The Chewing Test for Intelligence

Aaron Sloman

Note for editors/reviewers: it is impossible to anonymise this document: it is a semi-serious comment on the folly of the idea of a test for intelligence, which is not what Alan Turing proposed in 1950: rather than proposing a test, he was making a relatively weak prediction about what computers would be able to do 50 years later, which very nearly came true. A version of this document was posted on my web site after the publicity given to the 2014 Turing Test in London – I felt some satirical counter-propaganda was desirable. When I saw the call for articles for this special issue of the journal I thought the editors, as researchers in this field, might be interested in my document and sent them a link. To my surprise I was asked to submit it for the journal, which I am now trying to do, without altering the tone of the article though the format has been revised for publication. I shall not be surprised or offended if it is decided that this sort of contribution is not suitable for an academic journal. The messy online original remains available here:
https://www.cs.bham.ac.uk/research/projects/cogaff/misc/chewing-test.html

Minds and mouths

I first suggested in Sloman(1978) that human mouths are more important than generally appreciated for development of intelligence, even from birth, in ways that are relevant to debates about bottle-feeding *vs.* breast-feeding, since bottle feeding makes the control task for the infant easier.

I have also repeatedly argued not only that Alan Turing did not propose a behavioural test for intelligence (he was far too intelligent to do that Sloman(2013) but that what we really need are tests for a good **theory** of human intelligence that is relevant to a wide variety of forms of human learning, development, society and culture, in the way that the theory of Turing machines is relevant to a very wide range (indeed an infinite variety) of Turing machines, and Turing machine behaviours.

Theories about different sorts of intelligence, e.g. ant intelligence, squirrel intelligence, crow intelligence require different sorts of tests. The Turing-inspired Meta-Morphogenesis project aims to encompass all the required mechanisms in a unified theory, eventually.

Note:
Requirements for a machine with mathematical competences of ancient mathematicians (e.g. constrained triangle qualia) are discussed here (work in progress):
http://www.cs.bham.ac.uk/research/projects/cogaff/misc/ijcai-2017-cog.html

Proposing a behavioural test for intelligence based on ability to replicate human behaviour is partly like proposing a test for the ability of a planet to support life by counting the proportion of life forms that that planet shares with our planet. It's a silly form of cherry-picking, a charge that I hope my proposal below will not merit, despite its crucial use of cherries.

I expect most readers of this document will have seen cartoon pictures indicating the relative numbers of neuronal connections between brain and mouth, supporting my claim (below) about the profound role of the mouth (including lips, tongue, cheeks, jaw and other movable parts) in human intelligence, although the claim itself is not based on evidence from brain science, but on chewing over everything I know about the role of a mouth in a typical human life, from sucking to get precious milk, through exploring a vast collection of portions of the immediate environment, including toes, fingers, earthworms and bits of clothing, and playing an increasingly active role in the consumption of increasingly varied types of food, then later (in most but not all humans) learning to talk, in some cases more than one human language, in some cases with enormous variation in speed, tone and volume (which in itself may have nothing much to do with intelligence).

Having recently been chewing over the flaws in (surprisingly popular) theories that put too much emphasis on supposed connections between intelligence and sensory-motor morphology (embodied cognition, enactivism, situated cognition, "New AI", etc.), I've decided to put my money where my mouth is, swallow my pride, and albeit somewhat reluctantly, propose a behavioural test for intelligence, the "Chewing Test for Intelligence", partly inspired by a test reportedly used by a famous Oxford college for selecting its Fellows. Perhaps it should be called the "The Oxford Chewing Test for Intelligence".

It is, or used to be, rumoured that All Souls College selects Fellows by inviting the best applicants for dinner in College, and serving cherry pie for desert, in a rimless bowl. The Fellows, but not the candidates, get portions of pie containing only previously stoned cherries. The candidates have to deal with the cherry stones (i.e. the pips). (As far as I know the college has never been so heartless as to transfer the stones removed from Fellows' cherries to portions of pie served to the hapless candidates.)

The candidates who manage to cope with the stones until they can discretely dispose of them are obviously the pick of the bunch, since managing a mouthful of pips without swallowing any, while swallowing the delicious cherry flesh and pie filling, and engaging in profound conversation in between chewing or swallowing, is clearly a mark of great intelligence, as will be affirmed by all roboticists who have attempted to design robots capable of passing such a test, or have tried passing it themselves.

