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Submission of proposal for individual paper:
The topic of this paper relates to *multimedia interactive exhibits* using a range of *visitor interfaces* developed for an *interpretive exhibition* about chemistry. The *Chemical attractions* exhibition itself integrates many forms of media (eg computer and mechanical interactives, objects, photographic and cartoon graphics, audiovisuals, labels, a sculptural feature and more) to provide a range of experiences and levels of information for a variety of audiences.

Abstract:

Chocolate, fireworks, dollars and scents: the chemical attractions of a multiple media exhibition

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The aim of the *Chemical attractions* exhibition at the Powerhouse Museum in Sydney, Australia is to make a range of visitors more aware about chemistry and the role it plays in their lives. It does this by presenting aspects of the chemistry of everyday products in displays that integrate diverse media such as computerised and electro-mechanical interactives, objects, photographic and cartoon graphics, audiovisuals, labels, a sculptural feature and more.

Three of the multimedia interactive exhibits are particularly noteworthy. (1) The chocolate interactive dispenses different flavours of chocolate chips after the visitor activates animated and video information via a touch screen computer monitor. (2) The fireworks display uses a computer to link and control the illumination of individually selected fireworks components to a selection mechanism, a display of chemical information about each selection on an LCD screen and appropriate video sequences which show the visitor's particular firework being assembled and ignited. (3) Four fragrance interactives provide different experiences of scent. All use microprocessors to control the amount and type of aromatic chemical being dispensed and the playing of audio information stored on flash memory cards. These and other displays in the exhibition were conceived to entice visitors to explore the underlying chemistry of some of their favourite things.

Introduction
In this exhibition, called *Chemical attractions*, we try to make sense of everyday chemistry, particularly for those who are unaware of the ubiquitous chemical nature of their existence. These people are prone to confusing good and bad chemicals with natural and synthetic products, purity versus additives and so on. Actually they are like so many of us who are exposed to the chemical disaster reports in the media. That's because we rarely encounter stories about how we all depend on chemicals one way or another. The exhibition looks at this basic chemical dependency and aims to demystify at least some of the chemistry in the world. And if our visitors begin to consider that they live in an earth, sea and air of chemicals and chemical reactions, both natural and synthetic, we would be very happy. The challenge is to attract them to the display in the first place and then get by their preconceptions in the second.

We figured they would come to the exhibition if we displayed some of their favourite things. And if we let them have a sample or two they might stay long enough to become mildly curious about the chemical context we were placing them in. As variety is the spice of life, and might make people visit longer, we presented a range of themes and ideas using a diversity of media, such as computerised and electro-

mechanical interactives, objects, photographic and cartoon graphics, audiovisuals, labels, a sculptural feature and more. This integration of media is common to most science and technology exhibitions in the Powerhouse Museum, located in Sydney, Australia.

Our challenge in developing each of the interactives of the exhibition were to devise meaningful experiences that were easy to use, safe, reliable, produced non-toxic or no waste, required minimal regular servicing and were affordable. These are difficult criteria for a long term exhibition about chemistry.

The overall approach of the exhibition is to show how the use of chemistry interacts with people and the environment. This led us to develop sections about the chemistry of chocolate, colour and its neighbour on the electromagnetic spectrum, ultraviolet light, fragrance, plastics and surfaces. This also fitted in very nicely with the interests of the exhibition sponsors, the Royal Chemical Institute (NSW branch) and World's Finest Chocolates Australia.

Chocolate - tempting your tongue and brain
Flavour is what you experience when two chemical senses - taste and smell- work together. Food chemicals stimulate tastebuds and smell cells. The cells send signals to your brain, which then experiences a flavour sensation.

The chemicals in chocolate have titillated so many tongues, noses and brains that chocolate is the world's most popular flavour. With the temptation and stimulation caused by the contents of the showcase we would be cruel if we didn't give the visitor a taste of the subject. The interactive to do just that had to be pretty special. And we're fortunate that as part of their support for the exhibition, World's Finest Chocolates Australia supplies the various chocolate chips for the device we created.

What is chocolate?
Facts and fantasies
An instant queue forms in front of this interactive as soon as a school group enters the exhibition. And despite the entire experience taking 8 minutes, the kids patiently wait their turn. That's the power of chocolate!

