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The great transatlantic race: physiologic and otoneurologic considerations

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Abstract

Background. In the era of the competition for the first transatlantic flight at the beginning of the nineteenth century, numerous accidents occurred. Whereas engine failure, bad weather and navigational problems are usually held responsible, the human factor has hardly been addressed.

Methods. In view of current insights, an inventory was made of possible physiologic and otoneurologic factors that could have contributed to failures and accidents.

Results. Extreme fatigue, hyperventilation with vestibular hyperreactivity and airsickness may have played roles. When flying in the dark and in clouds, pilots were subject to spatial disorientation because of vestibulo-visual conflicts and gravitational misinformation. The loudness of the engines was deafening, which may have caused noise-induced vertigo. In some cases, asymptomatic third-window lesions may have become manifest and may have contributed to dizziness.

Conclusion. Accidents and failures in the early days of aviation were not only the result of technical defects. Undoubtedly, human physiology played a role as well.

Main Article

Kees Graamans takes responsibility for the integrity of the content of the paper

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Introduction

On December 17, 1903, Orville Wright was the first human being to fly a self-made heavier-than-air motorized plane. He bridged a distance of just 36 metres. The same day several other attempts were made, and his brother Wilbur made a flight of 256 metres. This was the start of a competition to fly longer distances. Louis Blériot crossed the English Channel in July 1909 and Jules Védrines flew from Paris to Madrid in May 1911. In September 1913 Roland Garros was the first to cross the Mediterranean. Eventually the Atlantic Ocean was considered the ultimate challenge.

In 1913 the *Daily Mail* announced a prize of £ 10,000 (currently around £ 1,446,000) for the first aviator to cross the Atlantic Ocean from any point in the USA, Canada or Newfoundland to any point in Britain or Ireland in not more than 72 hours. After an interruption by the First World War (1914–1918), in the spring of 1919 seven teams prepared to take part in this competition. Two participants (Wood and Wyllie, Hawker and Grieve) ditched in the sea after engine and navigation problems, another (Sunstedt) crashed during a test flight. Raynham and Morgan crashed immediately after take-off. Kerr decided not to take part, but shortly afterwards he too was involved in a serious crash landing. Three U.S. NC-4 flying boats tried to cross the Atlantic following a different pathway with stopovers in the Azores. Two of them were also involved in various accidents and dropped out. Just one flying boat reached Europe after 11 days. The flying-boat aviators were the first to cross the Atlantic. They did not meet the 72-hour criterion and were therefore not eligible for the Daily Mail prize.

Two British veterans, Captain John Alcock (pilot) and Lieutenant Arthur Whitten Brown (navigator), succeeded on June 14–15 (Figure 1). They flew from Newfoundland to Ireland in 16 hours and 28 minutes in a converted two-engine Vickers Vimy bomber (Figure 2). This epic event has been extensively described in newspapers, journals and books (Figures 3, 4).

Alcock and Brown experienced a disorienting event during their flight, possibly in combination with vertigo. At a given moment, as the aircraft was tossed around by turbulence, Alcock lost all sense of orientation and had no idea of the attitude of the plane. The forward motion stalled, and the plane started falling in a steep spiral dive. At just fifty feet above the ocean, they levelled out and were able to continue the flight. Other pilots must have experienced similar situations, though with less favourable outcomes.

Disorientation and vertigo of the pilots occurred in another transatlantic flight. The crew of the U.S. NC-flying boat had a life-threatening experience similar to that of Alcock and Brown. In zero-visibility conditions, suddenly a wing dropped, and the plane went into a spin. The pilot on duty, Elmer Fowler Stone, got the plane under control, an extremely courageous and outstanding performance. In the early days of aviation,

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Figure 1. Arthur Whitten Brown and John Alcock in 1919.[20]



Figure 2. Vickers Vimy ExCC.[21]

unsuccessful spin recovery due to spatial disorientation killed many pilots and is therefore known as the 'graveyard spin'.

In 1926–1927 there were five competitors for the Orteig Prize for the first non-stop flight across the Atlantic between New York and Paris. Three had fatal accidents and one (Charles Nungesser) disappeared, presumably having crashed in the ocean. Charles Lindbergh won the prize.

The problems encountered during these flights illustrate the state of aviation at the beginning of the twentieth century, when many pioneers risked their lives. Their failed attempts and accidents usually have been linked to bad weather, unreliable engines or navigation problems. However, the role of human physiology has hardly been addressed. The aim of this paper is, considering current otoneurologic insights, to make an inventory of physiologic problems that pilots possibly encountered which may have contributed to the occurrence of accidents and failures.