The new test for (Oxford) intelligence

I don't expect All Souls College to be prepared to spend time testing robots, and I don't expect robot designers to invest their ingenuity in designing robots that are not only highly intelligent, but also capable of sitting, eating and talking in a typical Oxford college chair. So I have devised a modified version of the test that is slightly more flexible, and much cheaper than the All Souls test. Moreover, no cherry pies need be harmed in this test, which also avoids the risk of breakage of precious rimless desert bowls.

The new test is applied to both humans and robots. It requires robots to have a human-like mouth (which most humans have by default), including tongue, lips, teeth, jaw mechanism, and a waste outlet for chewed cherry flesh. Passing the test involves being able to put N cherries in one's mouth, chew them, and swallow the cherry flesh without swallowing or otherwise disposing of any of the stones, or breaking any parts of the mouth. A weaker version of the test could allow one or more teeth to be broken on impact with a cherry stone. How the number N is selected is explained below.

Obviously designers will not be allowed to submit robots with special oral apparatus designed only to perform this task, though selection of required collateral capabilities is a task for the future. It might, for example, include checking whether the number of cherries in one's mouth is a prime number.

A wide variety of humans of varying shapes, sizes, ages, and cultures, will first be given this test, with N = 1, then 2, then 3, etc. until it is clear which value of N is the largest that the majority of the tested humans can cope with. Let's call that Nh. (Some further work is required to specify what should count as coping with N cherries in this context. A possibility might be managing to deal with N cherries and then going on to perform normal robot functions, such as cleaning carpets. A more challenging version would require both to be done in parallel.)

Pilot experiments suggest that Nh is likely to exceed 5, with cherries of types I have encountered. It may well turn out that the value of Nh is highly culture-dependent, being very low for cultures deprived of cherries and much higher for cultures with a passion for listening to poetry readings while eating cherries from a bag, at performances where cherry stone receptacles are not provided.

Readers wishing to propose a specific target value for Nh should email me, citing evidence. Perhaps future research will reveal an algebraic formula for deriving Nh from demographic data. In that case, instead of there being only one Chewing test for intelligence we shall have Chewing tests for English intelligence, for Scottish intelligence, for Indian intelligence, etc.

Robot candidates for this test will also be given variants of the test with N cherries, including N = 1, 2, etc. up to Nh, or some higher value (in the interests of scientific research rather than testing for intelligence). Future research will be required in order to select the appropriate value for robots manufactured, or designed, in one culture and tested in another. Alternatively it may be possible to devise procedures for robot brain-washing to ensure that each machine is tested using the value of Nh relevant to its current place of employment.

Those that cope with Nh cherries will be deemed to have passed the Chewing test. Any robot designer at least 30% of whose robots manage to pass the test will be acknowledged as an intelligent robot designer. (A future wealthy sponsor may be willing to provide suitable plaques to be awarded.)

Since I don't expect any robots able to take part in this test will exist for at least 10 years, and those that try will all fail, I suggest that the test be advertised and run once every 10 years till the end of the century. At that stage an international Chewing Test panel (containing humans and some robot philosophers if any have been produced by then) will decide whether and how the process should continue in the next century. If no humans are still alive on this planet by then, the panel may contain only robots interested in this problem.

After the chewing test has been passed...

If that stage arrives, the next level on the ladder to demonstration of Genuine Artificial Intelligence (GAI) will be demonstrating the ability to speak with tongue in cheek, as humans often do: (https://en.wikipedia.org/wiki/Tongue-in-cheek).

Note:

The Meta-Configured Genome project Chappell and Sloman(2007), Sloman(2013b) is a long term attempt to understand what enables a genome to produce new members of a species and how they can acquire various kinds of intelligence during their life-span, including out-performing their predecessors. This was partly influenced by Schrödinger's discussion of the role of chemistry, and its reliance on quantum mechanisms, in enabling the (mostly) reliable inheritance across generations, of genetically specified features, Schrödinger(1944) . For an online tutorial introduction see http://www.cs.bham.ac.uk/research/projects/cogaff/movies/meta-config/ (work in progress). This is an extension of the Meta-Morphogenesis project .

