Creating Science – Tactile Mazes & our Sense of Touch

It helps to keep us safe and warm, what would we do without it?! #CreatingScienceTactileMazes

Suggested outcomes

(NOTE: This is by no means an exhaustive list of possible outcomes, neither is it intended that ONLY these outcomes can or should be met. Science is a deeply interrelated activity, and you may find cross curriculum links you can and should use.)

Science Understanding

- Biological sciences 5: Living things have structural features and adaptations that help them to survive in their environment.

Science Inquiry Skills

- Planning and conducting F: Participate in guided investigations and make observations using the senses.

Cross curricular outcomes

Visual Arts

- Years 3 and 4 Content Descriptions: Use materials, techniques and processes to explore visual conventions when making artworks (ACAVAM111).

Health and physical education

- Contributing to healthy and active communities 4: Discuss and interpret health information and messages in the media and internet (ACPPS039) though exploring touch, and skin health and safety with some fun science activities.

Science vocabulary words

Tier 1 (Everyday words) – touch, feel.

Tier 3 (Specialised vocabulary)

- Tactile: something related to the sense of touch.
- Proprioception: A sense that relates to knowing what your body is doing, how it is shaped, and what those shapes are doing.
- Somatosensory cortex: the part of the brain that deals with touch and proprioception.
- Haptic perception: Using touch and proprioception to use a tool to explore the properties of an object, such as when a visually impaired person uses a rod to test the ground.

Warning

- Beware of sharing touched objects for students with allergies or sensitivities.
- If young people over do the touch activities they can hurt themselves; remind them to be cautious and sensible.
- Scissors and glue may be used, please be cautious.
- Activities involving water must be handled with care. Avoid contamination by washing hands before and after.

Preparation

- Preparing the size/weight tactile illusion by using:
    - Two containers, one small, one large, as similar as possible in every other way.
    - Scales to weigh them accurately.
    - Something to make them heavier – such as sand.
    - Measure sand (or some other inert weight) into each container until they weigh *exactly* the same. Offer both to the participants and have them decide which one feel heavier to them.
- Preparing to make tactile mazes (see the appendix below, or the book Creating Science) – you'll need:
    - Ridged cardboard to put them on – at least one or two per student. Older classes might like to make their mazes on a box, but this will take some experience and practice.
    - Thick cardboard to make their mazes. Students may also use sticky tape or waxy crayons, but these will be very hard for some students to detect by touch.
    - Wood glue, to keep the cardboard together.
    - Some tactile decorations to enhance the mazes, and to indicate a start and a finish. Velcro dots can be fun, as well as feathers or blue tack. Folded cardboard also works.
- Prepare a 'Touchy-Feely box' – an opaque box (or fabric bag) with a small collection of safe, easy to handle objects within. The idea is for students try to guess what the object is, using only their imagination, and their sense of touch.
- Prepare the Aristotle Illusion – everyone needs a pen or pencil, that's all.
- Prepare the warm or cool activity.
    - You'll need three bowls large enough for young hands.
    - Three temperatures of water – warm enough to touch, room temperature, and chilly cold.
    - Have students place their hands in the warm and chilly water for about 5 seconds, then place BOTH HANDS AT THE SAME TIME in the room temperature water. Which one feels hotter?
    - (You can sometimes fool the sense of touch into thinking it is scalding hot, or at least tingly and weird, by placing one hand in the warm water for 5 seconds, then straight away into the chilly water. The hand feels very weird, perhaps because the mind can't make up its mind between whether it should feel warm or chilly, and sometimes it interprets it as scalding hot – even though it isn't.)

Disposal

Be sure to make your tactile mazes out of recyclable materials such as cardboard. Velcro dots can be thrown in the bin, or you can use biodegradable materials such as sandpaper and feathers instead.

Suggestions for other year levels

As always, more material is presented here than can be used by the average class during the average lesson time. However, since the students' questions can and should guide student learning, more material is presented for your convenience. Remember, it is not uncommon for students to only remember those points which answered their personal questions.

Younger:

This activity can be quite challenging to this group, and they may need individual assistance. Planning out a tactile maze first can be very helpful.

Middle:

Challenge students to become even more creative with the tactile mazes – can they build a 3d tactile maze out of pipe cleaners? Or how about a paddle pop stick maze that goes around a box?

Teen:

This age group should be ready for some of the more difficult material in the section. Have them debate the terms 'sense of touch', 'proprioception', 'haptic perception' and 'somatosensory cortex' to see if they can be personally useful to them. What would THEY define as belonging to the 'sense of touch'?