Fatigue

The shortest distance between North America and Europe is 3000 km and the air speed of the planes in those days was around 150 km/h. Therefore, a transatlantic flight would have taken about 20 hours. During such long flights, exhaustion and lack of sleep would surely have led to reduced attentiveness. An indication for this can be found in Charles Lindbergh's biography describing his transatlantic flight in 1927, which took him 33 hours.[1] He wrote, "My mind clicks on and off […]. I try letting one eyelid close at a time while I prop the other open with my will. My whole body argues dully that nothing, nothing life can attain, is quite so desirable as sleep. My mind is losing resolution and control."

At the beginning of the twentieth century, airplanes were equipped with iron cables directly connecting the control column and the rudder bar in the cockpit with the control surfaces (i.e. ailerons, elevators and rudder). In this construction, the leverage capacity was minimal and there was no trimming equipment, so the pilot had to apply constant force to control the plane with both hands and feet. Furthermore, aircraft were generally single-seater types with only one pilot handling the instruments (Figure 5). This meant that flying required uninterrupted and rather strenuous physical effort as well as continuous focused attention. In 1919, Alcock had to eat and drink in snatches with one hand while handling the control wheel with the other. One can imagine that these continuous efforts were fatiguing. Fatigue could have been enhanced by environmental conditions such as cold, improper clothing, vibrations, noise and emotional stress.[2]

Effects of altitude

In order to navigate by the stars or the sun, pilots sometimes had to climb above the clouds to levels exceeding 10,000 feet. At that

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Figure 3. Daily Mail front cover, June 16 1919.[22]

altitude, lack of oxygen may induce hypoxia and hyperventilation. Research has shown that hypoxia impairs a pilot's situation awareness.[3] And hyperventilation is known to induce hypocapnia, which may provoke vestibular hyperreactivity and a distorted vestibulo-ocular reflex, although the exact mechanism is not known.[4] The afferent pathway of the vestibulo-ocular reflex leads from the semicircular canals along the vestibular nerve to the oculomotor nuclei in the brainstem, both directly and via the vestibular nuclei. The efferent pathway then evokes compensating eye movement during rotatory head movements. Vestibulo-ocular reflex dysfunction results in oscillopsia during head movements, which may affect instrument scanning in pilots. Another consequence of hyperventilation is fear, which may have occurred during early transatlantic flights. Altogether, the necessity to climb above the clouds without oxygen supply may have created physiological and cognitive challenges for the early transatlantic pilots.

Airsickness

At the time of the flight of Alcock and Brown, airsickness had been quite thoroughly investigated.[5] Its prevalence was documented more extensively during the Second World War (1940–1945), because it often prevented air crews from achieving their mission. According to a recent review, the incidence of airsickness among military aviators is 10–70 per cent.[6] Airsickness is a subcategory of motion sickness, which occurs when information from our orientation senses (e.g., the visual and vestibular system) does not match our expectations about our self-motion or orientation.[7] In an aircraft, such mismatch may be induced by unanticipated motion, such as turbulence, especially when visual references are scarce. It is well known that motion sickness can cause physiological discomfort, including headache, nausea and vomiting. But it may also lead to psychological symptoms such as drowsiness and apathy. These symptoms are known as the 'sopite syndrome', which may affect psychomotor and cognitive tasks. Considering this knowledge, it may be assumed that airsickness played a role in failures during long-distance flights in the early days of aviation.

Disorientation

Another problem that aviation pioneers faced during their efforts to cross the Atlantic is the need to fly in the dark and in clouds. As already recognized by researchers in the field of aviation medicine in that era, attitude awareness is compromised in the absence of valid visual input.[8] Lacking outside visual references, pilots in those days had to control the plane purely with a combination of proprioceptive and vestibular information. On the ground, these sensory systems provide reliable information about our self-movement and our orientation relative to the earth. In flight, however, vestibular feedback on aircraft motion and attitude may be unreliable, which results in spatial disorientation.[9–11] On the one hand, vestibular feedback may be missing when the aircraft motion remains under the perception threshold. On the other hand, above-threshold aircraft motion may produce noticeable but misleading vestibular feedback. For example, the semicircular canals in the inner ear only respond to changes in angular motion, not to constant rotation. Therefore, without valid visual references, a pilot may feel the entry of a turn, but during the turn itself he may have the sensation of flying straight. Stopping the turn may produce another response in the semicircular canals, which gives the sensation of entering a new turn in the opposite direction, while actually flying straight again. This is schematically depicted in Figure 6.