A gap in the theory

Bad luck (or unintelligence) recently created a gap -- a broken upper incisor. My dentist decided it would need a crown, requiring various nasty processes spread over a few weeks, which I'll leave to the imagination of readers who are not limited to embodied cognition. One of the early processes involved killing the root of the tooth in preparation for a post to be inserted to support a crown. The base of the nerveless tooth was then filled and sealed temporarily. That left me with an uncrowned top left front tooth: the space that had been filled by the lost portion of tooth, and which was later to be filled by a new crown had been left empty. I.e. there was a new gap.

Something strange then happened. A few days later I bought a bag of large and juicy cherries and ate a few each day for several days, having completely forgotten about this two and a half year old document. Gradually it dawned on me that I was hallucinating: it felt as if I had acquired cherry stones containing gaps. When a stone happened to get into the new gap I had the definite experience of a stone with a big gap in it, rather than a gap with a stone in it.

So, for the sake of science and philosophy, I had to try putting other solid objects into the gap, e.g. a thin propelling pencil. Curiously that also acquired a phantom gap at the location between the two whole teeth. Moreover, as I slid the pencil in and out of my mouth the gap seemed to move along the length of the pencil. However, straightening a wire clip and moving the wire between the remaining teeth produced no peculiar illusions, unless there was an illusion that I happened not to notice.

This seems to be a nice example of the unreliability of embodied cognition: after many decades of having a row of solid top front teeth, presumably backed up by many generations of human evolution, my brain had developed a strategy for interpreting sensory signals (changing pressure signals in this case?) coming from the base of the teeth, and the relevant portion of my brain had not been informed by other, more knowledgeable, portions that the signals now needed to be re-interpreted.

In short: miscognition triggered by the lack of customary pressures produced by solid cherry stones and pencils led to hallucinated holes. (This is slightly oversimplified in ways that are not relevant here.)

Fortunately, my disembodied cognitive resources (required for science and philosophy) are still fully functional so I was able to work out (roughly) what was going on, which may or may not have saved me from some dangerous action based on the faulty perception.

Just under two weeks remain before the new crown is to be installed. After that, if I remember, I'll add a report on what I hope will be return to normality.
28 May 2018: Just remembered. I've been back to normality for months.

Of course, anyone who does not believe my report is welcome to repeat the experiment, but please first make sure that you know a good dentist.

Appendices

A.1. Humans with abnormal morphology

Not all the scientists and philosophers who propose theories of embodied cognition, sensory-motor intelligence, etc. and who emphasise the importance of sensory motor morphology in constituting intelligence or cognition, seem to be aware of the psychological and ethical implications of their claims. For example, taken literally, their claims imply that humans with various physiological abnormalities are incapable of perceiving, thinking about, or talking about the same physical environment.

Such a philosophy could be contrasted with an alternative view based on two ideas (discussed in more detail in other papers):

- Although humans lack certain abilities at birth that they have later on, it does not follow that the change is based entirely on what they have learnt empirically. The genome could have important features that are not manifested at birth but which strongly influence later developments (as proposed in Chappell and Sloman (2007)). A highly abstract generic capability may be capable of being deployed via different sensory and motor modalities, which clearly happens during language development in children with and without hearing. Spatial competences supported by what evolution produced in our ancestors may also allow different developmental trajectories.
- Information acquired via specific sensory and motor modalities may be stored in forms that are amodal, e.g. map-like information stores that discard the sensory and motor details of the information-acquisition processes. (E.g. some SLAM systems used in robots for simultaneous localisation and mapping.) This sort of ability is essential for acquiring and using knowledge about spatial terrain that looks slightly different when traversed via slightly different routes, and looks very different during different seasons -- with and without leaves on trees, snow covering, etc. -- or even at different times of the same day, e.g. with and without rain falling, with and without winds blowing trees, and with and without crowds of people.

