Raspberry Pi Activity: *Scratch*ing the Surface

In this activity, you will learn about the Scratch programming language and design a simple game. You will need the following items:

- Raspberry Pi B v3 with power adapter;
- LCD touchscreen; and
- Keyboard and mouse.

The goal of this activity is to introduce you to the Scratch programming language and take you through the process of making a simple game in Scratch. Various programming constructs will be utilized and discussed (e.g., data types, constants, variables, sequence, selection, repetition, etc).

Although you won't actually design complex programs that solve interesting problems (yet), you will explore algorithm design and computer programming in Scratch, a visual programming language that replaces syntax with puzzle pieces. Unlike programming languages that are used in practice (e.g., C++, Java, Python), Scratch is intended for education and provides a great starting point for novice programmers. But don't get boxed in to the idea that Scratch is somehow not powerful. In fact, it is actually quite powerful and allows you to create games, animations, and interactive stories.

Scratch

Scratch is a basic programming language that utilizes puzzle pieces to represent the properties in the language (e.g., sequence, selection, and repetition). The programmer decides what pieces to use in order to implement the algorithm, and the puzzle pieces help identify what actions or statements can fit with each other and in what order they will be executed. More robust languages such as Python are entirely text-based where statements are text instructions used to represent actions.

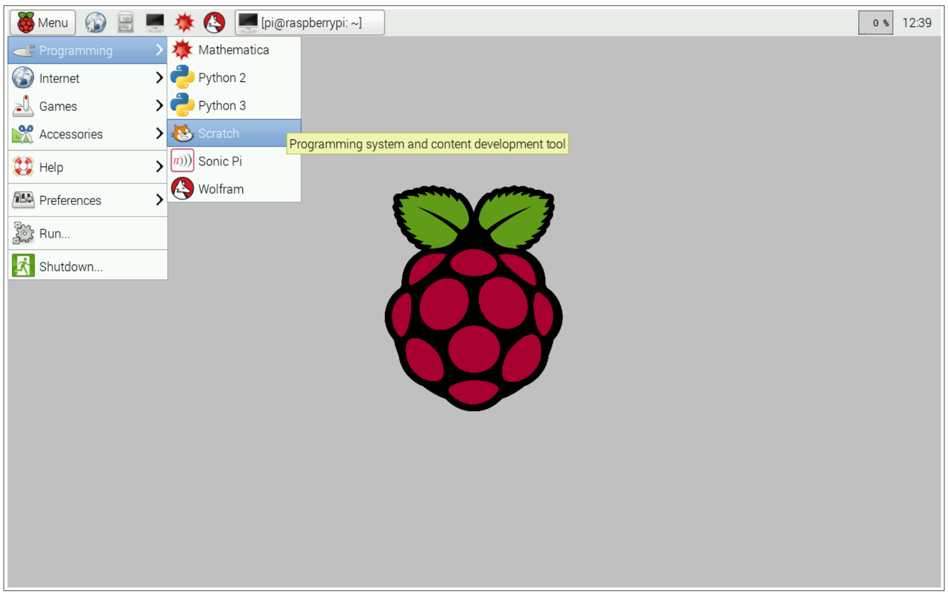
In real physical puzzles, certain pieces have meaning and can only be used in certain places (e.g., edge pieces and corner pieces). This is similar in Scratch, in that certain pieces have meaning and must be used in certain places in our programs. Some of a puzzle's pieces can only be combined with certain other pieces so that they make sense.

Scratch programs consist of scripts and is sprite driven. That is, a set of scripts can be defined for each sprite in a Scratch program (which we can more appropriately call a project). Scripts that are executed when the green flag is clicked can be defined for each sprite, and these scripts will execute *simultaneously* for each sprite! Sprites can communicate by way of broadcasting messages that can be received by other sprites. This is, in a way, a characteristic of object-oriented programming languages, where objects can communicate with each other by sending messages.

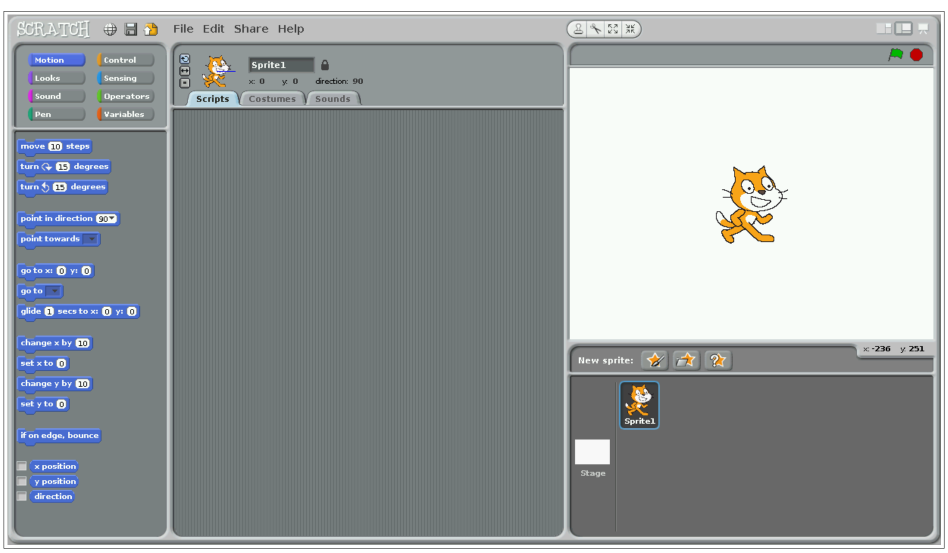
Scratch scripts are made up of various puzzle pieces (or blocks) that serve various functions. Blocks in the *motion* group provide programming constructs that deal with the movement or placement of sprites, while blocks in the *looks* group control anything related to the appearance of sprites (e.g., costume, graphical effect). *Sound* blocks provide the ability to incorporate sound in our Scratch programs, and *pen* blocks allow us to draw on the stage. *Control* blocks provide some of the most powerful functionality in Scratch. They allow us to implement selection and repetition quite easily, and in a variety of useful ways. They also provide ways to allow communication among sprites and to specify scripts to perform when events occur (e.g., when the green flag is clicked). Blocks in the *sensing* group provide ways of specifying input to our programs. We can, for example, detect if a sprite is touching another (and then specify some sort of action if desired). Blocks in the *operators* group provide math and string capabilities, something quite useful in our programs. These blocks allow us to compare values in order to determine an action to perform. Lastly, blocks in the *variables* group permit us to define variables and lists (i.e., a group of values). This is useful in virtually all programs, and you will find that declaring variables will become pretty routine.

Starting Scratch

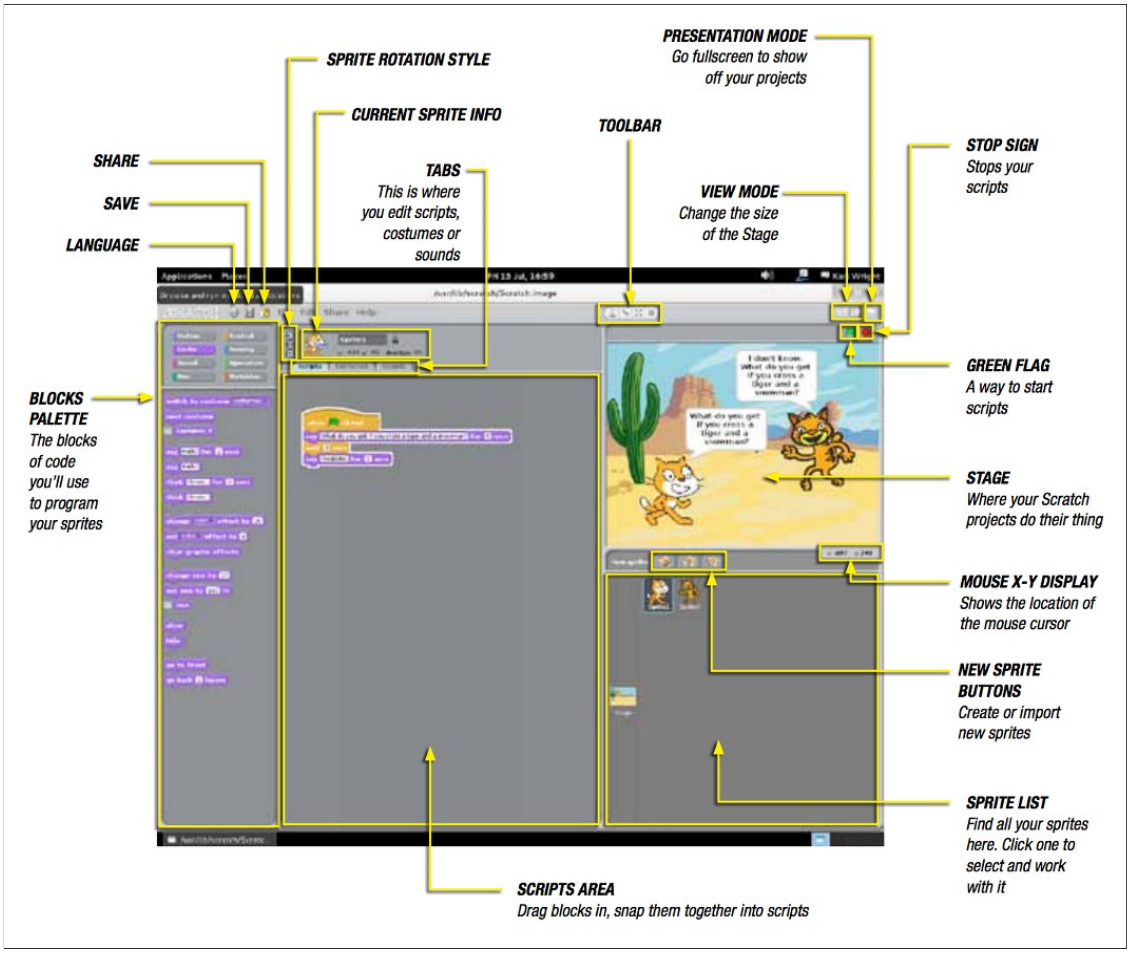
To begin, let's start Scratch from the menu:



After a short while, the Scratch interface will be displayed:



Although the interface looks a bit complicated, it really isn't. We won't make use of everything at first; however, here is an overview of the interface components:



The Scratch interface is quite busy; however, there are three main areas that you will find yourself interacting with often: the blocks palette, the scripts area, and the stage.

The **blocks palette** panel provides a variety of useful constructs that allow you to write programs. In total, there are eight different block types, accessible by clicking the groups in the top-left of the interface:

- *Motion*: anything related to the movement or placement of sprites (graphics);
- *Looks*: anything related to the appearance of sprites;
- *Sound*: anything related to incorporating sound in your programs;
- *Pen*: anything related to the pen which allows drawing on the canvas (background);
- *Control*: anything related to controlling the flow of programs;
- *Sensing*: anything related to detecting things (like movement, collisions, etc);
- *Operators*: anything related to math functions and string handling; and
- *Variables*: anything related to the declaration and upkeep of variables.

The **scripts area** is where you define your computer programs. This is done by dragging various blocks from the blocks palette and connecting them to make a program. It's almost like solving a jigsaw puzzle.

In fact, blocks have different types of notches and ridges that allow them to match up only to certain other blocks. This helps simplify the design of programs.

The **stage** is where your programs are executed. It's where to look to see if your code works...or not. On the stage, we can place sprites (graphics), variables, text, and drawings. At the top-right of the stage, a green flag and a red stop sign are used to start and stop your programs. The stage implements a two-dimensional coordinate system, where *x* and *y* represent the horizontal and vertical axes respectively. On our system with the LCD touchscreen, the center of the stage is at the point (0,0); the top-left corner is at (-240,180); the bottom-right corner is at (240,-180). Note that the stage is actually much larger (i.e., the cat sprite could technically be moved out of the viewable area of the stage).

