Introduction

Soap RPG Framework is a lightweight, modular framework that takes a different approach compared to other RPG solutions. While many existing frameworks offer comprehensive, pre-built systems, they often come with steep learning curves and rigid structures that can limit your creative freedom. Soap RPG Framework instead focuses on providing a clean, flexible foundation that you can shape to your exact needs.

Key advantages:

- **Modular Architecture**: Pay just for what you need. Soap RPG Framework serves as the foundation, with additional packages building upon it to extend functionality in a modular way.
- **True Flexibility**: Unlike more rigid frameworks, Soap RPG Framework defines only essential concepts, letting you model any game system without being constrained by pre-made assumptions. The limitations are minimal.
- **Gentle Learning Curve**: Start creating immediately with intuitive, inspector-driven workflows, avoiding the complexity of larger frameworks.
- **100% Inspector-Driven**: Make changes and balance your game without touching code. Game designers can tweak values through ScriptableObjects in real-time, even during play mode, without needing recompilation. This also enables rapid testing and debugging by allowing instant value adjustments.
- **Minimal Lock-in**: The framework's lightweight nature means you're never locked into specific game design patterns.

Whether you're creating a traditional RPG, a roguelike/roguelite, an MMO, or even a game with unique mechanics, Soap RPG Framework adapts to your needs without forcing you into predetermined patterns. It provides essential building blocks for managing attributes, statistics, levels, and classes, along with powerful systems for controlling stat growth through customizable formulas, handling game events, and implementing scaling calculations. This lets you focus on the creative aspects of game development while having precise control over how your game elements evolve and interact.

Vocabulary of Soap RPG Framework

The package is developed around the concept of *entity*, so let's clarify what we mean by this term in the context of Soap RPG Framework. In its most minimal version, an entity is a `GameObject` that has a set of statistics. Optionally, an entity can have attributes, can level up, and can have a class. Let's clarify what we mean by each mentioned term.

Statistics (Stat)

A statistic is a value that quantifies an aspect of the entity. The meaning of this aspect is solely due to the concept it refers to.

Examples

In an RPG, a statistic can be `physical damage`. The concept of physical damage refers the player to the amount of damage inflicted by physical attacks, whether with weapons or without. Other statistics can be `ability power`, `defense`, `speed`, `armor penetration`, `range`, etc.

Attributes

An attribute is a value that can influence the value of one or more statistics. The weight of its influence on the statistics can be variable.

Examples

In an RPG, attributes can be: `strength`, `dexterity`, `intelligence`, `constitution`, etc. Considering the previous example of statistics, `strength` could influence `physical damage`, `dexterity` would increase `speed`, `intelligence` would increase `ability power`, and `constitution` would increase `defense`.

Experience and Level

The entity can gain experience and level up. This functionality is used by the class to express how attributes and statistics grow with levels, for that particular class.

Class

The class is associated with a set of statistics and optionally a set of attributes. The class describes how statistics and attributes vary with levels.

Examples

In RPGs most common classes are: `warrior`, `rogue`, `mage`, `paladin`, and so on. These classes have different attribute values. For example, a warrior will have more `strength` and `constitution` than a mage. The `rogue` might have the highest `dexterity`, etc.

How is Soap RPG Framework organized and how does it work?

Entity

A `GameObject` becomes an entity once the `EntityCore` and `EntityStats` `MonoBehaviour`s (Mono) are added to it. `EntityCore` comes with a built-in `EntityLevel` (plain C# `class`) that manages the experience and the level of the entity.

Stat

A `Stat` is a class that derives from `ScriptableObject` (SO) and represents a statistic in the game. Each statistic has a name (the name given to the SO instance of the created `Stat`), and we can choose whether to provide it with a maximum and/or minimum value. Additionally, we can define how that statistic grows or is reduced, depending on certain `Attributes`.

StatSet

A `StatSet` is a class derived from ScriptableObject that defines a collection of `Stat`s. Stat sets can be composed by combining other sub-stat sets, enabling hierarchical organization and easy reuse of statistics among different entities or classes.

EntityStats

`EntityStats` allows us to configure:

- the base statistics
- the flat modifiers
- the *StatToStat* modifiers
- the percentage modifiers We will see what these modifiers are in the section [Understanding Stat Modifier Types].

The base statistics can be *fixed*, or instead derive from a class if the entity has one assigned. If we use the fixed ones, we must also provide a `StatSet`, while if we use those of a class, the class's `StatSet` will be used. If the entity levels up and we want its statistics to grow with levels, we are forced to use a class, as the *fixed* statistics are immutable.

Class

`Class` derives from SO and represents a game class. Each class has a name, a `GrowthFormula` that defines how the base Max HP grows with levels, a `StatSet`, optionally an `AttributeSet`, and associates each `Stat` of the provided StatSet with a `GrowthFormula` that describes how the statistic varies with levels. Similarly, if an `AttributeSet` is provided, it will be possible to associate a `GrowthFormula` for each `Attribute` present in the set, to describe how the attributes vary with levels.

EntityClass

`EntityClass` derives from Mono and allows us to assign a `Class` to our entity.

Attribute

An `Attribute` is a class that derives from SO and represents an attribute in the game. Each attribute has a name and, like statistics, can have a maximum and minimum value.

AttributeSet

An `AttributeSet` is a class that derives from SO and defines a set of `Attribute`s.

EntityAttributes

Optionally, we can add the Mono `EntityAttributes` to our entity if we want to give it attributes. `EntityAttributes` allows us to specify how many attribute points to provide at each new level. These points can be spent on various attributes to increase their value. For `EntityAttributes` we can configure:

- the base attributes
- the flat modifiers
- the percentage modifiers Similarly to `EntityStats`, we can decide whether the base attributes are *fixed* or if they instead derive from the class associated with `EntityClass`.

Growth Formula

To express how `Stats`, `Attributes`, Max HP, and the experience required to level up vary at each level, we can use instances of `GrowthFormula`. This is a class that derives from SO and allows us to define a mathematical function, or a system of functions, that describe how a value changes as levels increase. We will see in more detail how to define a `GrowthFormula` in the [Growth Formulas] section.

Scaling Formulas

Scaling formulas provide a flexible way to define how values such as damage, healing, or other effects are calculated based on one or more attributes or stats. They allow you to combine base values (which can be constant or level-dependent) with contributions from various stats and attributes, each weighted by customizable scaling components.

Scaling components

Specify how much a particular stat or attribute influences the final value of the scaling formula, enabling complex and dynamic calculations for abilities, equipment, or other game mechanics. This modular approach lets you easily adjust and extend scaling logic to fit your game's needs.

Game Events

Game events are ScriptableObjects that allow you to implement the Observer pattern in your game. They provide a way to decouple systems by broadcasting notifications when something happens (such as a player jumping, leveling up, or taking damage). Listeners can subscribe to these events and react accordingly, all through inspector-driven workflows. Game events can carry context parameters, making them flexible for a wide range of use cases.

Game Event Generators

Game Event Generators are ScriptableObjects that let you define custom game events with up to four context parameters. They automate the creation of event and listener classes, making it easy to extend your event system for complex gameplay scenarios. You can specify parameter types and documentation, and generate code and assets directly from the inspector.

How is Soap RPG Framework implemented?

The package is developed following the principles of SOAP (Scriptable Object Architecture Pattern), and has been inspired by the [GDC talk of Ryan Hipple](). In a nutshell, the main benefits provided by this architecture are:

- **encapsulation**: separation of game logic from data. Game logic code shouldn't mix with data. All data is nicely wrapped withing SO instances
- **game designers friendly**: game designers can make changes and balancements from the inspector without touching the code
- **greater reusability**: most features are `ScriptableObject`s that can be reused by many components
- **greater testability**: being data separated from code, is easier to isolate and fix bugs. Moreover, SO events can be raised with ease at the press of a button from the inspector interface, easing and speeding up debugging even further.

Flexibility of Soap RPG Framework

Although the package is specifically designed for RPG games or games with progression systems, its flexibility allows it to be used in almost any game. As it allows creating attributes like `strength`, `dexterity`, `agility`, etc., and statistics such as `physical attack`, `magic power`, `physical defense`, etc., in RPG, Roguelike, MMO games, etc., nothing prevents it from being used, for example, to implement a firearm. The attributes could be `weight`, `size`, `ergonomics`, etc., and the statistics `recoil`, `handling`, `stability`, `intimidation`, etc. Attributes can influence statistics. A heavier weapon could reduce `handling` but increase `stability`. A larger weapon could reduce `handling` but increase `intimidation`. A more ergonomic weapon could reduce `recoil` and increase `handling`. And so on... The weapon's levels, if present, influence the attributes and statistics, progressively improving them. Classes could represent weapon types (assault rifles, snipers, shotguns, etc.), and each class could have its own set of dedicated attributes and statistics. For example, shotguns could have, in addition to the aforementioned ones, the `barrel length` attribute that influences the `pellet spread` statistic.

Workflows

Creating instances of the objects

All the scriptable objects provided by the framework can be created through the Unity Editor by either right-clicking in the hierarchy and selecting `Create > Soap RPG` or navigating to the `Assets` menu at the top of the window and choosing `Create > Soap RPG`.

Mandatory and re-play fields

Fields marked with a red asterisk (*) are mandatory and must be filled out to ensure proper functionality of the framework.

Fields marked with an orange **R** are re-play fields. Any changes made to these fields during playtime will require a restart to ensure the changes take effect.