The human population is very varied not only as regards superficial features such as skin colour, hair colour, height, weight, vocal timbre, etc. but also in deep ways connected with genetic abnormalities or results of illness or injury, in some cases before or soon after birth. As a result there are humans born blind, deaf, blind and deaf, missing arms, missing legs, conjoined as twins, with cerebral palsy, seriously deprived by illness or injury while very young, or by drugs, such as thalidomide, taken by mothers during pregnancy. But despite all those surface differences their brains may develop common structures that are to a large extent based on instantiating shared abstract patterns provided through the genome -- not innate knowledge of specific places, but innate a-modal meta-knowledge about what places are and how they can be related. (Compare the meta-knowledge about language provided by the genome and used in developing knowledge of specific languages with many different details of semantics, vocabulary and syntax. See the example of the Nicaraguan deaf children below.)

Note added: 22 Dec 2014
Last night, on the BBC world service I heard a report about 37-year-old Claudio Vieira de Oliveira, including interviews: "Throughout my life I was able to adapt my body to the world. Right now, I don't see myself as being different." He was born with an extraordinary collection of deformities including a neck permanently bent over backward so that his face is upside down. Yet he sees and interacts with his environment, managed to get through school, get a degree in accounting, and even gives public lectures.
http://www.disabilityinaction.com/story-of-man-with-head-on-backwards.html

http://www.buzzfeed.com/richardhjames/man-born-with-upside-down-head-defies-doctors-to-become-a-pu#.eaarA9BMPJ
Man Born With "Upside-Down Head" Defies Doctors To Become A Public Speaker

Note added: 21 Dec 2014
The ability of a group of deaf children in Nicaragua to invent a new sign language suggests that what is normally called language learning should be regarded as collaborative language creation where the collaboration normally involves both expert and novice language users, where the novices are in a minority. In the Nicaraguan case the novices were not in a minority, so they were able to create something rich and new. See
The Birth of New Sign Language in Nicaragua
http://www.youtube.com/watch?v=pjtioIFuNf8

These children were not deriving linguistic knowledge empirically from a pre-existing linguistic community. Their shared genome allowed them to collaborate in creating a rich new sign language. I have argued elsewhere that rich sign languages must have evolved before spoken languages, and internal languages used for percepts, control of complex actions, formation of intentions, plans, reflection on past experience etc. must have evolved before languages for communication.
http://www.cs.bham.ac.uk/research/projects/cogaff/talks/#glang
Talk 52: Evolution of minds and languages.

Some of those unusual individuals manage (with varying amounts of help) to surmount their disadvantages, so as to lead rich and satisfying lives, and some of them become famous including, for example, Helen Keller (who lost sight and hearing very young), Alison Lapper, the artist and writer without arms, Esref Armagan, the painter born blind, Abigail and Brittany Hensel, the conjoined twins, and many others. (All of these, and more, can be found via internet search engines.)

An interesting discussion of blind mathematicians can be found here, with links to further online information: http://m-phi.blogspot.co.uk/2011/07/what-is-it-like-to-be-blind.html. It references this very interesting paper:

http://www.ams.org/notices/200210/comm-morin.pdf
Allyn Jackson, The World of Blind Mathematicians, in
Notices of the American Mathematical Society, 49, 10, 2002,

If the fashionable claim that cognition is inherently bound up with sensory-motor morphology were true, that would suggest some deep chasm between the minds of humans with "normal" physiology and those with varying degrees and kinds of divergence from those norms. For example, it would seem to imply that individuals with normal vision and motor control cannot converse about euclidean geometry or topology with those born blind, or without hands. (I have heard a well known researcher go further and claim that people born blind cannot understand spatial structures and relationships.)

It may be true that the rich sensory and motor capabilities deployed out of sight within a normal mouth do not directly support notions like straightness, or metrics for distance, area, volume, angle, curvature, velocity etc. However, the same is true of biological mechanisms involved in auditory, visual, haptic, tactile, or kinaesthetic perception of spatial structures and relations. Many vision researchers seem to be seriously misled by the fact that video cameras generally provide visual input in the form of rectangular arrays of measurements, quite unlike biological visual systems.

Far from Euclidean spatial structure (including notions of straightness, parallelism, etc.) being inherent in the biological mechanisms, a complex process of development (through learning, invention of new technology for measurement, and social evolution), is required to build our familiar Euclidean spatial ontology, e.g. for use in various practical tasks, such as way-finding or building houses using initially scattered materials.

This is clearly not a sensory-motor ontology but an a-modal ontology: the distance between two trees has nothing specific to do with whether the gap is seen, crawled along, estimated using outstretched arms, or measured in some other way.

