateful to those who do report, so do follow their example.

As with everything else these days, *'There's an app for that!'*; click on the links here or search for UKAB and you can download our App that has a reporting section, previous reports plus you can learn more about us.

GET IT ON Google Play   Download on the App Store

PUBLICATION CONTENT.
Unless expressly stated as CAA or MAA policy, the views expressed in Airprox do not necessarily reflect the policy of the Civil Aviation Authority or Military Aviation Authority. Articles are intended to stimulate discussion.

Publisher CAA UK Airprox Board, RAF Northolt, West End Road, Ruislip, Middlesex, HA4 6NG

Tel: 020 8842 6051
E: contact@airproxboard.org.uk

UK AIRPROX BOARD

How the eye CAN LIE

How many times have you said 'I just didn't see it…' Failing to spot something might not be your fault, but down to momentary 'blindness'

By PAUL SHEFFIELD

Most of us probably reckon we carry out a pretty good lookout when flying, but what about the eye — would it surprise you to know that it can lie without you even knowing it? How many times, for example, have you heard people say "I never saw the person, the bike or even the truck", it's not that they weren't looking, but rather that the eye wasn't seeing.

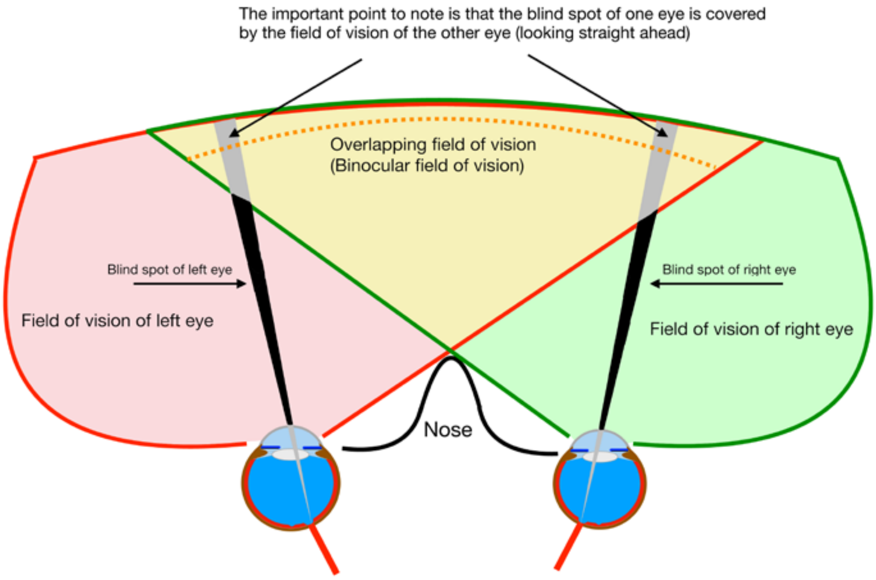
Remember the recently revived adverts from the Seventies fronted by actor Edward Judd that warned drivers to '*Think Once, Think Twice, Think Bike*'? The point wasn't simply about looking and thinking, it was also to give your eyes an opportunity to overcome a physical issue with eyesight — saccades, or momentary blind spots. Here's how it works.

