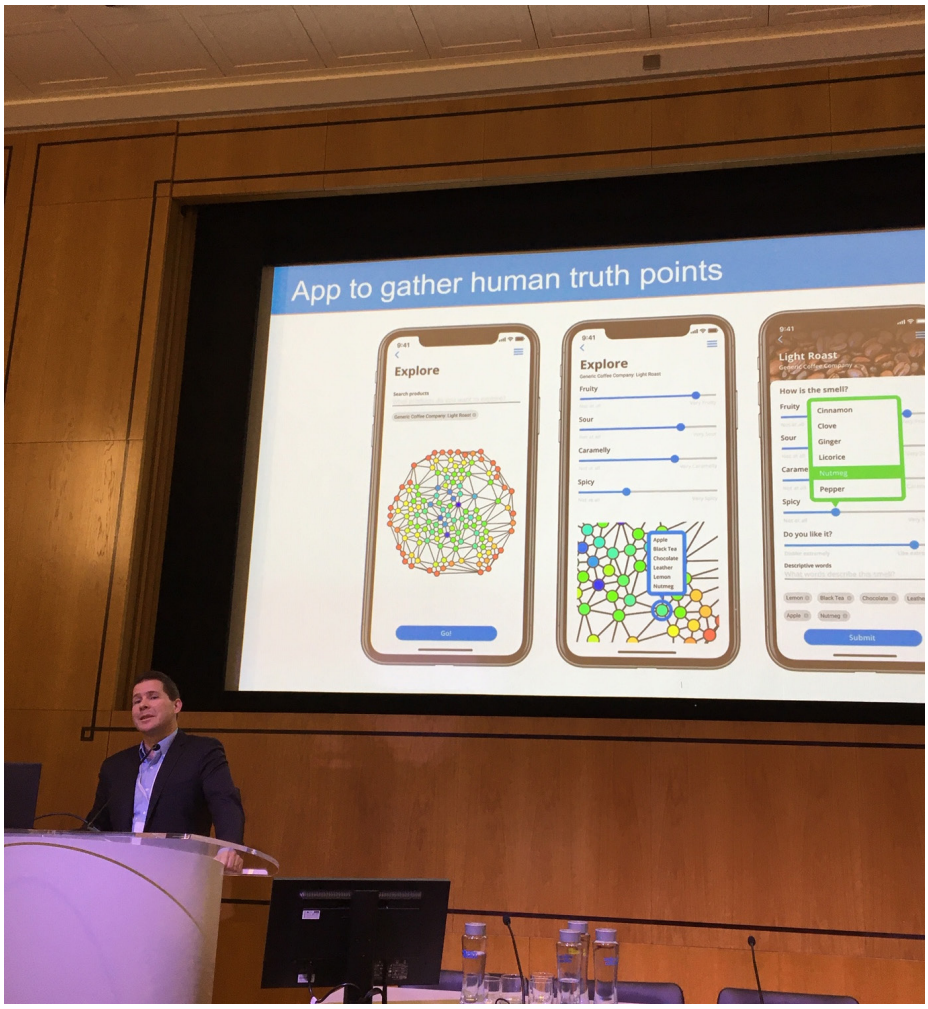
Josh Silverman of Aromyx describing the olfactory data gathering app.



9th Fragrance Forum: Scent and Artificial Intelligence

After a warm welcome from Lisa Hipgrave , Director of IFRA-UK, it was straight in to the deep end of technology as Alison George of the New Scientist introduced the first speaker, Alex Witschko from Google Brain for a presentation entitled 'Artificial Intelligence, machine learning and olfaction'. Google Brain is a deep learning artificial intelligence team, employing 3,500 globally and tasked with 'making programmes that learn to learn'. For example, the Google Translate visual app, constructed from learning from data, which uses examples and experiences of constructed sentences rather than translation of dictionary vocabulary. If a machine needs to learn to identify pictures of dogs then it learns the 'patterns of dogness' and the same applies to patterns of speech. Artificial Intelligence (AI) is used across all Google products and represents a technological sea-change over the last 10 years. Dr Witschko described the levels of learning driving artificial intelligence: the science of making things smart; machine learning; techniques to learn from data; deep learning; techniques to learn holistically. Google Brain has developed TensorFlow, opensource software for dataflow and machine learning applications such as neural networks, used by major global corporations such as Airbnb, Airbus, Dropbox and Uber.