If this is correct, researchers aiming to explain multi-modal integration of sensory information, e.g. in terms of statistical relationships between different sensory and motor streams, are misguided if they claim that that is all that's going on, ignoring the construction of a-modal, multi-functional stores of information, e.g. about local geography. Robotic techniques for SLAM (Simultaneous Localisation and Mapping) illustrate some forms of a-modal integration of sensory-motor information to achieve new power.

How cognitive systems develop abilities to think about and make use of such properties and relations inherent in spatial structures, is a non-trivial research topic. I have not yet encountered any plausible candidates based on sensory-motor theories, though there are obvious alternatives that depend on use of measuring rods, procedures for comparing objects by lining them up, and use of other external objects and processes.

In that case there is no obvious reason why the same ontology, and associated theory, could not be built by intelligent agents with different sensory-motor mechanisms but engaged with the same rich environment. This, after all, is how our increasingly versatile and accurate devices and procedures for assigning geometric properties and relations to objects have evolved over past centuries.

Compare the ways of using length, angle, volume, etc. available to ancient and medieval builders of houses, churches, temples, bridges, etc. and those available to modern scientists and engineers. Their tools and techniques can change without what they are referring to changing. See also:
http://www.cs.bham.ac.uk/research/projects/cosy/papers/changing-affordances.html

The moral for communication between humans with different sensory-motor organs and capabilities should be obvious.

Note added 4 Feb 2017
A useful antidote to anti-computational philosophical prejudices can be found in this Stanford Encyclopedia article: Michael Rescorla on Computational Mind

A.2. Note on tongue control
Anyone snorting at a cheeky child "Control your tongue!" needs to be aware of the complexities and difficulties involved in tongue-control. A human tongue has several muscles controlled by the brain using information both from sensors in tongue and other parts of the mouth sending information to the brain and information from brain to muscles in the tongue and other parts of the

mouth. The muscles and nerves enable your tongue to be used not only for spoken communication, but also for a considerable variety of other actions, including cleaning teeth in different parts of the mouth, detecting some kinds of tooth damage, and various kinds of food that can be stuck in the mouth, manipulating objects in the mouth (e.g cherry stones, and various kinds of food that need to be manipulated during chewing), sucking a source of fluid, squeezing objects (e.g. by pressing an object against the roof of the mouth, or against teeth). What humans can do with their tongues is partly similar to what elephants do with their trunks, and what an octopus can do with its tentacles. In addition there are many other kinds of control in speech and singing.

As far as I know, the important role of the tongue in human sensing and acting has been completely ignored by researchers attempting to build humanoid robots, including those who accept the slogan that replicating human cognition will require replication of human morphology. It follows that if their theories are correct their robot projects are failures.

Some other animals, e.g. giraffes, have much longer and more versatile tongues, which can grasp vegetation and pull to detach it from the rest of the plant.

A.3. Note on whimsy

It's possible that readers unfamiliar with British whimsy will need to be warned that not everything in this document is written with a straight face. Had it been a more serious document it would have drawn attention to the important distinction between online intelligence (on which which researchers emphasising embodied cognition, enactivism, and the like tend to focus) and offline intelligence used in considering possible actions, including planning multi-step actions, without actually performing any, and in discovering and proving theorems in various branches of mathematics, designing aeroplanes and skyscrapers, inventing deep scientific theories, composing music or poems in one's head, enjoying music or poetry without moving, and many more.

A related document: What's it like to be a rock?
http://www.cs.bham.ac.uk/research/projects/cogaff/misc/rock/rock.html

A.4 A test for DNA (gene-expression) mechanisms?

The Meta-Configured Genome theory (co-proposed with Jackie Chappell) investigates requirements for DNA to produce the many effects it has, including playing a key role in the evolution of all forms of biological intelligence as well as in the development of intelligence in the processes of development of a human embryo, and other embryos. When we have a better understanding of the details of those processes, and how they achieve the spectacular results of biological evolution, we'll be able to propose a test for evolutionary power that could be applied to proposed alternative mechanisms: artificial evolution mechanisms?

Progress in Sheffield?

