LIGHT, COLOURS, VISION – EXPLORING OPTICS

SUMMARY CARD

Our everyday experiential world offers lots of exciting opportunities to explore the topic of “Light, Colours, Vision” more closely. At dusk, for example, long shadows wander – sometimes in front of us, sometimes behind us; sunglasses change our perception of colour; we discover our reflection in a shop window; and we are dismayed when we realise that the fruit juice we spilled has left a coloured stain on our t-shirt.

Eight exploration cards enable the children to gather their first basic experiences of optical phenomena and to explore them more closely. Following on from the exploration cards, three inquiry cards invite the children to pursue some questions in greater depth with the “Inquiry Cycle” method and to practise using a scientific approach.

Although there is no prescribed order, it is a good idea to start with the exploration card “Light and Darkness”. Please note the general rules for inquiry activities on our red information card. You will find further ideas and lots of background information on the topic in the accompanying brochure and on our website, www.haus-der-kleinen-forscher.de. Children between the ages of six and ten can also use the accompanying exploration cards for primary school students. Moreover, they can find other ideas for inquiry activities on this topic on the children’s website: www.meine-forscherwelt.de.

Note on working with different age groups:

You will sometimes find this symbol on the cards. The “ladder” indicates that the inquiry activity in question, or the entire card, presupposes that children have already had certain basic experiences and/or have developed certain skills (e.g., in the area of perception, cognition, or motor development). As a rule, these experiences and/or skills are not acquired until children are of primary school age (i.e., between the ages of six and ten). Ideas and inquiry activities that do not bear this symbol are suitable for children of all ages.

A BRIEF OVERVIEW OF THE INDIVIDUAL CARDS:

EXPLORATION CARD LIGHT AND DARKNESS

The children explore light and darkness; they experience that without light they cannot see anything; and they consider what sources of light they know and use them to light up the darkness. They then try out what it feels like to perform the same activity in the light and in the dark.

EXPLORATION CARD EXPLORING SHADOWS

The children set off in search of shadows. They investigate their own shadows and those of different objects, and they discover that shadows need two things to form: light and objects or persons to block the light.

EXPLORATION CARD SHADOWS CHANGE

The children discover the reasons why shadows change their length, direction, and size. They become more familiar with the connection between directions, shapes, proportions, and distortions, and they develop the ability to purposefully change shadows.

EXPLORATION CARD NOW THINGS GET COLOURFUL

The children explore colourants from natural sources and try to extract natural colourants and pigments. They produce mixed colours, discover the variety of colours that can result from just a few primary colours, and they find out how they can create and mix different coloured light.

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EXPLORATION CARD
FILTERED WORLDS OF COLOUR

The children explore the way in which their perception of colour changes when they look at their surroundings through coloured plastic foil. Moreover, using green and red coloured pencils and coloured plastic foil, messages can be hidden and revealed again.

EXPLORATION CARD
EXPLORING MIRROR IMAGES

The children examine whether their reflection in a mirror or the reflection of an object corresponds to reality (e.g., in terms of colour, size, configuration, and movement).

EXPLORATION CARD
THE MIRRORED WORLD

The children create a collection of mirrors and other things with reflective surfaces, and they discover how their own mirror image changes depending on the nature of the surface. They explore their surroundings with the help of mirrors, and they investigate what makes shop windows and panes of glass become good mirrors.

EXPLORATION CARD
LIGHT CAN BE DIRECTED

The children discover that the direction of light can be changed by using reflective surfaces. They create spots of light in the room, produce flashing party decorations, and “transport” light through dark boxes and rooms.

INQUIRY CARD
WHAT COLOURS CAN WE SEE IN THE DARK?

The children investigate their ability to see colours in the dark.

INQUIRY CARD
DOES EVERYTHING END UP BROWN?

The children investigate how you always end up with a black-brown shade when you mix different colours.

INQUIRY CARD
CAN BROWN BECOME COLOURFUL AGAIN?

The children explore whether a black-brown colour mixture can be separated into its component colours.

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Explore the phenomenon: **Light and perception**

LIGHT AND DARKNESS

Where do we encounter it in everyday life?

In their everyday lives, children encounter many different sources of light and impressions of brightness. They take for granted the fact that, by day, the light of the sun creates brightness and that it gets dark in the evenings. Some are familiar with dark caves that they build themselves, with cellars, and perhaps with interior rooms without windows. And they experience artificial lighting provided by various kinds of lamps.

What it's all about

The children explore light and darkness and discover that they cannot see anything without light. They consider what sources of light they know and they use them to light up the darkness. They then try out what it feels like to perform the same activity in the dark and in the light.

What you need

- Room that can be darkened completely or a windowless bathroom
- Flashlight, candle
- Sunlight and lots of other light sources, for example ceiling-, desk-, or bedside lamps with different illuminants (halogen light bulb, energy-saving light bulb, fluorescent tube, LED lamp)
- Infrared lamp, glow sticks, and perhaps a computer screen, TV, etc.

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Why is the inside of the refrigerator bright?

Is the door light-tight?

Candlelight makes the transition to darkness more gentle.

LIGHT AND DARKNESS (WARM-UP)

Activate the children's prior experiences: Where is it light, where is it dark? On a summer's day, for example, it is very bright; our eyes are veritably blinded by the sun. When rain clouds appear and a storm is brewing, it suddenly gets darker. In the stage spotlight or underneath a lamp it is very bright. In cellars and sheds, or when you are falling asleep at night, it's dark; the inside of the refrigerator is bright when you open it. And when you close it? What do the children think? Why is it bright in some places and dark in others? What is the difference between the two types of places?

PITCH DARK

Enable the children to experience complete darkness. Usually, street lights, moonlight, or the light from the windows of the surrounding houses ensure that even at night it is never completely dark. Take the children to a windowless room with a light-proof door. Little cracks or the keyhole could prevent the room being darkened completely, so you should hang or stick something over them. Agree with the children in advance how much time you will stay in the room and explain what they will be doing while they are in there – for example, holding hands or whispering. In order to make the transition to complete darkness gentle and impressive, turn on a flashlight or light a candle before you close the door. Later, before you open the door, turn the flashlight on again or relight the candle. What experiences do the children have in the dark? Can they see how many fingers they are holding up? Can they see who is standing beside them? Afterwards, allow the children to process what they have experienced while drawing and discussing the darkness.

Look at this: *After the light from the flashlight has been turned off or the candle has been extinguished, you can see absolutely nothing in the completely dark room. If you turn the flashlight on again, or relight the candle, it will be only a little brighter, but it will be bright enough to see and to get your bearings.*

Investigate this further by using the inquiry card: "What colours can we see in the dark?"

What effect does red light have?

LET THERE BE LIGHT!

In the dark room, consider with the children all the things that "create light" and how more light could be introduced into the room. For example, you could open the curtains and let the sun shine into the room. Or the children could light a tealight candle, shine a flashlight, switch on a ceiling- or table lamp with a halogen or energy-saving bulb, or use an infrared lamp or a glow stick, etc. Perhaps you also have the possibility of investigating the light from a computer screen or a television in the dark with the children. Have the children try out and jointly compare lots of different lights and lamps. What do different lights look like? Do they vary in brightness and colour? What do the objects and the people in the room look like in the respective lighting? When do the children feel particularly at ease? Which light sources can you touch and which cannot be touched? With older children, you could also determine what illuminants are in the light sources and lamps. Where can they be unscrewed and compared more closely?

