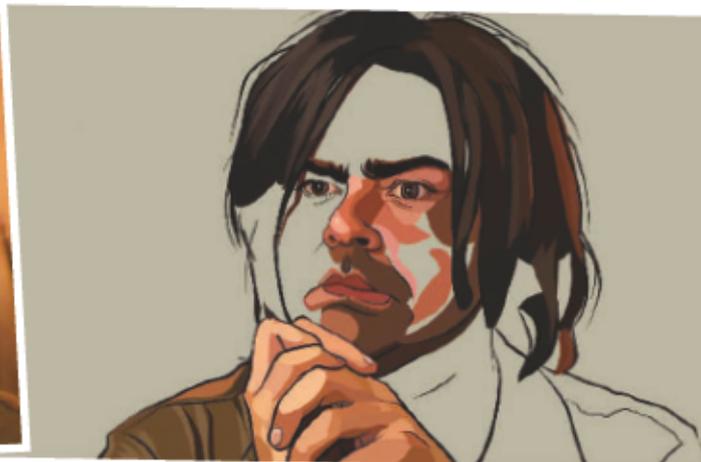


FROM MICROSCOPE TO MULTIPLEX

There's more to science at the movies than Lex Luthor's attempts to synthesize kryptonite. In the first of two features on film, **John Whitfield** looks at how a cinematographic technique can provide insights into the perception of reality. In the second, **Alison Abbott** meets Ben Heisenberg, a director whose first film is a taut moral fable of laboratory life.



An MRI scanner darkly

What is reality? And does anybody care? These questions permeate the work of science-fiction writer Philip K. Dick, whose characters' memories and identities are frequently products of drugs and other technologies — implying that recollections, as well as appearances, should never be trusted. Dick's themes have been catnip to film-makers — *Blade Runner*, *Total Recall* and *Minority Report* are all based on his stories. The latest example, *A Scanner Darkly*, directed by Richard Linklater, will be released this July.

Neuroscientists often ask the same questions. And one of the tools that they are using to address them is 'rotoscoping', a filming technique Linklater uses in *Scanner* and some of his earlier work to blur the distinction between reality and animation. Our notions of authenticity, brain scientists are finding, depend as much on emotional and psychological plausibility as they do on physical accuracy — and the brain will swallow almost anything, provided it comes in the form of a story.

"Our ability to think of others as having minds is very promiscuous, and applies itself across a wide range of entities," says neuroscientist Rebecca Saxe of the Massachusetts

Institute of Technology. Watch a crude animation of a big square tracking a small one, for example, and the word 'chasing' springs to mind. Art exploits this promiscuity, creating emotional impact from strings of abstract symbols such as the lines of letters in novels, or from flickering images on screens.

Studies of brain activity using functional magnetic resonance imaging (fMRI) show that the brain distinguishes movements that might seem to have intentions from other movements. Seeing mechanical motion, such as that of a pendulum, involves a different part of the brain from seeing biological motion, even if it's only that of a cartoon arm.

But how do neuroscientists know whether our responses to such lab-based fictions reflect the real world? "I was interested in whether people attributed intentions to cartoon people in the same way that they comprehend the intentions of real people, but finding or creating videos with cartoon and real people doing the exact same thing seemed very difficult," says neuroscientist and keen filmgoer Raymond Mar of the University of Toronto in Canada. Mar struck lucky; he discovered that Linklater's earlier rotoscope movie, *Waking Life* (2001) provided just

such material. In rotoscoping, conventionally shot footage is transformed into cartoonish animation using a combination of human animators and computers; *Waking Life* uses the technique as a way of presenting a constantly shifting world of dreams, whereas *A Scanner Darkly* uses it to evoke the estranged world of drug use. In the extras on the first movie's DVD, Mar found clips of the video footage that had been transformed into animation, ranging from mellow scenes of pillow talk between Julie Delpy and Ethan Hawke to a man tipping petrol over himself.