Your first program
Let's create a simple program. Your task will be to move the cat sprite on the canvas. One useful block in the control blocks group is the **when green flag clicked** block. It is used to specify what to do when the green flag at the top of the stage is clicked (in other words, what to do when your program starts). We can add it to the scripts area by dragging it from the control blocks group in the blocks palette. Let's also add the first instruction to **move 10 steps** (pixels) in the direction the cat is facing (i.e., to the right). For this, we can utilize a block in the motion blocks group. Drag the move steps block to the scripts area until it snaps in place beneath the green flag block:

Click on the green flag in the top-right corner of the stage to run this program. You will notice that the cat moves very quickly a very small distance to the right. Click the green flag several times so that the cat repeatedly moves to the right a bit more.

Modify the program to move a different number of steps by changing the value in the move 10 steps block to something like -100 (which will move the sprite 100 pixels in the opposite direction that the cat is facing). Click the field that specifies the number of steps and replace 10 with -100:

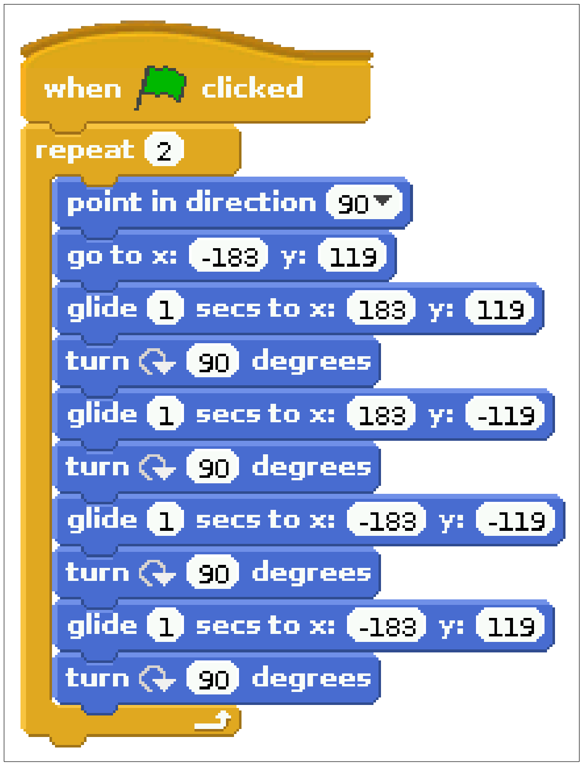
Clicking the green flag a few times moves the cat to the left quickly. This movement is too quick and quite joggy. In the motion blocks group, a **glide 5 secs to x,y** block allows motion to be more specifically defined. Let's replace the move steps block with this new block. To remove the move steps block, drag it away from the green flag block (you can just put it to the side if you anticipate using it again, or drag it back to the blocks palette to *trash* it). Tweak the values as you wish in the new motion block and watch the cat move smoothly to the specified coordinates:

You can actually click on the cat sprite to move it anywhere on the stage; then try running your program again.

An improvement?
Let's combine blocks to form a more complicated program. Create the following program and run it:

You'll notice that the program moves the cat around the perimeter of the stage, pointing in the direction of travel as it does so. How could the program be modified to repeat this some number of times (like 2)? There is a **repeat** block in the control blocks group that can be used to repeat an action some number of times.

Modify your program as follows:



Some of you will notice that the first two motion blocks (**point in direction 90** and **go to x,y**) can be moved out of and above the repeat block. Try it. You probably won't notice much difference, but these two blocks serve to initially orient and position the cat sprite. This really only needs to be done once at the beginning of the program.

At this point, let's cover some of the basic features of programming languages before continuing with the game.

Data types, constants, and variables

The kinds of values that can be expressed in a programming language are known as its **data types**. Scratch supports only two data types: text and numbers. The text data type provides the ability to represent non-numeric data such as names, addresses, English phrases, etc. The numeric data type allows the language to manipulate numbers, both positive and negative, whole numbers and fractions.

A **constant** is defined as a value of a particular type that does not change over time. Both numbers and text may be expressed as constants in Scratch. **Numeric constants** are composed of the digits 0 through 9 and, optionally, a negative sign (for negative numbers), and a decimal point (for floating point numbers). Numeric constants may not contain commas, dollar signs, or any other special symbols. The following are valid Scratch numeric constants: +15, -150, 15.01, 3200.

A **text constant** consists of a sequence of characters (also known as a string of characters – or just a **string**). The following are examples of valid string constants:

“She turned me into a newt.”

“I got better.”
“Very small rocks.”

Note that the quotes surrounding the strings are not actually necessary to define a text constant in Scratch.

A **variable** is defined to be a named object that can store a value of a particular type. Scratch supports two types of variables: text variables and numeric variables. Before a variable can be used, its name must be declared. Variables are declared in Scratch through the *variables* blocks group.

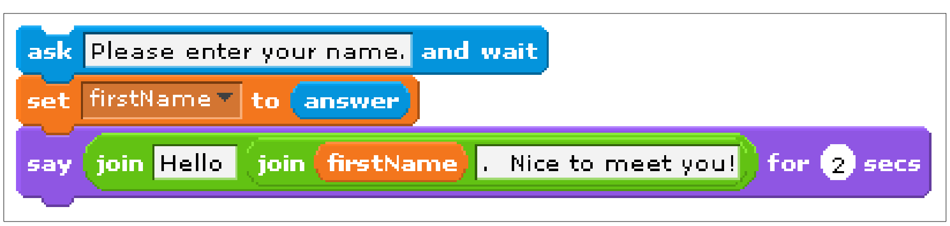
Input and output statements

In order for a computer program to perform any useful work, it must be able to communicate with the outside world. The process of communicating with the outside world is known as input/output (or I/O). Scratch includes various input and output statements, although they are not implemented in the same way as other *real* programming languages such as Python or Java.

For example, in Scratch, individual sprites can **say** ***something*** **for n secs** or **think** ***something*** **for n secs**, displaying voice or thought bubbles with text. These are located in the *looks* blocks group. Sprites can also switch costumes, and programs can play sounds, draw with the pen, and so on. These are all output statements. Input statements include sensing when sprites are touching (or near) other sprites, or at the edge of the stage. Scratch can also ask the user for input (either text or numeric), and store this input to a variable. Many input statements in Scratch are located in the *sensing* blocks group. Most imperative languages include mechanisms for performing other kinds of I/O such as detecting where the mouse is pointing and accessing the contents of a disk drive.

The flexibility and power that input statements give programming languages cannot be overstated. Without them the only way to get a program to change its output would be to modify the program code itself, which is something that a typical user cannot be expected to do.

General-purpose programming languages allow human programmers to construct programs that do amazing things. When attempting to understand what a program does, however, it is vitally important to always keep in mind that the computer does not comprehend the meaning of the character strings it manipulates or the significance of the calculations it performs. Take, for example, the following simple Scratch program:



This program simply displays strings of characters, stores user input, and echoes that input back to the screen along with some additional character strings. The computer has no clue what the text string “Please enter your name.” means. For all it cares, the string could have been “My hovercraft is full of eels.” or “qwerty uiop asdf ghjkl;” (or any other text string for that matter). Its only concern is to copy the characters of the text string onto the display screen.

Only in the minds of human beings do the sequence of characters "Please enter your name." take on meaning. If this seems odd, try to remember that comprehension does not even occur in the minds of all humans, only those who are capable of reading and understanding written English. A four year old, for example, would not know how to respond to this prompt because he or she would be unable to read it. This is so despite the fact that if you were to ask the child his or her name, he or she could immediately respond and perhaps even type it out on the keyboard for you.

Consider this Scratch program:

Here, input is numeric instead of text. The program prompts the user for two numbers, which it then computes the sum for and displays to the user. Note that two variables were declared in the *variables* blocks group: `num1` and `num2`. The first number is captured and stored in the variable `num1`. The second number is captured and stored in the variable `num2`. What do you think would happen if the user did not provide numeric input and, for example, inputted "Bob" for the first number? In the *real world*, programmers must create robust programs that examine user input in order to verify that it is of the proper type before processing that input. If the input is found to be in error, the program must take appropriate corrective action, such as rejecting the invalid input and requesting the user try again.

Primary control constructs

In order to create programs capable of solving more complex tasks we need to examine how the basic instructions we have studied can be organized into higher-level constructs. The vast majority of imperative programming languages support three types of control constructs which are used to group individual statements together and specify the conditions under which they will be executed. These control constructs are: sequence, selection, and repetition.

Sequence requires that the individual statements of a program be executed one after another, in the order that they appear in the program. Sequence is defined implicitly by the physical order of the statements. It does not require an explicit program structure. This is related to our previous discussion on **control flow**.

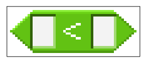
Selection constructs contain one or more blocks of statements and specify the conditions under which the blocks should be executed. Basically, selection allows a human programmer to include within a program one or more blocks of *optional* code along with some tests that the program can use to determine which one of the blocks to perform. Selection allows imperative programs to choose which particular set of actions to perform, based on the conditions that exist at the time the construct is encountered during program execution.

Selection

Selection statements give imperative languages the ability to make choices based on the results of certain condition tests. These condition tests take the form of **Boolean expressions**, which are expressions that evaluate to either *true* or *false*. There are various types of Boolean expressions, but the types supported in Scratch are based on relational operators. **Relational operators** compare two expressions of like type to determine whether their values satisfy some criterion. The general form of all Boolean expressions supported in Scratch is:

expression relational_operator expression

For example:



Scratch includes three relational operators for comparing numeric expressions:

- < meaning *less than*
- = meaning *equal to*
- > meaning *greater than*

For example, when *x* is 15 and *y* is 25, the expression `x > y` evaluates to false, since 15 is not greater than 25. Here are some additional examples of Boolean expressions that use these relational operators. These examples assume that the variable *x* holds 15 and *y* holds 25:

true `15 > 25 - 20`

true `15 + 10 = 25`

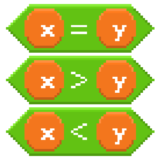
false `15 = 15 + 1`

Notice that the last expression always evaluates to *false* regardless of the value of *x*. This is because there is no possible value for *x* that will be equal to that value plus one. Another point illustrated by these examples is that relational operators have a lower precedence than mathematical operators. During expression evaluation, all multiplication, division, addition, and subtraction operations are performed before any relational operations.

The relational operators also work for text expressions as follows:

- < meaning *precedes*
- = meaning *equal to*
- > meaning *follows*

Note that Scratch does not differentiate between uppercase and lowercase letters. That is, `A` is equal to `a`. Here are some examples, assuming that the variable *x* holds `Bob` and *y* holds `bobcat`:

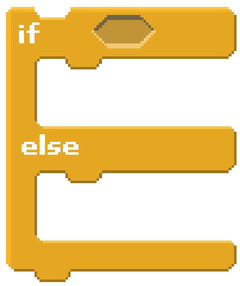


false `Bob = bobcat`
false `Bob > bobcat`
true `Bob < bobcat`

Since `Bob` precedes `bobcat` in alphabetical order, `Bob < bobcat` is *true*.

Selection statements use the results of Boolean expressions to choose which sequence of actions to perform next. Scratch supports two different selection statements: ***if-else*** and ***if***. An *if-else* statement allows a program to make a two-way choice based on the result of a Boolean expression.