Learning Intent (student friendly)

'We are learning to' (WALT) – explore our sense of touch

Success criteria

'What I'm looking for' (WILF) – build a successful mind maze, and be able to explain the science within. Students might also enjoy the tactile illusions and explaining them.

Student learning goals

Help students make a self-monitored learning goal for this lesson.

Evidence of learning

How will you know when the learning goal is achieved? What EVIDENCE do you have that your students have met or exceeded the learning expectations?

- Students have built a tactile maze, and can challenge others to complete it.
- Students more ready for a challenge can correctly use the terms tactile, somatosensory, and proprioception.

Engage

[Encourage students to write down any questions they may generate during this phase.]

- ⇨ Ask: What do you already know about your sense of touch?
- ⇨ Ask: What would you like to learn about your sense of touch?

Begin with the size/weight tactile illusion. Have students feel the objects and ask:

- ⇨ Which one do you think is heavier? (Almost everyone will think the smaller is heavier.)

When they have all had a go, reveal that they are actually the same weight. Allow students to try it again.

- ⇨ Why does our body think the smaller object is heavier? (It might be because the small item takes up a smaller space on our skin, and the brain has to judge weight by how tense the muscles in the arm are, which is not very accurate. The brain then mistakenly assumes the smaller is heavier since it takes us less space, and it can't really judge the difference between their weights[1].

Explore

- ⇨ Remember, 'I don't know' is a valid explanation in science – it is the beginning of learning new things!

Discuss: Our sense of touch, like all other senses, is far from biased or free from error. Many decisions we make about where things are, or what we're feeling, rely on much more than our sense of touch. Perhaps in the size/weight illusion our mind is taking into account how much pressure as well as touch the objects exert, and since the smaller object has more pressure (because it's exerting the same weight over a smaller space) the brain decides it must also be heavier![2]

So what is our sense of touch? It begins with the largest organ in the whole human body!

- ⇨ Play with the activity: Touchy, Feely Box.

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[1] Or perhaps our brains are hard wired to actually judge density, not weight, in much the same way as they are better at telling acceleration than speed. How can we find out?

[2] Size-weight illusion. To help explain this illusion: "J. Randall Flanagan of Queen's University in Kingston, Ontario, Canada, complicated matters further when he showed that we can unlearn the size-weight illusion. He got volunteers to spend several days manipulating boxes that became lighter the larger they were. At the end of the process he found that their size-weight illusion was reversed. They consistently judged the larger of two objects to be heavier even though they weighed the same.": taken may 17 from https://www.newscientist.com/article/mg20126997-500-tactile-illusions-3-boxing-clever/

Explain

Explain: Our sense of touch takes place predominantly in the SKIN, but there are similar receptors *all throughout* the body. Our sense of touch usually includes the following:

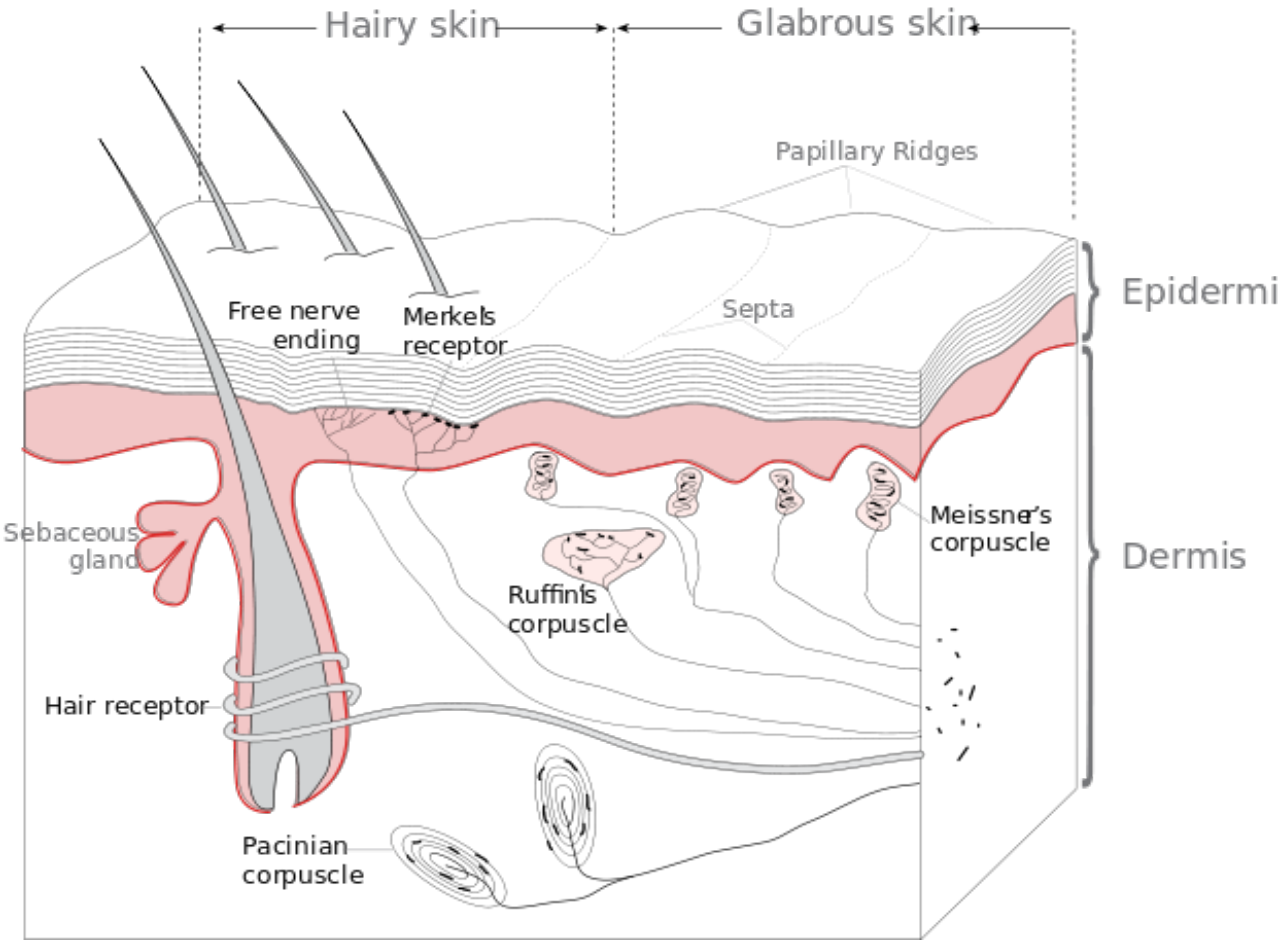
- Tactile – usually simply called "touch." Receptors to both touch and pressure are called **Mechanoreceptors**.
- Temperature – hot or cold. Receptors to temperature are called **Thermoreceptors**.
- Pain – When something is damaging your tissues. Receptors to pain are called **Nociceptors** (Pronounced "NO-si-sep-tors).
- Pressure – a "heavy touch." (AKA "Squisho-receptors"??)
- Vibration – an "on-and-off" type of touch.

Try some sense-of-touch activities:

- Tactile – the Aristotle illusion, two point discrimination.
- Temperature – Warm or chilly?
- Pain – No activities for this one. Don't mess around with pain receptors.
- Pressure – the touchy-feely box.
- Vibration – illusory motion and the comb illusion.

Nerves in detail – need to know more? The biology of touch.

Taken 1 may 2017 from http://www.interactive-biology.com/3629/7-senses-and-an-introduction-to-sensory-receptors/



Glabrous skin - e.g. the palms of your hands.

Papillary ridges - aka dermal ridges, where sweat gets out.

Free Nerve Ending - They can perceive pain, touch and temperature. They can be found in the epithelial layer of the skin.

Merkle's disc - They respond to light pressure. They can be found in the upper layers of the skin. They can perceive fine differences in location, a process known as two-point discrimination. (This is what enables people to read Braille with their fingers).

Perifollicular - They wrap around hair in the skin and they can perceive when the hair on your body or face is being touched.