Speaking of whimsy, perhaps this video is evidence that the university of Sheffield has already (in 2008) taken the first steps toward addressing the chewing test: https://www.youtube.com/watch?v=ZFT9B6DT6wA

Anton, the animatronic tongue

Sheffield PhD student Robin Hofe has developed this animatronic tongue in order to study the mechanisms of speech production. His hope is that eventually this will lead to a better understanding of variability in speech, which in turn will allow better automatic speech recognition

systems to be built.
Uploaded on 27 Nov 2008. Reported in:
Robin Hofe & Roger K. Moore (2008)

For more on the difference between online and offline intelligence see this abstract for an invited presentation at a "Computers and Minds" workshop in Edinburgh, 21st Nov 2014.
http://www.cs.bham.ac.uk/research/projects/cogaff/misc/c-and-m-2014.html
Disembodied Motionless Intelligence
Why offline intelligence is as important as online intelligence for many animals and future robots.

BACKGROUND AND REFERENCES

Ron Chrisley on Extended Mind

Ron Chrisley (Sussex University) has a page mentioning early versions of the extended mind theory, including an interesting quote from John Dewey's introduction to his "Essays in Experimental Logic" (1912), also mentioning Dewey's remarks on the reflex arc in 1896.
https://paics.wordpress.com/2014/11/17/aaron-sloman-on-the-extended-mind-in-1978/

Michael Rescorla on Computational Mind

Michael Rescorla, Michael (2016), "The Computational Theory of Mind", *The Stanford Encyclopedia of Philosophy* (Winter 2016 Edition), Edward N. Zalta (ed.),
https://plato.stanford.edu/archives/win2016/entries/computational-mind/

Sloman, A, 1978-2020

http://www.cs.bham.ac.uk/research/projects/cogaff/crp/
The Computer Revolution in Philosophy: Philosophy, Science and Models of Mind
(Revised online edition with additional comments 2001--2017)
Originally published by Harvester Press and Humanities Press 1978

This document

This is part of the Meta-Morphogenesis (M-M) Project, the sort of project I think Alan Turing might have worked on had he lived longer. Related web pages on this site include the following:

http://www.cs.bham.ac.uk/research/projects/cogaff/misc/meta-morphogenesis.html

http://www.cs.bham.ac.uk/research/projects/cogaff/misc/toddler-theorems.html

http://www.cs.bham.ac.uk/research/projects/cogaff/misc/turing-intuition.html

http://www.cs.bham.ac.uk/research/projects/cogaff/misc/kant-maths.html

http://www.cs.bham.ac.uk/research/projects/cogaff/misc/mm-conclusions.html

http://www.cs.bham.ac.uk/research/projects/cogaff/misc/impossible.html

https://twitter.com/aaronsloman/status/1159849248931889152
The twitter tangle test for intelligence.
http://www.cs.bham.ac.uk/research/projects/cogaff/misc/construction-kits.html

For more links see:
http://www.cs.bham.ac.uk/research/projects/cogaff/misc/mm-background.html

References

Chappell and Sloman(2007) Jackie Chappell and Aaron Sloman, Natural and artificial meta-configured altricial information-processing systems, in *International Journal of Unconventional Computing*, 3, 3, 2007, pp. 211–239, http://www.cs.bham.ac.uk/research/projects/cogaff/07.html#717

Hofe andMoore(2008) Robin Hofe & Roger K. Moore (2008), Towards an investigation of speech energetics using 'AnTon': an animatronic model of a human tongue and vocal tract, in *Connection Science*, 20:4, 319-336, http://dx.doi.org/10.1080/09540090802413251

Schrödinger(1944) Erwin Schrödinger, *What is life?* (1944) Cambridge University Press,

Sloman(2013a) Aaron Sloman, The Mythical Turing Test, in *Alan Turing—His Work and Impact* 2013, Eds. S. B. Cooper and J. van Leeuwen, Elsevier, Amsterdam, pp. 606-611, http://www.cs.bham.ac.uk/research/projects/cogaff/11.html#1106c

Sloman(2013b) Aaron Sloman, Virtual Machinery and Evolution of Mind (Part 3): Meta-Morphogenesis: Evolution of Information-Processing Machinery, in *Alan Turing—His Work and Impact* 2013, Eds. S. B. Cooper and J. van Leeuwen, Elsevier, Amsterdam, pp. 849-856, http://www.cs.bham.ac.uk/research/projects/cogaff/11.html#1106d