Some utilities

Almost every class provided by this package uses events or variables in the form of `ScriptableObject`. Therefore, let's quickly introduce these concepts so that we are clear about what we are talking about when we encounter them in the following paragraphs.

Game events as `ScriptableObjects`

The SOAP architecture allows us to implement the Observer pattern through scriptable objects. In the simplest case, with events without context, we can define various game events as `GameEvent` instances: a class that derives from `ScriptableObject`. For example, we can create an instance called `PlayerJumped` that represents the event "The player has jumped". This event will notify all listening systems when it occurs. Systems subscribe to this event using the `MonoBehaviour` `GameEventListener`. We can assign a `GameEvent` to this component, and it will handle the subscription and invoke a callback when the event is triggered. The callback is a UnityEvent, so we can select a callback to invoke in response to our event directly from the inspector.

For more details, see the Game Events section.

Int and Long Vars

Another common use of `ScriptableObject` in the SOAP architecture is to define variables. The main advantage of these variables in the form of SO is that they can be easily shared between various objects that may decide to share the same value. A common example is the player's game score. There could be a game manager that adds or removes points from this variable, while the UI HUD uses it to display its value on the screen. This way, we can keep the game manager and UI completely decoupled, passing shared values (like variables) through the inspector.

From the code, we can access the values held by these variables using the `Value` getter and setter:

```
// intVar is an instance of IntVar
int value = intVar.Value; // Get the value

// Thanks to implicit conversion, we can also use it as an int directly
int intValue = intVar; // Implicit conversion to int

intVar.Value = 10; // Set the value
```

Int and Long Refs

`IntRef` and `LongRef` allow choosing whether to use a native value (`int` or `long`) or an `IntVar`/`LongVar`. As mentioned in the previous paragraph, `IntVar` and `LongVar` have the advantage of being shareable between different components/game objects, while native values are more immediate to use and require less setup (no need to instantiate an `IntVar`/`LongVar` and assign it in the inspector).

Thanks to a custom property drawer, it will be possible, from the inspector, to check a checkbox named `Use constant` to use a native value instead of a `Ref`, and vice versa.

`IntRef` and `LongRef` are widely used in the package's `MonoBehaviour`.

From the code, we can access the values held by these references using the `Value` getter and setter. It is worth mentioning that when we use the setter, we need to provide a native `int` or `long` value. If `Use constant` is unchecked, this value will be assigned to the `Value` property of the referenced `IntVar` or `LongVar` instance; if `Use constant` is checked, the assignment only updates the local constant value and does not affect any referenced variable.

```
// intRef is an instance of IntRef
int value = intRef.Value; // Get the value
// Thanks to implicit conversion, we can also use it as an int directly
int intValue = intRef; // Implicit conversion to int
intRef.Value = 10; // Set the value

// Assigns the value of intVar to intRef.Value using implicit conversion.
// Note: This does not change the IntVar reference held by intRef, only its value.
intRef.Value = intVar;
```

Game events

The package also supports game events with up to 4 context parameters. They are generics, but in Unity, it is not possible to instantiate classes that derive from `ScriptableObject` if they are generics with unspecified type parameters. To use them, we must explicitly declare classes that derive from the generic

GameEvent and fix the type parameters with concrete types. To simplify the definition of new event types, with specific types as context parameters, the package provides `GameEventGenerator`. These generators, which derive from SO, allow generating the concrete classes of `GameEvent`. We will see these generators in more detail in the [Game Event Generators] section. Some game events are already defined and made available by the package (see the [Samples] page).

Growth Formulas

Relative path: `Growth Formula`

As already mentioned in [Introduction], `GrowthFormula` allows defining how a certain value varies as levels increase. A `GrowthFormula` can be instantiated through the hierarchy context menu by going to `Soap RPG Framework -> Growth Formula`. The package provides a custom property drawer for `GrowthFormula`.

Max level for the values

In the inspector of a `GrowthFormula`, we can pass an `IntVar` to define up to which level to grow the values.

Use constant at level one

If the checkbox named `Use constant value at level 1` is checked, the respective constant value will be used.