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"All the News That's Fit to Print."

The New York Times.

THE WEATHER
Showers today; Tuesday probably fair; fresh north winds.

VOL. LXVIII....NO. 22,423. NEW YORK, MONDAY, JUNE 16, 1919. TWENTY-EIGHT PAGES. TWO CENTS

ALCOCK AND BROWN FLY ACROSS ATLANTIC; MAKE 1,980 MILES IN 16 HOURS, 12 MINUTES; SOMETIMES UPSIDE DOWN IN DENSE, ICY FOG

OUR TROOPS CROSS BORDER TO STOP JUAREZ FIGHTING

Infantry, Cavalry, and Artillery Enter Mexico and Are Rounding Up Villistas.

GUNS ALREADY IN ACTION

General Erwin States That He Purposes Only to Protect City and Plans No Intervention.

SHOTS HIT AMERICANS

One Killed, Several Wounded, When Villa Renewed Attack on Juarez.

EL PASO, Texas, Monday, June 16—The 20th Infantry, Fourth Battalion, crossed the international border at Juarez at 11 o'clock last night.

The 5th and 7th Cavalry Regiments crossed at other fords east of El Paso.

A battalion of the 82d Artillery crossed east of the stock yards.

There were approximately 5,000 American troops on Mexican soil two minutes after they were ordered to make the crossing.

Colonel Irish H. H. Tompkins of the 7th Cavalry was in command of the cavalry brigade which crossed at the fords and Colonel Hadley was in command of the infantry. Two armored motor cars crossed the International bridge at 10:15.

The first shrapnel shot from United States Army guns was fired over Juarez at 12:30 in the morning in the direction of the Juarez race track to dislodge Villistas. A second shot followed in five minutes, which struck near the race track, followed at two-minute intervals from two guns placed near the International bridge on the Mexican side.

Following a signal rocket, the American cavalry near Ysla Lerdano started an enveloping movement to the east and southeast of Juarez to surround the rebels, then in the vicinity of the race track. It was not known whether Villa was with his men or not.

A second green signal rocket indicated that the cavalry were advancing at a charge.

Heavy firing by the American artillery is going on.

Following the killing of one artillery-man of the 82d Artillery and the serious wounding of another by Mexican snipers, General Erwin ordered twenty-five support riflemen to that point to return the snipers' fire. The shots which killed the artillerymen were fired before American artillery began the bombardment of the race track.

The reasons given at military headquarters for ordering the troops to cross was "to prevent firing from the Mexican side on El Paso."

Brig.-Gen. Julius G. Erwin told the Associated Press immediately after issuing the order for the crossing that it was not to be an invasion of Mexico, that the situation was fully understood by General Francisco Gonzalez and the Carranza officials and that no resistance was anticipated from the Carranza troops which have been fighting in Juarez. No strong resistance was reported from the Villa forces, General Erwin added.

A statement issued by General Erwin reads:

"Upon the affidavits of three responsible citizens of El Paso that the Villa bandits fired into El Paso and upon the investigation of the wounding of the Mexican girl on El Paso's streets, she was wounded by a shot fired by Villistas and upon investigation by the deputy inspector of these headquarters and two officers of the police force of El Paso, I was shown that the shots undoubtedly coming from the direction of the Villista forces, had been fired into El Paso.

"Further, because of the wounding of several Americans and the abiding purpose residing in El Paso and the surrounding of two United States soldiers, who, on the discharge of their duty, fell at dinner on June 14 and 15 therefore, under the authority given me in telegrams from the headquarters of the Southern Department, June 15, 1919, I ordered troops of my command to cross the border and disperse the Villistas. But, upon no account, were they to undertake an invasion into Mexico.

"As soon as I have accomplished this and have assured the safety of the citizens of El Paso, then the troops of my command will be withdrawn to the American side of the border."

Earlier in the day General Erwin had ordered the port closed and the international bridges taken up by the soldiers, after Corporal Edward Purdy, Motor Transport Company, had

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President Wilson to Sail for Home About June 24

PARIS, June 15.—President Wilson probably will remain in Paris only three or four days after his return from Belgium next Friday. He will then embark at a French port for the United States.

President Wilson expects to visit Belgium Wednesday or Thursday, accompanied by Mrs. Wilson and Rear Admiral Grayson. They will leave Paris Tuesday night by special train, returning to Paris Friday morning.

Elaborate plans for the entertainment of President Wilson and his party in Brussels have been made by King Albert and Queen Elizabeth.

GERMANS OBJECTED STRONGLY TO TERMS

Reply to Allies Showed They Thought Themselves Equal Negotiators.