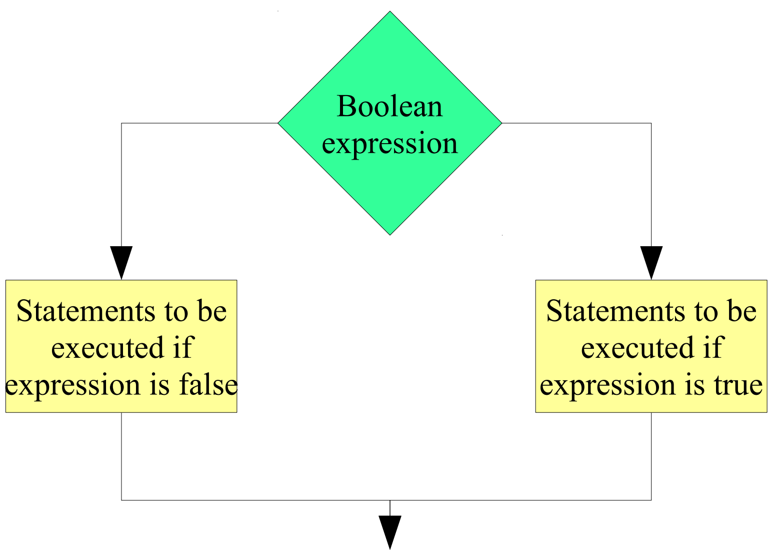
The general form of an *if-else* statements is shown below:



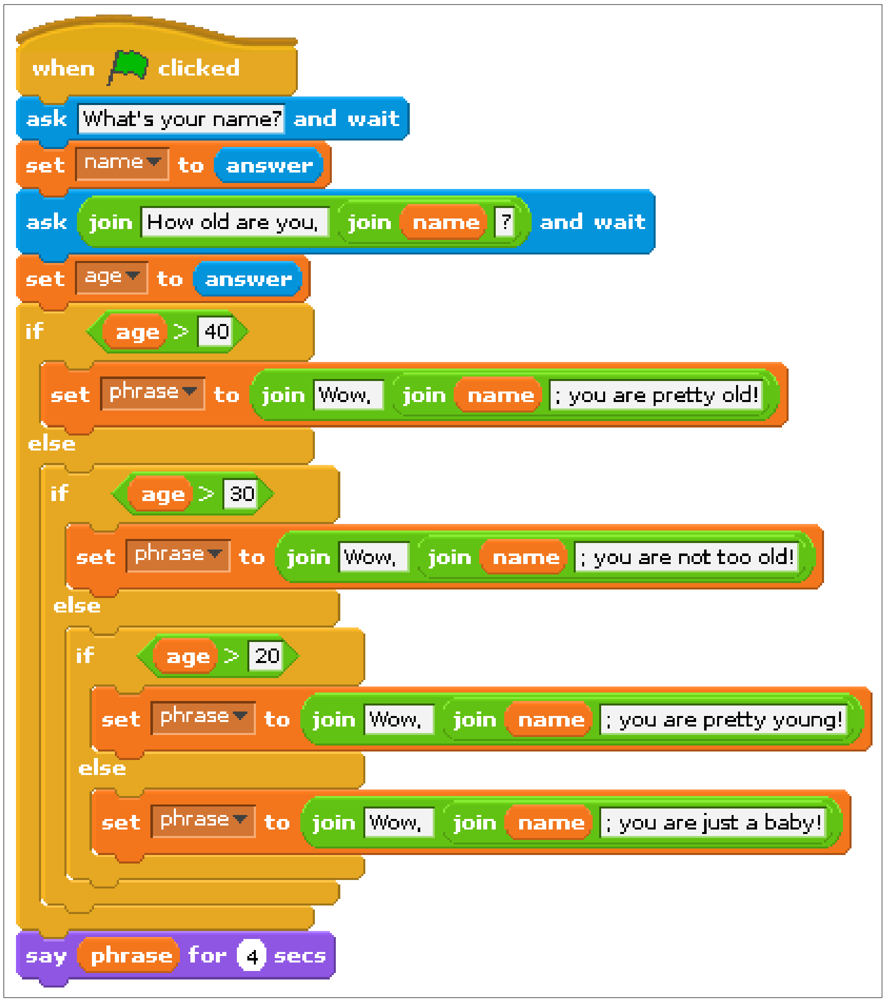
← statements to be executed if the expression is *true*

← statements to be executed if the expression is *false*

If-else statements specify a Boolean expression and two separate blocks of code: one that is to be executed if the expression is true, the other to be executed if the expression is false. Here's a flowchart for an *if-else* statement:



And here's an example of a program that implements an *if-else* statement (several, actually):



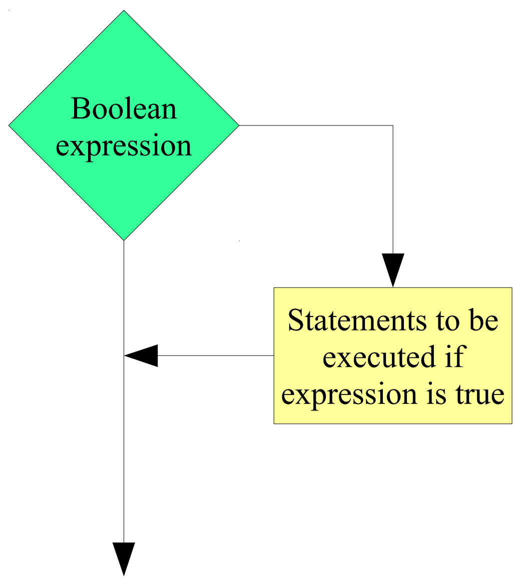
This program prompts the user to enter a name and age, and responds appropriately. It compares the user's age to several constants (40, 30, and 20), and sets the variable phrase depending on the user's age. If the user's age is more than 40, then the program responds that the user is pretty old; otherwise, the program then checks to see if the user's age is more than 30. If so, the program responds that the user is not too old; otherwise, it then checks to see if the user's age is more than 20. If so, it responds that the user is pretty young; otherwise (any age less than or equal to 20), it responds that the user is just a baby.

Note that we can nest an *if-else* statement inside of another *if-else* statement to provide more than two alternatives or paths. Here's the program above represented in pseudocode:

```
name ← prompt for name
age ← prompt for age
if age > 40
then
     phrase ← "Wow, " + name + "; you are pretty old!"
else
     if age > 30
     then
```

```
            phrase ← "Wow, " + name + "; you are not too old!"
        else
            if age > 20
            then
                phrase ← "Wow, " + name + "; you are pretty young!"
            else
                phrase ← "Wow, " + name + "; you are just a baby!"
            end
        end
    end
    display phrase
```

The *if* statement is similar to the *if-else* statement except that it does not include an *else* block. That is, it only specifies what to do if the Boolean expression is true. Here's a flowchart for an *if* statement:

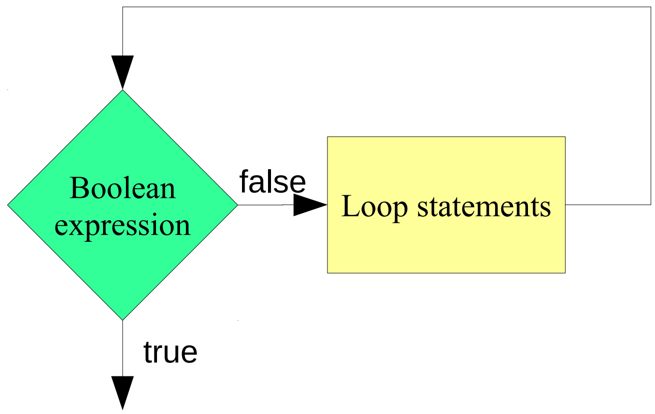


If statements are generally used by programmers to allow their programs to detect and handle conditions that require *special* or *additional* processing. This is in contrast to *if-else* statements, which can be viewed as selecting between two (or more) *equal* choices.

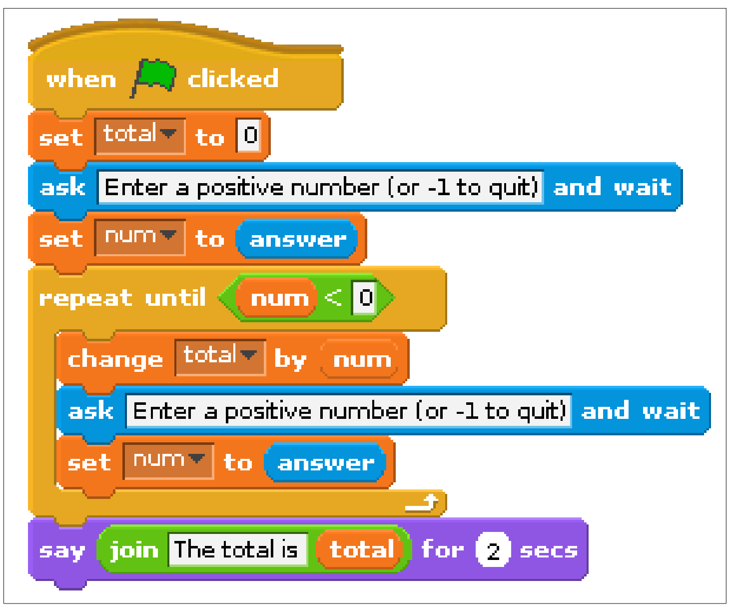
Repetition
Repetition is the name given to the class of control constructs that allow computer programs to repeat a task over and over. This is useful, particularly when considering the idea of solving problems by decomposing them into repeatable steps. Repetition constructs contain exactly one block of statements together with a mechanism for repeating the statements within the block some number of times. There are two major types of repetition: iteration and recursion. **Iteration**, which is usually implemented directly in a programming language as an explicit program structure, often involves repeating a block of statements either (1) while some condition is true or (2) some fixed number of times. **Recursion** involves a subprogram (e.g., a function) that makes reference to itself. As with sequence, recursion does not normally have an explicit program construct associated with it.

Scratch supports iteration in two main forms: the *repeat* loop and the *forever* loop. The *repeat* loop has two forms: *repeat-until* and *repeat-n* (where *n* is some fixed or known number of times). The *repeat-until* loop is condition-based; that is, it executes the statements of the loop until a condition becomes true. The *repeat-n* loop is count-based; that is, it executes the statements of the loop *n* times.

Here's a flowchart of the *repeat-until* loop:



The Boolean expression is first evaluated. If it evaluates to false, the loop statements are executed; otherwise, the loop halts. Here is an example:

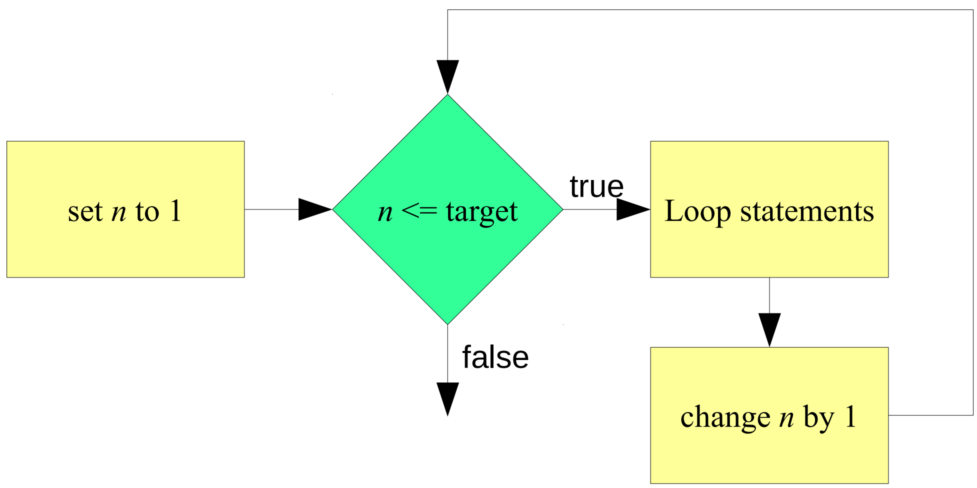


This program asks the user to enter a positive number or -1. If a positive number is entered, it is added to a running total. If -1 is entered, the program displays the total and halts. The *repeat-until* loop is used here to repeat the process of asking the user for input until the value entered is less than 0. It is interesting to note that although the program instructs users to enter -1 to quit, the condition that controls the loop is actually `num < 0` (which will be true for any negative number). Thus, the loop will actually terminate whenever the user enters any number less than zero (e.g., -5).