Look at this: *Light is never just there. Rather, it is always created by a light source. However, the light emitted by the various light sources differs greatly: it can be warm or cool, glaring or dimmed; it can flicker or shine evenly; and it can be different colours.*

Older children can discover even more by using the exploration card for primary school students "Light Images".

FIRST IN THE DARK, THEN IN THE LIGHT

At the end, suggest to the children that they perform the same tasks in a dark or dimly lit room and in a bright room. Jointly consider what activities you want to try out, for example having breakfast, listening to music or to an audio drama, drawing, resting, building a tall tower, tidying up, putting on shoes, etc. Afterwards, compare together which activities could be performed better in the dark and which could better be performed in the light. What peculiarities did the children notice? What did they find most fun?

Look at this:: *Activities such as drawing, building, tidying up, or eating, where you have to be able to see well, are better performed in the light. However, lots of things are more fun in the dark. Some things suddenly taste quite different in the dark, music sounds more impressive, and you can dream, cuddle, and rest much better.*

What's it like to draw in the light ...

... and in the dark?

INTERESTED ADULTS MIGHT LIKE TO KNOW

We can see the things around us only if light emanating from them enters our eyes. Some objects – for example, the sun or a bedside lamp – emit this light themselves. However, most objects (and people) only reflect the light that falls on them. (You can find out more about this in the accompanying brochure.)
Objects that generate and emit light themselves are called light sources. A distinction is made between natural and artificial sources of light. The most important natural light source for us humans is the Sun. However, natural light sources also include glow worms, lightning during a storm, and the Northern Lights (Aurora Borealis). Moreover, researchers estimate that some 90 percent of deep-sea animals create their own natural light. However, most of the light sources that we use in everyday life are artificial – that is, made by humans. And their number continues to grow. They include incandescent lamps and fluorescent lamps, halogen lamps and light-emitting diodes (LEDs), candles, oil lamps, and computer and TV screens.

Explore the phenomenon: **How shadows form**

EXPLORING SHADOWS

Where do we encounter it in everyday life?

At dusk, in dimly lit rooms, and on sunny days, children experience shadows as companions. Younger children sometimes find shadows frightening, especially when they cannot assign them to a particular person or object. However, children can also have lots of fun with shadows, for example when creating funny shadow animals or a shadow play.

What it's all about

The children set off in search of shadows and investigate their own shadows and those of different objects. They discover that in order to form, shadows need two things: light and objects or persons to block the light.

What you need

- Flashlights
- A dark room with a light-coloured wall or a large sheet of white cardboard as a projection surface for the shadows
- Desk lamp as light source
- Objects that cast a shadow (e.g., kitchen utensils, plants, toys, etc.)
- Chalk
- Large sheets of white paper (e.g., the back of sheets of wallpaper or sheets of paper in A3 format) and pencils
- Umbrella
- Objects and materials with varying degrees of translucency, for example a book, a wooden board, a cup, a plastic beaker, a glass, greaseproof paper, a clear plastic exercise book cover, a loose-knit woollen scarf, a t-shirt, transparent plastic bags
- Transparent colourful objects, e.g., a coloured bottle, coloured foil

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What does the shadow of the rocking horse look like?

How many arms does the shadow monster have?

When does the shadow stick out its tongue?

SHADOW HUNT (WARM-UP)

On a sunny day, the children search outdoors for their own shadows and the shadows of objects such as bicycles, fences, balls, and plants. A suitable alternative on cloudy days is a dimly lit room where the children shine their flashlights around. Which shadow belongs to which object or to which child?

SHADOW MONSTER

The children can create a funny shadow play in the sun or on an illuminated wall in the darkened room. For example, several children can jointly bring a particularly scary monster to life. Or the children can use various utensils – for example, a cooking pot, a spoon, or a long cardboard tube – to change their silhouettes. Jointly examine the shadows of different objects. What does the shadow of the garden fence in front of the house look like? Or the shadow of a doll or a blade of grass? Outside on the asphalt, the children can use chalk to trace the shadow figures; indoors, they can lay sheets of white paper under the shadows and use a pencil to trace them.
Are the other children later able to guess which silhouette belongs to which object?

Look at this:

Shadows are images of objects or living things. They change when the objects or living things change their position. In contrast to a mirror image, a shadow shows only the outline of the object or living thing. That's why it is often not that easy to guess the object or person behind the silhouette.

Children between the ages of six and ten can use the exploration card for primary school students "Shadow Images" to explore the topic further.

When can I see my shadow? When does it disappear?

LIGHT AND SHADOW

Pay attention with the children to the light conditions under which shadows can be observed. For example, on an overcast, rainy day search for shadows outdoors with the children. Can they still be found? Have the children shine flashlights around a dimly lit room and observe the shadow images. Then turn the lights on. Where do the children think the shadows have suddenly disappeared to? The children can also examine the shadows under different light conditions: When can they be seen more clearly? When are they fainter?

Look at this:

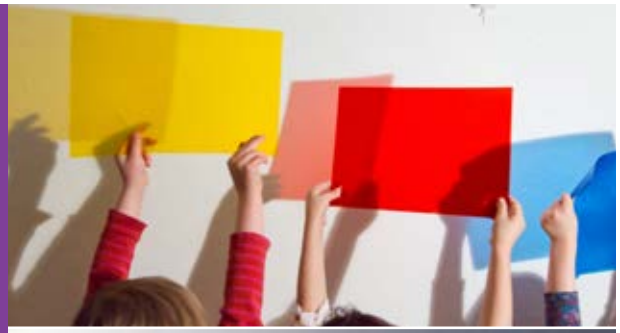
Shadows occur only where there is light. Once all the lights have been turned off, shadows can no longer be seen in the dark room. Outdoors, the light comes from the sun. If the sun is hidden behind dense clouds, you hardly see any shadows. But when the sun is shining brightly in the sky, you can discover many dark shadows.

SHIELDED

On a sunny day, or underneath a lamp, explore with the children the way shadows form. Compare sunlight (or lamplight) with rain: When used as a parasol, an open umbrella shields you from the light in the same way as it shields you from the rain. Jointly observe the shadow that the umbrella casts on the ground. Search together for other objects that do not let much light pass through them. To do so, have the children shine their flashlights diagonally on the objects in the darkened room. If the sun is shining, the various objects can simply be brought outdoors. Which objects prevent the light from passing through and cast shadows? Which don't? Do the children notice any differences between the shadows? Are there particularly dark, bright, or perhaps even coloured shadows? Why is that?

Look at this:

Shadows form when light hits an object. If the object is made of a particularly dense material – for example, wood, porcelain, or thick plastic – a dark shadow forms. In the case of transparent materials, the shadow looks brighter. If the object is not only transparent but also brightly coloured, coloured shadows may even form.



Create interesting shadows with coloured foil and glasses.

INTERESTED ADULTS MIGHT LIKE TO KNOW

Shadows could be characterised as protected or shielded spaces. Like the area under an umbrella where the rain cannot reach us directly, a shadow is a space that the light from a light source does not reach directly because an object is in the way. Rays of light travel in straight lines, and unlike a jet of water, they cannot avoid an object and go around it. If a ray of light hits an object, the object stops the light by absorbing and reflecting it. As a result, a "gap in the light" – or a shadow – forms behind the object. Transparent materials let part of the light pass through them. That's why the shadows cast by transparent objects are brighter than those cast by opaque objects.