PROTESTS AVAILED LITTLE

Final Answer from Council Gives Relief on Only a Few Points.

By RICHARD V. OULAHAN.

PARIS, June 15.—The memorandum of the German peace plenipotentiaries, which in now made public, shows that the Germans attempted to press on the negotiators with open sights in the Peace Conference, instead of as defensive foes, ready to learn the character of the [illegible] they should undergo.

Even in light of the knowledge of the modifications in the treaty made by the Council of the great Powers, the complaint and argument regarding many of the severest features of the treaty failed to move the allied statesmen. Yet the German representatives were successful in some important particulars.

The German plenipotentiaries laid great stress on President Wilson's Fourteen Points, but sought to persuade the allied peacemakers that these were intended in every instance to apply to the treatment of Germany in making peace instead of being regarded as mere application similar to the smaller nations which Germany had conquered or sought to conquer.

In this situation the German delegation advanced the contention that the treaty was inconsistent with the President's declaration that the Allies were making war on the German people, entirely overlooking that in imposing punishment on the German Government the subjects were obliged to bear their share of the burden in expiation of the wrongs they had approved.

Many concessions of this sort appear throughout the voluminous document, in connection of German territory, such as the Saare Basin, and the question of German captivity in France and the smaller nationalities among the German plenipotentiaries to indulge in fantasies on how wrong it is for the Allies even to live up to their assertions of the rights of peoples to self-determination.

In the response now being completed to the German complaints and counter proposals the Council of the Great Powers adopts a moderated tone which is apparently intended to give a light coating of sweetness to the nasty dose they said necessary to swallow. Of the many German contentions, designed to prove the good wrong being committed, the most cogent answer will indeed prove totally all except that concerning Upper Silesia, which is to have a plebiscite to determine whether it shall go to Poland, as the draft of the treaty stipulates, or remain under German sovereignty.

This part of the German memorandum makes interesting reading, if for no other reason than in showing the character of the argument advanced to prove that non-Germans peoples who are released from German citizenship through territorial transfers really would be happier if they remained German subjects.

The German contentions for more liberal terms with respect to payment of reparation are to be treated in the allied response in a manner similar to that in regard to territory. The proposal is the enemy memorandum that the total reparation be fixed at a hundred billion marks without interest and to include the cost of the war and damage to property forfeited to the Allies who, however, agree to have the allied Governments and Canadians fix the amount of reparation within a few months instead of leaving advantage of the peace to be made for so doing as provided in the treaty.

The German memorandum also proposed that a German commission work in

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Full Dull Pattern Cigarettes. For the discriminating.—Park Tobacco Co.—Adv.

SEE IT! BELL-ANS IN HOT WATER quickly relieve indigestion.—ADV.

Captain John Alcock

Lieutenant Arthur W. Brown

Airmen Who Accomplished the First Non-Stop Transatlantic Flight

FOCH OFF TO RHINE; PERSHING TO GO, TOO

Departures Emphasize Allies' Serious Plans to Meet Eventualities.

SIGNATURE SEEMS LIKELY

Conference Officials Who Doubted Now Inclined to Share Wilson's Optimism.

By RICHARD V. OULAHAN.

Copyright, 1919, by The New York Times Company (by Wireless and Cable to The New York Times).

PARIS, June 15.—Speculative comment as to whether the German Government will accept the allied peace conditions appears to have little value in the face of the belief of President Wilson and others who have the advantage of obtaining reports from intelligence agents in Germany that the enemy plenipotentiaries will be instructed to sign the treaty.

The statements coming from various places in Germany that officials have begun to remove supplies and documents to points remote from the western frontier do not have with the President and others who are well informed the effect which the German authors evidently intended them to have.

It would not be surprising, if one may judge from information received by the allied chiefs, if the delinquent Cabinet resigned when called upon to say, as it will be this week, whether the German Government will accept the peace conditions. That a new ministry would be speedily formed, probably with Erzberger at the head, is the belief in the best informed circles in Paris.

No doubt is felt that the new Ministry would respond to the apparently widespread demand among the German people that peace—even the most severe sort of peace dictated by the victorious Allies—be brought about without delay.

The Allied Governments, however, are taking no chances. They have completed practically all their preparations for meeting possible contingencies. Fresh military movements and plans for ensuring the blockade have been put into motion under consideration in the last stages of taking care of the allied food supply in Germany pari. Including the steps which rattled food for the German populations. That a new ministry formed in Germany, these steps could all be seized by the German authorities most of them are be speedily forthcoming.