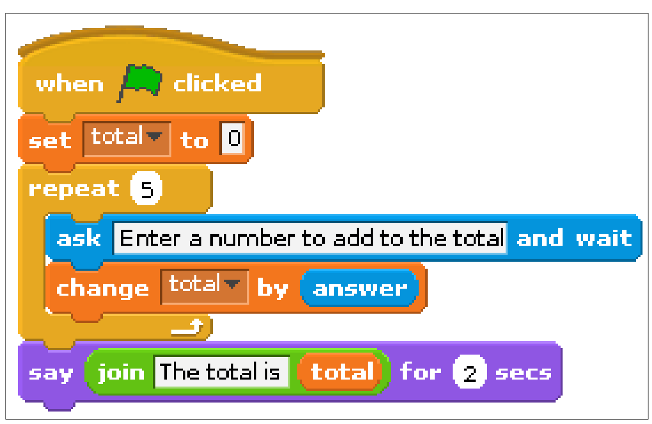
Here's the program above represented in pseudocode:

```
    total ← 0
    repeat
        num ← prompt for a positive number (or -1 to quit)
        if num > 0
        then
            total ← total + num
        end
    until num < 0
    display total
```

The *repeat-n* loop executes the loop statements a fixed (or known) number of times. Here's a flowchart of the *repeat-n* loop:



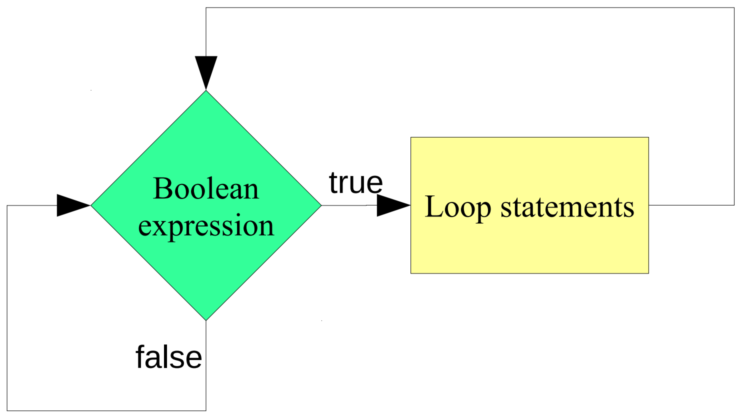
Although the programmer does not have access to a variable that counts the specified number of times (shown as *n* in the figure above), the process works in this manner. A counter is initially set to 1. A Boolean expression is then evaluated that checks to see if that counter is less than or equal to the target value (e.g., 10). If so, the loop statements execute. Once the loop statements have completed, the counter is incremented, and the expression is reevaluated. Here is an example:



This program asks the user to enter five numbers. Each time, the number is added to a running total. After all five numbers have been entered, the total is displayed.

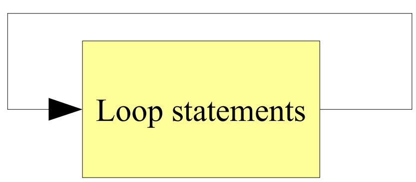
The forever loop also has two forms: *forever* and *forever-if*. The *forever* loop executes the statements of the loop forever. Well, it's not technically forever, since we can click the stop button to halt all scripts at any time. The *forever-if* loop is condition-based (like the *repeat-until* loop), and executes the statements of the loop if a condition is true. Note that the *forever-if* loop also runs forever (until the stop button is clicked). the difference is that the loop statements are only executed if the condition is true.

Here is a flowchart of the *forever-if* loop:



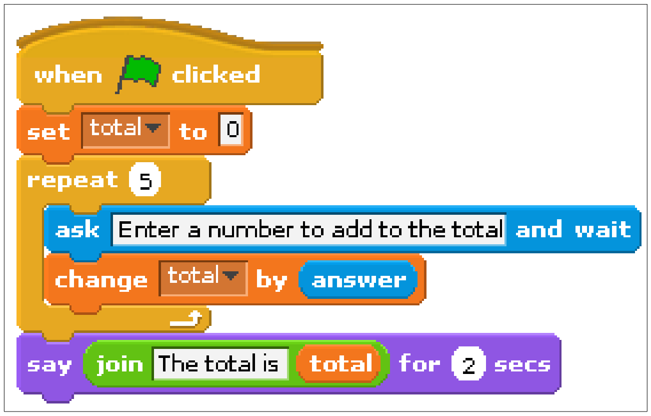
This loop construct is often used to perform real time checking of sprites and execute statements if, for example, the sprite is at a certain position on the stage. Another example is to constantly check the value of a variable that is changed by some other sprite. In this way, a sprite can monitor a variable, and when changed to an appropriate value, perform some action.

Lastly, here is a flowchart of the *forever* loop:

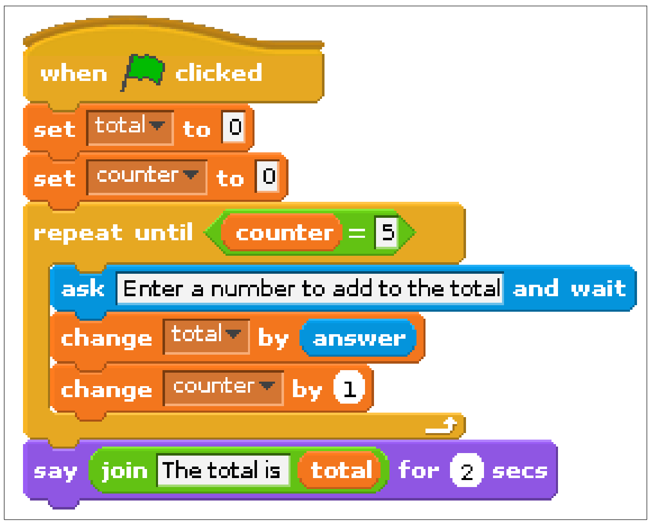


Pretty straightforward...

Note that any program written using a *repeat-n* loop can be rewritten as a *repeat-until* loop. Take, for example the *repeat-n* loop shown earlier:



Here it is, rewritten using a *repeat-until* loop:



The only difference is that, in the *repeat-until* loop, the programmer must keep track of (and modify) the counter each time the loop statements execute. In the *repeat-n* loop, Scratch automatically takes care of this.

Is the opposite true? That is, can every program that uses a *repeat-until* loop be rewritten using a *repeat-n* loop? The answer is no. A *repeat-n* loop simply loops a fixed or known number of times. A *repeat-until* loop repeats until some condition is true. That condition could be, for example, when the user inputs -1 to terminate. The idea of expressing a condition that represents a sentinel value in a manner that requires knowing how many times the loop statements will execute is nonsensical. There is no way to tell how many times the loop statements will execute until the user inputs -1. It could be the very first time (or the 10,000th). Because *repeat-n* loops can always be replaced with *repeat-until* loops, but not all *repeat-until* loops can be replaced with *repeat-n* loops, we say that the *repeat-until* loop is more general than the *repeat-n* loop.

Subprograms

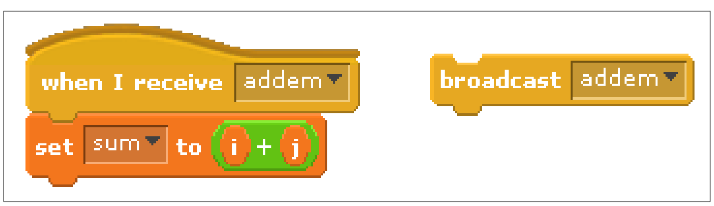
A **subprogram** is a program within a program. Recall an earlier lesson on representing algorithms as to-do lists. One algorithm represented the steps necessary to *get to class*. One of those steps was *eat breakfast*. We noted how we could zoom in to that step and identify the sub-steps necessary to complete the *eat breakfast* step. Control flow shifted from the main to-do list to the *eat breakfast* to-do list when the *eat breakfast* step was encountered, and then returned to the main to-do list at the point where it left earlier. We can consider the *eat breakfast* to-do list as a subprogram.

Very few *real* programs are written as one long piece of code. Instead, traditional imperative programs generally consist of large numbers of relatively simple subprograms that work together to accomplish some complex task. While it is theoretically possible to write large programs without the use of subprograms, as a practical matter any significant program must be decomposed into manageable pieces if humans are to write and maintain it.

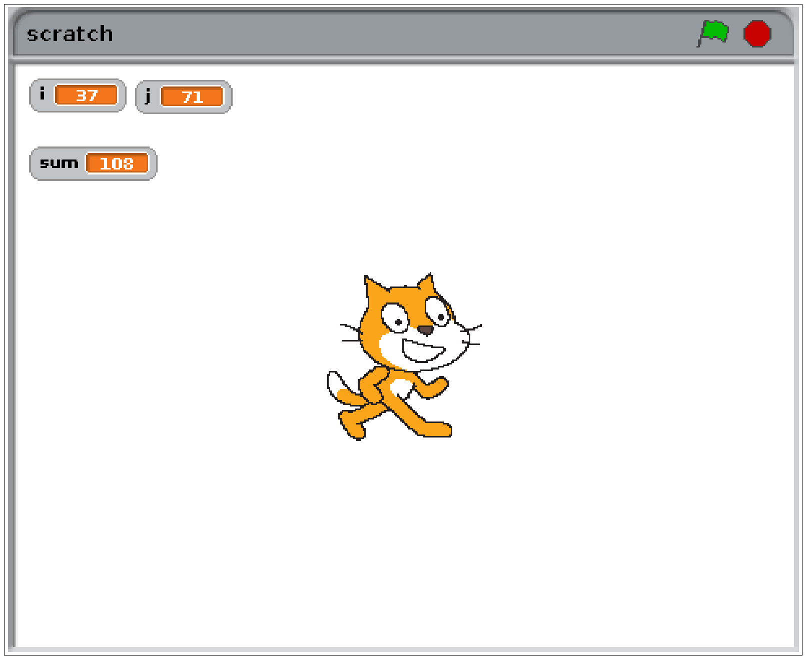
When a subprogram is invoked, or called, from within a program, the *calling* program pauses temporarily so that the *called* subprogram can carry out its actions. Eventually, the called subprogram will complete its task and control will once again return to the *caller*. When this occurs, the calling program *wakes up* and resumes its execution from the point it was at when the call took place.

Subprograms can call other subprograms (including copies of themselves as we will see later). These subprograms can, in turn, call other subprograms. This chain of subprogram invocations can extend to an arbitrary depth as long as the *bottom* of the chain is eventually reached. It is necessary that infinite calling sequences be avoided, since each subprogram in the chain of subprogram invocations must eventually complete its task and return control to the program that called it.