Explore the phenomenon: **Properties of shadows**

SHADOWS CHANGE

Where do we encounter it in everyday life?

If you walk past a street light in the evening, you can discover your own shadow – sometimes it gets longer, sometimes shorter; sometimes it appears in front of you; sometimes it's beside you; and sometimes it's behind you. Football players in a stadium sometimes have several shadows pointing in different directions.

What it's all about

The children explore why shadows change their length, direction, and size. They become more familiar with the connection between directions, shapes, dimensions, and distortions, and they develop the ability to purposefully change shadows.

What you need

- Pavement chalk
- Darkened room
- Flashlights
- Objects and figures that cast a shadow, for example objects and figures made of wood, cardboard, wood skewers, and play dough
- Light-coloured paper and pencils
- Desk lamp
- A light-coloured wall or a large white projection surface for the shadows

! Do not use lamps that can get hot (e.g., halogen lamps).

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Your shadow changes.

When is the shadow short?

How does it get longer?

A SHADOW GOES WANDERING (WARM-UP)

Choose a place outdoors (with a stone or asphalt surface) that gets the sun all day. Have the children work in pairs. First, they mark their footprints with chalk and then they trace each other's silhouette. Repeat this every hour (each child must step back into his/her own footprints). How does the shadow change over time? What does it look like in the morning, at midday, and in the afternoon? What changes do the children notice, and what causes do they find?

SHADOWS ARE SOMETIMES SHORT AND SOMETIMES LONG

First, the children can make shadow figures. To do so, they cut a figure out of cardboard and stick it on a wooden skewer. Then they stick the figure to the table with a little ball of play dough. In the darkened room, the children shine their flashlights on their figures. Observe together how different the shadow of the same figure can look. For better comparison, have the children place a sheet of white paper under their figures and then trace the shadows. Ask the children to make a really short shadow and a really long one. Have them measure the length of each shadow. How big is the difference between them? Afterwards, jointly discuss how the difference came about.

Look at this:

The length of the shadow depends on the position of the flashlight relative to the figure: The shadow is shortest when the light shines from above. By contrast, the figure casts the longest shadows when you hold the flashlight down low, parallel to the surface of the table.

Remind the children of what they did during the warm-up phase. Why did the shadows sometimes grow longer and sometimes shorter outdoors? What do a flashlight and the sun have in common? Ask the children to continue to look out for particularly short and particularly long shadows in their everyday lives and to search for the cause. Later, discuss the commonalities.

How many shadows does the figure cast?

SHADOWS ARE SOMETIMES ON THE LEFT AND SOMETIMES ON THE RIGHT

In the darkened room, have the children place the shadow figure on a sheet of paper again and illuminate it with a flashlight. Can the children create shadows in all directions: one shadow on the left of the figure, one on the right, one above the figure, and one below it? Have the children trace the shadows and make a note of where the light from the flashlight came from in each case. Jointly discuss the results. Do the children succeed in imitating the floodlight masts in a football stadium? What happens to the shadow of the figure when it is illuminated from four corners?

Look at this: *The direction of the shadow depends on the relative positions of the flashlight and the figure: If you illuminate the figure from the left, the shadow will be on the right; if you illuminate it from the right, the shadow will be on the left, etc. If the figure is illuminated from several sides, it also casts several shadows in different directions.*

Jointly recall the shadows you observed outdoors. Why did they wander during the course of the day? Can the children think of other situations in their everyday lives? For example, how does the shadow change when you walk past a street light in the dark? Can the children find an explanation for this?

SHADOWS ARE SOMETIMES BIG AND SOMETIMES SMALL

Illuminate a light-coloured wall in the darkened room with a desk lamp or a flashlight (from a distance of between two and three metres, at least). Have the children hold their figures up between the wall and the lamp and slowly move them backwards and forwards. Do they succeed in changing the shadow in such a way that it first appears to be very big and then to be much smaller? How is the smallest and the largest possible shadow created?

Look at this: *The size of the shadow depends on the relative positions of the lamp and the figure: If you hold the figure very close to the wall, the shadow gets smaller. The closer you move it to the lamp, the longer its shadow gets.*

Have the children use their own bodies to create really big shadow monsters. Where do they have to stand so that the "monster" becomes really scary? How could you use this effect for a shadow play? Jointly perform a short shadow play on the wall by casting big and small shadows.

Making big and small shadows at the same time

INTERESTED ADULTS MIGHT LIKE TO KNOW

The length, direction, and size of a shadow are determined by the distance and orientation of the light source relative to the object. In the natural world, the Sun is our natural light source. During the course of the day, it wanders from east to west and the shadow changes accordingly. For example, if you observe the shadow of a tree throughout the morning, you will notice that it changes its direction and length over time. By midday it has reached its shortest length because the Sun is now at its highest altitude. Moreover, if you observe the shadow at midday over a period of several weeks, you will note that it gets shorter in spring and longer in autumn. Hence, the course of the seasons can also be read from the length of the shadows: they are longer in winter when the Sun is lower and shorter in the summer. The reason for this is the tilt of the Earth's axis. In summer, the Northern Hemisphere is tilted towards the Sun and the sunrays strike the Earth at a steep angle. In winter, the Northern Hemisphere is tilted away from the Sun and its rays hit the earth at a shallow angle.

Exploring the phenomenon: **Object colours and light colours**

NOW THINGS GET COLOURFUL

Where do we encounter it in everyday life?

Many children are already familiar with painting and mixing colours as they have used drawing ink and water colours before. Nowadays, when painting and writing we can choose from a large selection of drawing or writing inks, chalks, fibre pens, coloured pencils, and lead pencils. In the olden days, colours were extracted from natural materials. Light can also be coloured: Colourful lights can be discovered at Christmas time especially – or all year round as party lights in the garden or in a discotheque.

What it's all about

The children explore colourants from natural sources and try to extract natural colourants and pigments from natural materials. They manufacture mixed colours, discover the diversity of colours that can result from just a few input colours, and find out how they can create and mix different coloured light.

What you need

- Crepe paper in many different colours
- Small, transparent vessels, test tubes, glasses
- Old clothes or aprons
- Several sheets of white paper
- Natural materials (plants, fruits, stones, earth), from which colourants or pigments can be extracted
- Spoons, pestles and mortars, graters, stones, sand, etc.
- Paintboxes, paint brushes
- Pipettes
- Flashlights
- Colourful cloths

! Please make sure that the children use only non-poisonous plants for painting! You can find a list of recommended plants in the brochure.

! Please do not use lamps that can get hot (e.g., halogen lamps).

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Crepe paper dyes the water.


Painting directly on paper with plants.


Grinding soil finely in a mortar to extract pigments

COLOUR BLEEDING AND STAINING (WARM-UP)

The colours in the crepe paper are water soluble. The children can make use of this property to produce coloured water. Each child chooses one colour of crepe paper. What other things of the same colour do the children know (e.g., red, like a strawberry or blue, like the sea)? The children place a scrap of the crepe paper they have chosen in a small glass of water. They then peacefully observe what happens to their scrap of paper in the water. How does the water change? What does the scrap of paper look like when it is removed from the water? Do the children know other things that stain or bleed (e.g., grass that stains their jeans, or red socks that bleed in the washing machine)?