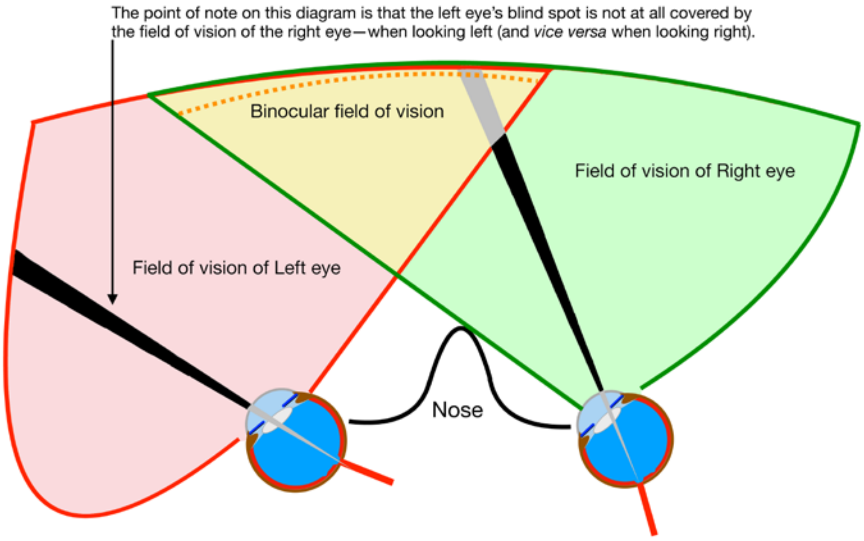
Just imagine for a moment you're sitting in a car at a 'T' junction as a cyclist rides past on a main road in front. You'll follow their path smoothly from right to left and see everything along that path, but try moving your eyes just as smoothly when there's no bike to follow, you can't it's impossible. You won't be aware of it, but without something to track your eyes will be moving in sudden jerks, or saccades, then pausing for a moment (fixating), before another saccade and so on.

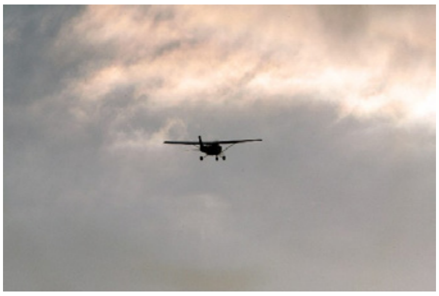
During this very rapid and short — around 20–200 milliseconds — saccadic eye movement you are effectively blind. This is because the brain suspends vision during the saccade and nothing new is seen for that small duration. If that wasn't the case the world would whizz past in a very blurred and disconcerting fashion.

There is, of course, a related process that causes the same suspension of vision — blinking.

During normal subconscious blinking the world doesn't go dark (or pink if it's a sunny day) as the light is cut off or filtered by the closed eyelids. Vision is momentarily suspended during a blink until the image can be updated. The same is true with a saccade, in fact a more complete cut-off occurs, vision is only updated when our eyes have come to rest and had a moment to interpret the image.







As a collision threat approaches, its size on the retina roughly doubles with each halving of the separation distance, so colliding aircraft stay relatively small until shortly before impact when it all happens rather quickly

The consequence of this is that with large saccadic eye movements we could easily jump over any number of aircraft while we are 'blind' and if there are none where our eyes come to rest, or fixate, we will assume there are none anywhere. Even a bright flash of light would not be seen during a saccadic eye movement — you are effectively totally blind for that short moment.

If an aircraft is moving relative to us in that jumped over part of the visual scene, we might see it after the saccade ceases if our peripheral vision detects movement, but if it's on a constant relative bearing (collision course) it's very probable we wouldn't see it until it's alarmingly large in the field of view.

In addition to saccades, understanding how the visual system works explains why you so often hear "I just didn't see it…".

Light enters the eye through the cornea, continues through the pupil and adjustable crystalline lens and finally falls into focus in the form of an image on the retina. This retinal image is analysed by more than 100 million light sensitive cells, and a huge number of additional cells that convert the light (i.e. image) to nerve impulses.

The result is only superficially analysed in the retina and so is compressed and sent to the brain for further interpretation. Note that compression of the data means assumptions have to be made by the retina. The main thing it does is to break down the image into edges and contours — a contour map of edges.

One of the biggest assumptions is that anything within a given contour is assumed to be uniform, in other words nothing else exists within that particular boundary. There are roughly one million nerve fibres leaving the retina (the optic nerve) so clearly there has been at least a 100:1 data compression of the 100 million light sensitive cells. It's also worth looking at the retina's two types of light sensitive cells in more detail: rods and cones.

Cones require a lot more input energy (brightness) to work and therefore generally only function in daylight conditions (photopic conditions). Cone cells peak in number in the centre of your retina—the macula (and the macula therefore gives rise to the centre of your field of vision and its peak resolution), and rapidly decrease in number more peripherally.