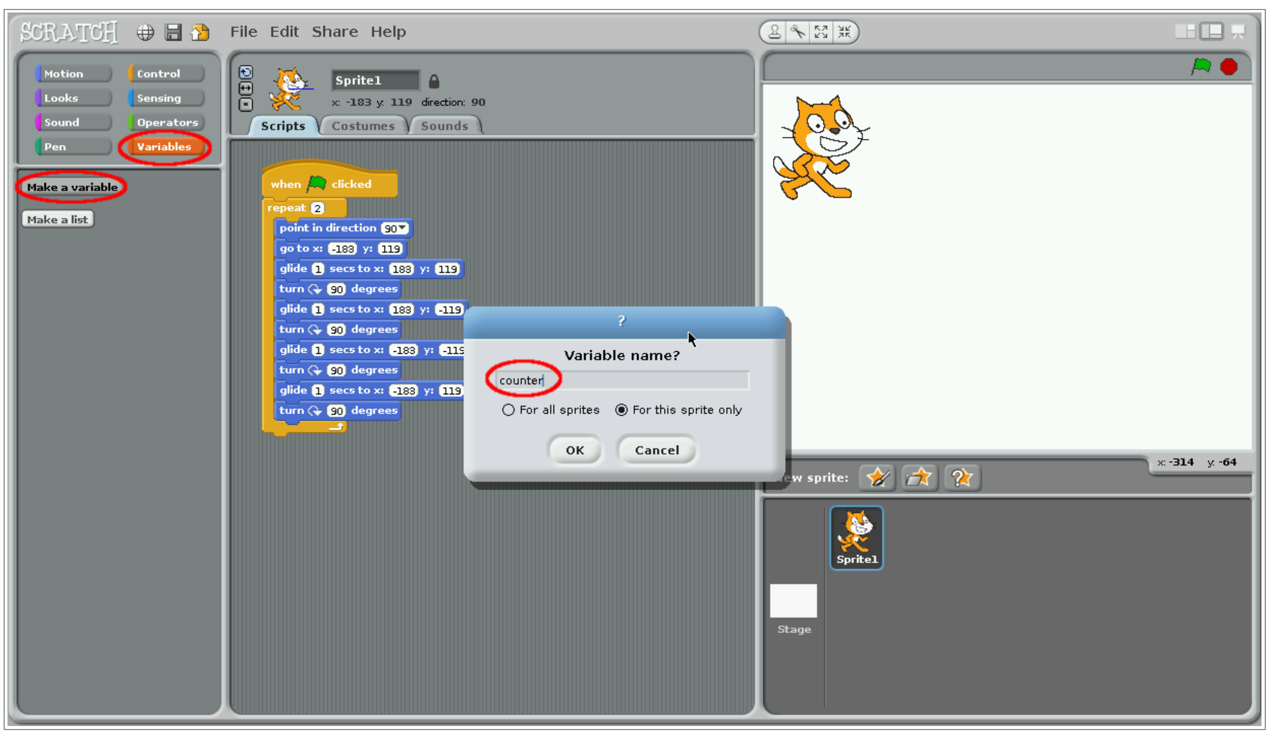
In Scratch, we define subprograms as broadcasts. That is, a sprite can broadcast a message that can be received by another sprite (or even the same sprite). We can think of this as calling a subprogram. When receiving a broadcast, we can specify the script (subprogram) associated with it. Here is a simple example of a subprogram that computes the sum of two numbers stored in the variables `i` and `j`:



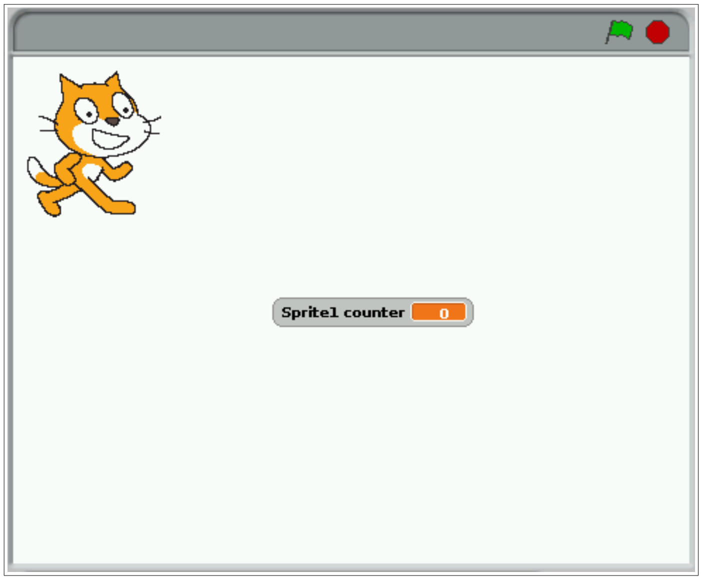
The left side shows the subprogram defined by receiving the broadcast *`addem`*. The right side shows the broadcast (or the subprogram *call*). Assuming that the variables *`i`* and *`j`* have been declared and given numeric values, then the *addem* subprogram would add the two variables together and store the result to the variable *`sum`*. Here is an example when *`i`* is 37 and *`j`* is 71 (note that the *addem* subprogram has been *called* by being broadcasted):



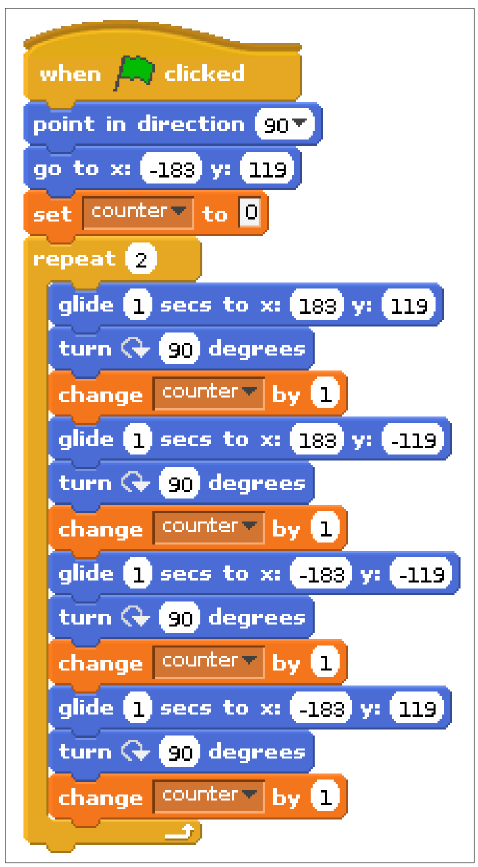
Back to the game
It would be neat to count the number of 90 degree turns that the cat makes during its journey. To do this, let's define a variable (called `counter`) that will be updated each time the cat turns. Defining variables can be done by selecting **make a variable** in the variables blocks group.



This adds the variable on the stage. Drag it to the center of the stage so that it doesn't get in the cat's way as it moves around:



To use the counter in your program, it will first need to be initialized (with the value 0) and then incremented each time the cat makes a 90 degree turn. We can modify our program as follows:



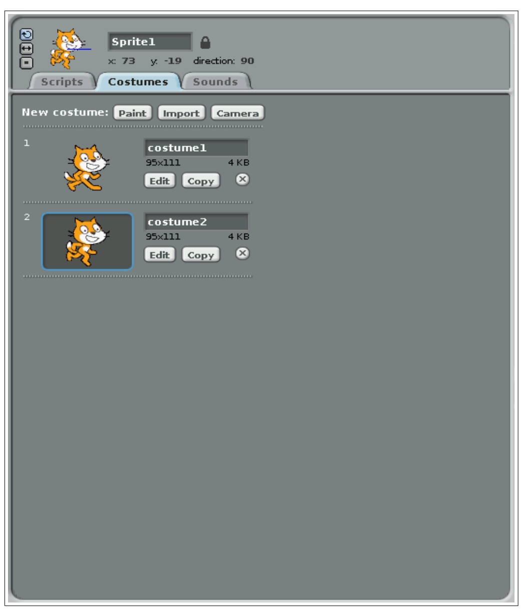
A first game?
Modify your program (you can save the current version first if you wish) so that it looks like this:

Notice that we now have two block groups in the scripts area. One that is executed when the green flag is clicked; and another that is executed when the cat sprite (Sprite1) is clicked. What does the program do?

Did you know?

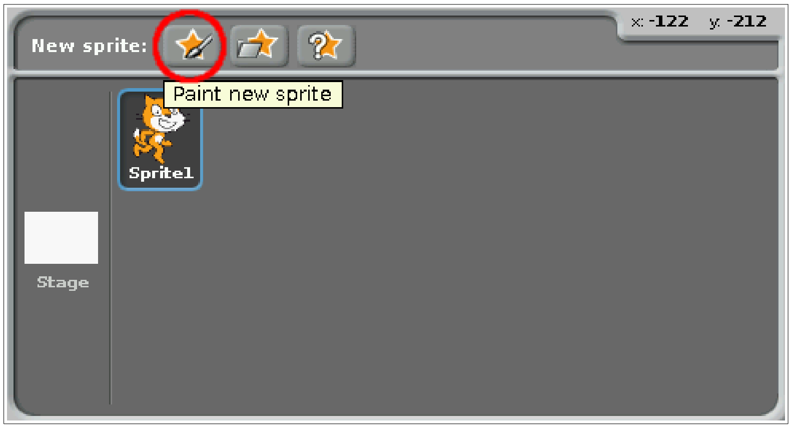
You can change the name of the cat sprite at the top of the scripts area. Make sure that the cat is selected in the **sprite list** below the stage.

Playing with sprites
At the top of the scripts area, there are several other tabs that provide sprite costume and sound tools. Click on the **costumes** tab. You will notice that the cat actually has two sprites, one named costume1 and another named costume2:



By alternating them, we can make it look as if the cat is walking or running. Modify your program as follows:

You can also create your own sprites via the paint new sprite button in the sprite list:

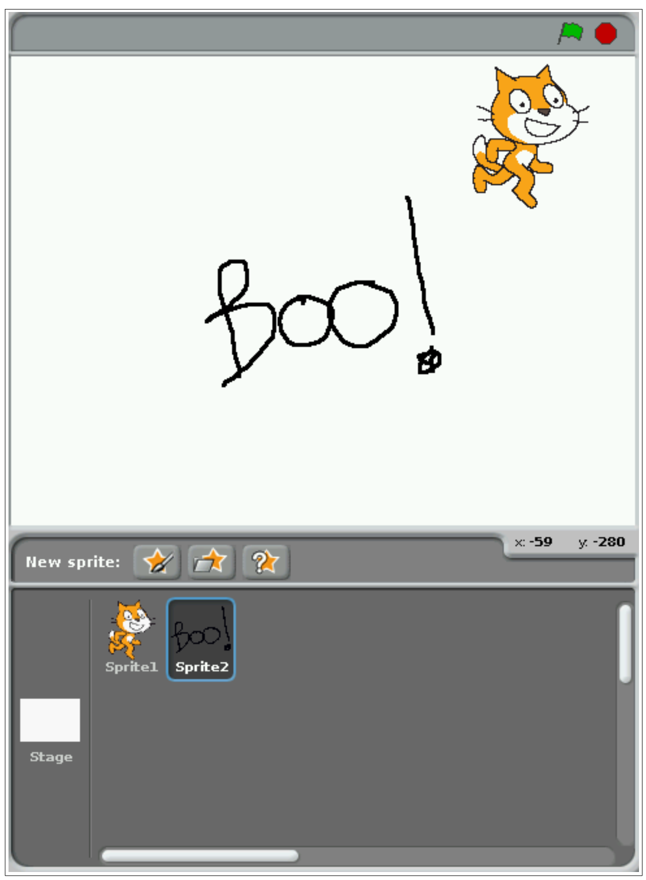


This displays a **paint editor** that can be used to create a new sprite of your design. The other buttons to the right allow saved sprites to be loaded (Scratch comes with many different sprites) and a random sprite to be added to the sprite list.