NATURE, THE MASTER PAINTER

Each season, you find different colours in nature. Set off with the children in search of blossoms, fruit, leaves, grasses, earth, stones and sand. Create a collection of the things the children have found and arrange them on a large sheet of paper. How many different shades were the children able to find altogether? Jointly examine whether the plants and stones that were found have left coloured stains on the paper. To leave coloured stains, they must often be reduced to small pieces. This can be done in different ways, for example by tearing, cutting, mashing, grating, or crushing them. Have the children try out different methods. The cell sap that exudes from the plants contains colourants and it can be spread on the sheet of paper. Sieved earth, chalk, loam, and clay can be crushed to form a colour pigment powder. When you mix it with water, you get a thick, coloured paste, which can be applied to paper with a brush.

Look at this: *Nature offers a wide range of colours: from yellow, through red, blue and violet, to grey and brown. Many of the colours can be extracted by crushing or squeezing natural materials. However, you can often paint directly on paper with the blossoms, leaves, and little stones. Some plants and fruits produce very strong colourants that dye even the skin or fabric.*

How many shades of green can be produced by mixing blue and yellow?

A HUNDRED AND ONE WATERS

Provide the children with small glass vessels full of water (e.g., test tubes). To produce many different-coloured waters (see "Warm-Up"), have the children dye the water with a little drop of drawing ink or a scrap of coloured crepe paper. The children then mix the different coloured waters together in empty vessels – only a few drops of two coloured waters are mixed each time. (Depending on how exact they want to be, the children can use pipettes.) How many different colours can they produce? Do they also succeed in producing shades of the same colour, for example several shades of green (from light green to dark green) by mixing yellow- and blue-coloured water? What do the children observe happening to the water over time, the more colours they mix in?

Look at this: *Mixing two colours yields a new colour. Moreover, many different shades of the same colour can be produced – from light shades to really dark shades. And the more colours that are mixed in a glass of water, the darker the shade becomes.*

You can jointly investigate this further by using the inquiry card: "Does everything end up brown?"

DISCO LIGHTS

What colour is light? White or yellow? Do the children have any ideas about how light could be coloured? Jointly recall the last lantern procession or the colourful tealight candles at Christmas time. There is usually something coloured in front of the light source – for example, colourful paper, glass, or foil. Colourful disco lights can be made the same way. For example, the children can put brightly coloured cloths or crepe paper over flashlights and secure them with elastic bands. In the darkened room, they can then shine the flashlight onto a white wall or a light-coloured table. Is it also possible to "dye" things in this way, for example your own face or a light-coloured cuddly toy? With the children, examine whether it is also possible to mix the coloured lights.
What happens when lots of light colours hit the wall and overlap?

Look at this: *If you hold brightly coloured cloths or paper in front of the lamp, the light will be coloured. Lots of things look different in the coloured light. For example, in a green light, faces also become very green. The lights can also be mixed. If lots of light colours hit the wall, the colour of the light gets lighter and lighter.*

Does that mean, in turn, that white light is made up of lots of different light colours?
What do the children think? Try it out: Using a CD, for example, you can split sunlight into its component colours. Children between the ages of six and ten can discover more by using the exploration cards for primary school students "On Stage" and "Objects Transmit Their Colour".

Children use colourful lights to illuminate their own stage.

INTERESTED ADULTS MIGHT LIKE TO KNOW

The colours that occur in nature, and the colours we are familiar with from paintboxes, are called "object colours". They consist of pigments, which are tiny colour-giving particles that are suspended in a medium such as coloured water and are sometimes so small that they are not visible to the naked eye. They absorb, or "swallow" certain components of the incoming light. Depending on which components they absorb, we see things (e.g., the coloured water) in a certain colour. So when you mix paints, you are mixing different light colour filters. And if you mix lots of different colours together, almost all of the original components of light are filtered – that is, "swallowed" – and there is hardly any light left that can be reflected back to the eye. This process is also referred to as subtractive colour mixing. Light colours work the other way around. The light that we perceive as white actually contains lots of spectral colours: red, orange, yellow, green, blue, and violet. Normally, we don't see them individually – unless the light is deflected, for example by the grooves in a CD. When this happens, the light spreads out into its component colours like a colour fan. The creation of white light by mixing the spectral colours is called additive colour mixing.

Exploring the phenomenon: **Colour filters, colour absorption**

FILTERED WORLDS OF COLOUR

Where do we encounter it in everyday life?

When you look through sunglasses, the world looks like it's bathed in another colour. Tinted windows in cars or buildings also change your perception of colours. In supermarkets, slightly reddish light above the fruit and vegetable stands enhances the attractiveness of the products, because warm light colours emphasise the red and green shades and make the fruit and vegetables look fresher.

What it's all about

The children explore how their colour perception changes as soon as they look at their surroundings through coloured foil. Moreover, with green and red coloured pencils and coloured foil, messages can be hidden and revealed again.

What you need

- Transparent coloured foils (e.g., colourful plastic folders, window or windmill foil) in several colours – at least red, green, blue, and yellow
- Shoe box
- Flash light
- Different-coloured fruit and vegetables or colourful fruit gums
- Scissors or a box cutter
- White paper
- Coloured pencils or wax crayons
- Light green coloured pencils or text markers
- Red-orange coloured pencils or text markers

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Looking at the world through coloured foil

Colours change when you look through yellow foil.

Fruit looks quite different in the light showcase.

A COLOURFUL DAY (WARM-UP)

When you look at the world through coloured foil, many things seem to have changed colour. Give the children some coloured foil and let them explore their surroundings with it. Jointly discuss what the children perceive when they look through the foil. Does everything appear to be a different colour, or only certain details? Can you still recognise the original colours through the foil? What colour effect do the children especially like: the blue, the yellow, the green, or the red world? And why?

LIGHT SHOWCASE

Jointly make a light showcase out of a shoe box. Cut a small hole in the narrow side so you can shine a flashlight into the box. Cut a big rectangle out of the lid so that the box is almost completely open on top. Have the children put different coloured fruit and vegetables or colourful fruit gums into the box. Place a sheet of coloured foil over the hole in the lid and switch the flashlight on. Jointly compare the colours of the fruit and vegetables or the fruit gums outside and inside the box. Does a red tomato look different under the blue foil, or does a yellow banana look different under the green foil? Are the children still able to tell the different coloured fruit gums apart when they look at them through the coloured foil? And what happens when you put all the different coloured foils on top of each other?

Look at this:

The colours of the fruit, vegetables, and fruit gums seem very different when you look at them through coloured foil. Under the yellow foil, you can usually still tell the individual colours apart quite easily. However, under green or red foil this is much more difficult. When all the coloured foils are placed on top of each other, you can hardly recognise anything in the box.

How do the colours of the coloured pencils change under the foil?

COLOUR FILTERS

The children draw something on a sheet of paper with coloured pencils and place a piece of coloured foil over it. Jointly discuss the changes that the children perceive when they look through the foil. Have the children swap foils with each other. Take time to compare with the children what each pencil colour looks like through the respective foils. When doing so, bear in mind that younger children might find it hard to name the changed colours. Moreover, we all perceive colours or shades differently. What some people perceive to be green, appears to other people to be blue.

Look at this:

The colours of the brightly coloured drawings appear to change when you look at them through the foil. Red pencil strokes appear to be very dark – almost black – under a blue or green foil. Similarly, blue or green drawings look very dark when you look at them through a red foil. If the pencil colour is similar to that of the foil, then the drawing is hardly visible, or even disappears.