The actual state of war will be revived immediately on the expiration of the armistice, which becomes inoperative at the end of the first day period allowed the German Government to determine whether it will accept the peace conditions if German accepts, as is generally believed, the armistice will be in-

Continued on Page Eight.

HARTSHORN, PAINE & CO., Boston & N. York Exchange. 31 Nassau St.—Adv.

CALOX TOOTH POWDER Cleans—Whitens—Protects—Adv.

Northcliffe, Congratulating Capt. Alcock, Says That Airplane is Faster Than Cables

Special Cable to THE NEW YORK TIMES.

LONDON, June 15.—Lord Northcliffe has sent the following letter to Captain Alcock:

"My Dear Alcock—A very hearty welcome to the pioneer of direct Atlantic flight. Your journey with your brave companion, Whitten Brown, is a typical exhibition of British courage and organizing efficiency.

"Just as in 1913 when I offered the prize, I felt that it would soon be won, so do I surely believe your wonderful journey is the warning to the cable monopolists and others to realize that within the next few years we shall be less dependent upon them unless they increase their rates and speed up. Your voyage was made more quickly than the average press message of 1919.

"Moreover, I look forward with certainty to the time when London morning newspapers will be selling in New York in the evening, allowing for the difference between British and American time, and vice versa in regard to New York evening journals reaching London the next day.

"Then we shall no longer suffer from the danger of garbled quotations due to telegraphic compression. Then, too, the American and British peoples will understand each other better as they are brought into closer daily touch.

"Please permit me shaking you by the hand and personally presenting the prize, but I can assure you that your welcome will be equal to that of Hawker and his gallant American composer, Read, whose great accomplishment has given us such valuable data for future Atlantic work.

"I rejoice at the good augury that you departed from and arrived at those two portions of the British Commonwealth, the happy and prosperous Dominion of Newfoundland and the future equally happy and prosperous Dominion of Ireland.

"Yours sincerely,

"NORTHCLIFFE."

Labor Fails to Move Congress to Repeal of War-Time Dry Law

Lawmakers Are Unresponsive to Big "Wet" Demonstration and Inclined to Put Responsibility Up to President—Enforcement Act Unlikely Before July 1.

Special to The New York Times.

WASHINGTON, June 15.—Republican leaders remain unimpressed by the protest of labor yesterday against the enforcement of wartime prohibition, and no action will be taken by Congress looking to the repeal of prohibition, which becomes operative July 1. This opinion was expressed tonight by a member of the House Steering Committee, who added that the President alone has the responsibility for taking the first step toward repeal, and that no action to carry out the President's recommendation that the war-time and beer laws will be taken by Congress.

Labor's informal ultimatum made to Congress yesterday, that unless the Lever food control law, the Overman act, and the war-time prohibition law are repealed by July 1 labor will take drastic action, such as a general strike, was received in the House in the customary indifferent manner. Many members declared that they would not be influenced in the slightest degree by any such threat, and that labor's opposition to the war-time laws would only result in augmenting the sentiment in favor of their retention.

It is the belief of many members of Congress that the war-time prohibition law will be in force in fact when the treaty of peace is signed, and that there is no use in repealing the Overman act, which is the enforcement law for war-time prohibition, and the Lever food control act, which is the food control law, as the President has the power to declare that the war has ended and the national emergency, but with both Senators Chamberlain and Kenyon introducing resolutions which would be passed by July 1, there is no doubt that the enforcement bills will be repealed. The Department of Justice has the authority to enforce prohibition, but it is not expected that it will do so unless the President declares that the war has ended and the national emergency no longer exists.

SEE IT! BELL-ANS IN HOT WATER quickly relieve indigestion.—ADV.

ZURICH REDS RIOT; 2 DEAD, 17 HURT

Prefecture Stormed and Its Archives Burned by a Mob.

POLICEMAN MORTALLY HURT

Mob Returns Fire of the Guards—Rumor of Leader's Arrest Started the Rioting.

PARIS, June 16.—German anarchist and Bolshevist disorders broke out in Zurich, Switzerland, last night at 5 o'clock. Firing was still going on at 9 o'clock, according to a dispatch received from Geneva.

Reports received this morning state that the local workmen's union of Zurich, which has certain extremist associations, was holding a meeting in memory of Rosa Luxemburg, the German radical leader, who was killed following her arrest in Berlin early in the year, when the news was circulated that the dictatory of the union, Conrad Wyss, had been arrested on Wednesday.

A furious crowd marched upon the Prefecture, stoned the windows, broke down solid doors, and, after a half hour of battering, looted the Hall of Justice and burned the archives in the principal corridor of the building.