Fact or fiction?

Mar and his colleagues showed both cartoon and video clips to subjects in an MRI scanner. They found that two areas of the cortex previously associated with detecting intention, the superior temporal sulcus and the temporal parietal junction (TPJ) fired more strongly in response to the video footage than to the cartoons¹. Cartoon sequences, on the other hand, produced more activity in an area called the bilateral orbitofrontal cortex, which responds to rewarding stimuli. Mar's team speculate that this region may have been more tickled by the trippy cartoon footage than the more



Life like: a filming technique in which normal footage is transformed into cartoons is being exploited by neuroscientists to assess how the brain responds to more or less realistic scenes.

mundane video; it's certainly the case that watching the rotoscoped dreamscapes is a peculiarly rich experience.

"It's an elegant but challenging study," says Saxe. "It's hard to imagine a more minimal contrast that more effectively manipulates this dimension. But the findings are mysterious." The mystery is what the patterns of brain activity in the two treatments mean. It may be that the lower activity in the TPJ stimulated by the cartoons reflects the fact that the animations are easier to process into ideas about intention than the 'real life' footage. Mar, however, plumps for an alternative, although not necessarily contradictory explanation — that the more detailed video footage contains more cues of intention, ticking more of the brain's boxes. His next plan is to show subjects both a real, live hand poking into the scanner and a video of the same event, and see how their brains respond.

"It suggests a template-matching mechanism," adds neuroscientist Kevin Pelphrey of Duke University in Durham, North Carolina. "It may be that the more realistic stimuli portray more intentionality, which these brain regions prefer." But more realistic doesn't necessarily just equal more convincing. The best graphics and robots risk toppling into what, in 1970, the Japanese roboticist Masahiro Mori dubbed the uncanny valley, where their almost-but-not-quite realness becomes creepy and repellent.

Earlier studies have indicated that the brain's mind-reading areas work harder if they believe they are perceiving a real person. Chris Frith of University College London and his colleagues found that when a person played the game known as paper, scissors, stone, another area associated with attributing intention, the anterior paracingulate cortex, fired more strongly if the subject thought they were playing a person rather than a computer — even if he or she was in fact playing a computer². What we perceive can depend on what we believe; imagining a thing produces brain activity very similar to the genuine experience.

As well as tapping into pre-existing biases,

film and animation mould the brain, says Frith. "The brain responds to cultural effects, and the conventions of realism are constantly changing," he says. What counts as real, according to these conventions, depends on technologies of representation; as technology has changed, so has our perception of the hallmarks of reality. People once believed newsreels only if they were in black and white. Currently, the mark of authenticity — exploited, for example, in Paul Greengrass's *Bloody Sunday* and *United 93* — is wobbly handheld footage. The coarseness of video stock, as used in *The Blair Witch Project*, is a similar signifier of reality.

Our understanding of the social brain is still rudimentary, Frith adds. "We know quite a lot about which regions are involved, but almost nothing about what they're actually doing, and