SCRIBBLE MAGIC

The children use a light green coloured pencil to draw or write a message on a sheet of white paper. Using a red coloured pencil, they then scribble all over the message until it is no longer recognisable. Only "those in the know" can now decipher what is hidden under the red scribbles: They place a piece of red coloured foil over the sheet of paper. What happens then?

Look at this:

Under the red foil, the red scribbles suddenly disappear and the green message is legible once again

Jointly explore whether this also works the other way around: Can a red message that has been scribbled over with a green coloured pencil be revealed by placing green foil over it? And does red foil make only red coloured pencil strokes disappear or does it also work with other coloured pencil colours?

Children between the ages of six and ten can explore further by using the exploration cards for primary school students: "Flip Images" and "3D Vision "

The green writing is scribbled over with red pencil and is visible again under red foil.

INTERESTED ADULTS MIGHT LIKE TO KNOW

A rainbow impressively demonstrates that white light is actually made up of many colours. When an object is illuminated, it absorbs – or "swallows" – some of the colours in the light colour spectrum and reflects the others. Our brain assembles these reflected portions of light to form a colour impression. Simply put, we see a red ball in red because it reflects only the red portions of light. When we use colour filters, such as coloured foils, they also "swallow" part of the light reflected by the object or the drawing. As a result, we perceive the colours differently. Under a yellow foil, for example, blue changes into a shade of green. In the case of the "scribble magic," the red foil absorbs the portions of light reflected by the red coloured pencil strokes. Hence, they can no longer reach our eyes and the red strokes seem to disappear. When all the coloured foils are placed on top of each other, almost no reflected light gets through, which is why you can hardly see anything through them.

Exploring the phenomenon: **Mirrors**

EXPLORING MIRROR IMAGES

Where do we encounter it in everyday life?

Even in very early childhood, mirrors and mirror images are part of the children's everyday experiential world. For example, children look at themselves in the bathroom mirror when they are cleaning their teeth, they like to dance in front of long mirrors in the hall or the bedroom, and they discover mirrors in shops and in, or on, their parents' car.

What it's all about

The children investigate whether what they see of themselves or of an object in a mirror corresponds to reality (e.g., in terms of colours, size, configuration, and movement).

What you need

- A mirror that is big enough for the children to see their full reflection
- A simple standing mirror for each child (e.g., mirror tiles with stands)
- Small play figures, building blocks, rubber balls, and the like
- Post-it notes
- Paper and pencils
- Alphabet biscuits or letters made of wood, cardboard, or plastic

Explain to the children that glass mirrors are breakable and must therefore be handled with care. If necessary, the mirrors should be safeguarded with protective film. Some mirrors are made of unbreakable plexiglass.

If you glue a wooden wedge onto the back of a mirror tile, it will stand upright and won't have to be held.

Recognising yourself in the mirror

Will the mirror image join in all my movements?

Will he succeed in grasping the dice in the mirror?

MIRROR, MIRROR ON THE WALL (WARM-UP)

At the beginning, the younger children find it exciting to catch sight of themselves in the mirror. Give the children time to explore their reflection in the mirror. What kind of things can they get up to? They can pull faces, stick out their tongue, bend down, dance, hold out their hand to the mirror image, and much more besides. Does the mirror image really join in everything? Have the children ask themselves: "Is that really me in the mirror?" How could they find that out?

IMAGE AND ILLUSION

Have the children place different objects in front of small standing mirrors. Suddenly the objects appear to exist twice! But how do the things in front of the mirror differ from those that you can see in the mirror? The rubber ball in front of the mirror is soft to touch, for example, and the children can feel its shape in their hands. However, if they try to grasp the ball in the mirror, they touch the smooth surface of the mirror. Try this out with a sandwich, too. The children can touch, smell, and even eat up the sandwich in front of the mirror. But what about the sandwich in the mirror? Can you touch it, smell it, or eat it up?

Look at this:

Although your own body and the objects appear to be duplicated in the mirror, they are not real. You can pick up the objects in front of the mirror and you can feel them; you can stroke your own face or hair. But if you try to grasp your body or an object in the mirror, you touch only the cold, smooth surface of the mirror.

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What do you see in the mirror? And what don't you see?

SEARCHING FOR NOTES

Have the children look at themselves at length from all sides in a big mirror. Then stick post-it notes on their backs. Can they see the notes when they are facing the mirror? How must they turn in order to be able to discover the notes in the mirror? Repeat the game, but this time stick the post-it notes onto another part of the body. Help the children to consciously perceive what they see of themselves in the mirror and what they don't see. Depending on the way they are standing in front of the mirror, do they see their face or the back of their head, the tips of their toes or their heels, their chest or their back?

Look at this: *The mirror always shows only the side of your body that is turned towards it. If the note is stuck on a part of your body that is completely turned away from the mirror, you won't be able to see it in the mirror.*

COMPARING THE ORIGINAL AND THE MIRROR IMAGE

The children arrange different coloured building blocks in a row in front of the small standing mirrors. Suggest that they look very closely and compare: Is the number of blocks in front of the mirror the same as the number of blocks in the mirror? Are the blocks in the mirror image in the same order? Is the red block in front of the mirror standing opposite the red block in the mirror image? And are the blocks in the mirror as big as the original blocks? Which side of the blocks does the mirror show? Have the children try drawing in front of a mirror. If they move the pencil away from themselves, the pencil in the mirror moves towards them. And the other way around? Have the children follow with a pencil a predrawn maze or path. When doing so, they should look only into the mirror. What aspect of this task do the children find difficult? What do they find easy? The older children could also write something or place alphabet biscuits in front of the mirror. What happens to the writing in the mirror? Where do you have to place the mirror in order to produce mirror writing? Take a close look together once again: Are the letters in front of the mirror in the same order as the letters in the mirror?

Look at this: *The mirror shows only the side of the object that is facing it. Neither the colour, the size nor the sequence of objects is distorted by the mirror. Moreover, you can also see movements in the mirror. If you look only into a mirror when you're drawing, it is sometimes difficult to find the correct direction with the pencil – although the mirror does not reverse left and right, it does reverse front and back!*

Gathering lots of experiences on the subject of mirror images

INTERESTED ADULTS MIGHT LIKE TO KNOW

The mirror image in a mirror with a flat surface is a true and undistorted reflection. Contrary to common belief, the sides are not reversed. For example, if you look in the mirror and raise your right hand, the mirror image raises the hand that is exactly opposite your right hand. However, when two real people are sitting opposite each other and both are asked to raise their right hand at the same time, they – in contrast to the mirror image – raise diagonally opposite hands. In other words, the sides really are reversed. However, the mirror reverses the side facing towards it and the side facing away from it. You notice this, for example, when you are doing your hair or drying it with a hairdryer. When you are looking in the mirror and you want to put your hand on the back of your head at the same time, you often don't touch the exact spot that you actually wanted to touch.

Discovering the phenomenon: **Reflective surfaces**

THE MIRRORED WORLD

Where do we encounter it in everyday life?

We find mirrors in lots of places: in the bathroom; in the dressing room; in, and on the car; on street corners where visibility is restricted; in department stores. They are used for different purposes, which influences the way the individual mirror is constructed. You can see your own reflection not only in mirrors but also in the lids of metal pots, in spoons and soup ladles, and sometimes also in shop windows.

What it's all about

The children compile a collection of mirrors and other things with reflective surfaces. They discover that their reflection changes, depending on the nature of the surface. They explore their surroundings with a mirror, and they investigate what makes shop windows and glass panes become good mirrors.