But for us to deliver on the promise of a flavourful experience, we had to create a hygienic way of storing and delivering chocolate, limit the amount of chocolate given to each visitor, make a reliable delivery system and address concerns about visitor reaction to possibly unpleasant bitter tastes (eg spitting out a sample of raw cocoa mass).

The lively rhythms of a Jamaican steel drum band attract the usually more than willing visitor to the exhibit. When they accept the invitation to touch the monitor screen to start the program they interface with a Pentium computer. The computer, fitted with an MPEG card, provides the animated graphic and video images to the monitor. It also controls the museum designed microcontroller which manages the chocolate delivery system.

The program gives a short narrated graphic introduction showing where cocoa beans, needed for making chocolate, are grown in the world. Then the visitor is asked to touch the first in a row of 4 differently coloured antropomorphic caricatures of cocoa beans. These represent respectively cocoa mass (made from the ground fermented and roasted cocoa bean), dark, milk and white chocolate.

This starts the video and animated sequence where the cocoa bean shows the chemical and mechanical processes of how it's turned into cocoa mass, the material used to make chocolate. This and the three other chocolate stories are about 2 minutes long. Near the end of each segment the visitor is invited to place the palm of a hand under the vertical tube near the monitor and to touch the screen to get a sample of the chocolate flavour they've been learning about.

This touch brings into action the chocolate storage and delivery system which is enclosed in a perspex box at the top of the exhibit above the tube. The microcontroller activates a movable arm in one of four hoppers, each containing chips of one flavour of chocolate. The arm drops 1 to 4 chips into the tube where a funnel guides them past an optical sensor. If no chips are detected, the controller turns on a vibrating device to redistribute the chips toward the front of the hopper above the arm. Up to two more attempts are made to deliver chips. Unfortunately if the third attempt is unsuccessful the visitor will have to go without for this particular segment. If not too disappointed they proceed optimistically to the next chocolate story.

Staff service the hoppers twice a day to maintain adequate levels of chips and to ensure that the chips aren't lying in a steep angle along the sides and back of the hoppers. To prevent the chips sticking together a Peltier cooling device and fan in the perspex box keeps the chips at around 18°C, the optimum temperature for storing chocolate.

For reasons of hygiene, components that come in contact with the chips such as the hoppers and movable arms are made of stainless steel. There is also a stainless steel lined opening in the bench under the tube. If the visitor doesn't have their hand under the tube the chips fall irretrievably into a bin instead of onto the bench top. We find that virtually no one discards any of the chips they get. That's partly because we cheated with the composition of the cocoa mass chips - they're sweetened to take the edge off the strong bitter taste.

A colourful (and ultraviolet light) world
The chemistry of colour is a complicated subject although there are many artefacts available to help visualise some concepts. We display chemists' equipment used to identify chemicals by analysing the characteristic colours they absorb or emit. Next to these are a pool chlorine test kit, litmus paper and a home pregnancy test to show everyday chemical analysis by observing a colour change. Further along are bottles of dyes and some naturally and synthetically coloured decorative arts objects. For the environmental side we look at the use and dangers of ultraviolet light and the chemicals that are associated with it. A showcase features CFCs and halons which were once viewed as wonder chemicals but now are being phased out of production and use because they destroy ozone in the upper atmosphere, the UV screen for the earth. Three interactive exhibits add movement to the colour to help demonstrate the points raised by the showcased content.

Create your own fireworks
for a fireworks spectacular
This interactive was made possible by the assistance of Syd Howard Fireworks International Pty Ltd.
For fans of fireworks this interactive is a computer aided design and virtual manufacturing dream. It has become a major attraction and talking point for the exhibition and is especially welcomed by chemistry teachers and their students. Although it is the most technically and interpretively complex interactive in the exhibition it is very easy to use. Simple controls coupled to voice and screen based information help the visitor select from a wide range of possible choices. When they have completed their virtual firework they are rewarded with a dramatic large screen video projection of the results of their efforts.

The heart of the exhibit is a Pentium computer with an MPEG playback card. The card takes compressed video information from the hard disk and sends a composite video signal to a video projector. We selected a card that could provide a high quality video signal to obtain good resolution in the projected video image. This option was less expensive and faster to set up than using laserdisk technology although the tradeoff is reduced, but still adequate, image resolution.