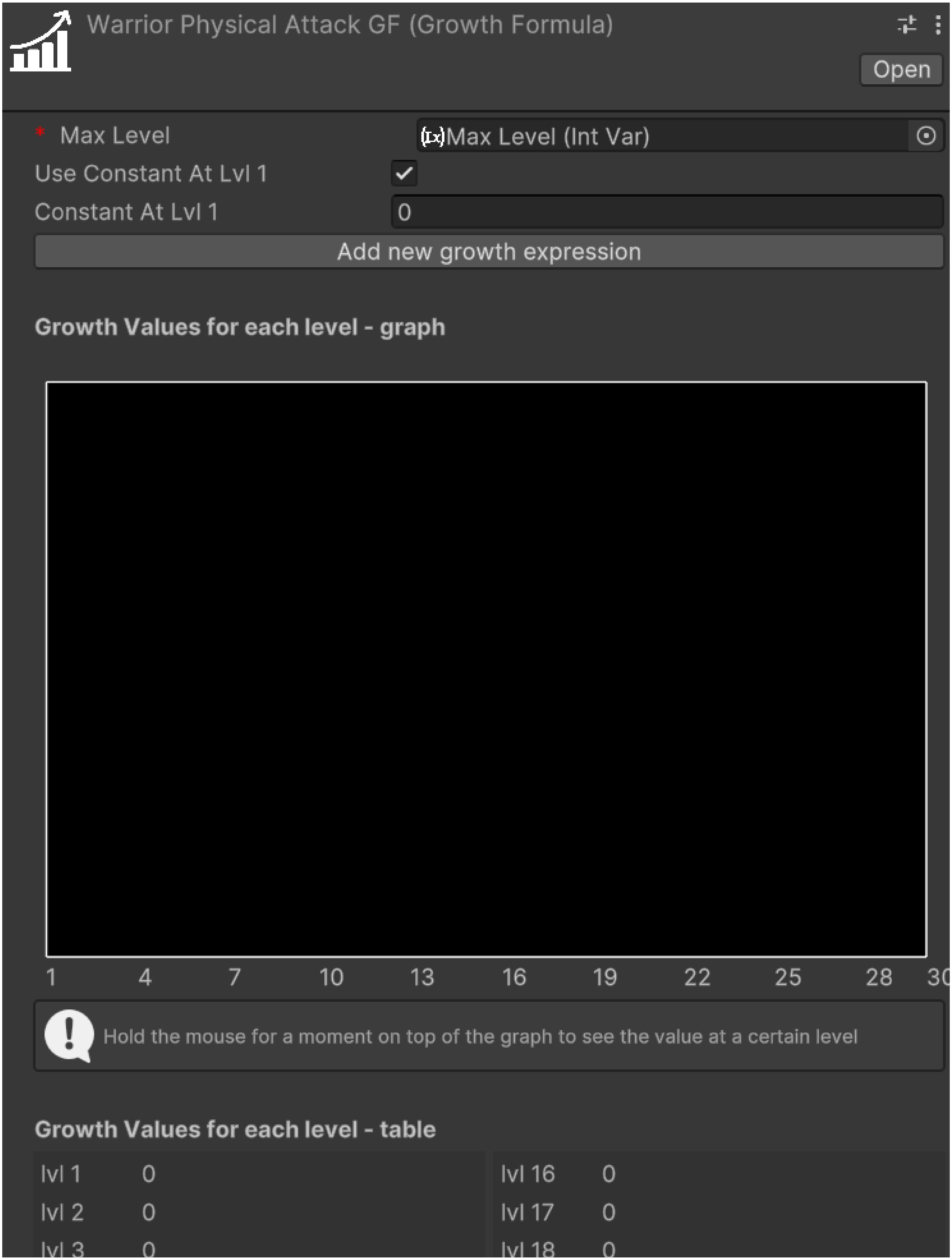
Growth expressions

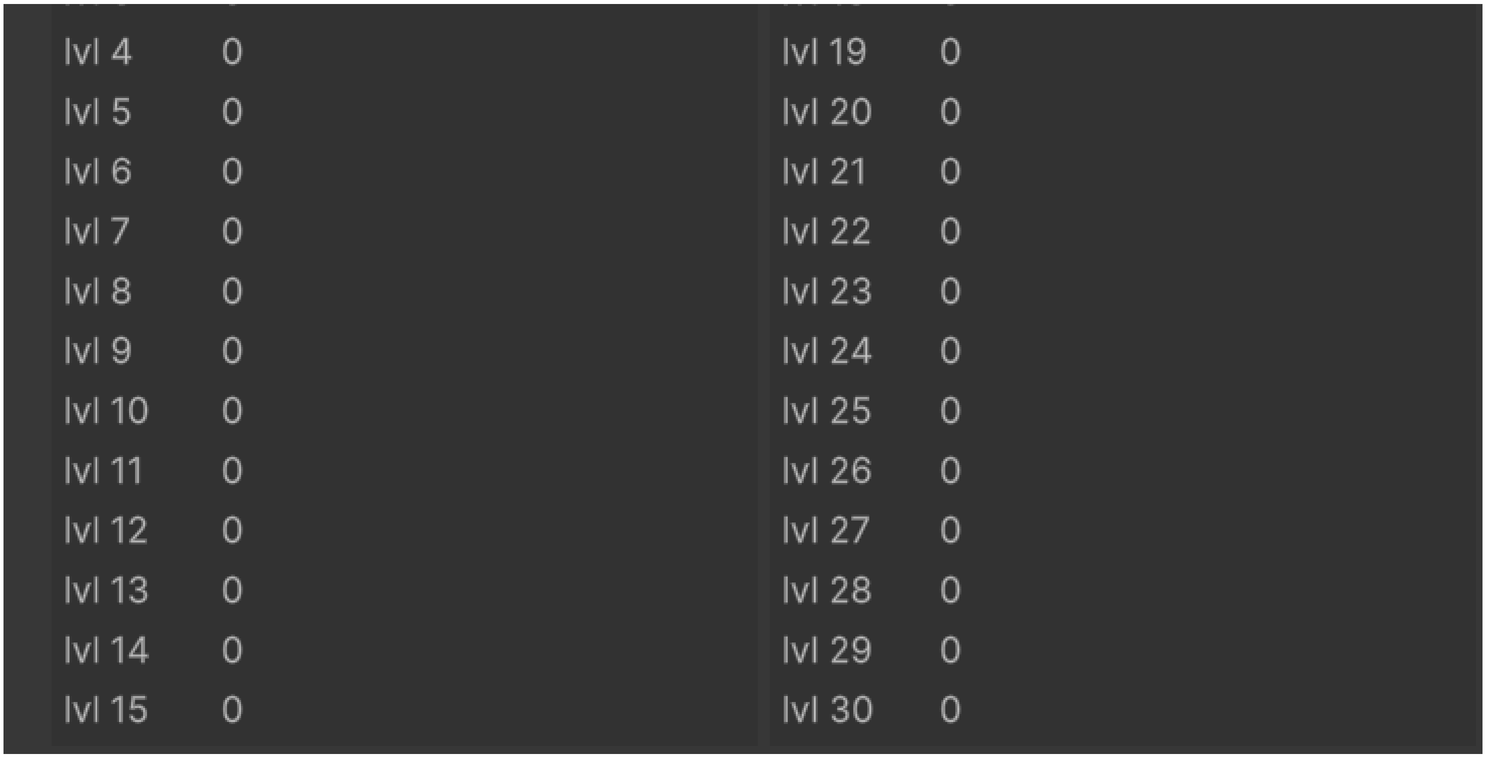
The various values of the `GrowthFormula` are defined by a function where values, the y-axis, are expressed as a function of the levels, the x-axis. Such a function is defined as a composite function. Each segment of the function is represented by a string that specifies a mathematical expression for a range of levels. The string can be defined by using the [Unity ExpressionEvaluator] syntax. On top of it, the following terms can be used:

- `LVL`: the level at each iteration
- `PRV`: the previous value of the `GrowthFormula` (value evaluated at the previous level)
- `SPRV`: the second previous value of the `GrowthFormula` (value evaluated 2 levels ago)
- `SUM`: the sum of the values of the `GrowthFormula` from level 1 up to the previous level

Example of a `GrowthFormula`

Let's see an example of how to define a `GrowthFormula` for defining the Physical Attack of a warrior class. First of all, let's create a new `GrowthFormula` instance and name it `Warrior Physical Attack GF`. In the inspector, it should look like this:


Warrior Physical Attack GF (Growth Formula)
Open
Max Level
Max Level (Int Var)
Use Constant At Lvl 1
Constant At Lvl 1
0
Add new growth expression
Growth Values for each level - graph
1
4
7
10
13
16
19
22
25
28
30
Hold the mouse for a moment on top of the graph to see the value at a certain level
Growth Values for each level - table
lvl 1 0
lvl 2 0
lvl 3 0
lvl 16 0
lvl 17 0
lvl 18 0

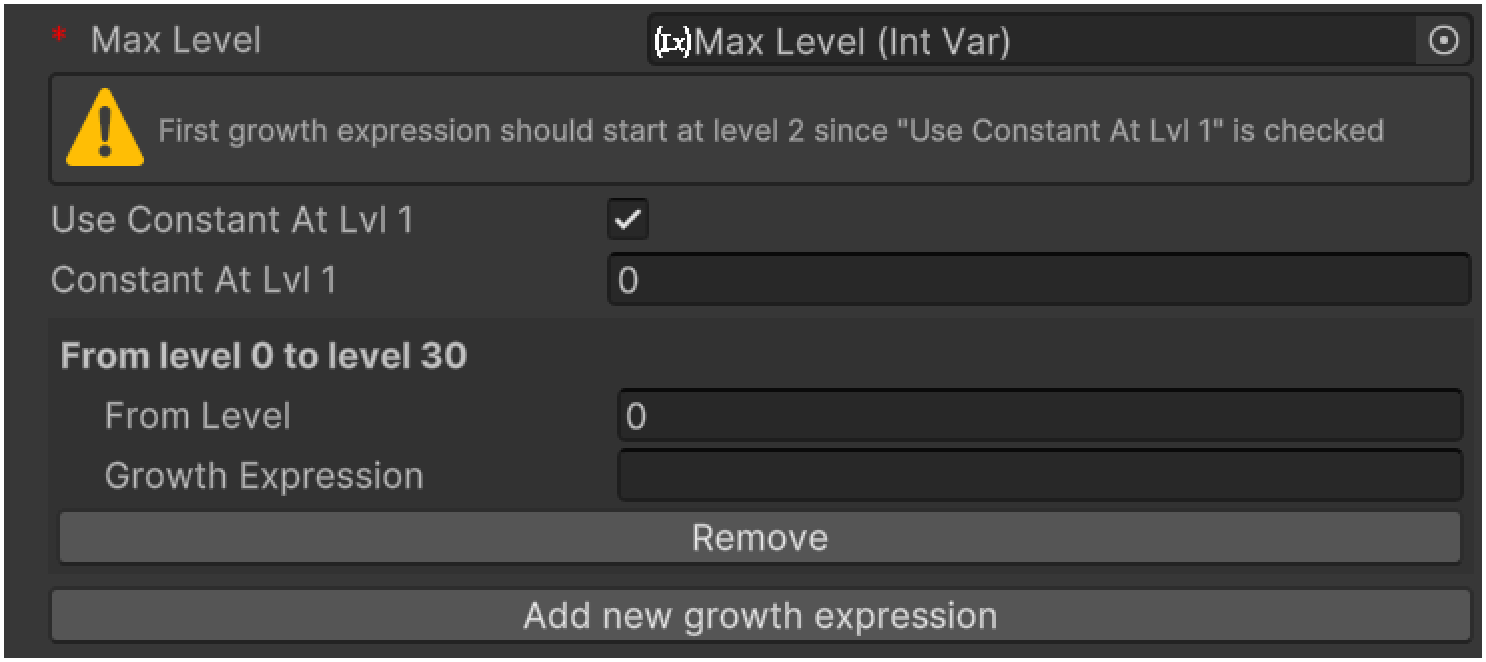


The `Max Level`, a mandatory field, is set with an `IntVar` assigned by default. We can edit that variable to change the maximum level that will be computed for our growth formula.

> **WARNING**
>
> When modifying the value of a variable referenced in growth formulas, such as Max Level, the growth formulas are not directly updated unless you select them in the inspector. To update all growth formulas simultaneously after changing the maximum level, a command is available in the menu: `Tools > SOAP RPG Framework > Validate All Growth Formulas`.
> Validation occurs automatically during script compilation, upon entering play mode, and when instantiating a prefab. This is achieved through the `OnValidate` callback, which ensures that formulas are updated accordingly.

The `Use constant value at level 1` checkbox lets us decide whether to use a constant value at level 1 or not. If checked, the `Constant Value` field will be enabled, and we can set a value for it. In this case, we set it to 10.

The `Add new growth expression` button lets us add a growth expression for a certain range of levels of our choice. If we press it, we will see the following:



The new section includes two fields: `From Level` and `Growth Expression`.

- **From Level**: Specifies the starting level at which the corresponding `Growth Expression` becomes effective.
- **Growth Expression**: Defines how the value evolves starting from the specified level.

If the `Growth Expression` overlaps with the `Constant At Lvl 1` option, a warning will appear. To resolve this, set the `From Level` field to `2` or higher, and the warning will disappear.

We want to model the Physical Attack of a warrior as follows:

- Level 1: 10
- From level 2 to level 5: +2 per level
- At level 11: flat +30 (like a bonus due to other game mechanics, such as an awakening)
- From level 12 and onward: grows by 7% each level