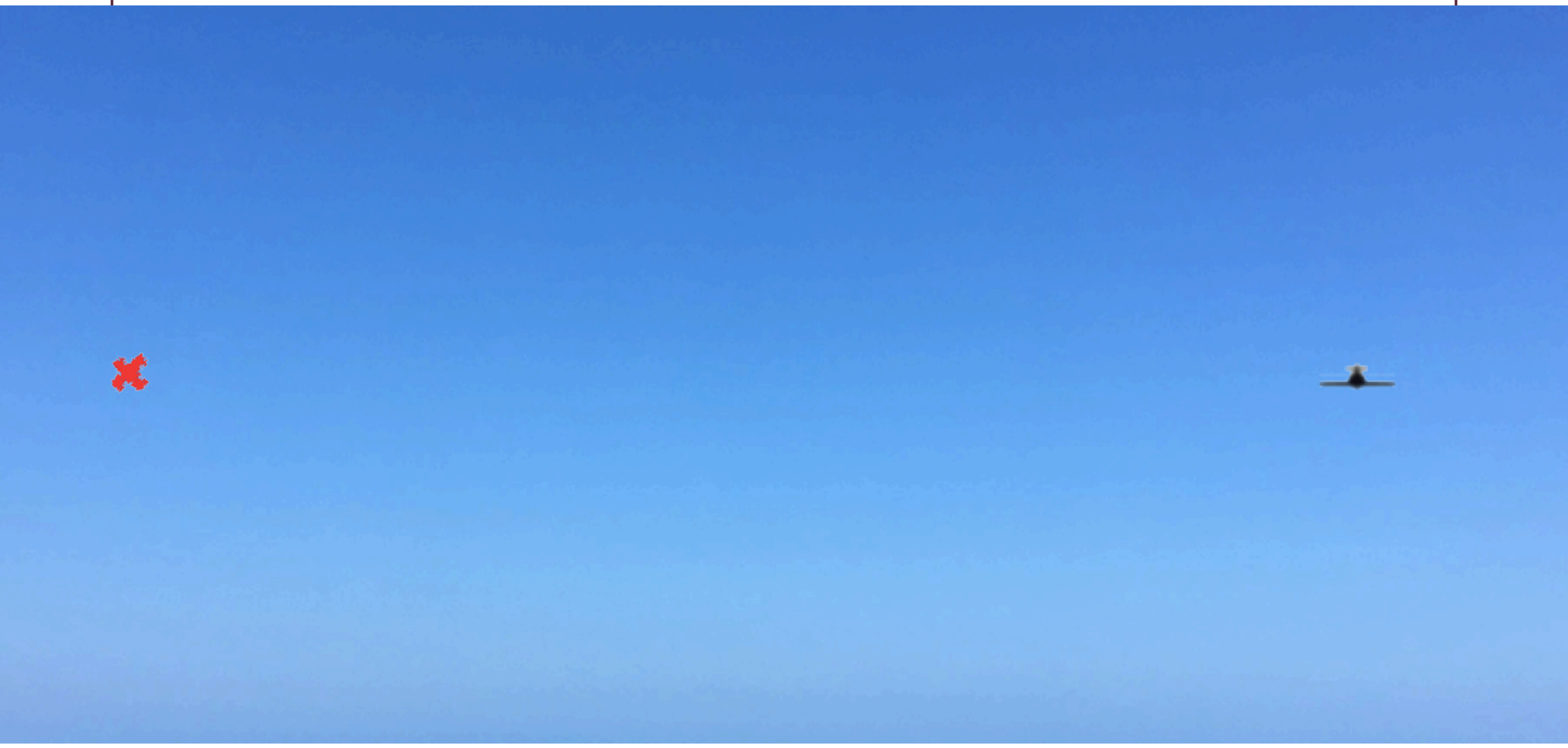
Rod cells only work in low light (scotopic conditions) and are completely bleached out and functionless in daylight conditions. Rod cells are much less numerous in the very centre of the retina (which is why a faint star appears to fade if directly looked at, and brighter if looking just to one side of it at night-time). Rod cells cannot detect colour, and so the colour of navigation

DEMONSTRATION OF THE NATURAL BLIND SPOT

Cover your left eye and look at the red cross with your right eye only. The aircraft will disappear, if it doesn't, move your head slightly closer, or further away from the page until it does. The aircraft is now in the blind spot of your right eye. Now open your left eye (while still looking at the red cross). The aircraft will re-appear, but not that obviously. The left eye's field of vision is now making up for the blind spot in the right.