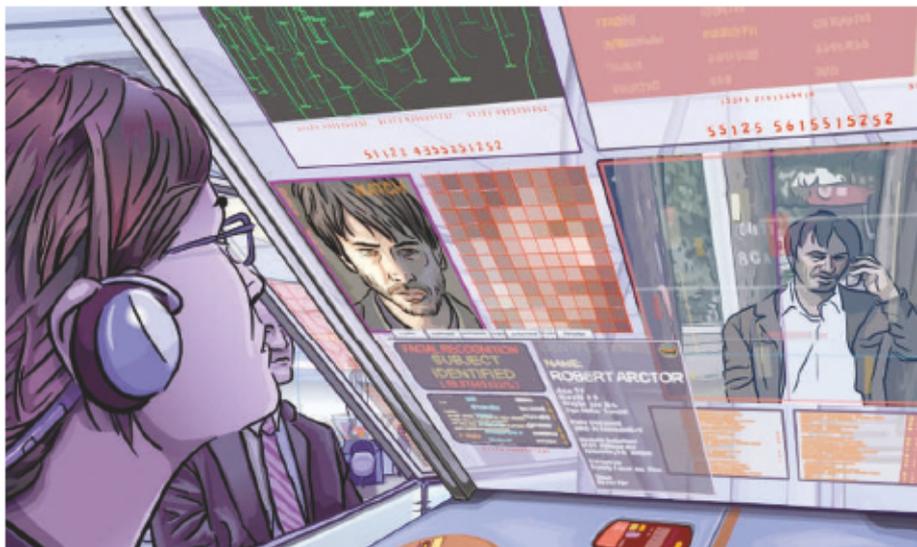
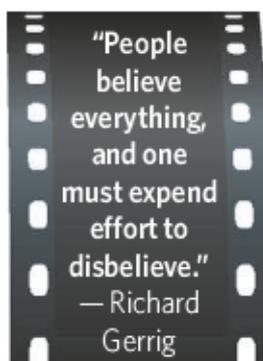
what neuronal computations are involved." What's needed, he says, are imaging studies that can reveal the timing of activity more precisely, showing how different brain regions interact, and theoretical analyses of how the brain solves social problems. "Ultimately, in a science-fiction way, I'd like robots that can do theory of mind and attribute intention." This would be beyond what even Dick imagined — in his novel *Do Androids Dream of Electric Sheep?*, filmed as *Blade Runner*, the Voight-Kampff empathy test is a way of spotting replicants' emotional deficiencies.

Easily deluded

The mental state that arises when we interact with unreality is complex. We get involved to the extent that, say, we cry when Bambi's mother dies, but not so involved that we walk out of the cinema and strike up a conversation with the nearest rabbit. Whatever the explanation is, says psychologist Richard Gerrig of the State University of New York, Stony Brook, it isn't the much-touted suspension of disbelief, because disbelief is not the default. "People believe everything, and one must expend effort to disbelieve," says Gerrig.

The brain, it seems, has a default setting of credulity, and a keen appetite for consuming and producing stories. Narrative is a crucial tool in our efforts to understand the world and some brain areas seem specialized for processing it³. Information presented in narrative form lowers our critical faculties, and experiments show that the more deeply

people become immersed in a story, the easier it is to sway their attitudes towards those advocated in that story⁴. This resonates with *A Scanner Darkly*, when an undercover cop becomes so engrossed in his 'fictional' identity as a drug dealer that his police persona begins to pursue his criminal one. Resisting our



Mind twisters: cartoon animation and real video footage seem to activate different brain areas.

susceptibility to stories is a useful skill in a media- and advertising-saturated world, says Gerrig. "We need to get kids and adults to construct disbelief. Because people don't know about this tendency, it puts them at risk."

"It's not important whether you label something as fiction or non-fiction," Mar agrees. "The true distinction is between narrative and non-narrative expository forms that don't draw you into their world." It also looks as if the abil-

ity to lose yourself in a fictional world might reflect your ability to navigate the genuine social world. Mar and his colleagues have found that the more time a person spends reading fiction the greater his or her empathy and social skills; for readers of expository non-fiction (such as, to pick an example at random, science journalism) the correlation is negative⁵. I thought it would be best to keep back that particular piece of reality until the end. ■

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OLAF UNIV./COOP99/JUCY FILM



In Benjamin Heisenberg's first feature film, a molecular biologist (left) informs on his colleague (centre, left) to a woman from the secret service, with chilling consequences.

Betrayal at the bench

Johannes walks across the grass to a Munich research institute on his first day in the lab. A woman approaches him. She is from the secret service and she wants him to spy on a fellow postdoc, Farid, a French citizen of Algerian origin, vaguely suspected of being a sleeper terrorist. Disgusted, Johannes refuses.