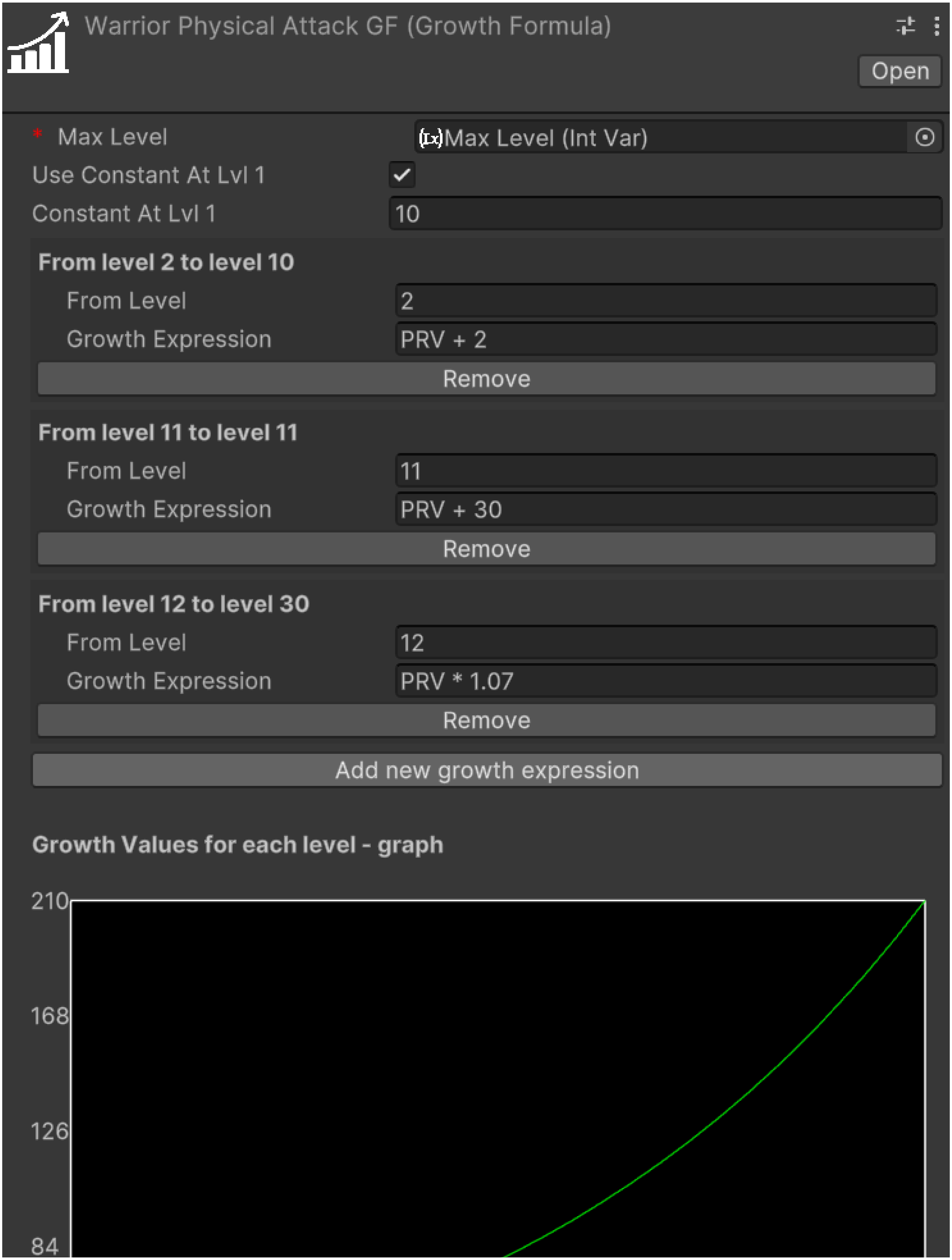
To achieve this, set the `Constant At Lvl 1` field to `10`. For the first growth expression, use `PRV + 2` as the formula. `PRV`, as we saw before, represents the value of the growth formula at the previous level (in this case, `10` at level 1).

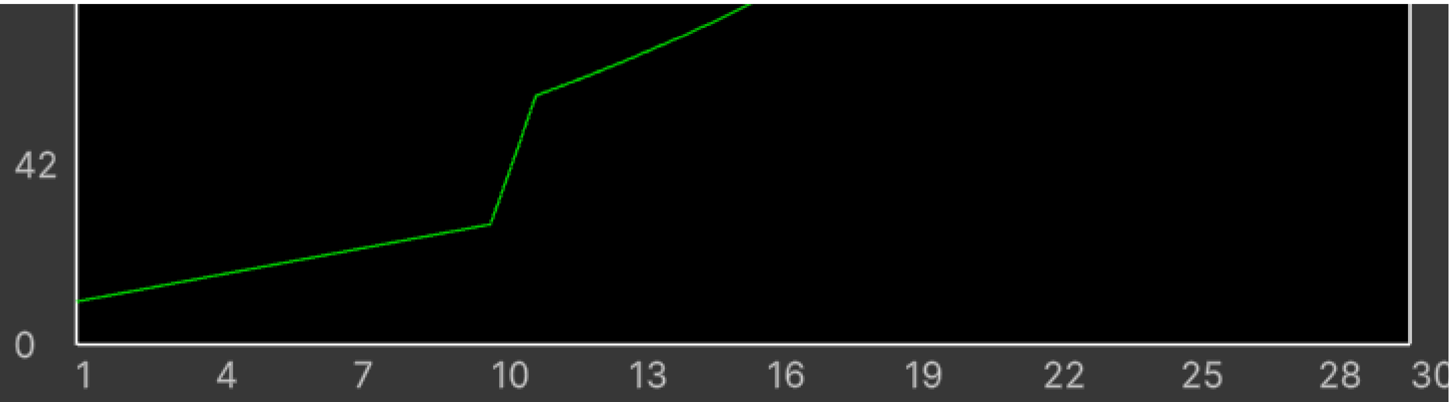
This formula ensures that the value grows by `2` times the level at each subsequent level.

Next we want to press the `Add new growth expression` button to add the next growth expression for the levels. For the second growth expression, set `From Level` to `11` and use the formula `PRV + 30`. This ensures that at level 11, a flat bonus of 30 is added to the previous value.

Finally, for the third growth expression, set `From Level` to `12` and use the formula `PRV * 1.07`. This ensures that from level 12 onward, the value increases by 7% each level.

After adding these growth expressions, the `GrowthFormula` for the `Warrior Physical Attack GF` should look like this:


Warrior Physical Attack GF (Growth Formula)
Open
* Max Level
Max Level (Int Var)
Use Constant At Lvl 1
Constant At Lvl 1
10
From level 2 to level 10
From Level
2
Growth Expression
PRV + 2
Remove
From level 11 to level 11
From Level
11
Growth Expression
PRV + 30
Remove
From level 12 to level 30
From Level
12
Growth Expression
PRV * 1.07
Remove
Add new growth expression
Growth Values for each level - graph
210
168
126
84



Hold the mouse for a moment on top of the graph to see the value at a certain level

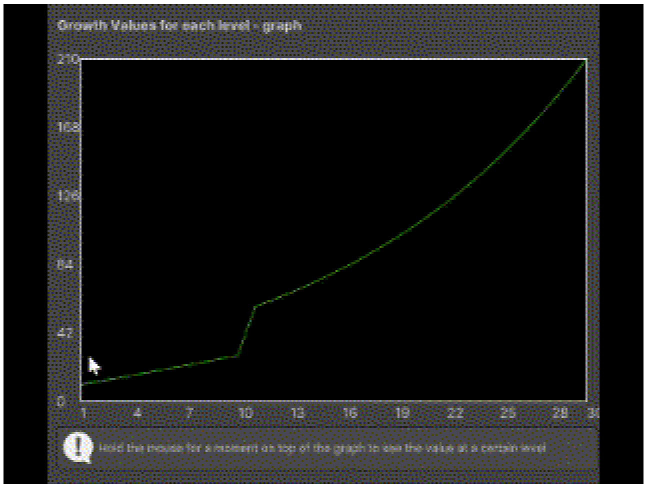
Growth Values for each level - table

lvl 1	10	lvl 16	81
lvl 2	12	lvl 17	87
lvl 3	14	lvl 18	93
lvl 4	16	lvl 19	99
lvl 5	18	lvl 20	106
lvl 6	20	lvl 21	114
lvl 7	22	lvl 22	122
lvl 8	24	lvl 23	130
lvl 9	26	lvl 24	139
lvl 10	28	lvl 25	149
lvl 11	58	lvl 26	160
lvl 12	62	lvl 27	171
lvl 13	66	lvl 28	183
lvl 14	71	lvl 29	196
lvl 15	76	lvl 30	209

With this setup, the `GrowthFormula` will correctly calculate the Physical Attack values for the warrior class based on the specified rules.

Interactive Chart

If you hold your mouse for a moment onto the chart, a label will show up, showing the exact value of the growth formula at the pointed level:



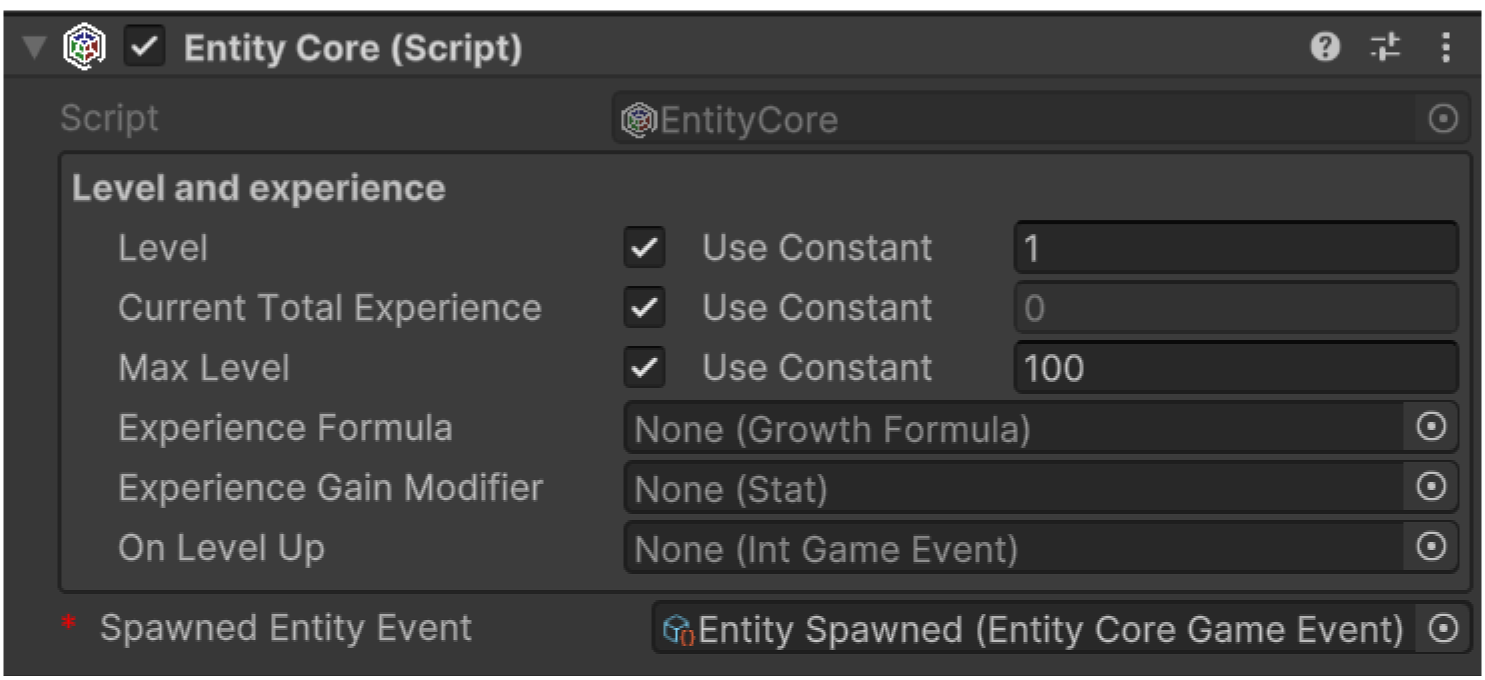
Retrieving growth values from code

To retrieve the values of a `GrowthFormula` from code, you can use the `GetGrowthValue(int level)` method. For example, to get the Physical Attack value at level 5, you can do:

```
// warriorPhysicalAttackGF is a reference to the Warrior Physical Attack Growth Formula
int physicalAttackLevel5 = warriorPhysicalAttackGF.GetGrowthValue(5);
```

Make a `GameObject` an entity

To make a `GameObject` an entity, we need to add the `MonoBehaviour EntityCore` to it. Select your object from the hierarchy and click, in the inspector, on "Add component". Then search for and select `EntityCore`.



From the inspector, we can configure several values. Let's analyze them one by one.

`Level`: defines the entity's level. By changing its value, we can assign a different level to the entity directly from the inspector. This can be useful for testing purposes. You'll notice the `Use Constant` checkbox. If checked, you can pass an `IntVar` instead of using a constant.

`Current Total Experience`: Represents the total experience possessed by the entity.

> **WARNING**
> If you've passed a `LongRef` for the current total experience, the value contained in this variable should not be modified manually. If `Use constant` is checked instead, the value is readonly.

`Max Level`: The maximum level the entity can reach

`Experience Formula`: `GrowthFormula` that describes how the total experience required to reach the next level grows at each level.

`On Level Up`: `EntityLeveledUpGameEvent` that should be raised when the entity levels up.

`Spawned Entity Event`: `EntityCoreGameEvent` that should be raised when this entity's `Start()` method is executed.

You may notice that a game event is already assigned to `Spawned Entity Event`. This is because an instance of that game event has been explicitly assigned directly in the inspector of the `EntityCore` script. This choice was made since in most cases the same event instance will always be used for entity spawning. This means you don't have to reassign this event every time you create a new entity in Unity. As we'll see later, this default assignment mechanism has been used for other components as well.

EntityLevel code APIs

It is honorable to mention some code APIs that can be used to interact with the `EntityLevel` component.

EntityLevel exposes a `Action<EntityCore, int> OnLevelUp` property that can be used to subscribe to level-up events from code.

If we want to grant experience to the entity, we can use the `AddExp(long amount)` method. This method will automatically raise the `OnLevelUp` event if the entity levels up. Alternatively, it is available also the `SetTotalCurrentExp(long totalCurrentExperience)` method, which allows setting the total current experience of the entity. This method will also raise the `OnLevelUp` event if the entity levels up.

Finally, there are the `CurrentLevelTotalExperience()` and the `NextLevelTotalExperience()` methods. These methods return the total experience required to reach the current level and the next level, respectively. They are useful, for example, for checking how much experience is needed to level up.

Creating Soap RPG Framework assets

All the instances of the various assets that derive from `ScriptableObjects` can be created in the following ways:

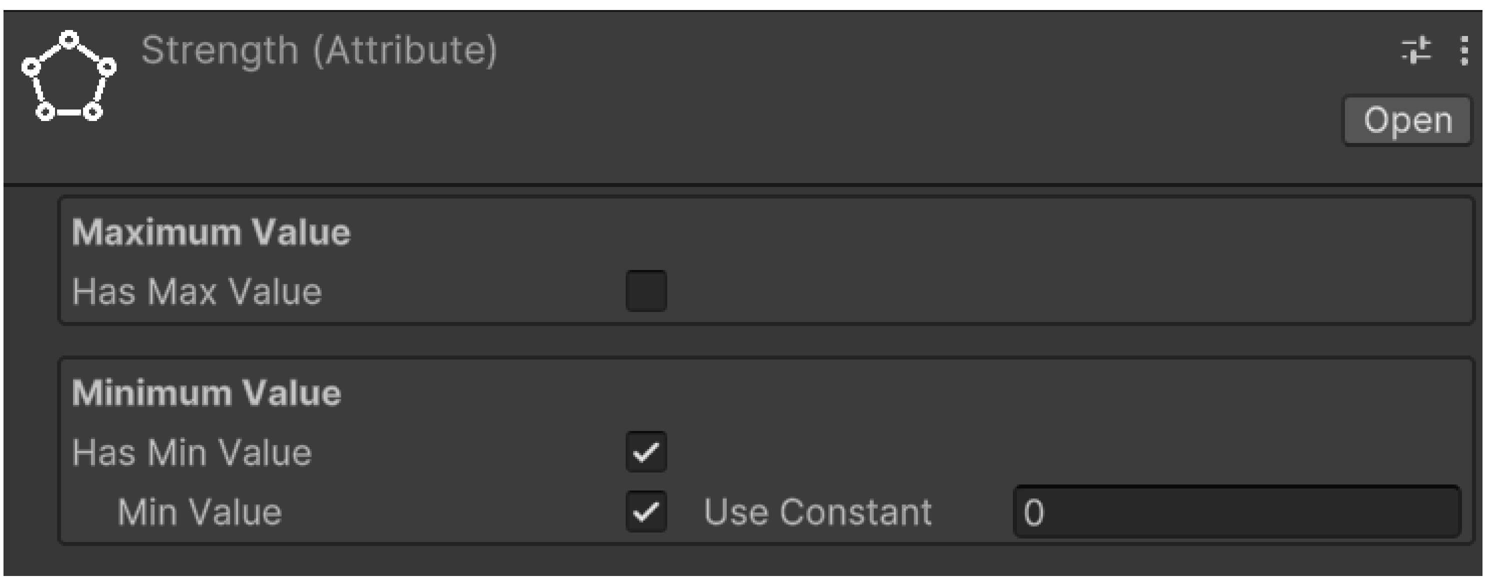
- Context menu: `Right click on the hierarchy > Create > Soap RPG Framework`
- Top bar: `Assets > Create > Soap RPG Framework`
- Hotkeys: By pressing the respective keyboard shortcut while a folder or an element of the hierarchy is currently selected

> **NOTE**
>
> For Mac users the `Ctrl` key corresponds to the `Cmd` key.

Create attributes

Keyboard shortcut: `Ctrl + Alt + A`
Relative path: `Attribute`

Once created a new attribute you can name it as you wish and you'll be able tweak some settings in the inspector. For example lets create a `Strength` attribute. Create an `Attributes` folder in your hierarchy, then press `A` and name the newly created attribute `Strength`.
In the inspector it should look like:



By checking `Has Max Value`, we will set a maximum value for the attribute. By default, there is no maximum value.

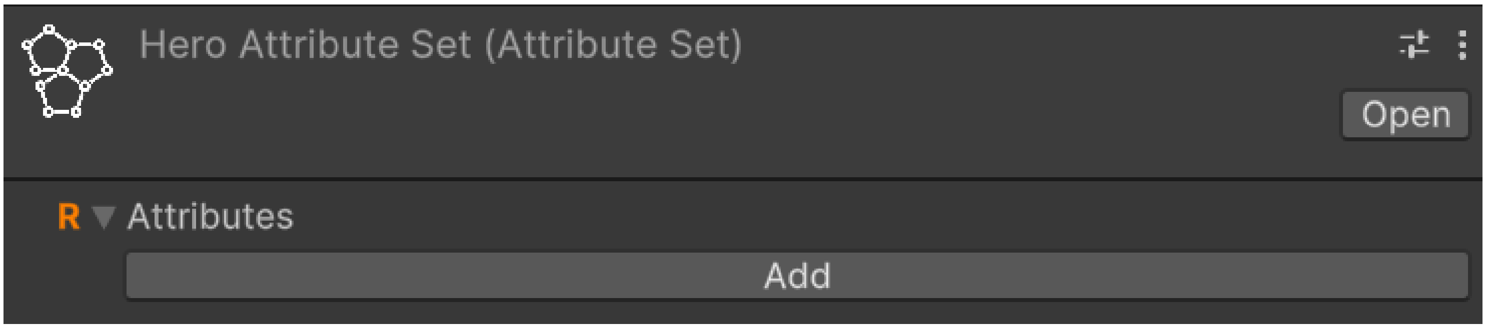
By checking `Has Min Value`, we will set a minimum value for the attribute. By default, the minimum value is zero.