One of the guards fired on the crowd, in which being answered. A number of casualties are reported, but details are lacking, as telephone and telegraph lines appear to have been tampered with.

There are large foreign colonies of anarchists, Bolsheviki, and revolutionaries in Zurich.

BERNE, June 16.—The casualties in the disturbance at Zurich are given officially as two persons killed and seventeen wounded. One policeman was mortally hurt.

Among the rioters were many German anarchists and communists.

POPE TO DISCUSS WORLD SITUATION

Will Deal with Post-War Conditions in Allocution at Consistory on June 26.

ROME, June 15.—Pope Benedict will hold a Consistory June 26. The Pontiff will [illegible] for the appointment of Bishops and the confirmation of the Patriarch of Antioch of the Greek Melchite Rite.

The only importance of the Consistory to the outside ecclesiastical world will be a papal allocution, which it is expected will deal with the situation of the world after the war.

WOODWARD'S TOE. A Real Pants to the tune of $ 7. Clothcraft Shop, 44 Broadway.—ADV.

LAND AT CLIFDEN, IRELAND, IN A BOG

Airmen Moving at an 120-Mile Speed Were Unable to See Sun, Moon, or Stars for Hours Owing to Fog.

THEY LOOPED THE LOOP UNINTENTIONALLY AT TIMES

Fliers Temporarily Dazed and Deafened by Landing—Alcock Expects to Continue Journey to England—London Unprepared for Quick Flight.

Captain Alcock's Own Narrative Of His Flight From Newfoundland to Ireland

By Captain J. Alcock, D. S. C.

Special Cable to THE NEW YORK TIMES.
(By Courtesy of the London Daily Mail.)

LONDON, June 15, (By telegraph from Clifden, Ireland.)—We have had a terrible journey. The wonder is that we are here at all. We scarcely saw the sun or the moon or the stars. For hours we saw none of them.

The fog was very dense and at times we had to descend to within 300 feet of the sea. For four hours the machine was covered in a sheet of ice, caused by frozen sleet. At another time the fog was so dense that my speed indicator did not work, and for a few seconds it was very alarming.

We looped the loop, I do believe, and did a very steep spiral. We did some very comic stunts, for I had no sense of the horizon.

Winds were favorable all the way, northwest, and at times southwest. We said in Newfoundland we would do the trip in sixteen hours, but we never thought we should. An hour and a half before we saw land we had no certain idea where we were, but we believed we were at Galway or thereabouts.

Our delight in seeing Kantal Island and Turbot Island, five miles west of Clifden, was great. People did not know who we were when we landed and thought we were scouts on the lookout for the Vimy.

We encountered no unforeseen conditions. We did not suffer from cold or exhaustion, except when looking over the side. Then the sleet chewed bits out of our faces. We drank coffee and ate and ate sandwiches and chocolate.

The flight has shown that the Atlantic flight is practicable. It should be done not with an aeroplane or a seaplane but with a flying boat.

We had plenty of reserve fuel, using only two-thirds of our supply. The only thing that upset me was to see the machine at the end get damaged. From above, the bog looked like a lovely field, but the machine sank into it up to the axle and fell over on to her nose.

[Alcock's message to the Daily Mail, by whose courtesy the NEW YORK TIMES is enabled to print it, did not reach London until after 10 o'clock to-night, although filed in Ireland shortly after 5 o'clock in the afternoon.]

LONDON, June 15, (Associated Press.)—The final goal of all the ambitions which flying men have held since the Wright brothers first rose from the earth in a heavier than air machine was realized this morning when the young British officer, Captain John Alcock, and his American navigator, Lieutenant Arthur W. Brown, landed on the Irish coast after the first non-stop flight across the Atlantic Ocean.

Their voyage was without accident and without unforeseen incident, so far as can be learned. It was a straightaway, clearest flight, achieved in 16 hours and 12 minutes, from Newfoundland to Clifden, Ireland, a distance of more than 1,900 miles.

The report of Alcock and Brown to the Aero Club was as follows:

Landed at Clifden at 8:40 A. M., Greenwich mean time, 25th of June, Vickers-Vimy Atlantic machine leaving Newfoundland coast at 4:28 P. M., Greenwich mean time, 14th of June. Total time, 16 hours 12 minutes.

ALCOCK AND BROWN.