Johannes reports to his new boss, virologist Professor Behringer, who introduces him to Farid. Behringer, an authoritarian department head, wants the two young scientists to work on the same problem in molecular biology from different angles. Farid's approach is genomics, while Johannes is studying proteins.

Through work, Farid and Johannes become friends — of sorts. And therein lies a tale of trust, ambition and betrayal. By the end of *Schläfer* (*Sleeper*), a many-layered and earnest film selected for the 2005 Cannes film festival and now playing in European cinemas, Johannes will have informed on Farid. In doing so, he will have benefited his own career and may have won the girl.

Critics have praised this award-winning

first feature by a graduate of the Munich Film School. As an art-house film addressing big moral issues, it will not be to everyone's taste. But for an audience of scientists, three things will be remarkable.

First, that the director chose to set a study of post-9/11 paranoia in a molecular-biology laboratory. Second, that the laboratory setting, and the interactions between the scientists, are unusually realistic — even though the plot itself has nothing to do with science. And third, that the director is the grandson of Werner Heisenberg, 1932 Nobel laureate and originator of the uncertainty principle in quantum mechanics.

Benjamin Heisenberg was born in 1974, about a year before his grandfather died, but he is keenly aware of his forebear's legacy. The German physicist was criticized for working for the Nazi nuclear programme during the Second World War. But

Benjamin suspends judgement on Werner's decision to stay in Germany, asking: "How can anyone ever be sure that things turn out the way they expect and want, and that other generations won't judge their decisions differently?"

Werner was not the only high-achiever in the family. Benjamin's father Martin, a professor at the University of Würzburg, is one of the most highly cited behavioural scientists in Germany. His maternal grandmother was sister to Carl Friedrich von Weizsäcker, physicist turned philosopher, best known for his theories of the nuclear processes inside stars, and to Richard von Weizsäcker, the popular former German president. Two of his brothers studied sciences.

But Benjamin's interests took him to art school, where his interest in film awakened.

Film school was disappointingly superficial. "The philosophy of the school was to learn

"I realized how similar the procedures of film-making are to doing a research project." — Katerina zu Eulenburg

A. ABBOTT

craft, not art," he says, recalling the scepticism some teachers had of his earlier short films. "Their film history started with *Terminator II* and they told me 'oh no, don't do art, no one will watch it; it's just a mindfuck.'" He laughs at his own audacity and earnestness.

The idea for *Schläfer* came to Heisenberg shortly after 11 September 2001. "I saw that domestic security was being tightened and that no one was objecting," he says. "There would have been mass demos if politicians had tried to pass even a part of the new security laws ten years ago." Fear, he noted, was changing people's politics. It led him to wonder: how do fear and politics affect personal lives and relationships? How much does it take to weaken someone's moral convictions?

Growing up among scientists, Benjamin knew that the scientific environment had the dramatic potential for examining these questions. Scientists are dedicated, driven and sometimes ruthlessly competitive. Scientific conflicts could illustrate how much pressure — or how little — it takes to break a person's ethical spine. The international nature of science was also important to the plot, because an Arabic researcher would not be so unusual. Benjamin created a potentially explosive, but plausible, mix of characters: a ruthlessly ambitious principal investigator; and two equally ambitious, inexperienced young researchers who collaborate, yet compete with each other.

Two events test their friendship and collegiality. First, they fall in love with the same girl, Beate. When she chooses Farid, Johannes makes contact with the secret service agent he had previously spurned. But when Farid turns moody on Beate — he has learnt that he is being watched, but doesn't know by whom — she takes temporary comfort with Johannes. Uplifted by his romantic triumph, Johannes tells the secret service he will no longer speak with them.