Repeat the process for also the `Constitution`, `Intelligence`, and `Dexterity` attributes.

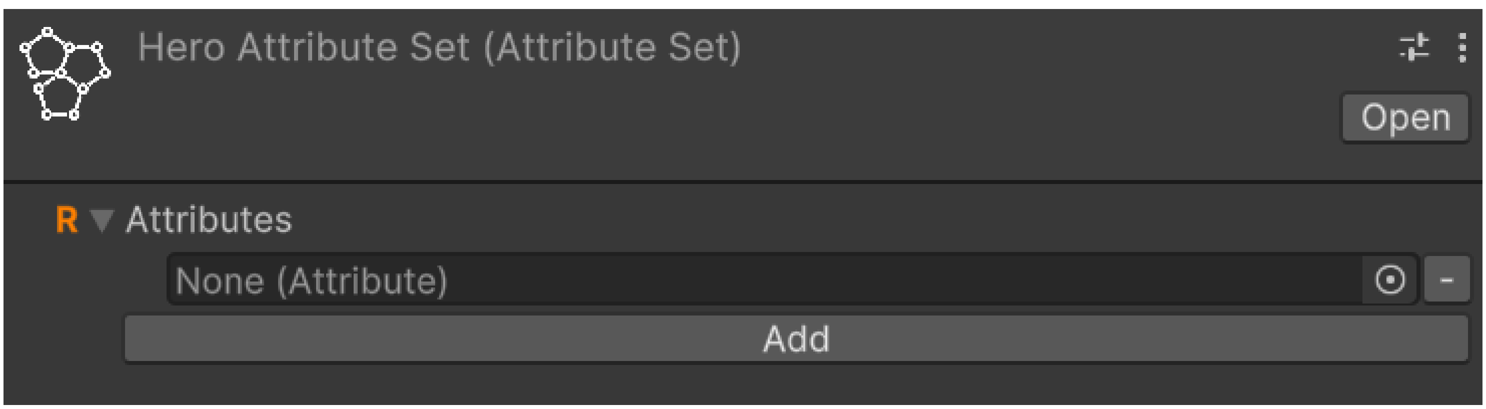
Create an attribute set

Relative path: `Attribute Set`

Now that we have some attributes let's create an `AttributeSet` named, for example, `Hero Attribute Set`. In the inspector it should look like this:



An attribute set without attributes isn't very useful, so let's add the previously created ones, one at a time. To do this, click on the `Add` button. Notice that an entry with `None (Attribute)` appears:

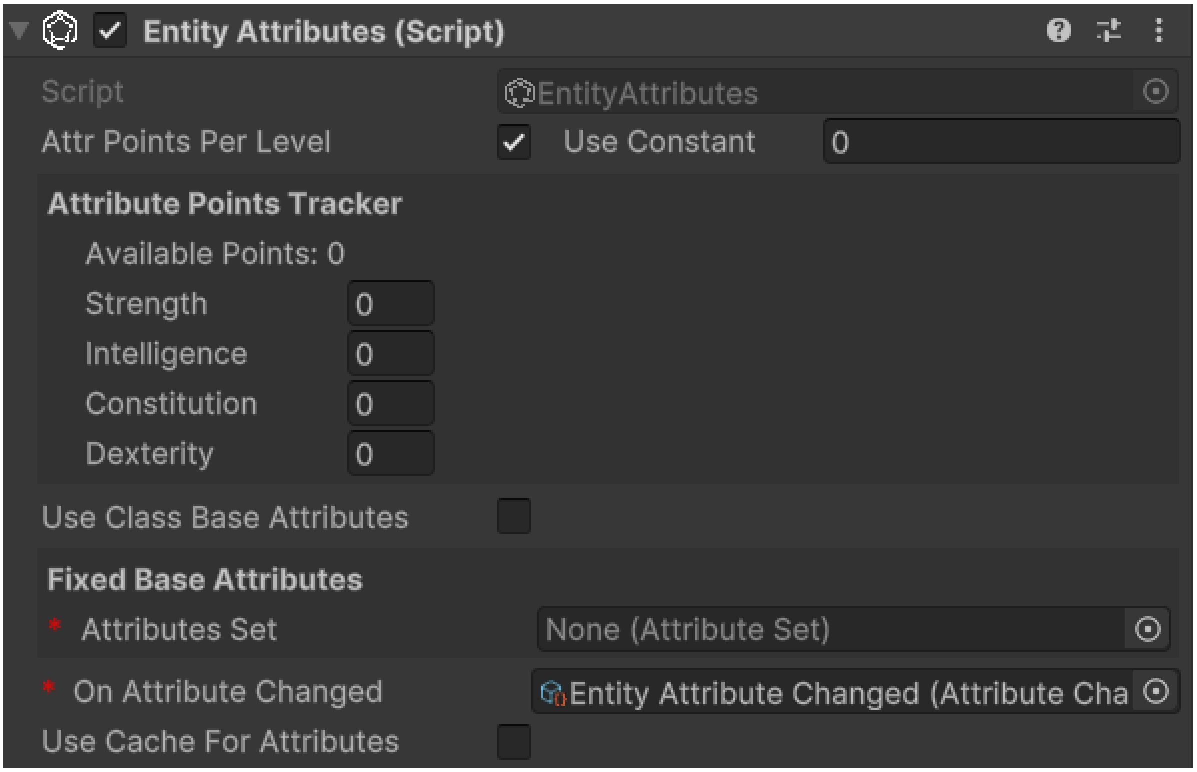


To assign an attribute to the entry, we can either drag & drop from the hierarchy or click on the small circle button on the right of the newly appeared entry. This mechanism is the same used for public variables or, more generally, for fields annotated with `SerializeField`, so it will be familiar to you. Let's add `Strength` using whichever method you prefer. Repeat the process of adding an attribute to the set for `Constitution`, `Intelligence`, and `Dexterity` as well.

If you want to remove an attribute from the set, you can click on the small `-` button on the right of the attribute you want to remove.

Add `EntityAttributes` to an entity

The next step is to assign the attribute set we created to an entity. To do this, let's add the `EntityAttributes` component to our game object. The inspector will look like this:

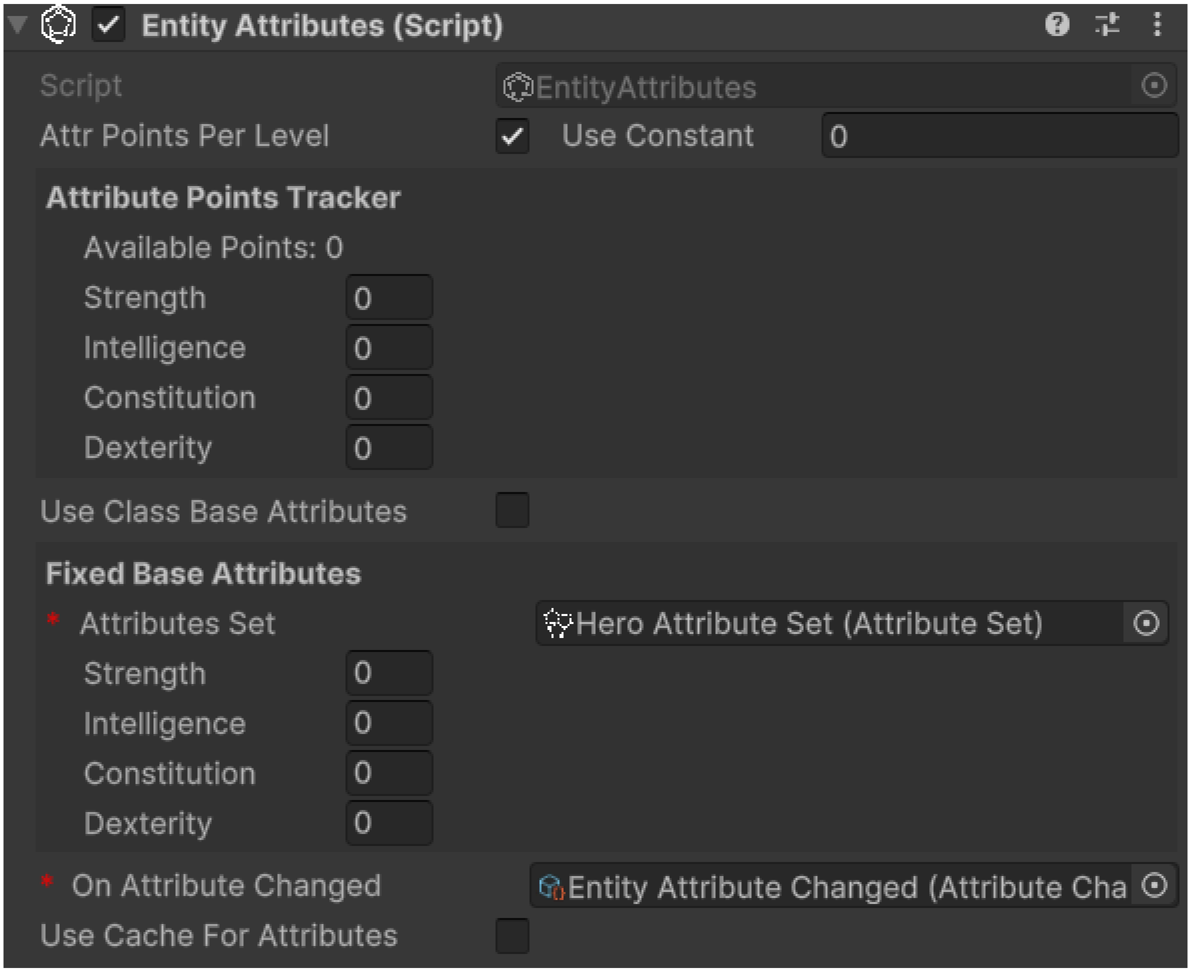


An entity has base points for attributes, which can be either fixed or derived from a class, a configurable amount of attribute points that can be arbitrarily assigned, and these points are granted at each level-up, along with flat and percentage modifiers for the attributes. Except for the modifiers, which can only be assigned via code, all other values can be configured from the inspector.