Now, keep looking at the red cross with both eyes open and slowly turn your head to the left (which is in effect the same as glancing to your right without a head movement), the aircraft will disappear again as your nose cuts off the overlapping field of vision from your left eye. This could be quite a small movement if your nose is larger, or your head held slightly chin high.

This latter demonstration shows that when looking to your right, without moving your head, it is possible that an aircraft further to the right is lost in your blind spot even though your field of vision extends well beyond that point. Moving your head, ideally roughly pointing your nose in the direction you wish to scan, will allow the fellow eye to cover the other's blind spot. The same is true for the other eye if looking the other way — close your right eye, look at the aircraft with your left and the red cross will disappear.



lights are only seen by the cone cells, and they only function when there is sufficient focused light energy at night to stimulate them. Fortunately, rod cells at night are extremely sensitive and excellent at detecting flashes.

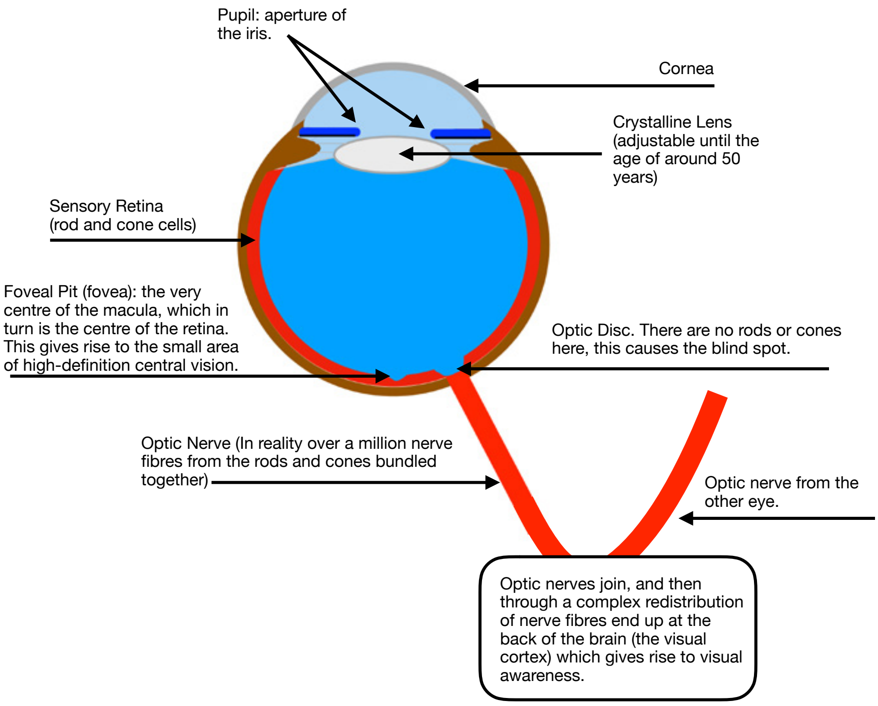
In daylight conditions then, what you might think of as one big clear, detailed picture is far from it; detail is only seen very centrally, an area roughly that of a thumbnail held at arm's length. Not only is this area small, but also an image falling on it has to be stable for a moment for retinal processing, and the higher brain centres (the pilot's attention) to be directed towards it for active interpretation. The more peripheral your field of vision the less resolution. Try reading a car number plate by moving your eyes (your point of fixation) just one car width to the side.

Meanwhile, the cones in the periphery of the retina are responsible for the peripheral visual field in daytime, and it's now motion detection that comes to dominate. You may have noticed a flickering fluorescent light bulb in your peripheral vision which appears less flickery when looked at directly. Peripheral vision is especially good at detecting motion and flicker. Movement of an object is a very important attention-grabber. This is fine if an object isn't on a constant relative bearing — a collision course.