Try creating one now:

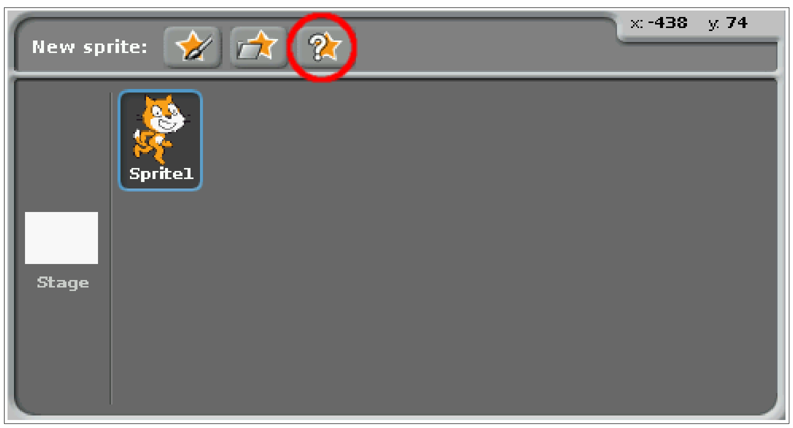
Click OK when done. This will drop your new sprite in the sprite list and on the stage:

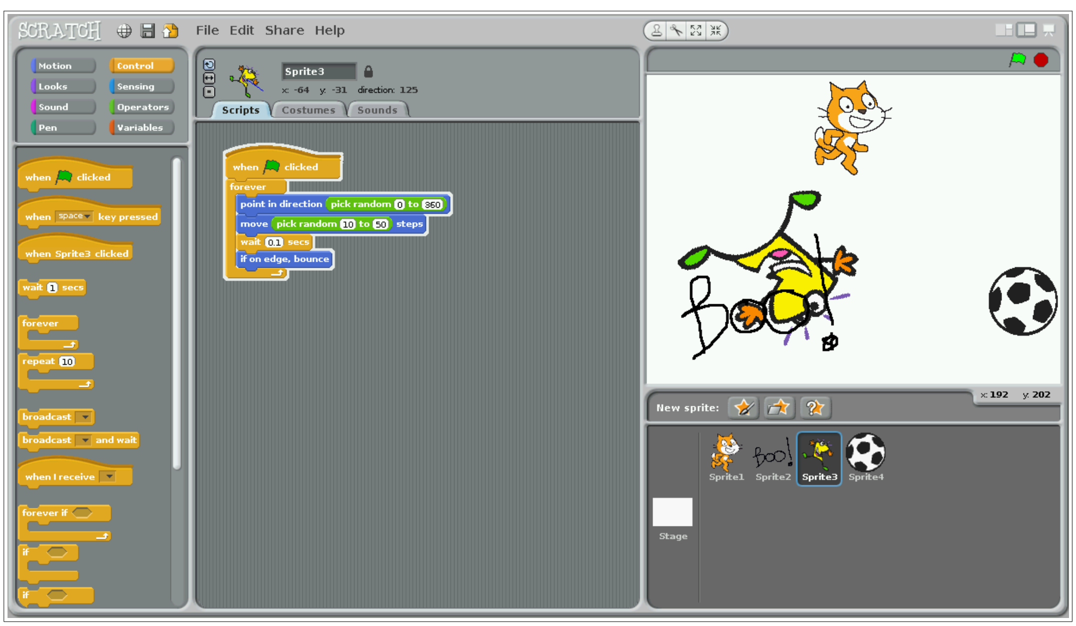
As mentioned earlier, you can also load a saved sprite if you click on the middle button in the row at the top of the sprite list:



Feel free to select any sprite from any category that you wish:

Again, you can have a random sprite brought to the stage too by clicking the right-most button:





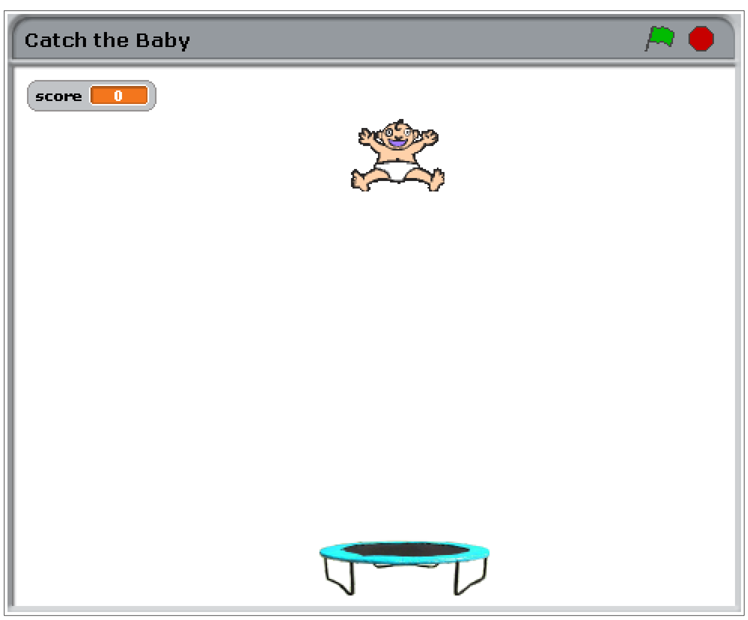
You can click on any sprite in the sprite list, and its scripts load in the scripts area. This allows you to have a separate program for each sprite in the sprite list. Think about what this means. You can separately control each sprite while they all run their programs simultaneously!

Try clicking on one of the sprites in the sprites area and create the following program for it:

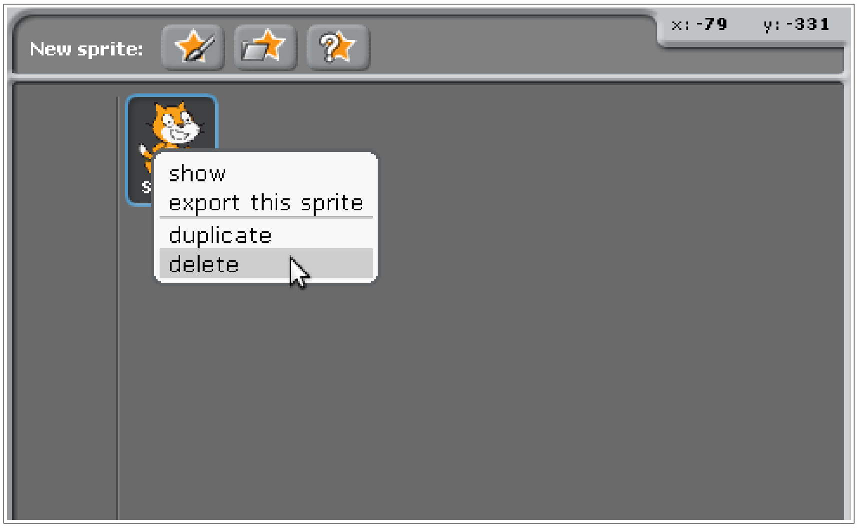
What does this program do? What does the **if on edge bounce** block do?

Catch the Baby!

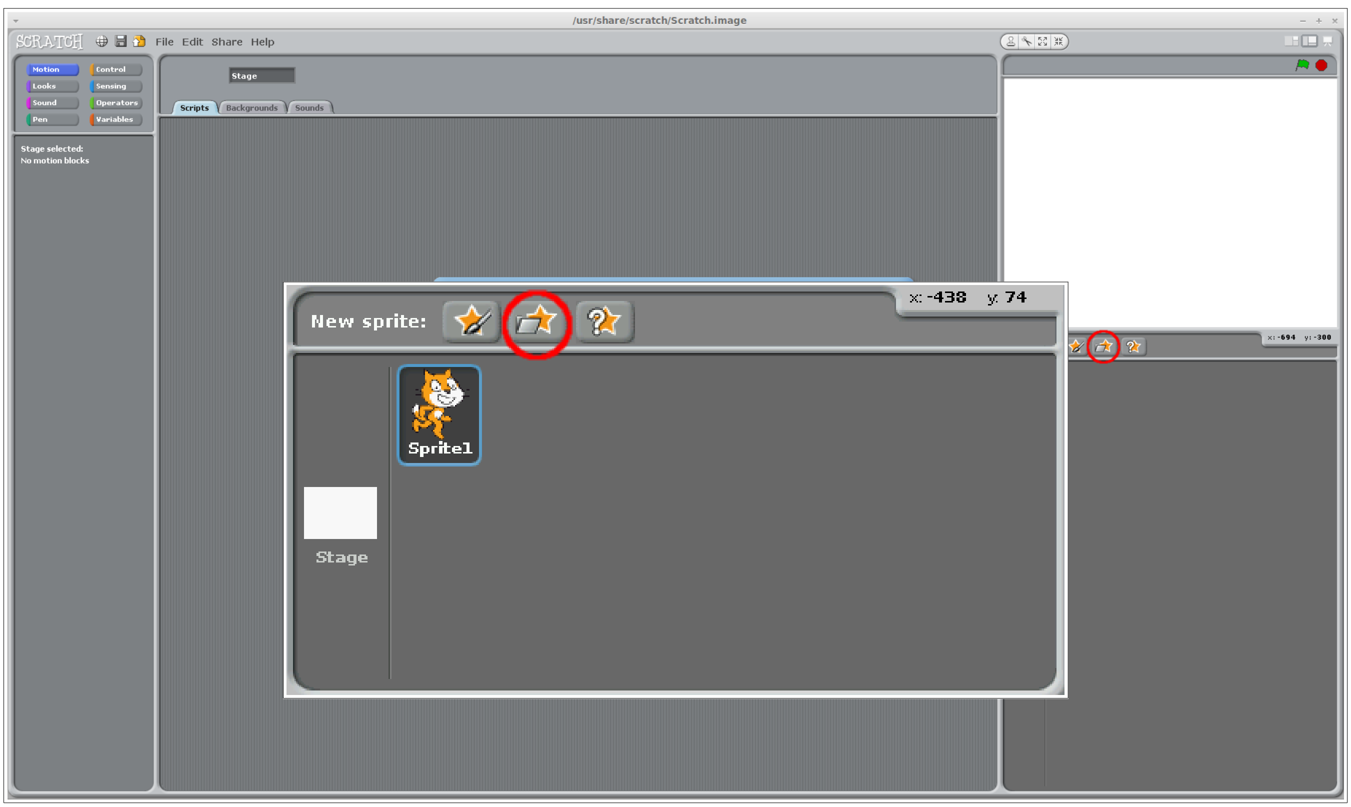
The objective of the game *Catch the Baby!* is, well, to use a trampoline to catch a falling baby. Each time the baby is successfully caught by the trampoline, the player's score increases. The baby is randomly placed somewhere at the top of the screen, and then quickly descends to the bottom. The player can control the trampoline with the left and right arrow keys to position it below the falling baby. Technically, the baby can barely touch the trampoline to be saved. Here is a screenshot of the stage at the start of play:



The game
Start a new Scratch project. Remove the default cat sprite by right-clicking on the cat and selecting **delete**:

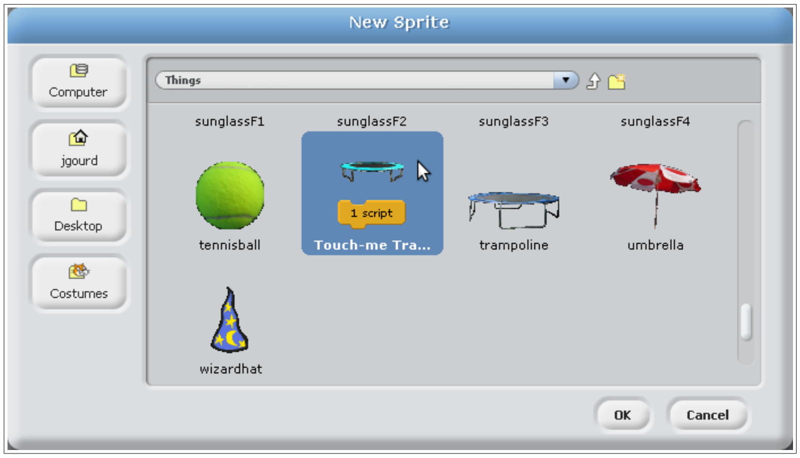


This is a good time to add the two sprites that you will need: the baby and the trampoline. To add the baby, click on the **choose new sprite from file icon**, then browse through the **People** folder and select the baby:



Rename the baby to something more appropriate, like **Baby**.