`Attr Points Per Level` defines how many arbitrarily spendable attribute points are provided at each level-up. They are assigned starting from level 2 on.

`Attribute Points Tracker` allows monitoring and assigning spendable points. `Available Points` defines how many unspent points are still available.
If you change the level of the entity you'll see that available points change accordingly. And as you spend them, `Available Points` will decrease.

Moreover, there is a checkbox labeled `Use Class Base Attributes`. For now, let's leave it unchecked since we haven't added a class yet. However, in this case, we need to manually assign an attribute set. Therefore, let's set the `Attribute Set` field found under `Fixed Base Attributes` with the `Hero Attribute Set`. By doing this, we now have access to additional fields in the inspector:



We can assign values to the attributes of `Fixed Base Attributes` as we see fit.

Understanding Attribute Modifier Types

The framework provides two distinct types of attribute modifiers that work together with spent attribute points to determine final attribute values. Understanding how each type works is essential for creating predictable character progression and balanced gameplay mechanics.

> **NOTE**
>
> General considerations for attribute modifiers
>
> - When adding modifiers through code, the `OnAttributeChanged` event will automatically be raised if the final value changes
> - If cache is being used: when adding modifiers through code, the attribute cache will automatically be invalidated to ensure the correct value is returned on the next access

Spent Attribute Points

Before diving into modifiers, it's important to understand that spent attribute points form the foundation of the attribute calculation system. These points are allocated by players during character progression and are applied immediately after the base value.

Characteristics:

- Player-controlled allocation of points earned through leveling
- Applied directly after base values in the calculation order
- Permanent increases (until points are redistributed)
- Each point provides a 1:1 increase to the attribute

Code example:

```
// Spend 3 points on Strength
entityAttributes.SpendOn(strengthAttribute, 3);

// Check available points before spending
int availablePoints = entityAttributes.AvailableAvailableAttributePoints;
if (availablePoints >= 2) {
    entityAttributes.SpendOn(constitutionAttribute, 2);
}
```

Flat Modifiers

Flat modifiers add or subtract a fixed amount to an attribute's value. They are applied after base values and spent points but before percentage modifiers.

Use cases:

- Equipment bonuses (e.g., +3 Strength from gauntlets)
- Temporary buffs (e.g., +5 Constitution from a fortitude potion)
- Race or class bonuses (e.g., Dwarves get +2 Constitution)
- Status effects that provide fixed bonuses or penalties
- Environmental effects (e.g., library affecting Intelligence)

Code example:

```
// Add a flat +4 bonus to Strength
entityAttributes.AddFlatModifier(strengthAttribute, 4);

// Add a flat -2 penalty to Dexterity (negative values work too)
entityAttributes.AddFlatModifier(dexterityAttribute, -2);
```

Calculation example:

- Base Strength: 12
- Spent points: +3
- Flat modifier: +4
- Result after flat modifiers: 12 + 3 + 4 = 19

Percentage Modifiers

Percentage modifiers apply a multiplicative increase or decrease to the current attribute value. They are the most powerful type of modifier and are applied last in the calculation chain, after all other values have been calculated.

Use cases:

- Powerful equipment bonuses (e.g., +20% to all attributes)
- Character traits or talents (e.g., "Natural Athlete: +15% Strength and Dexterity")
- Temporary powerful buffs or curses
- Class features
- Magical enchantments or artifacts

Code example:

```
// Add a 20% increase to Strength
entityAttributes.AddPercentageModifier(strengthAttribute, 20);

// Add a 10% decrease to Intelligence (negative percentage)
entityAttributes.AddPercentageModifier(intelligenceAttribute, -10)
```

Calculation example:

- Previous value: 19 (from previous steps)
- Percentage modifier: +20% = 19 × 0.20 = 3.8
- Final result: 19 + 3.8 = 22.8 (rounded to 23 for integer attributes)

Important notes:

- Multiple percentage modifiers are additive before being applied (e.g., +20% and +10% = +30% total)
- The percentage is calculated based on the value after base, spent points, and flat modifiers
- Percentage modifiers can be negative to create penalties

Complete Calculation Example

Let's see a complete example showing the full attribute calculation process:

Initial setup:

- Base Intelligence: 14
- Points spent on Intelligence: 4
- Equipment flat bonus: +2 (from a circlet)
- Trait percentage bonus: +25% (from "Scholar" trait)

Step-by-step calculation:

1. Start with base: 14
2. Add spent points: 14 + 4 = 18
3. Apply flat modifiers: 18 + 2 = 20
4. Apply percentage modifiers: 20 + (20 × 0.25) = 20 + 5 = 25

Final Intelligence value: 25

Comparison with Stat Modifiers

Unlike stats, attributes have a simpler modifier system:

Attributes have:

- Base values
- Spent attribute points (player-controlled)
- Flat modifiers
- Percentage modifiers

Stats additionally have:

- Stat-to-stat modifiers (attributes don't have attribute-to-attribute modifiers)
- More complex scaling relationships
- Stats can scale upon attributes

This simplicity makes attributes more predictable and easier for players to understand, while stats can have more complex interactions. Keeping them simple helps maintain clarity in gameplay

Retrieving Attribute Values from code

Due to the relevance of retrieving attribute values from code, the methods to do so are worth mentioning here.

To retrieve the final value of an attribute, you can use the `Get` method:

```
// strengthAttribute is a reference to the Strength Attribute
int strength = entityAttributes.Get(strengthAttribute);
```

To retrieve the base value of an attribute, you can use the `GetBase` method:

```
// strengthAttribute is a reference to the Strength Attribute
int baseStrength = entityAttributes.GetBase(strengthAttribute);
```

Spending attribute points

If the entity's `Attr Points Per Level` is greater than zero and the level is greater than 1, we can spend attribute points on the attributes. To do this, we can use the `SpendOn` method:

```
// strengthAttribute is a reference to the Strength Attribute
entityAttributes.SpendOn(strengthAttribute, 2);
```

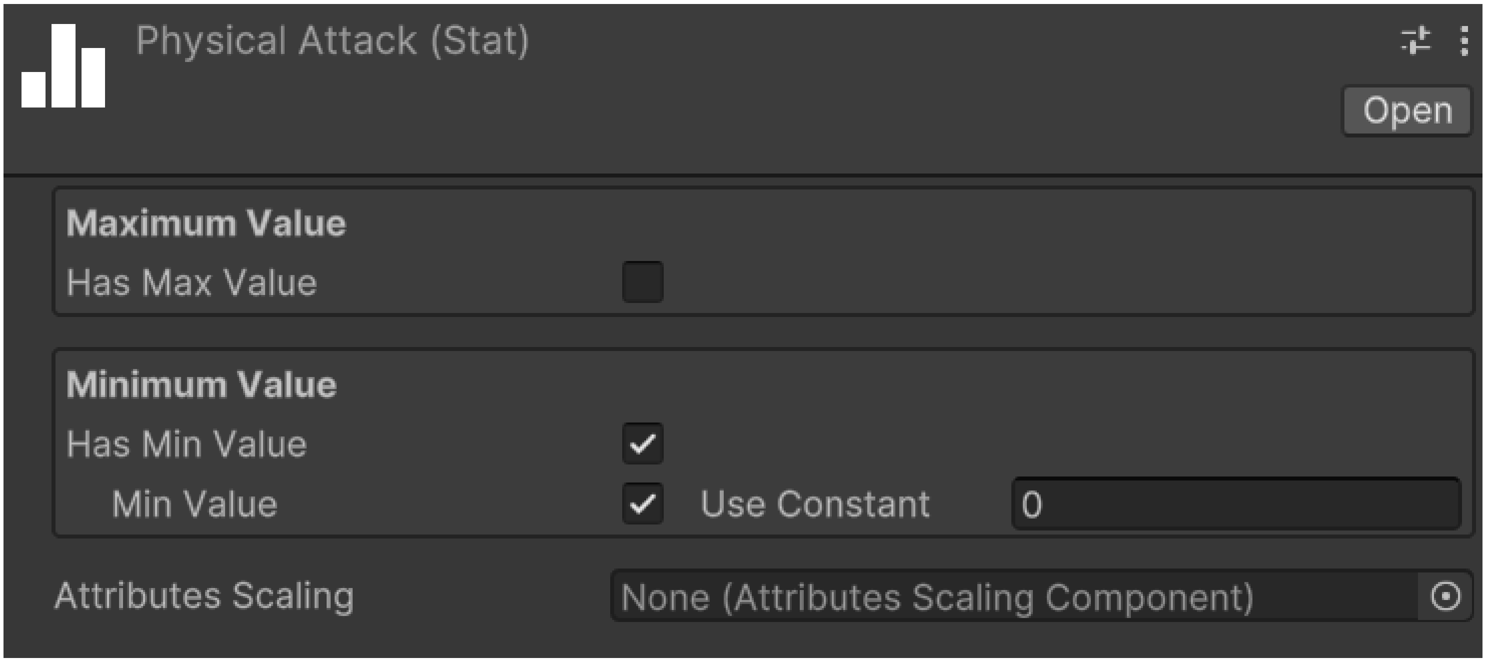
This will spend 2 points on the `Strength` attribute, increasing its value by 2. If there are not enough available points, a Debug.LogError will be raised.