On top of all this, the nerves from the rods and cones pass through a hole in the retina, the optic disc, which has no rods or cones so there's a small, circular area about 12.5 degrees from your absolute central vision (your fixation point), about the size of a fingernail at a hand-span's distance, where there is no vision whatsoever.

This area of blindness is to the right in the right eye, and to the left in the left eye on the horizontal plane (see images on page 4). Each eye simply fills in the blind area with whatever it sees around the edge of the blind spot, so in a blue sky it will be filled in with blue — the retinal data compression assumption. Thankfully, one eye tends to cover for the other blind spot with its visual field when looking ahead. It is possible when just moving your eyes to the left that the right eye doesn't cover the blind area in the left eye, and vice versa when looking to the right, so it's critical to move one's head when looking around to maintain a full field of vision. Just glancing to one side with little head movement may well cut off the one eye's overlapping field of vision of the other's blind spot.

So how do we lookout properly? I'm a glider pilot and I don't have my own glider, so I have to wait for a club single-seater to land. On an excellent day, when the thermals are so strong that even dustbin lids are going up and not coming down, I



search the bit of sky 'my' glider was last seen in to see where it's got to, and whether it's coming back.

I make lots of small eye movements in the area it's most likely to be, pause, look intently and examine that small bit of sky before moving a little further to the adjacent piece of sky. If on a non-flying day someone had asked me to look for an aircraft in the sky, I would probably make large saccadic eye movements, pausing for as short a time as possible so as to cover as much of the sky as possible. In reality I'd almost certainly not see an aircraft if one was there. Here lies the clue on how to lookout for other aircraft.

The first step is attitude of mind. If I think it's unlikely there's an aircraft there then the temptation is not to expect to find one and therefore not to look properly. So when looking out, absolutely assume there's someone out there. Next, look in the area of sky the threat is most likely to be.

In normal flight, most of the risk of a mid-air collision can generally be reduced by scanning an area at least 60° left and right of the intended flight path (although it's important to acknowledge this doesn't mean the rest of the sky should be forgotten).

At least 10° above and below should also be searched. Simply, the more, smaller saccades and attentive fixations the better. Move your head, too, as you look along your zone of horizon to ensure no blind spots.

Quite apart from the physiological limitations, the eyes are vulnerable to other visual distractions; lighting, foreign objects, illness, fatigue, emotion, the after-effects of alcohol, certain medications, dehydration and age all play their part. There are also additional challenges, such as atmospheric conditions, glare, deterioration of transparencies, aircraft design and cabin temperature, which all take their toll on your eyes and what you can see.

You'll probably be familiar with the problem of 'constant relative bearing', or 'stationary in the field of view', mentioned earlier where colliding aircraft have a relative bearing constant to each other until impact. The subjective effect of this is that the collision threat remains in the same place (stationary) on the canopy, so looking intently is key.

An unfortunate consequence of 'constant relative bearing' is that pilots are most likely to see aircraft that are moving in the field of view and therefore not on a collision course; frustratingly, it's the very ones on a collision course that are so hard to see because they don't move in your field of view. So moving your head, relative to the canopy or windscreen is an important aid to lookout, and helps take out the blind spots such as canopy furniture, pillars, high/low wings etc.

A quick bit more science shows that as a collision threat approaches, its size on the retina roughly doubles with each halving of the separation distance, so colliding aircraft stay relatively small until shortly before impact when it all happens rather quickly. This presents a bit of a challenge even if you do perform a good 'lookout', but it underlines the importance of apportioning the correct amount of time for a systematic and repetitious scan pattern to spot aircraft early.

It's a curious thing about flying that many pilots believe they keep a good lookout when, in reality, it's less-than-effective; glancing out and scanning with continuous eye or head movements is unproductive because for the pilot to perceive another aircraft, time is needed for a stable image of it to fall on the centre of the retina, at least about one second in fact.