What you need

- Different mirrors
- Brightly polished objects (e.g., metal spoons, pot lids, soup ladles)
- A simple mirror with a flat surface for each child (e.g., mirror tiles)
- Large sheet of reflective foil and thin (pliable) cardboard
- Empty CD covers, rulers, or other objects made of transparent plastic
- Small panes of glass (e.g. from picture frames)
- Light- and dark-coloured paper

! Explain to the children that glass mirrors are breakable and must therefore be handled with care. If necessary, the mirrors should be safeguarded with protective film. Some mirrors are made of unbreakable plexiglass.

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What does your reflection in a Christmas tree ball look like?

... the same as in a spoon?

What happens when you bend the reflective foil?

WE COLLECT MIRRORS (WARM-UP)

Where can you find mirrors and other things in which you can see your reflection? Compile a collection with the children (and with the help of the parents). At home, besides hand mirrors, cosmetic mirrors and standing mirrors, you can also find reflective objects: cutlery, soup ladles and cooking pots, jewellery, metal buttons, mobile phones, sunglasses, metal balls and Christmas tree balls, and shiny plastic bowls. The German word for fried egg is *Spiegelei*, which means "mirror egg". Is it called that because you can see your reflection in a fried egg? What do the children think? Try it out for yourself! Set off together on a "mirror walk" in nature or in town. Where do the children discover other mirrors and reflective surfaces?

SOMETIMES FAT, SOMETIMES THIN, SOMETIMES UPSIDE DOWN...

Jointly look at your reflections in the things that you have collected. Is your own mirror image the same as always or has it changed? In which reflective surfaces do the children look distorted, upside down, reduced in size or magnified? Suggest to the children that they should describe in words or in drawings whether and in which way their mirror image changes. In the inside of a spoon, for example, you see yourself upside down. Is it possible to make the mirror image appear right-side up by looking into the spoon upside down? And what does your reflection look like on the outside of the spoon? Use reflective foil to jointly make a distorting mirror like the ones in a hall of mirrors. To make it easier to handle, stick the reflective foil onto a piece of thin cardboard. How does the mirror image change depending on whether the children bend the mirrored cardboard outwards or inwards?

Look at this:

The mirror image in a mirror with a smooth, flat surface is undistorted. However, if the reflective surface is bent or curved, the mirror image changes: It looks distorted and funny, and sometimes it is upside down.

What do you see when you look into the mirror from below?

LOOKING AROUND THE CORNER

Jointly explore the surrounding area with the help of handy little mirrors such as pocket mirrors or mirror tiles. For example, you could undertake an expedition to the playground or to the woods. Do the children succeed in detecting with their mirrors who or what is behind them without having to turn around? How must the children hold their mirrors in order to be able to look into the sky or the crown of a tree without having to direct their eyes upwards? And how must they hold their mirrors in order to be able to see their own shoes without having to look down? Do they also succeed in using their mirrors to look around the corner of the house or over a wall? Have any of the children noticed the convex mirrors on roads or in shops? What do the children think these mirrors are for? Why does the dentist use a small mirror to look into the patient's mouth?

Look at this: *Mirrors enable you to see things that are hidden behind you, around a corner, or over a wall without your having to look in that direction.*

Children between the ages of six and ten can explore further with the exploration cards for primary school students "Mirror Spy" and "Periscope".

REFLECTIVE WINDOWS

You can sometimes also discover mirror images in shop windows, glass doors, and window panes. Investigate with the children the conditions under which this is possible. Distribute empty CD covers, small panes of glass from picture frames, and transparent rulers. When can the children see through them well and when do they see their reflected image? Provide the children with different-coloured sheets of paper to hold behind the CD covers and glass panes. Which background reflects very well?

Look at this: *You can always see your reflection really clearly in glass or plexiglass when the background is very dark – that is, when you hold glass or plexiglass in front of a dark wall, a dark cushion, or a sheet of black paper.*

Fill a (white) washbasin with water and have the children see if they can see their reflection in the water. Then go outside together and look into a puddle or a self-made pool of water on a dark background. What commonalities do the children detect between this inquiry activity and the one with the (white) washbasin? Have they any ideas about how they would have to change the washbasin in order to be able to see their reflection in the water?

When is the CD cover reflective?

INTERESTED ADULTS MIGHT LIKE TO KNOW

When light rays hit a mirror with a smooth, flat surface, they are reflected at the same angle as they arrive. As a result, the mirror image is the same as the original object. However, most objects do not have an absolutely smooth surface, or they are curved. Hence, the light is scattered in all directions. This gives rise to distortions. Mirrors that curve inwards slightly (e.g., makeup mirrors) magnify the image, while mirrors that curve inwards strongly (e.g., the inside of a spoon) make the image appear smaller and upside down. A mirror surface that is curved outwards (e.g., the outside of a spoon) makes the image appear smaller. Half-mirror (semi-reflecting) effects can be observed in the case of windows. Glass has a very smooth surface, which reflects light rays well. However, because it is transparent, light rays also get through from behind. Whether you can see your reflection in the glass or see through it depends on which side is brighter. If it is brighter behind the glass, you won't see any reflections but rather what is behind the glass. If it is darker behind the glass, you will see your reflection. That is why, for example, you see your own reflection in the window when you are sitting in a bright room and looking out into the dark night.

Exploring the phenomenon: **Reflection**

LIGHT CAN BE DIRECTED

Where do we encounter it in everyday life?

If the sun shines on the glass of your wristwatch, a spot of light is formed on the ceiling or the wall of the room. If you move the arm on which you are wearing the watch, the spot moves, too. This is a great way to tease and dazzle other people. The same phenomenon can be observed in the case of open windows or sequins on clothes.

What it's all about

The children discover that reflective surfaces can be used to direct light. They produce spots of light in the room, make flashing party decorations, and "transport" light through dark boxes and rooms.

What you need

- Small mirrors, mirror tiles
- Objects with reflective surfaces, e.g., kitchen utensils
- Flashlights
- Thick and thin cardboard
- Black paint, paintbrushes
- Glue
- Old CDs
- Reflective foil
- Reflective tesserae from a handicraft store (optional), other things with a reflective surface, shiny sweet wrappers, etc.
- String
- Scissors
- Adhesive strips
- Shoe boxes

If you glue a wooden wedge onto the back of a mirror tile, it will stand upright and won't have to be held.

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Making a spot of light with a mirror

A self-made mirror ball

The illuminated party decorations glitter.

DAZZLED (WARM-UP)

Have the children transport light through the darkened room. To do this, they use mirrors and reflective objects, such as shiny kitchen utensils, to direct the light of the sun or a flashlight. What things are particularly suitable for directing the light? What things are not suitable? Have the children flash their light around and dazzle each other. Can they recognise the spot of light that comes from their mirror or reflective object? Who manages to hit a specific point in the room?

PARTY DECORATIONS

Make flashing party decorations with the children. To make a mirror ball, cut two large disks out of a sheet of stiff cardboard. Then make a cut in the top of one of the disks and in the bottom of the other disk so that they can be inserted into each other. Have the children paint the cardboard disks black. After the paint dries, have the children stick reflective tesserae or little pieces of cut-up CD on the black surfaces. Then hang the finished ball from the ceiling with a piece of string. To make a glitter curtain, stick mirror foil on both sides of a sheet of thin cardboard. Have the children cut different-sized shapes out of it. These shapes can be threaded together on a piece of string and attached to the ceiling. Turn up the music, darken the room, and have the children shine their flashlights around. What happens to the light when it hits the party decorations?