But the brief and modest description which occurs from the airmen at Clifden tells of an adventurous and exceedingly hazardous enterprise. Fog and sleet hung over the North Atlantic and the Vickers-Vimy biplane climbed and dived, struggling to extricate herself from the folds of the airplane's worst enemies. She rose to 11,000 feet and swooped down almost to the surface of the sea, and at times the two voyagers found themselves flying upside down, only ten feet above the water.

Mists robbed the night of the advantage of the full moon and the wireless apparatus was torn away by the wind soon after the start. To the two young pioneers of the Atlantic flight without a stop were thrown upon their own resources. The skilful navigation which brought the machine near to the centre of the Irish coast line was one of the finest features of the flight.

Before coming to earth near the Clifden wireless station Alcock circled the world's aerials, seeking the best spot to reach the earth, but no suitable ground was found, so he chanced it in a bog.

The wireless staff rushed to the aid of the aviators. They found Brown dazed and Alcock temporarily deafened by the force of the impact. As soon as they were able to be escorted to the wireless station they telegraphed the news to their friends, then had breakfast.

"That is the best way to cross the Atlantic," said Lieutenant Brown after he had eaten.

Wireless Out of Action.

The Daily Mail's correspondent found Alcock and Brown at Clifden, packing their gear into a huge sack. Alcock's face lit up with a smile

Figure 4. New York Times front cover, June 16, 1919.[23]

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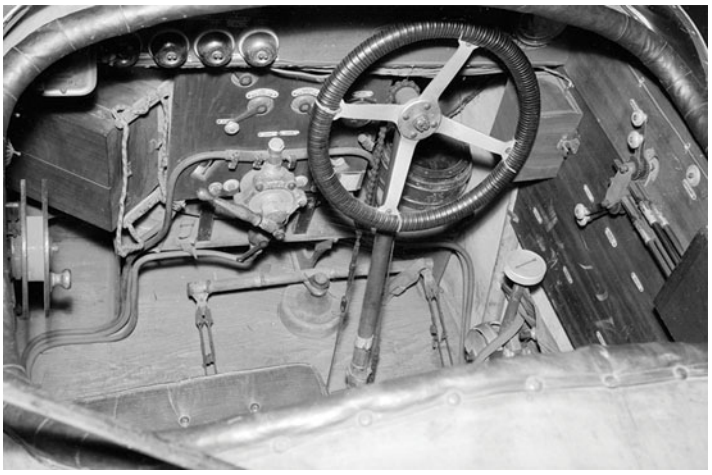


Figure 5. Single-pilot cockpit of the Vickers Vimy flown by Alcock and Brown.[24]