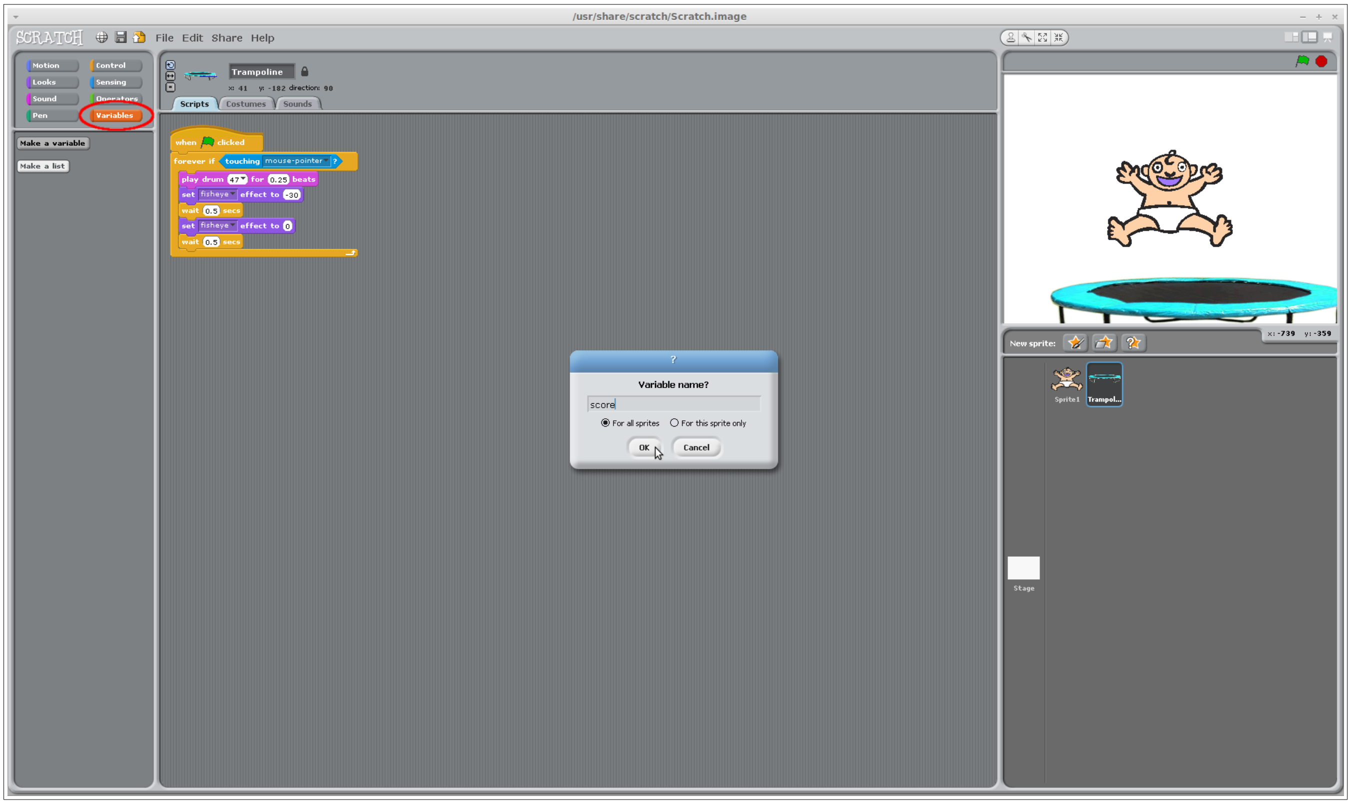
To add the trampoline, go through the same process, but browse through the **Things** folder and select the light blue trampoline:



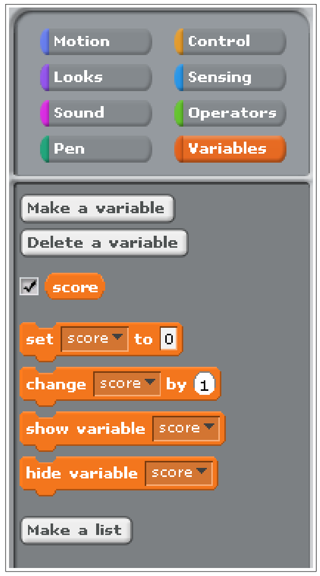
Note that the trampoline has a script associated with it. That is, it comes with a preloaded program that plays a short drum sound and changes the sprite if it is collide with. We will make use of some of this later. For now, resize the baby and trampoline sprites so that they are smaller (as in the image at the beginning of this activity).

Variables

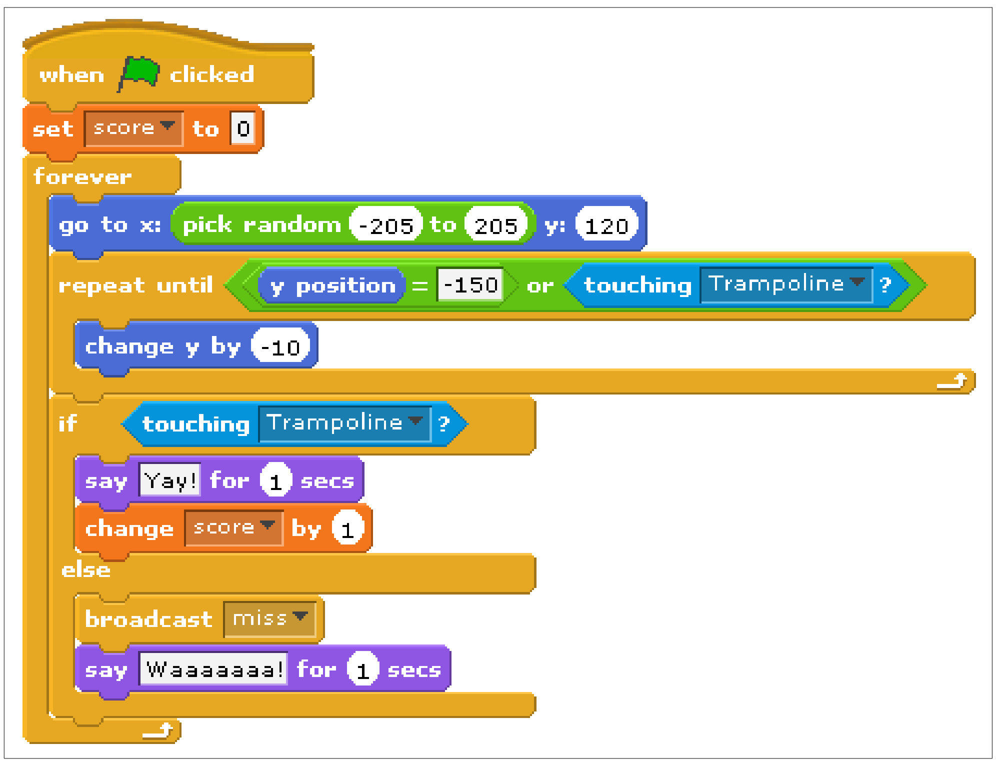
We will need one variable in our game: `score`. Add it now through the **variables** blocks group:



This adds the variable and allows us to modify it as we wish:



Make sure the baby sprite is selected in the sprites list and implement the following script for it:



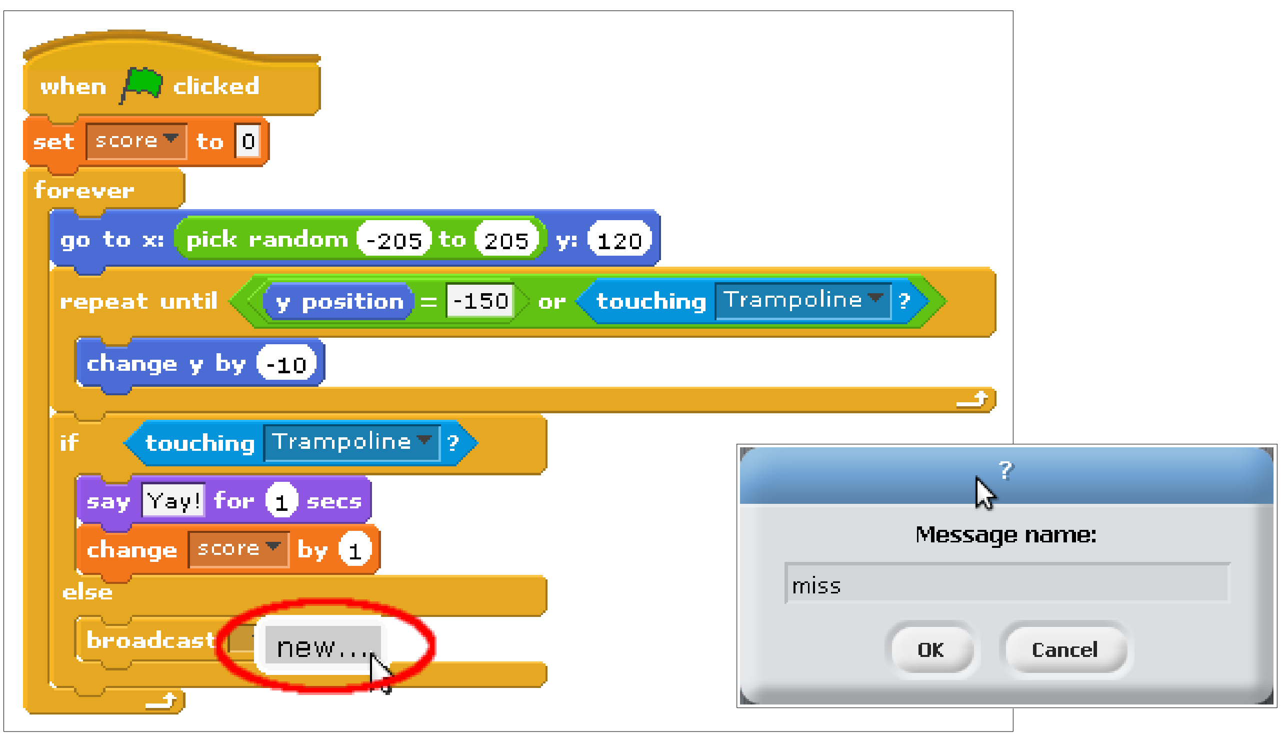
Let's explain what's going on here. This script runs when the green flag is clicked (i.e., when the game is started). The first statement sets the score to 0. Then, a group of statements is repeated forever (well, at least until the stop sign is clicked by the user).

The grouped statements in the **forever** construct first instruct the baby to move to a random position at the top of the screen (where y=120). By experimenting, it was calculated that the leftmost position for the baby should be at x=-205 and the rightmost at x=205.

At this point, a **repeat-until** construct is entered. Note that this is, in effect, repetition within repetition! The repeat-until condition instructs the baby to move down 10 pixels (**change y by -10**) until its is at position y=-150 or until it is touching the trampoline. In effect, it is instructing the baby to move down until it either collides with the trampoline or it reaches the bottom of the stage. Once either of these conditions occurs, the repeat-until construct is exited.

Note that we are using a literal value (y=-150) to detect when the baby reaches the bottom of the stage. This works fine so long as we initially place the baby at y=120 and repeatedly move the baby down 10 pixels at a time. That is, we can guarantee that the baby will eventually reach y=-150. But what would happen if the baby were initially placed at y=121 (or any value that isn't a multiple of 10)? Or if we decremented by 6 instead of 10 (i.e., **change y by -6**)? A better way may be to, instead, detect when the baby reaches a vertical position that is less than or equal to -150; that is, y<=-150.

The next statement is a selection statement in the form of an **if-else** construct. The script is now going to potentially do two different things, depending on whether or not the baby has collided with the trampoline. If it has (i.e., **touching Trampoline**), then it will say, “Yay!” for a bit, and the score will be incremented (since the baby was successfully caught by the trampoline). Otherwise (**else**), it will cry. Note the **broadcast miss** statement. This is a useful way to send another sprite a message. Any sprite can broadcast a message that other sprites can receive. In this case, the goal is to notify the trampoline that it has missed the baby. Adding a broadcast message is as simple as adding the block and creating a new message using the block's arrow:



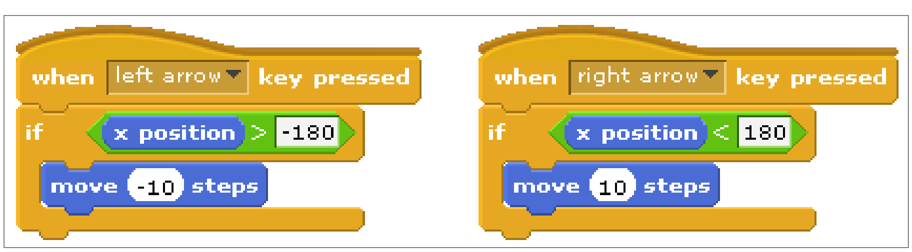
That's it for the baby! Now click on the trampoline in the sprites list and change the existing script to the following new script:

This change instructs the trampoline to move to the bottom-left corner of the stage when the green flag is clicked. It then repeats a set of statements forever, but only when it has collided with the baby (i.e., if **touching Baby**). If so, it first, it alters the trampoline sprite a little bit applying a *fisheye* filter (which makes the sprite appear to bend a little). A drum sound is then played, which is followed by a small delay, an undo of the *fisheye* filter, and another small delay.