Look at this:

The smooth surfaces of the pieces of CD or the reflective tesserae reflect the light from the flashlights. As a result, lots of little spots of light are formed throughout the room. When the mirror ball and the glitter curtain move, the spots of light fly around the room.

Jointly consider what objects would be very suitable as decorations because of their shiny surfaces. For example, the children could make unusual party decorations out of kitchen utensils or reflective sweet wrappers.

Children between the ages of six and ten can explore this topic further by using the exploration card for primary school students "Sparkling and Glittering".

Using a mirror to direct light from one box to another

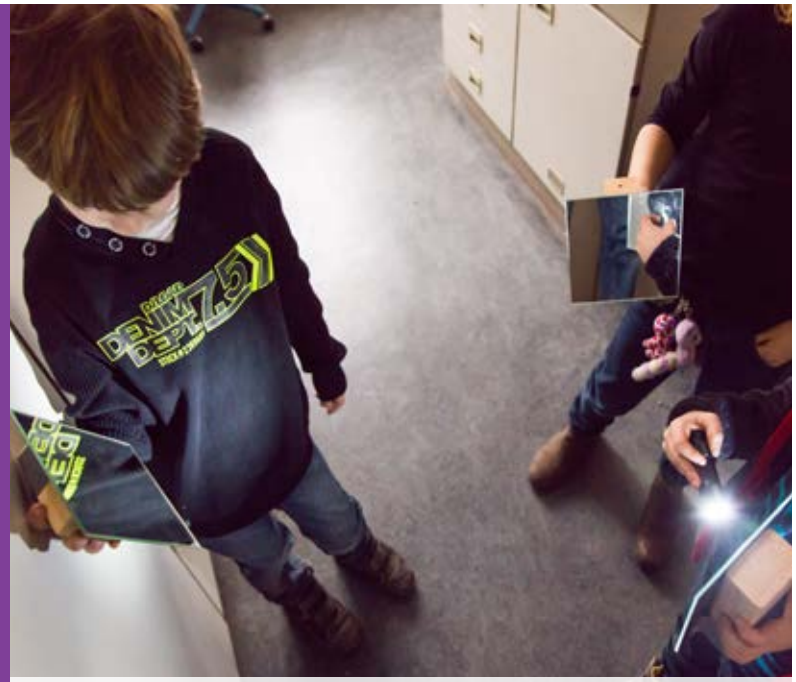
TRANSPORTING LIGHT

Have the children use a mirror to direct the light from a flashlight (the most focused beam possible) through a cardboard box in which a small hole has been cut in the narrow and the broad side. Darken the room. Have the children shine the flashlight through one of the holes and try to find out how the mirror tiles should be positioned in the box so that the light emerges from the box through the second hole. To test whether the light actually emerges through the hole, the children can hold one hand in front of it. Can they see a spot of light on their hand?

Via how many mirrors do the children succeed in directing the light from the flashlight through the darkened room? Give each child a mirror or mirror tile. The first child shines the flashlight on the first mirror. Where does the beam of light go to? The next child has to "catch" it and direct it with a mirror. This continues from mirror to mirror. How long is the row of mirrors? Is a row actually formed or is the light passed on in lots of different directions – sometimes to the left, sometimes to the right, sometimes upwards? Can the children find explanations for the change in the direction of the light? What happens when the mirrors are turned slightly?

Look at this: *Mirrors can be used to pass light on or to change its direction. In this way, light can be "transported" and passed on from mirror to mirror . However, the beam of light gets a little weaker in the process.*

Children between the ages of six and ten can explore further by using the exploration card for primary school children "Light Language" and by visiting the website www.meine-forscherwelt.de



Via how many mirrors can the light be passed on?

INTERESTED ADULTS MIGHT LIKE TO KNOW

Rays of light bounce off mirrors and other very smooth materials almost completely. In other words, they are "reflected". Reflective surfaces are therefore suitable for deflecting or bouncing off light. A light source always emanates light in all directions. However, lighthouses and other light sources such as office lighting or bicycle lamps are supposed to transmit light in only one direction or only to a small sector. A lot of light therefore goes unused. That is why reflective surfaces are used to deflect or bounce off this unused light so that it focuses in one direction. In old lighthouses, for example, large concave mirrors direct the light of the beacon in the desired direction. On the inside of bicycle lamps and office lamps, the area behind the halogen lamp or the fluorescent tube is often mirrored. The same principle is used in light conductors, for example fiber optic cables. On the inside, they reflect the light almost without any losses, and thus transport it over long distances. Modern communication networks (e.g., intercontinental submarine Internet cables) are made up almost entirely of fiber optic cable networks, in which information that has been encoded into light pulses by means of binary code is transmitted.

LIGHT, COLOURS, VISION – EXPLORING OPTICS

Investigating the phenomenon: **Colour vision**

WHAT COLOURS CAN WE SEE IN THE DARK?

ASK A QUESTION ABOUT THE NATURAL ENVIRONMENT

At dusk, all objects appear to be grey even if they look quite colourful in daylight. Can't we see colours in the dark?

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COLLECT IDEAS AND ASSUMPTIONS

Experience absolute darkness with the children (see the exploration card "Light and Darkness"). Afterwards, discuss with the children what they could see in the semi-darkness in the light of a flashlight or a candle. How does vision change in darkness? Have any of the children ever heard the saying: "All cats are grey at night"? What could it mean?

Suggest to the children that they repeat the above mentioned activity "seeing in the dark," and that this time they pay closer attention to the colours. How can they find out whether they can see colours in the dark? What ideas do the children have? For example, do they want to observe the colours of the objects with a dimmed light or with a candle?

Collect the children's assumptions: Can we also see colours in the dark? Or can we see only certain colours in the dark? What reasons do the children come up with?

TRY THINGS OUT AND CONDUCT INQUIRY ACTIVITIES

If you don't have a dark room at your disposal, you can use a shoe box in which you have cut a small peephole and two or three small holes to allow light to enter. The coloured objects are placed in the dark room or the box. Can the children tell the colours apart in the dark? If you are conducting the activity in a dark room, ask the children to pick out objects of a certain colour. Do they succeed in picking out all the blue objects, for example? Or do they confuse them with green and red objects in the dark?

Do the children succeed in distinguishing bright and dark colours – for example, yellow and dark blue? Have them sort the objects in the dark. Then jointly examine the result in the light. If you are using the shoe box, put only one object in at a time – without letting the children see what you are doing – and have them judge the colour through the peephole.

Materials:

- *Identical objects (e.g. building blocks) in different colours – in yellow, red, blue, and green, at least*
- *Dark room with a lighted candle or a dimmed flashlight; alternatively: a shoe box*
- *For the follow-up activity: one white and one black object, reflective tape, or clothing with reflective luminous strips; flashlight*

OBSERVE AND DESCRIBE

Do the children succeed in telling the colours apart in the dark? What difficulties arise? Have the children describe exactly what they find difficult when identifying or sorting the colours. Do they always identify or sort the colours correctly? Are there colours that look the same in the dark?

Jointly observe the colours in the dark. Are they as colourful as ever? Have the children describe what the colours of the objects look like outside the dark room and what they look like in the dark.