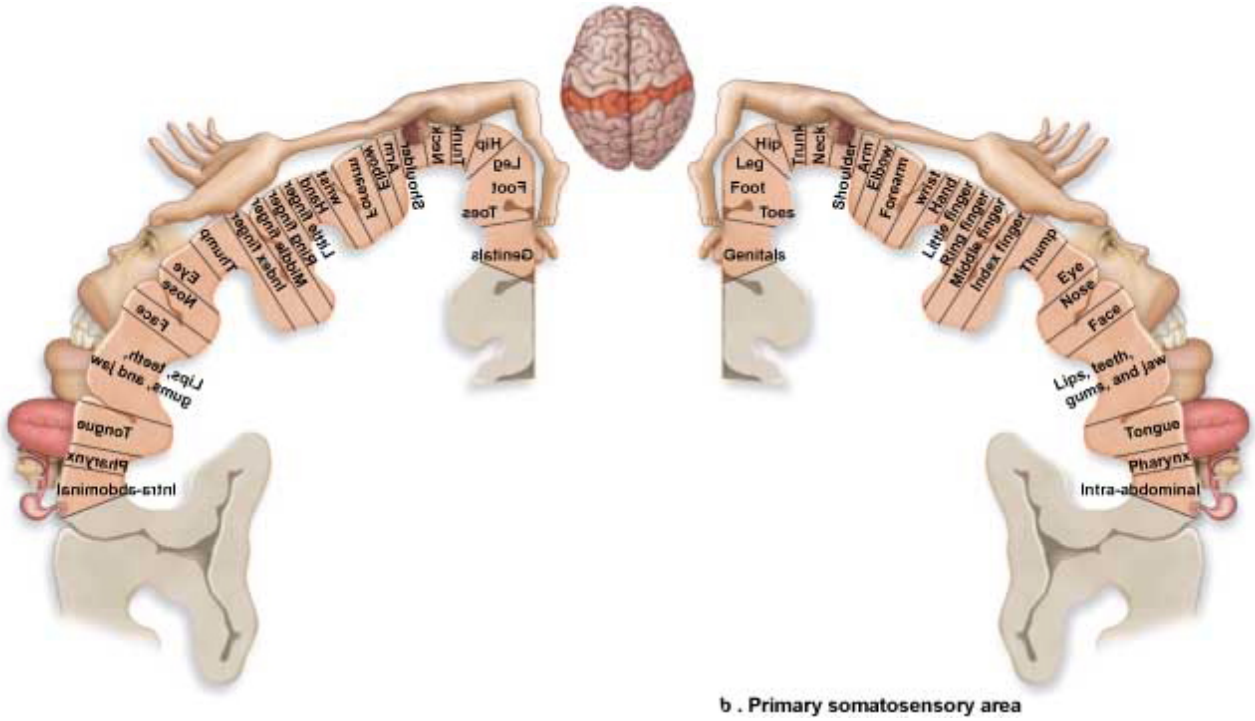
Ruffini corpuscle - They respond to touch and pressure. They are found deeper within the skin, in the subcutaneous layers. They are known to be sensitive to changes in angle, and as such, they also carry a proprioceptive role involved in telling the brain where the fingers are located in space.

Meissner's Corpuscle - They are involved in two-point discrimination. They are usually found in the "hairless" portions of your skin such as the palm of your hand and your fingers.

Pacinian Corpuscle - They are sensitive to pressure and vibration. It's the biggest type of nerve ending. In fact it's so big that it can be seen by the naked eye!! They are characterized by a large, flat "disc." They are found deeper within the skin (this is the reason why they respond so well to pressure).

The somatosensory cortex – where your brain 'senses touch'.

Nerves run together, through the spinal cord, up to the midbrain for initial processing, and on to the cortex of the brain for detailed processing.



b . Primary somatosensory area

(adapted 23 may 17 from http://www.fullfrontalanatomy.com/images/F13/NS/Brain_SC/homunculus.jpg

Damage to left side of the somatosensory cortex numbs the right side of the body. But you should still be able to move unless you damage the motor cortex, which is the next slice of the brain moving forwards.

Cortical homunculus

The part of the brain that maps the human body is called the cortical homunculus. Where the body is more sensitive, the brain dedicates more space to processing it, making for this rather curious image. Note how much processing space is dedicated to the hands and face, compared with the body. It can also change over time. Everyone's will look a little different, and numb spots aren't dark, they simply aren't there (much like our blind spot isn't a black patch).

Figure 1 Weird right? "A sensory Homunculus, demonstrating how large the hands are compared to the arms and legs. Study undertaken by Sharon Price-James B.A (Hons)" Taken 26 may 2017 from By Mpj29 - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=54045144

Elaborate – tactile illusions

Sense of touch

There are no touch sensors in the brain – so once you get past the skin and skull bones, you can poke and prod the brain without causing pain at all, which, if you're not careful: IS A VERY BAD THING!!!

So let's just start with some safe 'touch' illusions.

Warm or chilly?

One well known yet very discombobulating tactile illusion is to place one hand in warm water, another in cool

water, then place them both into normal-temperature water. Each hand will disagree very much about the temperature of the normal water.