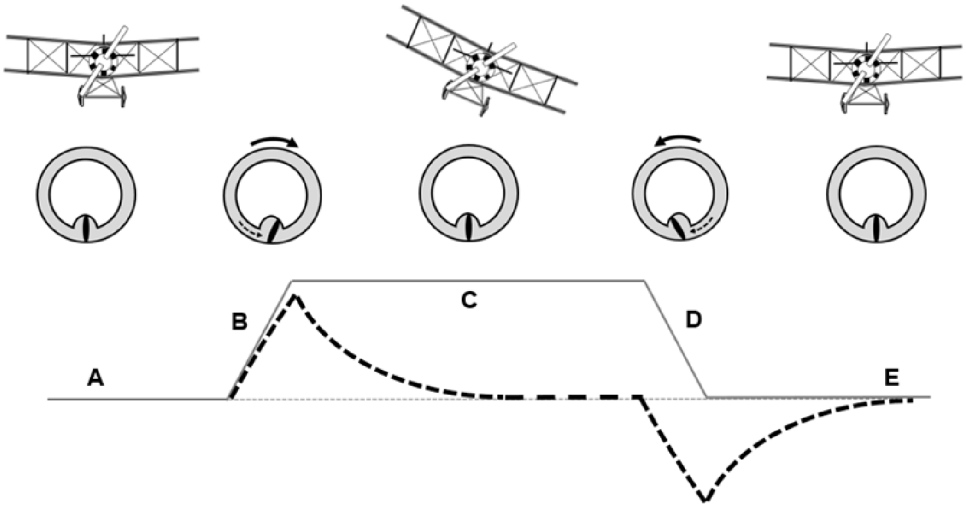


Figure 6. Schematic visualization of the response of the semicircular canals (middle row) to roll motion, as shown by the time history at the bottom, in which the solid gray line depicts the roll angle of the aircraft, and the dashed black line depicts the perceived roll motion based on activation of the semicircular canals. During straight and level flight (A) the cupula (black valve-like symbol inside the canal) is in its neutral position, and the pilot does not perceive any roll motion. During the entry of a turn (B), the inertia of the endolymph fluid causes it to lag the roll motion of the head (solid arrow), which causes the cupula to deflect (dashed arrow), triggering a neural discharge in the vestibular nerve. This gives the pilot the sensation of roll motion. Once a steady-state roll angle is reached (C), the endolymph fluid and the cupula assume their neutral condition again, so that the pilot no longer perceives any roll motion, while the aircraft is in fact still turning. Upon exiting the turn (D), the roll motion that brings the aircraft back to straight-and-level causes the cupula to deflect again, but now in a direction opposite to the original turn. This causes a sensation of rolling in opposite direction, which can persist when the aircraft is already straight-and-level. This aftersensation is known as the post-roll illusion, which ultimately subsides when the aircraft keeps flying straight-and-level (E).

We should note that the airplanes used in the transatlantic race in 1919 were not equipped with a gyroscopic artificial horizon. Thus, to avoid spatial disorientation, the pilots had to rely on rather ineffective and vulnerable instruments such as a compass, an air speed indicator and a spirit level of some sort. Pilots also had the so-called Abney's spirit level, but that instrument was intended for navigational purposes (i.e., to identify the horizontal plane when using a sextant). This hand-held instrument was useless as and inclinometer or attitude indicator, since the function of spirit levels depends on the false perception of gravity. Despite the advent of gyroscopic attitude indicators and other technical improvements, flying in the dark has remained a hazardous and challenging task, as evinced in the famous book *Vol de Nuit* (Night Flight) by pilot and author Antoine de Saint-Exupéry, which was published in 1931.[12] Even in contemporary aviation, spatial disorientation remains a serious safety risk, contributing to more than 20 per cent of all fatal aircraft accidents.[13]

Noise-induced vertigo

In 1929, 10 years after the transatlantic competition, Italian biologist Pietro Tullio from Bologna described experiments demonstrating that noise above a certain level may produce unsteadiness and vertigo.[14] Afterwards, this was referred to as the Tullio phenomenon or Tullio's sign. It may be an epiphenomenon of a variety of otologic and non-otologic conditions such as Ménière's disease, endolymphatic hydrops, cholesteatoma, Lyme borreliosis, syphilis, status after ear surgery and head trauma. However, Tullio phenomenon may occur in normal, otologically sound people when they are exposed to noise levels exceeding 100–110 dB. Perilymph leakage or a (silent) labyrinthine fistula is presumed to be the pathogenetic mechanism. All pilots at the beginning of the twentieth century were sitting in the open air (Figure 7), and the seats of Alcock and Brown were very close to the two engines that produced a deafening level of noise. This is illustrated by the fact

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Figure 7. Vickers Vimy Rolls Royce biplane, complete with two Rolls Royce engines and propellers.[25]

that they had to communicate mainly by written messages during the flight. After landing in Ireland, they suffered from profound deafness and tinnitus.

In 1998, Lloyd B. Minor *et al*. described the superior canal dehiscence syndrome:[15] a defect in the bony covering of the superior semicircular canal, leaving just a soft-tissue separation between the labyrinth and the middle-cranial fossa, a so-called 'third window'. This third window can be responsible for noise-induced vertigo and oscillopsia. The prevalence of superior canal dehiscence in the normal population is not yet known. Computed tomography examinations of the temporal bones of patients with non-otologic symptoms indicate a prevalence varying from 1.2 per cent to 9.6 per cent.[16–19] It is not excluded that some form of (silent) third window might have caused vestibular symptoms in aviators at the beginning of the twentieth century.

- The competition to make the first transatlantic flight has been extensively documented. Numerous books and publications attribute the failures and accidents mainly to technical problems, bad weather and navigation error.
- Reports on the success and failures hardly mention the physical limitations of the air-crew, however.
- This paper addresses the functioning of pilots at the beginning of the 20th century using current physiologic and otoneurologic insights.
- In that light, a variety of impairments can be identified. In retrospect, the physical limitations of the aviators must also have played a role in the failures.

Conclusion

While there is no doubt that bad weather, engine failure and navigational problems were responsible for many failures and accidents in the early days of aviation, we assume that human physiologic and otoneurologic factors must have played roles as well. With our current knowledge of vestibular functioning, it is possible to elucidate in retrospect the major challenges faced by pilots in the first decades of aviation. The combination and interaction of extreme fatigue, lack of sleep, hyperventilation, airsickness, spatial disorientation and noise-induced vertigo must have affected pilot performance and may have contributed to failed attempts to cross the Atlantic. That was the price that had to be paid for the first successful transatlantic flight.

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