Add another script to the trampoline as follows:

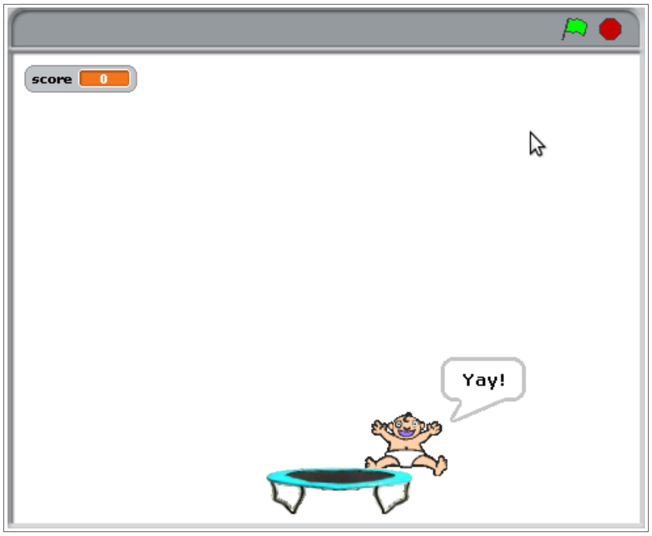
This script instructs the trampoline to say something appropriate when it receives the broadcasted message **miss**. Recall that this message was defined in the baby's script earlier. So the baby can broadcast the message which is then received by the trampoline. That is, if the baby reaches the bottom of the stage (i.e., the trampoline missed the baby), it broadcasts this message that the trampoline receives. This alerts the trampoline that it has missed the baby, and it utters an appropriate message.

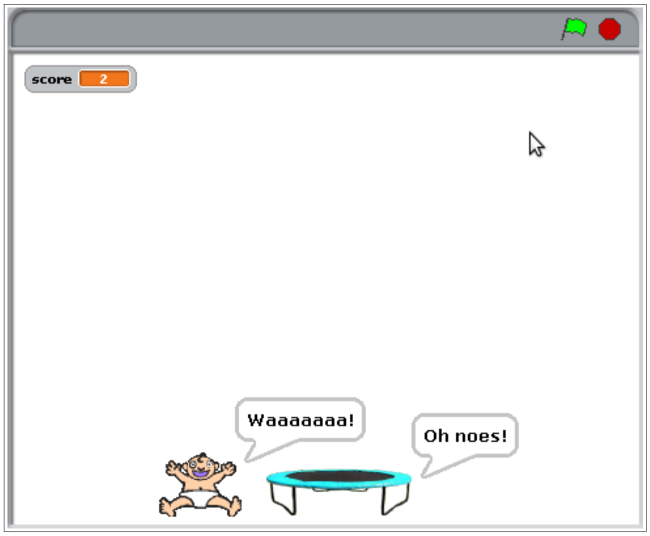
The last thing to add is the ability to move the trampoline with the left and right arrow keys. We can do this by adding the following two scripts:



These scripts instruct the trampoline to move 10 steps (to the left or right) when the arrow keys are pressed. In order to prevent the trampoline from going beyond the left or right border of the stage, however, additional **if** statements are added. These selection constructs prevent the trampoline from moving any further toward a border if it is already at one. For example, take a look at the left-arrow script. The left-most position for the trampoline is at x=-180. This was determined by testing (i.e., moving the trampoline with the mouse and capturing the x coordinate). The script checks to see if the trampoline's x-position is to the right of the established left-most position x=-180 (i.e., its **x-position > -180**). If so, it allows the sprite to move to the left; otherwise, it simply ignores the keypress.

At this point, you should be able to play the game by clicking on the green flag icon.





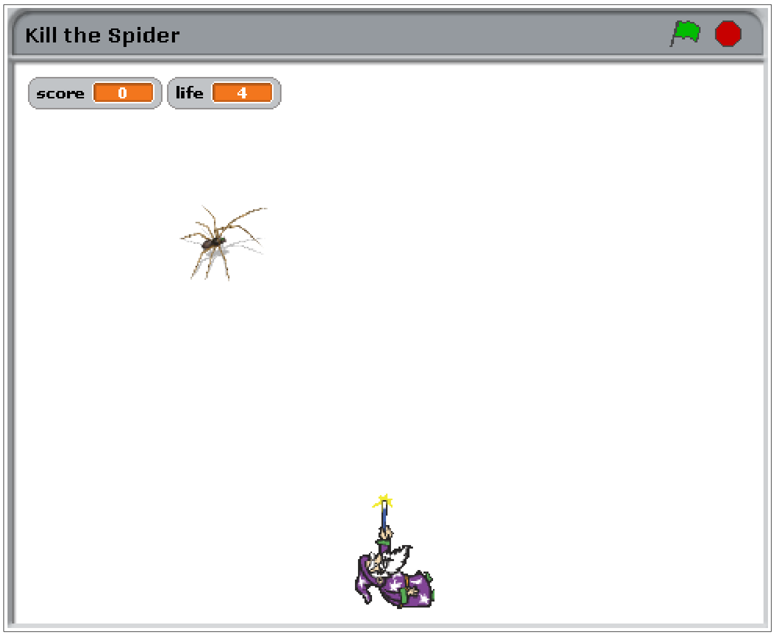
Click on the red stop sign icon to end the game.

Improvements
Although the game ends here, improvements can be made. For example, the baby could bounce in a random direction once it collides with the trampoline. Maybe it can defy the laws of gravity and move from side-to-side as it falls down. Experiment a bit.

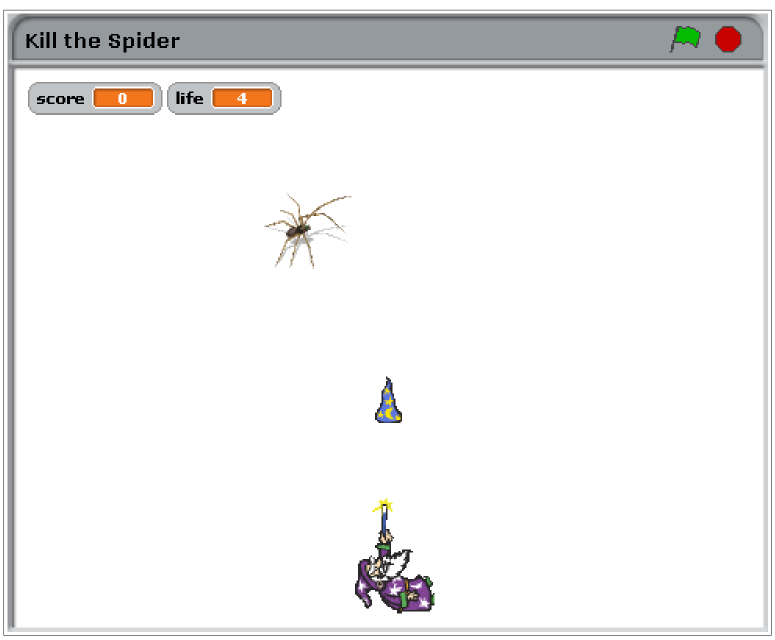
Homework: Kill the Spider!
In this activity, you will design a game based on *Catch the Baby!* Of course, it will be a bit different. **You are to submit your Scratch v1.4 (not v2.0!) file (with a .sb extension) through the upload facility on the web site.**

This game has two characters: a wizard and a spider. The wizard stands at the bottom of the stage and can move horizontally (just like the trampoline). The spider is placed to the left of the stage. At the beginning of the game, the wizard has five lives and a score of 0. Like the baby, the spider moves around the stage; however, it only does so horizontally. It is initially placed to the left of the stage at some random vertical position above the wizard. It then moves to the right until it reaches the right side of the stage.

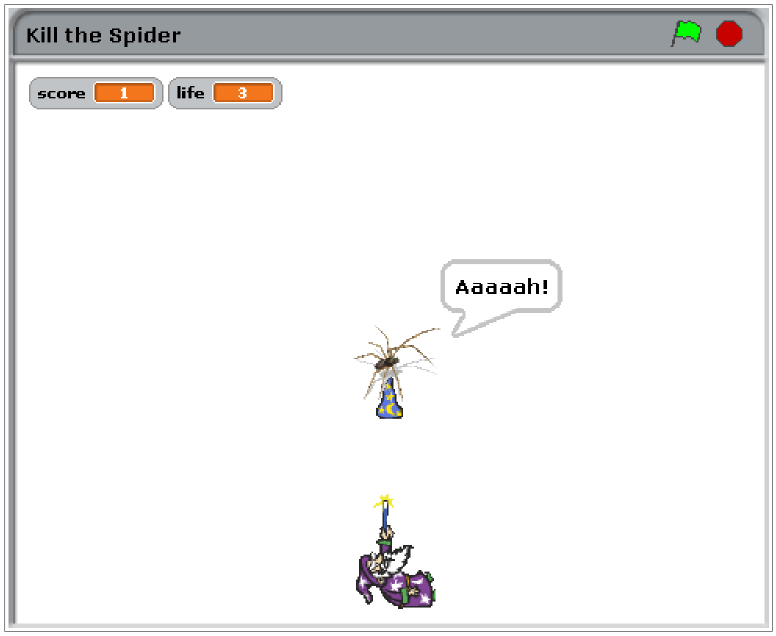
Spiders are scary and therefore should not be allowed to live. So the wizard can, of course, kill the spiders by shooting a wizard hat out of his wand. The player can make a hat shoot out of the wizard's wand by pressing the space bar. The hat starts at the wizard's wand and moves upward until it either collides with the spider or reaches the top of the stage. If the hat collides with the spider, the player's score increases by 1, and the spider reappears to the left of the stage at another random vertical position above the wizard for another round. If the spider is able to reach the right side of the stage, the wizard loses a life (since the spider was left to live and that is worthy of losing a life). The game ends when the wizard uses up all of his lives. Here's what the stage looks like during the game:



Here's what it looks like when the wizard shoots a hat:



And here's what it looks like when the wizard kills a spider:



Code your game in Scratch according to the description above. Feel free to add extra features or embellishments (although this is not a requirement) for **up to five bonus points**. At minimum, your game should feature a wizard that can shoot a hat from his wand in order to kill spiders. The wizard should move via the left and right arrow keys, and should shoot a hat from his wand via the space bar. If the hat collides with a spider, the spider should say something appropriate, another spider should reappear to the left of the stage, and the game should continue. Each time the wizard kills a spider, the score should increase by one. Each time a spider reaches the right of the stage, the wizard should lose one life. Start your game with five lives.

A note about the spider sprites: You can use your own spider image (e.g., a JPG or PNG). You can find some on the Internet through Google image search. Feel free to edit the image as you see fit. In Scratch, you can access the image and add it as a sprite the same way that you normally do to add sprites already in Scratch (i.e., via the **choose new sprite from file** icon). You will need to browse to the location where your spider image was saved. The spider sprite used in the example above is actually made up of 16 individual images so that it can appear to be crawling as it moves across the stage. The first image was selected as the sprite. The other 16 were added as separate costumes by selecting the costumes tab above the scripts area.