

PROLOGUE

The Wings of the Eagle

The Eagle has landed

The voice from the space ship Eagle, just above the surface of the moon, was clearly understandable despite the static. The other voice came from the Johnson Space Flight Center in Houston, Texas, and, not surprisingly, was much clearer. Both men spoke in short, efficient, factual statements, without outward emotion.

EAGLE: 35 degrees. 35 degrees. 750, coming down at 23. 700 feet, 21 down. 33 degrees. 600 feet, down at 19 . . . 540 feet . . . 400 . . . 350 down at 4. . . We're pegged on horizontal velocity. 300 feet, down $3\frac{1}{2}$. . . a minute. Got the shadow out there . . . altitude-velocity lights. $3\frac{1}{2}$ down, 220 feet. 13 forward. 11 forward, coming down nicely . . . 75 feet, things looking good.

HOUSTON: 60 seconds.

EAGLE: Lights on. Down $2\frac{1}{2}$. Forward. Forward. Good. 40 feet, down $2\frac{1}{2}$. Picking up some dust. 30 feet, $2\frac{1}{2}$ down. Faint shadow. 4 forward. Drifting to the right a little.

HOUSTON: 30 seconds.

EAGLE: Drifting right. Contact light. Okay, engine stop.

HOUSTON: We copy you down, Eagle.

EAGLE: Houston, Tranquillity Base here. The Eagle has landed.

I was a twenty-two-year-old graduate student when Neil Armstrong and Buzz Aldrin landed on the moon. Today, thirty years on, I still get a deep thrill whenever I read the transcript of those last few minutes of the descent, as Armstrong guided the lunar landing craft — which the crew had christened “the Eagle” — to the spot where humans would first set foot on another planet.

As the culmination of a decade long struggle to put a man on the moon (and bring him back alive), the actual landing did not represent a huge technological advance over the previous Apollo missions. To use Armstrong's own words, as he made the historic first step onto the moon's surface, the Apollo 11 moon was just “one small step for [a] man.” But the symbolic importance of the event was inescapable. It was, as Armstrong went on to say, “One giant leap for Mankind.” Though often touted as an achievement for science and engineering — which it was — I have always felt that the Apollo 11 mission was much more a triumph of the human spirit, and of two mental abilities that on the face of the earth are unique to humans: mathematics and language.

Getting to the moon was heavily dependent on mathematics, which underpins all the sciences and all of engineering. Every aspect of the mission was calculated(!) to the finest detail: how much fuel to carry for each stage of the flight to the moon, what path to take so that fuel would not be wasted in correcting the path, how much fuel would be required for the landing, how

much for taking off again, how long each engine burn should last, how much oxygen was needed to keep the crew alive. The dialogue between Eagle and ground control during the final descent was almost entirely mathematical. They had little room for error: after Armstrong finally maneuvered the Eagle to a safe landing, there was just ten seconds' worth of fuel left.

So, it took mathematics to get to the moon. But where did language come in? Why do I say the moon landing was a triumph for language? Because the Apollo mission was a huge collaborative enterprise involving the coordinated efforts of thousands of people. Though only two men made those historic first steps on the moon, the project involved many thousands of individuals, spread all over North America — and elsewhere on the globe, if you include the people manning the tracking stations. Language provided the thread that tied the team together and allowed them to coordinate their actions to produce a single event.

Of course, it doesn't require a moon landing to remind us that language and mathematics are powerful tools. Both have led to countless other achievements that have transformed not only humankind but much of our planet.

One of my aims in this book is to convince you of just how remarkable and powerful — and uniquely human — language and mathematics are. Let me once again quote Neil Armstrong. When the lunar module broke free from the command ship that would remain in orbit above the moon during the course of the moon walk, Armstrong declared that “The Eagle has wings.” The acquisition of language and mathematics gave humanity the wings to soar above our fellow creatures.

My other aim is to argue that these two faculties are not separate: both are made possible by the same feature of the human brain.

Along the way, I shall examine the questions of what exactly is mathematics, what exactly is language, and how they arose? I shall also consider a third, distinctly human faculty: our ability to formulate — and follow — complicated plans, worked out in advance, incorporating various alternatives to be followed, depending on how things turn out at the time. This faculty is closely linked with our abilities to use language and to do mathematics. And it too played a major role in the Apollo missions, every detail of which was worked out well in advance, with every imaginable contingency accounted for.

For example, the main flight plan called for the on-board computer to land the Eagle at a site determined months before the flight. But in the event, the lunar crew saw that the chosen site was uneven and littered with boulders. As they descended toward the moon's surface, Armstrong overrode the computers and landed the spacecraft manually. The possibility of a manual landing had been considered well in advance, and the Apollo crew had trained for it.

This last human ability — to imagine the future taking several different paths, and to make adaptable plans in response to our imaginings — is, in essence, the source of the other two (mathematics and language). Arguable, therefore, it is the most important of all.