Lookout should be performed using a series of small eye and head movements with intervening fixations, the latter being the only time when the outside world is really being interrogated. Carrying out regulated scans may sound a bit formulaic and, let's be honest, boring, but they do work. That said, there is no one technique that suits all situations or all pilots, so it is important to develop your own comfortable and workable scan. ■

Paul Sheffield is a glider pilot and has been an Optometrist for 35 years

IN SHORT

Ensure your eyesight is properly focused in the first place with clean spectacles and canopies, and your eyes focused in the distance.

Only a small, central area of your vision is high definition.

The peripheral retina is good at detecting movement, but an aircraft on a collision course, a constant relative bearing, has virtually no movement until the last few seconds.

You must move your head as well as your eyes for an effective lookout.

Develop a methodical scan routine, the 'rule of threes' (see next page) is a good starting point, but the more, smaller saccadic eye movements with moments of pause along your zone of interest the better.

SECONDS COUNT

How long do you reckon it takes from spotting another aircraft to hitting it – 30 seconds to a minute, maybe? You'd be wrong

If you're unlucky enough to have a very close encounter you'll have nowhere near as long as even 30 seconds to take action; a bit like a slow motion train crash everything seems to take a long time until the last few moments when it all happens in split seconds.

Apart from split-second survival instinct push or pull moments, research suggests that in normal circumstances the average pilot and aircraft needs anything up to 10-12.5 seconds (about as long as it's taken you to read to here…) from spotting another aircraft to processing the closure geometry and avoiding a potential collision in a controlled manner.

Take two PA-28s meeting head-on at around 90kt each – at the eye's maximum acuity, there's around ten seconds from the most eagle-eyed pilot seeing the other aircraft before they impact. In the first 5 seconds there's not much change in the size or motion of the oncoming PA-28, it's only in the last five seconds that it suddenly blooms in size; the mind then takes a couple of seconds to recognise it as a threat, leaving just three seconds to take action.

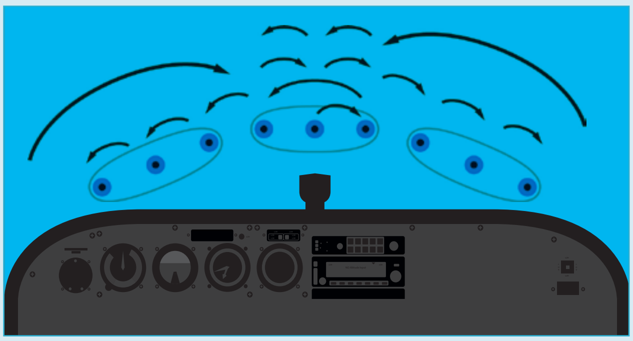
Naturally, the likelihood of spotting a potential collision increases in relation to the time spent looking out, and the best rule of thumb is the 80:20 rule – 80 percent of the time looking out and just 20 percent inside the cockpit. But just 'looking' for other aircraft isn't enough.

Glancing out and scanning with smooth and continuous eye movements is less-than-effective because, as discussed in the main article, time is needed for a stable image to fall on the centre of the retina and the pilot's attention be directed towards it.

An effective scan of the sky in front (and to the side) needs to be in a systematic and repetitious pattern. It should be performed by using a series of small eye and head movements with intervening rests, the latter being the only time when the outside world is really being interrogated.

That said; there's no one technique that suits all pilots; although horizontal back-and-forth eye movements seem preferred by most. It's important to develop a comfortable and workable scan. First, know where and how to concentrate 'lookout' on the most critical areas at any given time. In normal flight, most of the risk of a mid-air collision can generally be avoided by scanning an area at least 60° left and right of the intended flight path. This doesn't mean the rest of the area to be scanned should be forgotten. At least 10° above and below the projected flight path should also be searched.

One of the simplest and effective is the 'rule of threes' as detailed in the graphic below:



RULE OF 3s: 3 zones, 3 areas in each. Allow eyes 1 second per pause. Start scan on centreline (greatest threat); return scan to centreline (greatest threat). First look at centre 3, then 3 hops left; back to centre, 3 hops right; back to centre, look inside.