Then a lab drama sets things on their final, fateful course. One day Farid barges excitedly into Johannes' lab: "*Nature* has said 'yes!'" Suppressing his annoyance that he didn't know a paper had been submitted, Johannes is thrilled. He had, after all, helped Farid's project by reanalysing his sequence data and identifying two overlooked genes that were key to solving their biological puzzle. They celebrate. But then he learns that the manipulative Behringer has excluded him from the author list. His rage is ignited, with chilling consequences for Farid. After Farid is arrested for suspected involvement in a failed Munich bombing, Behringer replaces Farid's name with Johannes' on the *Nature* paper.



Benjamin Heisenberg's film *Sleeper* asks what it takes to weaken a person's moral convictions.

We are never told the details of the research project. "People would stop listening — they only need to know enough to understand why a conflict has developed, and glimpse its complexity," says Benjamin. But any milieu has to be convincing to make viewers believe in the film. This is why Benjamin took pains to ensure the science throughout was as real as possible.

Enter Katarina zu Eulenburg, Benjamin's cousin, and an immunology PhD student at Berlin's Humboldt University. She read the script and hosted the actors in her lab, teaching them how to pipette liquids and handle animals. She was on set, ensuring that in each lab scene the actors and extras were working appropriately. She even provided her gloved hands for close-ups of detailed procedures. "It was such fun — and I realized how similar the procedures of film-making are to doing a research project," she says. "It is hard and disciplined work which you really have to believe in, because it takes such a long time to get the idea, write the script, find the financing and then make the film."

Her and Benjamin's efforts were rewarded when *Schläfer* won the 2005 Midas Prize for the best European drama featuring science. But after seeing the film, Martin Heisenberg told his son that no one — not even a scientist as ruthless as Behringer — can swap names on a paper already accepted by *Nature*. But Benjamin didn't reshoot. "The dramatic moment was too important to the plot,

and I was sure that one incorrect detail would not disturb the realism of the lab scenes."

His father suspects he was the source of Benjamin's view of the importance of a *Nature* paper, something he finds a little embarrassing: "I always tell my students that these things shouldn't matter so much." And Benjamin says he himself has only experienced labs with very positive atmospheres. "My portrayal of a pushy lab, whose competitive atmosphere became poisonous, comes from what other scientists tell me exists."

In *Schläfer*, this poisonous atmosphere leads Johannes to betray Farid, a decision we condemn but understand. His betrayal is foreshadowed by a scene in which Johannes kills a lab mouse. "We see a parallel in Johannes' ability to coldly kill an animal, even though we know from other scenes that he is a caring and sensitive person," says Benjamin. "Killing an animal for the greater good of science requires a decision to cross an ethical border — and then you just do it without thinking about the ethics every day." Benjamin imagines something similar must happen when someone decides to spy for the secret service.

Would the German secret service really recruit scientists in a public research lab? It's not out of the question, says Martin Heisenberg, who witnessed an east German spy in his former lab at the institute for virology at the University of Tübingen before German reunification. "He regularly went through notebooks and transmitted information."

Alexander Kekulé, a microbiologist at the University of Halle, Germany, says that spying on a suspected terrorist in a German lab today is entirely conceivable. "There have been recent scandals in Germany about the BND [secret service] getting journalists to spy on their colleagues — there would be even fewer scruples in spying in other professions, including science."

With *Schläfer*, Benjamin says he has got the big moral issues out of his system, at least temporarily. His next film is about a bank robber in Vienna.

But he knows he will come back to science in the future. "Mostly science in films is characterized by the classical mad professor, or someone running around saying 'Oh my God! The organ emulator is running at 400%! — with no one having a clue what that could mean.'" But film-makers are becoming much more aware of the dramatic possibilities of science, he says: "The time of science in films is coming." ■

Alison Abbott is *Nature's* senior European correspondent.

The DVD of *Schläfer* with English subtitles is available from September. It can be bought from www.filmgalerie451.de.



When Johannes decides to spy on his colleague, he crosses an ethical line.

"My portrayal of a pushy lab comes from what other scientists tell me exists." — Benjamin Heisenberg

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