enormous difference to my chances of getting hurt. In a sealed-bid auction, when the bids are very close, small differences can change the winner. There is no way Nash's result can be twisted to accommodate such situations, however common they are, and there was no way to prove that an equilibrium existed until now. This is what Reny has done[3]. He turns his attention away from the pay-offs, and concentrates on the players' best responses to the others' actions. He defines a game as 'better-reply secure' if, whenever it is out of equilibrium, some player could change his action to get a better pay-off (up to now, this is simply stating that we are not in a Nash equilibrium), and that this new action would still guarantee him the higher pay-off, even if all the other players were to slightly change their own actions (this is Reny's new condition). He then shows that if a game is better-reply secure, and if it satisfies some technical conditions (compactness and convexity of certain sets, basically the same requirements as for Nash's old theorem), then an equilibrium exists.

Reny's theorem introduces Nash equilibria in situations where Nash's own result does not. Take two examples. First is a game of timing ('noisy duel'), where two opponents (of different skills) walk towards each other on a straight line, each having one shot (the duel is 'noisy' because both can hear the shot fired by the other). These games are used to model patent races, for example. Here Reny's condition is satisfied, and the game has a Nash equilibrium (which amounts to saying that there is a precise moment in time when each player should fire).

The second is an auction, where bidders compete for a single indivisible prize. Each bidder receives a signal, which is used to appraise the bounty. Different bidders receive independent signals, and no one sees the signal except the recipient; but everyone knows the probability distribution of all signals, and how each signal will affect the actions of the recipient. The highest bidder wins the auction, pays his bid and walks away with the prize. Note that the simple-minded strategy of simply bidding your own appraisal may not be a Nash equilibrium, because you may find yourself overbidding everyone else: reducing your own bid would still yield the prize, while saving money. Reny's theorem applies to this situation, and shows that there is indeed a Nash equilibrium, which means that there is a way for all participants to exploit the public information to bid optimally.

Of course, the main problem with Nash equilibria is still there: they may exist, but how does one reach them? There are two answers. The first way is by brute calculation; which requires that the agents have enormous computational power at their disposal, and are confident that their opponents are doing the same. The second route is by trial and error, possibly extending over generations; there is no guarantee, however, even with extremely long-lived agents, that such a process will ever reach an equilibrium. We are in a situation akin to the beginning of mechanics: we can do the statics, but we don't have the dynamics. Even so, Reny's result stands out; it is a significant improvement on Nash's original work, and I am sure that it will prove as deep and fruitful as its predecessor. □

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**Science in art**

## Turning the other cheek

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**Imagine you are going overseas and wish to have a portrait done as a gift for your family. You want them to remember you as warm-hearted and affectionate. How would you pose?**

**This question was put to 165 psychology students by Michael Nicholls and colleagues, who report in *Proceedings of the Royal Society* (266, 1517–1522; 1999) that most of the students posed with their left cheek turned towards the camera. When asked to try and look unemotional and intelligent, however, the students were more likely to present their right cheek.**

**The authors found a similar leftward bias in portraits by a number of artists. They believe that, in informal portraits, sitters present their left cheek because this side of the face is controlled by the 'emotive' right cerebral hemisphere. But when Nicholls *et al.* looked at portraits of scientists, such as the one of Louis Pasteur shown here, they found the right cheek turned towards the artist in every single case.**

**Alison Mitchell**

**Daedalus**

## Eclipse of the Earth

**Inspired by yesterday's eclipse of the Sun over Europe and Asia, Daedalus wants to set up a permanent eclipse. It could be sited at one of the Lagrangian points of gravitational stability in the Earth–Sun system, at which a spacecraft would 'keep station' relative to the Earth and Sun.**

**The outer Lagrangian point L2, 1,500,000 kilometres beyond the Earth along the Earth–Sun axis, seems the most promising choice. Seen from that position, the Earth subtends an angle of very nearly half a degree, as does the Sun. At L2, therefore, the Sun is almost perfectly obscured by the Earth. It would provide a permanent 'eclipse of the Earth'.**

**This novel eclipse would give splendid new insights into the Earth's atmosphere. Seen from L2, the Earth would be surrounded by a bright halo of sunlight, transmitted and scattered by its atmosphere. The light would be reddened, and would suffer selective absorption by dust and specific molecules in the air. In addition, it would suffer radial refraction. Rays which skim the Earth's surface are refracted round the Earth by almost a degree in the process. Those whose closest approach is high in the atmosphere are less refracted. So the Earth should show a radial rainbow or 'glory' of atmospheric light, encoding its density and composition as a function of height and latitude. As the Earth turned, the spectrum would sample the sunrise and sunset regions of the atmosphere over the whole globe. Within and behind this display, the night side of the Earth would emit its own less dazzling radiant signature. It would include the glow of lightning and aurorae, and infrared from natural and artificial thermal emissions.**

**The resulting spectra and images would be complicated and enriched by the Moon. A platform at L2 would keep station, not with the Earth, but with the centre of mass of the Earth–Moon system. The Earth itself librates monthly through this point. So much of the time the eclipse would be partial, with a sector of the Sun visible beyond one limb of the Earth, and the other showing a shifted pattern of atmospheric refraction. This useful monthly 'scan' would give meteorologists and atmospheric scientists even more detailed information. A TV camera relaying the whole spectacle back to Earth would also please the lay public, who have been taught that eclipses are dangerous to the health and should never be observed directly.**

**David Jones**