The visitor operates the interactive from in front of the 'laboratory bench' showcase. This is a glass covered counter with an opalescent perspex bottom. A variety of 30 chemicals and materials used to make the various components of 6 different kinds of fireworks are displayed. 30 lamps are located below the perspex sheet, one positioned under each chemical or material. Two boards designed in-house, each of which can control up to 16 lamps, turn the lamps on, off or to intermediate light levels according to RS232 signals from the computer.

A monochrome LCD monitor is located in the centre of the laboratory bench. The screen displays text and diagrams about the main components of each type of fireworks. There is also information about the characteristics of individual chemicals which the visitor selects for their pyrotechnic creation. Each label or description on the screen is basically a graphic produced on a Mac using a drawing program and then transferred to the Pentium computer. Each new screen is called up as one image.

Visitors rotate a selector knob to make individual chemicals or materials light up and have relevant information appear on the screen. The knob is attached to an optical switch making a robust interface with few moving parts. The optical transmitter and receiver are standard components fitted into a custom designed housing. The visitor presses a yellow button to finalise their selection and to move onto the next set of chemical or material choices.

The sound system employs Bose Acoustimass 5 components to produce high quality sound of the explosions of fireworks as well as the accompanying narration, music and background sounds.

A proximity sensor detects the presence of a visitor. This signals the computer to stop the audio/video sequence used to attract visitors to the exhibit and to start the main program. A narrator invites the visitor to press a button to make their own fireworks. The narrator then guides the visitor through their various selections, providing brief introductions to each group of materials needed for their particular type of firework. More detailed information and diagrams appear on the LCD screen for each group of materials and individual items. Each time the visitor turns the selector knob one item within a group is illuminated and the narrator names the item.

After the visitor presses the yellow button the selected chemical remains dimly lit as a reminder of the visitor's choice. When all the components of a particular type of firework have been selected a video sequence commences. This shows how a pyrotechnic worker actually makes each component of that firework and then assembles the various parts. Finally the finished product is taken outside to a field after dark, placed in position and the fuse is lit. Whether the result is a visual spectacular or a fizzer the narrator and the LCD screen provide a chemical explanation about what has occurred.

Another interactive, **Hot metal atoms show colour,** brings to life the high school chemistry lab test of heating a metal salt in a bunsen burner to see it give the flame a characteristic identifying colour. Our flame emission exhibit uses inexpensive caterers food warming candles which burn for 5 days each. When you turn the handle, a wire loop dips into a chemical solution and carries a drop of it to the flame. From the 4 reservoirs of metal salts, lithium turns the flame purple, copper green, strontium crimson and sodium yellow.

The flame and mechanism are enclosed in an aluminium sphere with a eyepiece offering a magnified view of the flame. A flue carries away combustion vapours. A series of 6 microswitches detect which particular wire is moving to the flame and trigger the audio card to produce a narration about each element being heated. When unattended the narrator has a speech to attract you to the exhibit.

Now you see it, now you don't is the exhibit to discover the secrets of fluorescence. You are invited to stamp your hand and then place it under a ultraviolet light to see the stamp glow. Then by pushing a button you activate the audio card which controls lights and sound and starts the motor to the turntable under the dome. Lit by UV, the balls on the turntable glow in various colours to symbolise electrons of different energies. The narrator explains how electrons of some chemicals absorb UV light and then release the energy as visible light. The interactive also contains a display of various natural and manufactured fluorescent materials, all glowing under UV light.

Whiffs and sniffs - it's a gas on the nose

A family of 4 interactives offer 5 stimulating sensory surprises for the olfactoraly inquisitive. Each interactive relates to the sub-themes about fragrance and the sense of smell in nearby showcases. In **Smell a mirror image** you can sniff vapours of the left and right handed forms of the molecule carvone. One molecular structure smells like spearmint, the other like caraway. The related showcase explains a favoured theory about how we smell; that the olfactory nerve endings detect differences in the molecular shape of gases and the brain interprets their signals as a particular aroma. These exhibits encourage you to associate rather abstract concepts of molecules to a common sensory experience.

The next theme is about what causes body odours and the chemical tools we use to deal with it. We chose a polite subject for the interactive, **The secret of air fresheners,** to let you sense how a generically foul smell can be masked by another chemical.