Why does this work?

Acclimatisation.

Because our bodies senses often work by *acclimatisation* – they get used to things that are there constantly and adapt to cancel them out. You use the skill every day, do you even notice the pressure of the ground on your feet? Or the smells in the air that are simply always there?

Thus when change occurs, our bodies tend to notice it. Like how ten minutes in a green tent makes all the world look pink!

If you refuse to allow for change, the sensory mechanisms simply don't work as well. Eyes are always moving, jiggling about on their own so that the input is always changing. Force your eyes to stay still – by staring – and eventually any still images will disappear! [taken 1st of May 2017 from: https://au.pinterest.com/pin/505036545689859794/]. Keep your eyes still enough, and not only will the illusionary green dot appear, but the pink dots will disappear too…

Thus it could quite accurately be said that most of our body's senses work less on the *presence* of a stimulus, and more on a *change* in that stimulus.

Next, try this old trick – cool one hand in cold water, then place it in warm water. For just an instant the blend of hot and cold might just trick your hand into thinking it's in scalding, super-hot water! (You can sometimes get the same effect gripping an ice block with a warm cloth).

Aristotle illusion

Taken 20 may 17 from https://www.newscientist.com/article/mg20126997-500-tactile-illusions-3-boxing-clever/

"One of the oldest tactile illusions is the Aristotle illusion. It is easy to perform. Cross your fingers, then touch a small spherical object such as a dried pea, and it feels like you are touching two peas. This also works if you touch your nose."

"This is an example of what is called "perceptual disjunction". It arises because your brain has failed to take into account that you have crossed your fingers. Because the pea (or nose) touches the outside of both fingers at the same time – something that rarely happens – your brain interprets it as two separate objects."

"A variation on the Aristotle illusion is to cross your fingers, close your eyes and then touch two different objects simultaneously – a piece of Blu Tack and a dried pea, say – one with each fingertip. You will need someone to guide your fingers onto the objects, and the illusion doesn't always work, but if you're

lucky your sense of touch will tell you that the objects are the opposite way round from where they actually are. This is because your brain fails to correct for the fact that your fingers are crossed over."

"There's also the reverse Aristotle illusion: cross your fingers and touch the inside of a corner of a room or a box. This time, because the wall is contacting the insides of your fingertips, you should feel one surface, not two. Some people even experience three."

Illusionary motion

Comb illusion (Take an ordinary comb and pencil and lay your index finger along the top of the comb, then run the pencil back and forth along the side of the teeth. Even though the teeth are

moving from side to side in a wave-like motion, your finger will feel as if a raised dot is travelling up and down the comb.) From https://www.newscientist.com/article/mg20126997-600-tactile-illusions-4-i-feel-it-in-my-fingers/ 20 may 17. Why does the brain seem to ignore the points that aren't moving, and focus on the point that is?

Bent fork illusion. Take a fork and press the tip of your tongue between the prongs. You will feel as though the middle two prongs are bent out of shape.

Two point discrimination test

How sensitive is your sense of touch? And what parts of your body are the most sensitive?

Try this science test – but skin only. Do NOT try it on anything too dangerous, like eyeballs.

1. Get two small points like a pair of blunt pins or needles, or pencil ends.
2. Start at about 1cm apart.
3. Hold them in your hand/s, and touch them LIGHTLY to another person's skin. (After all, we don't want to set off the Ruffini or Pacinian corpuscles as well.)
4. Without looking have your volunteer tell you if they can feel one point or two.
5. Move the points together by about 2mm at a time until they can only detect one point.
6. Try different parts of the body. How sensitive is the elbow compared to the fingertips, for example?

⇨ How can this test be more fair? What if your participant is making up results they think you want? What can you do make your results extra reliable?

Is this all there is to our sense of touch?

Maybe touch is even more than the five things we've talked about…

How can you know where your body is without looking at it? Touch nerves inside your muscles help you to know where you're standing and how you're moving. We call it **proprioception** – do you think this should be counted as a separate sense, or is it just another kind of touch?

Proprioception – sense of position and movement

Nerves in the muscles help them know how tense or relaxed they are, which the brain can use to tell where our body is without looking.

- Try touching your nose with your eyes closed.
- Try touching your fingertips together, arms outstretched, without looking.

The sense of balance is involved in proprioception as well – is that a separate sense? Or does it belong to a whole new sense we just ignore?

Fooling proprioception.