DOCUMENT RESULTS

Do the children succeed in identifying the colours and sorting the coloured objects in the dark? For example, have them draw a table with two columns. They should keep a tally of the correct colour identifications in the left-hand column and a tally of the incorrect identifications in the right-hand column. When drawing the tally strokes, it is best to use coloured pencils that correspond to the colour of the object in question.

At the end, compare the columns and have the children count up the scores. Are there more correct identifications or incorrect identifications? Is there one colour where very few mistakes were made? What colour was incorrectly identified most frequently?

DISCUSS RESULTS

Jointly discuss what the children have found out. Did they succeed in distinguishing the colours in the dark or in semi-darkness? Which colours could be told apart and why was this the case?

Focus on the fact that light-coloured objects – for example in yellow, orange, or light green – can be seen quicker. Dark red, green, and blue are also difficult to recognise in semi-darkness, and it is very hard to tell the objects apart. Continue investigating together: Place one white object and one black object in a dark room and have the children shine a flashlight on them. Which object can the children recognise easier? Why is that? Add the reflective tape and repeat the inquiry activity.

Jointly transfer the results to behaviour in road traffic: Why are we supposed to wear light-coloured clothing in autumn and winter when it does not get bright until late and when it gets dark early? What purpose do the reflective strips on clothing, shoes, and schoolbags serve?

LIGHT, COLOURS, VISION – EXPLORING OPTICS

Investigating the phenomenon: **Mixing object colours**

DOES EVERYTHING END UP BROWN?

KLEINE FORSCHER
Naturwissenschaften und Technik für Mädchen und Jungen

ASK A QUESTION ABOUT THE NATURAL ENVIRONMENT

When you paint with different colours, the same thing always happens: After a while, the water that you dip your brush in turns a dirty-looking black-brown colour. Does a mixture of different colours always end up brown?

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COLLECT IDEAS AND ASSUMPTIONS

After they have finished painting with water colours, draw the children's attention to the water in which they dipped their brushes and to the way it has changed colour. No matter whose paintbrush water the children look at, it always looks black or brown.

What colours did the children use? Do they have any idea why everyone's paintbrush water turned a similar shade of black-brown although they painted many different pictures with lots of different colours? What ideas do the children have: Does it depend on the number of colours that were used, or are some "strong" colours responsible? How would the children like to check this?

TRY THINGS OUT AND CONDUCT INQUIRY ACTIVITIES

Have the children mix different colours on a sheet of paper. Many of them will proceed in a similar way: First they mix two initial colours, for example blue and yellow. Later, they add a third colour, for example red. Then they go back to the initial colours, and so on. They go on mixing colours in this way until they end up with a shade between brown and black.

Depending on their age, the children can also mix colours systematically. In other words, all the children mix the same two colours and compare the resulting mixed colours. Then, they all add the same third colour and compare the result once again, and so on.

Materials:

- *Artists' colours (at least the primary colours red, blue, and yellow)*
- *Paintbrushes*
- *Paper*
- *If necessary, surface protection film or a vinyl coated tablecloth to protect surfaces against splashes and stains*

OBSERVE AND DESCRIBE

Pause frequently while mixing the colours and jointly look at the resulting mixed colours. For example, did all the children end up with the same shade of green after mixing blue and yellow? If not, how many shades of green can the children find? How is it possible that so many different shades of green mixed colour occurred?

Do the mixed colours get darker and darker? Or is any mixed colour lighter than one of the initial colours with which it was mixed? At the end, compare the shades of brown. Did all the children end up with a brown or a black mixed colour?

DOCUMENT RESULTS

Collect all the sheets of painting paper with the black-brown mixed colour. For example, the children could stick them on a larger sheet of paper or on the back of a strip of old wallpaper and exhibit them in the corridor of your institution. Later, have the children supplement the documentation with the results of the inquiry card "Can brown become colourful again?"

DISCUSS RESULTS

Jointly discuss the results of the colour mixing. Return to the initial question and to the assumptions voiced by the children. Did the mixed colour always end up black-brown? Have the children describe the order in which they mixed the colours. Did that influence the result?
In addition, the children could also discuss the intermediate steps: How many different mixed colours could be made from the colours yellow and green? Why did mixing the same colours yield such different results?

Continue investigating together: Do you also end up with a black-brown shade when you mix colours using coloured pencils, crayons, finger paints or felt pens? And could you turn the whole thing around and get the many bright colours out of the black or brown mixture again?
Continue your joint investigation with the felt pen example on the inquiry card "Can brown become colourful again?"

LIGHT, COLOURS, VISION – EXPLORING OPTICS

Investigating the phenomenon: **Mixing object colours**

CAN BROWN BECOME COLOURFUL AGAIN?*

KLEINE FORSCHER
Naturwissenschaften und Technik für Mädchen und Jungen

ASK A QUESTION ABOUT THE NATURAL ENVIRONMENT

As the children discovered when painting with different colours, when you mix them you get a black-brown colour. Is it possible to separate this dark mixed colour into its components? Can brown become colourful again?

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COLLECT IDEAS AND ASSUMPTIONS

First, investigate with the children whether mixing lots of (felt pen) colours yields a black-brown shade (see inquiry card “Does everything end up brown?”).

What do the children think: Are the bright colours still in the black-brown colour? How could you get them out again?

Consider with the children whether the bright colours are always hidden in the black-brown colour, and thus in black and brown felt pens as well. What assumptions do the children have?

TRY THINGS OUT AND CONDUCT INQUIRY ACTIVITIES

The children draw a thick line with a brown or black felt pen, just above the bottom end of a filter paper.
The bottom end of the filter paper is then briefly dipped into a bowl of water, taking care to keep the line drawn with the felt pen above the surface of the water. Make sure that the children remove the paper from the water after a few seconds, because if they leave it in the water for too long, the colour will get washed out and will merge with the water in the bowl. The filter papers can now be hung up with clothes pegs on a string line to dry.

Materials:

- *Several brown and black water-soluble felt pens*
- *White tea or coffee filter papers; alternatively: white blotting paper*
- *Shallow bowl filled with water*
- *String and clothes pegs*

* This inquiry activity was previously on an inquiry card in an earlier edition of the set of "Water" cards. The topic "solubility" was investigated under the title "Mysterious Black".

OBSERVE AND DESCRIBE

Jointly observe how the filter paper absorbs the water and the water spreads out in the paper. Have the children describe what happens when the water meets the lines drawn with the felt pen and takes the colour with it.

Observe the colourful patterns and the bright rings of colour that are forming. How many different colours can the children recognise? Compare the patterns. Do the children find differences between them, depending on which felt pen was used?

DOCUMENT RESULTS

Have the children supplement the documentation of the inquiry card "Does everything end up brown?" with the colourful filter papers. For example, on the left you could arrange all the sheets on which the black-brown mixed colour was painted, and opposite them on the right you could arrange the filter papers with the colourful patterns that emerged from the lines drawn with the black and brown felt pens.

DISCUSS RESULTS

Jointly examine the sheets of paper with the black-brown mixed colour and the colourful filter papers. Have the children recall how mixing many different bright colours resulted in a dark brown colour, and that the brown and black lines drawn with felt pens have now turned into colourful patterns.

Then return to the initial questions: Were the bright colours in fact still hidden in the black-brown colour? Did the children succeed in getting them out again? Do all the brown and black felt pens contain the many bright colours? And are the colours always the same?

Investigate further together: Are other felt pen colours also a mixture? For example, are several colours also hidden in violet or green felt pens? And are they the same mixed colours as in a paintbox?