Three showcases deal with the making of fragrances for fine perfumes and functional products. In **Perfume is music to the nose** you can enjoy the smell of a complex perfume and then separately inhale the completely different aromas of its main components, which are called 'notes' by the perfumer. **Pick the real lemon** challenges you to identify the natural lemon essence from three synthetic chemicals used to give lemony scents to various functional products. Or you can delight in a four course meal, or at least the surprisingly accurate synthetic smell of one, in **Mmm, dinner smells good!**

Each of these exhibits uses similar technology. Individual programs were written in 'C' on a PC, compiled and transferred to 4 Mb PCMCIA flash memory cards. Also audio is recorded onto DAT, transferred to a PC, MPEG compressed and then stored on the card along with the control program. The cards can store up to 8 minutes of CD quality audio which is used to produce a narrator's voice via a playback card designed in-house. This playback card also controls reed switches and solenoid valves.

Pushing a button initiates the program on the microprocessor. A narrator (an actor using a character voice) explains the purpose of the interactive, says when to smell the vapours from each tube and explains the effects.

Each interactive has a row of 4 clear glass tubes which contain a specific aromatic oil. When a vapour is about to be released a bicolour LED above the tube glows red. As you lean forward to get a sniff your head interrupts an infra-red beam. This signals the microprocessor to open specific solenoid valves to direct a metered stream of nitrogen gas to the tube. The LED turns green as the gas bubbles through the oil, puffing fragrant vapour through a nozzle above the tube.

In the exhibit about smelling a four course meal, a graphic of the particular course lights up on the back panel as the scent is released. This helps you visualise the food as you contemplate its aroma.

On the surface and **Plastics galore**

Some sections of the exhibition proved very difficult to come up with ideas for interactives that met our criteria for functionality and relevance to content. The theme on the chemistry of plastics proved intractable in the end as our only feasible idea involved a screen based virtual chemical laboratory. Unfortunately we were too short of time and money for this worthy concept. Maybe we'll do it someday.

The chemistry of surfaces also posed problems. While this subject is rich in everyday chemical events, such as painting, washing with detergents and treating rust and corrosion, it lends itself to wonderful demonstrations more than unsupervised interactives. We finally decided to show how the surface tension of water is effected by adding a drop of detergent.

Using a microcontroller, **Break the surface tension** combines water, a powder of glass microbubbles and a drop of detergent. You press a button to introduce a radial spray of fresh water into the centre of the shallow tank. This pushes the waste water over the edge into a storage tank under the counter. After three sprays an air pump blows a fine coating of white microbubbles onto the water. You insert the metal probe into the detergent container and then touch the tip to the water. Voila! The microbubbles seem to race away in all directions over the surface of the water from the point of contact.

When the detergent is added, it spreads to form a thin layer on the surface of the water. The sideways forces on water molecules near the detergent are no longer balanced. These water molecules are pulled outwards - the microbubbles makes this movement visible. If this arouses your curiosity you may chose

to study the nearby showcase which has molecular models and other examples to clue you in about surfaces and the chemistry that happens there.

The interactive has 3 water level detectors for automatic operation and safety. When the storage tank is full, a high level detector activates a pump which sends the water to a waste line in the ceiling. A low level detector turns off the pump. An emergency detector is in the spillover tray surrounding the storage tank. When a major leak is detected, the inlet water spray is turned off and an alarm light flashes. All systems are low voltage and well insulated because of the presence of water.

But is it a chemical attraction?

Has this exhibition succeeded in achieving its aims? It certainly seems popular with visitors who encounter it as a new section in our large science exhibition called *Experimentations*. We have done visitor counts in *Experimentations* before and after *Chemical attractions* opened and find that numbers have increased by 10%. We have had praise from the sponsors of the exhibition, the Royal Chemical Institute (NSW branch) and World's Finest Chocolates Australia. Visiting science centre workers want a duplicate of the fireworks interactive. After the usual running in period we have been able to maintain the displays at a satisfactory level. But beyond this I can't say whether visitors are leaving the exhibition with more awareness of chemistry than when they entered. They seem to be having such a good time I haven't had the heart to interrupt them to ask.

Acknowledgments

The development and production of the *Chemical attractions* exhibition was a team effort. Debbie Rudder and I developed the content for all sections of the exhibition and prepared the design, interactive, audio-visual and other briefs; Peter Coulter designed the exhibition; Hugh White and Catriona White researched and designed the interactives; Tim Docker, assisted by Jonathan Hirsch, devised and installed the electronics for the interactives; Richard Taylor coordinated the activities of the team. And this is just to name a few of those involved.