⇨ Stand in a doorway, arms by your side. Then push your arms out and against the doorway for at least

30 seconds – make sure you really try (but DO NOT hurt yourself!) Then step out, and your arms feel like they still want to lift up and sideways. WHY?

Perhaps you have acclimatised your proprioceptors in your arm muscles to a state they aren't naturally at, and they feel you need to be pulling more just to keep your arms at your side.

Haptic perception

The sense of being able to sense something by using a tool – such as the roughness of the floor by using a stick, or the pressure in the seat as a car rides on the noisy bumps that indicate it is going outside the lines.

From Wikipedia: The concept of haptic perception is related to the concept of extended physiological proprioception, according to which when a tool such as a stick is used, perceptual experience is transparently transferred to the end of the tool.

Haptic perception relies on the forces experienced during touch.[5] This research allows the creation of "virtual", illusory haptic shapes with different perceived qualities,[6] which has clear application in haptic technology.[7]

More on sense - Somatosensory mechanisms

From Wikipedia:

"Sensory receptors are found all over the body including the skin, epithelial tissues, muscles, bones and joints, internal organs, and the cardiovascular system."

"Somatic senses are sometimes referred to as somesthetic senses, with the understanding that somesthesis includes the sense of touch, proprioception (sense of position and movement), and (depending on usage) haptic perception."

Is our sense of touch more than all we have discussed today? Instead of 'touch' (which is just heat, soft and light pressure, vibrations and pain), should we really be talking about our somatosensory sense, which includes touch, proprioception, and even haptic perception?

Evaluate

- ⇨ Review with students what they felt they learnt from this lesson. Did they have any questions at the start that they feel were answered?

Success criteria

- ⇨ Review the Learning Intentions of this lesson with students. Was it met?

At the end of each class, review the learning objective and see how we did. Ask:

- Did you achieve your learning goal?
- What did You learn?
- What worked to help you achieve it?

Assessment

Prior Learning:

Ask students:

- What do you already KNOW about our sense of touch?
- What WOULD you like to learn more about our sense of touch?
- And as you go along, what have I LEARNT about our sense of touch?

Formative:

Place a large sheet of paper on the wall, or use a whiteboard (or student science journals). As the lesson progresses, encourage students to write down every interesting thing they learn. Help them to self-monitor their own learning and achievements.

Summative:

Help students consider ways they can communicate their new understanding to others, just as scientists need to do.

Make up a mind maze game to try and test other students. Can they involve other aspects of the sense of touch, or perhaps some tactile illusions?

- Rough materials for the vibratory sense.
- Completing the maze using a pencil to touch with, for haptic feedback.
- Warm or cold materials to help direct the maze goers.
- Look for special objects glued to the maze, such as the three rubber duckies or similar. Students can have three lives, and 'lose a life' if they touch a dinosaur, for instance.

So what?

The sense of touch is fascinating, and knowing about our bodies is amazing! The sense of touch has many aspects – heat, pressure, light and touch, to name a few. The sense of touch has related aspects which may or may not be included, such as somatosensory mechanisms.

There are loads of tactile illusions to fool your friends and family with.

Creating science

As we learnt about our sense of touch, we had the chance to:

- Science Understanding. Biological sciences 5: Living things have structural features and adaptations that help them to survive in their environment.
- Science Inquiry Skills. Planning and conducting F: Participate in guided investigations and make observations using the senses.

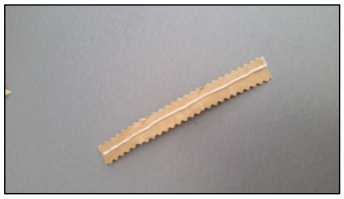
Appendix: Tactile mazes

Can you make your way through a maze without your sense of sight? Making an image with our imagination can really help. Also, it's a whole lot easier if you let your sense of touch guide you – use all your fingers and not just one fingertip.

You'll need:

- Some thick cardboard for a base
- Strips of cardboard to make your maze
- Glue to keep it all together
- Some materials to mark the start and end of your maze, such as a rough Velcro dot to start, and the soft Velcro dot to end.

Note:



If you don't use too much glue, it'll all stick together much quicker.

You may need to put the tactile mazes in a dark box, to help prevent 'cheating'

Extension:

Can you put things into your maze to make it more interesting? Fur bridges? Cupcake cup walls?

Can you put things on your maze to make it more challenging? Find the ducks? Dodge the dinosaurs? Can you make a 3D touch maze using the outside of a box?