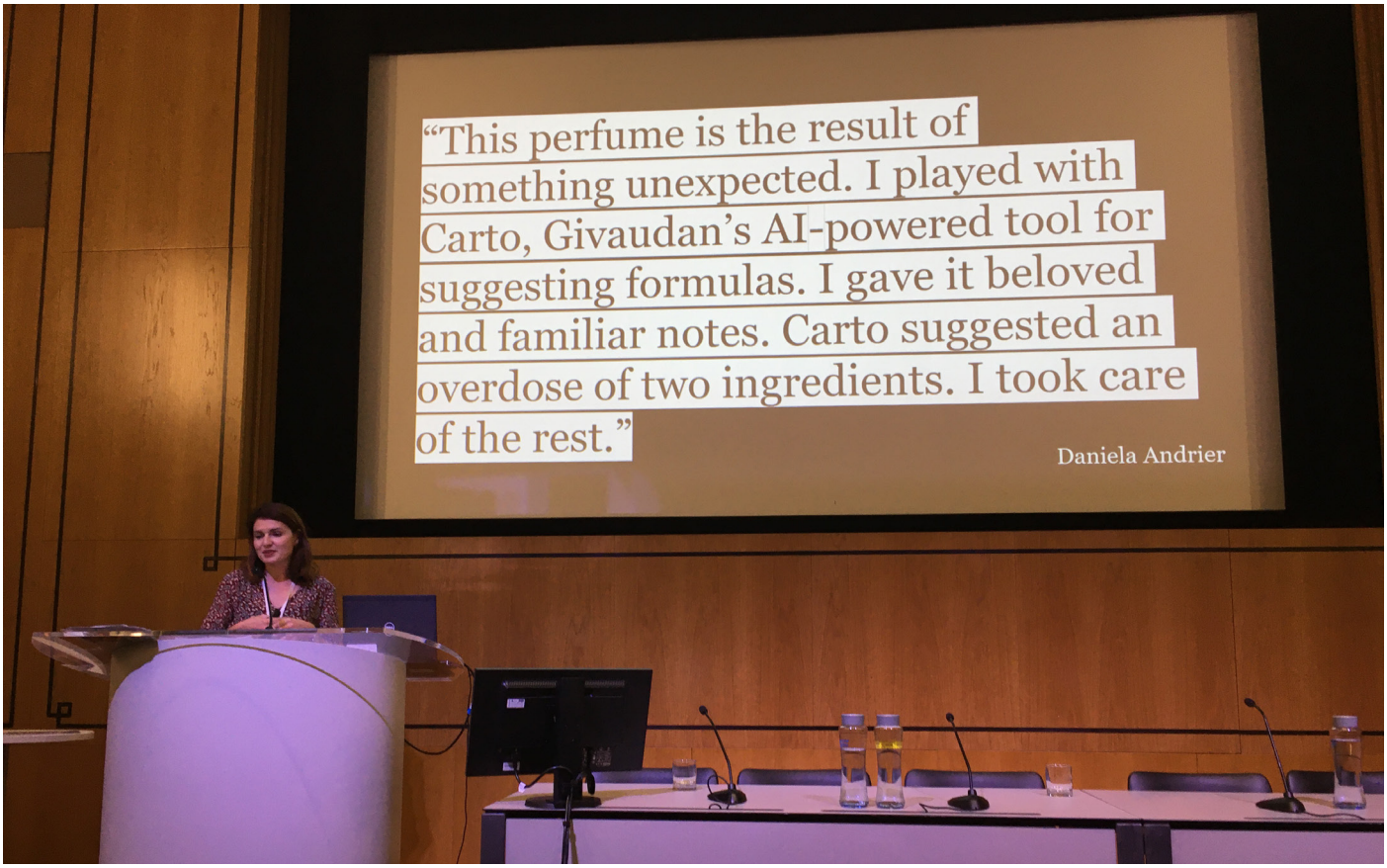
What does all this mean for the flavour and fragrance sector?

- molecular adaptation e.g. to adapt the biodegradability of products. AI can get 80% of the way there for final refinement by humans.
- Product formulation e.g. moving a fragrance from eau de parfum to a shampoo
- Understanding environmental impact of products
- Predicting consumer behaviour

The technological frontier is how to enable machines to recognise smells with sensor hardware. This issue is the main barrier; what would sense the smells?

Professor Thomas Nowotny of the University of Sussex discussed the lessons from the olfactory system of insects. Prof. Nowotny firstly described the olfactory system of humans, through mucus and odour binding proteins, through olfactory receptors to the olfactory bulb and piriform cortex. By contrast insects smell with their antennae and have been shown to have much faster olfactory perception. Scents, rarely a single odour, were graphically depicted in complex rippling structures, known as odour plumes, and the challenge of separating components of scents within these plumes was considered. Compare this with the ability to segregate out the sound of one voice in a noisy cocktail party. Nowotny's study of bees showed that the insects could be trained to recognise and respond to smells and this work is now being extended to extreme learning machines. His research could, in time, lead to new discoveries on how humans, and robots, can make sense of the complex range of components of a scent.

Josh Silverman of Aromyx shared the latest from biotechnology and AI; how new technology is solving sensory problems. Aromyx is a Silicon-Valley based tech company that was



initially aiming to digitize the taste and smell of canine receptors in order to detect explosives and poisonous gases. The scope of the technology has broadened to industrial and consumer markets and could be used, for example to detect spoilage, disease and pathogens. This sets the goal of systematic classification and the need for quantitative descriptors for one trillion perceived odours/flavours. A simple example is the quality assurance step of a human 'nose checking' the smell of a new car as it rolls off the production line. If the human sensory properties can be quantified then an AI-led process would be repeatable, consistent and easy to use and interpret. Quality assurance in lemon juice is already successfully using biosensors to grade the juice, replacing the need for a supplementary taste panel.

The complex technological roadmap of data insight and olfactory receptors leads to a point in the future when machine learning can design, create and improve products. Comparing the human vision system (which evolved from the olfactory system) our understanding of colour perception is much more straight forward with the red/blue/green palette that can be encoded to create any colour. The hypothesis is that odour/flavour perception can be structured similarly to colour, but the chemical space is significantly more complex. 'Receptors measuring related areas of chemical space are grouped orthogonally by the olfactory bulb. This is likely a self-reinforcing network process similar to the development of other neural connections.'

The aim is to get an olfactory standard similar to colour mapping, e.g. that used in adobe software, using a standardised language but with cultural differences as part of the model. Partners will be involved in this project of 'untangling the rainbow' for odour and an app is being used to gather the data, the 'human truth points' of scent perception. This area of science, the odour percept, is also discussed by contributor Charles Sell on page 11 of this edition.

Dr Dmitrijs Dmitrenko, from the Sussex Computer Human Interaction (SCHI) Laboratory at the University of Sussex discussed scents and self-drive cars; can scent be used to make it safer? The development of self-drive cars continues, but not without incidents of technology failure. Systems do exist to alert the driver to take over control from autopilot and to date these have been auditory or visual signals. Multi-modal may be best approach and so why not use scents? Short puffs of scent could be used as notification of potential hazards with the benefit of directly reaching the primary cortex. Mercedes and BMW already have digital scent diffusers for comfort and various studies have already shown that scents can be used to increase alertness, improve braking performance and decrease drowsiness. Dr Dmitrenko's driver simulation study showed that a burst of scent, delivered in advance of reaching a potential hazard, could heighten awareness and response. The key premise of the presentation was to question whether we can trust autopilot and whether the use of scents can lead to more trust in the reliability calibration of such systems. The key limitations to progress are the varying levels of olfactory sensitivity, personal differences in scent perception and how to ensure that habituation and adaptation is avoided.

The big question for AI and fragrance to consider is of course – can AI be used to create new scents? Valerie Drobac of Givaudan provided an insight into the possibilities for this emerging field. Unlike most other processes in the value chain, perfume creation is a domain that has not yet been seen as a process that could

be digitised, however, Givaudan is developing in-house expertise and committing to innovation in this field. Drobac introducted 'Carto' an intuitive and interactive AI-powered tool, enabling perfumers to transform the art and science of fragrance creation. You can view a short video on Carto here youtube.com/watch?v=mc1-9ow_xe0

Carto has been used to create an accord and sample the scent instantly using complex data, formulas, ingredients and insights, enabling it to offer suggestions to perfumers. The audience were then able to smell a Carto-supported creation, Etat Libre d'Orange 'She was an anomaly', a scent with iris, sandalwood and musks. Perfumer Daniela Andrier who created the scent described the AI supported process: 'This perfume is the result of something unexpected. I played with Carto, Givaudan's powerful tool for suggesting formulas. I gave it beloved and familiar notes. Carto suggested an overdose of two ingredients. I took care of the rest.' Carto therefore has the potential for faster development, meeting changing customer demands and tastes. Although perfumes could be created with just AI, the human perfumer still adds the confidence required to take a new scent to market.

The event's panel discussion was lively, considering if AI would dampen creativity or free up time for creativity. There are also significant issues around trust and the complex brain processes deciphering odours. As Dr Wiltschko concluded, 'somebody has to decide what to do and why', comparing it to architecture and design where AI opens the door for greater effectiveness and potentially greater innovation but the creativity still needs to be led by someone at the helm. And as for the consumer's possible wariness of AI, it was considered that, for the future customer, the AI creation of a product could in fact become part of the emotional story that drives a purchase.

As always the Fragrance Forum provided food for thought with an impressive selection of speakers from the world of AI and fragrance creation.

Above Left: Valerie Drobac of Givaudan shares the AI creation process.

Above: *(Left to Right)* Dr Allison George, Dr Josh Silverman, Valerie Drobac, Professor Thomas Nowotny, Dr Dmitrijs Dmitrenko and Dr Alex Wiltschko

Left: Sharon Shand at the conference exhibition