> **NOTE**
> Debug.LogError messages are shown only in development builds. If you run a production build, you won't see them. This is useful to avoid cluttering the console with error messages that are not relevant in production.

Create stats

Keyboard shortcut: `Ctrl + Alt + S`
Relative path: `Stat`

As with attributes, you can create stats as you wish and assign them the names you prefer. Let's create the `Physical Attack` stat together. Create a new `Stats` folder, select it and press `S`. Name it `Physical Attack`. In the inspector, it should look like this:



As with attributes, you can assign both a maximum and a minimum value to a stat.

Repeat the process for the `Magical Power`, `Defense`, and `Critical Chance` stats.

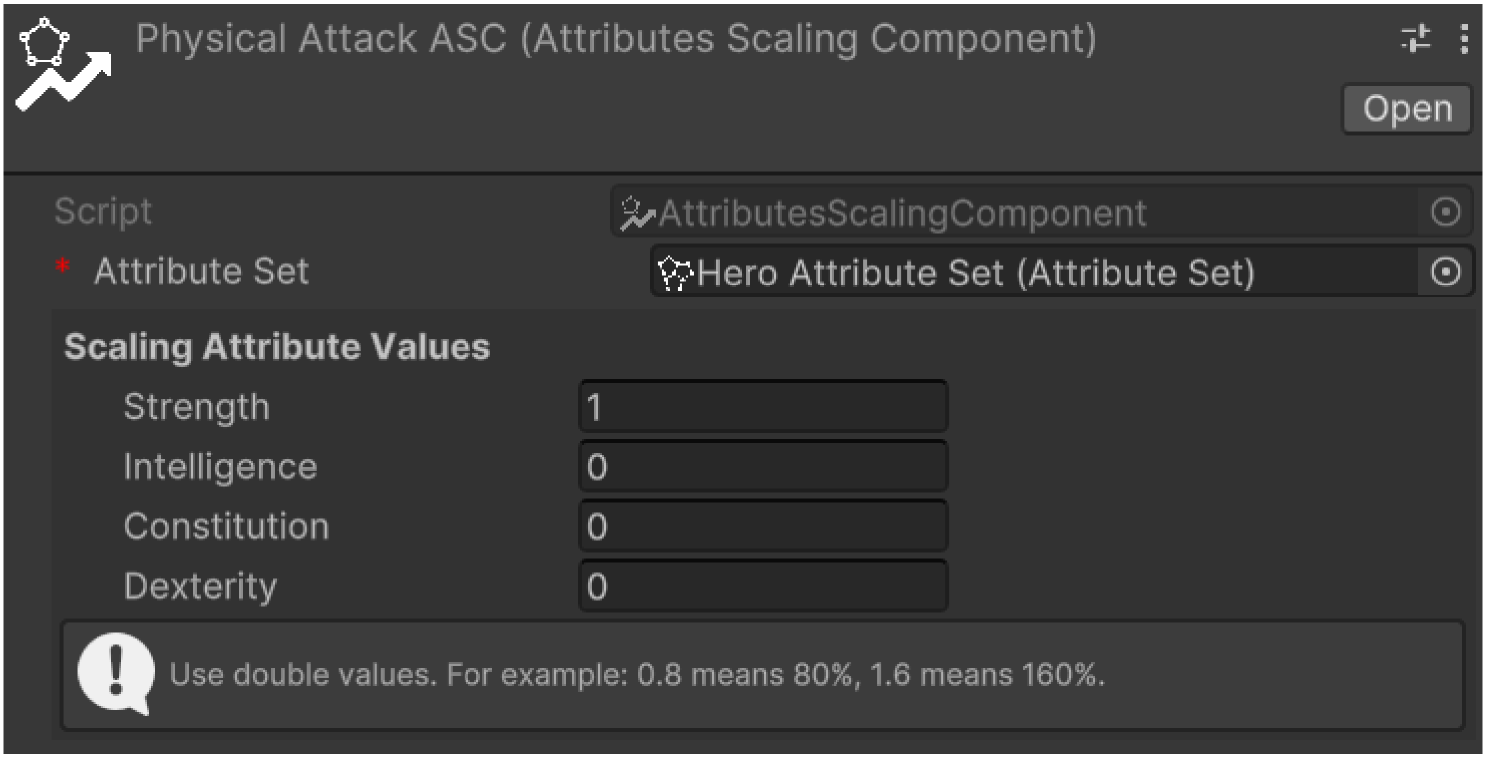
Unlike attributes, however, stats include `Attributes Scaling`.

Create an Attribute Scaling Component for Stats

Relative path: `Scaling -> Attribute Scaling Component`

Let's create a new `Attribute Scaling Component` to use with the strength stat we created earlier. Create a new folder named, for example, `Attribute Scalings for Stats`, and inside it, create an attribute scaling component called `Physical Attack Strength Scaling`.

Assign the previously created `Hero Attribute Set` to the `Set` field. You will see the attributes of the set appear. Here, you can assign scaling values using `double`. For example, set the scaling of `Strength` to `1.0`. This component defines a 100% scaling on the value of `Strength`.



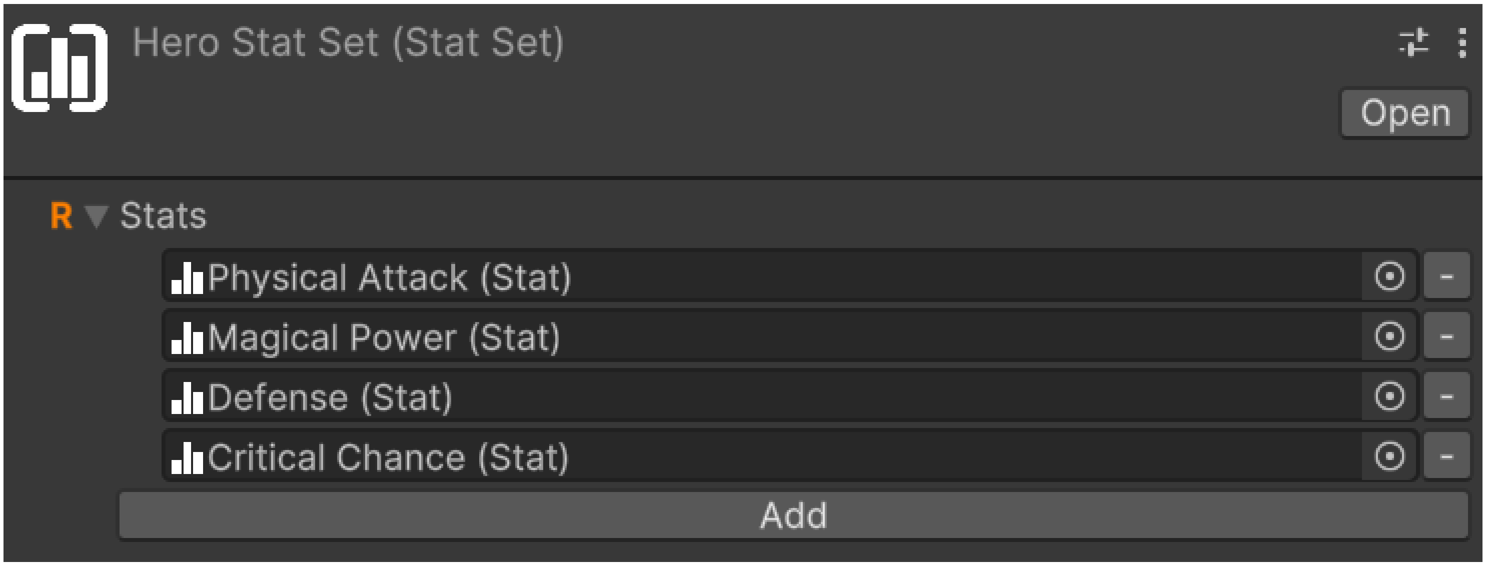
Now, assign this scaling component to the `Physical Attack` stat to ensure it scales with the `Strength` attribute.

Create a stat set

Relative path: `Stat Set`

Now that we have some stats, let's create a `StatSet` named, for example, `Hero Stat Set`.

A stat set without stats isn't very useful, so let's add the previously created ones, one at a time. To do this, click on the `Add` button. Notice that an entry with `None (Stat)` appears. To assign a stat to the entry, we can either drag & drop from the hierarchy or click on the small circle button on the right of the newly appeared entry. This mechanism is the same used for public variables or, more generally, for fields annotated with `SerializeField`, so it will be familiar to you.
Let's add `Physical Attack` using whichever method you prefer.
Repeat the process of adding a stat to the set for `Magical Power`, `Defense`, and `Critical Chance` as well.
The stat set should look like:



If you want to remove a stat from the set, you can click on the small `-` button on the right of the stat you want to remove.

Modular stat sets

Stat sets can include other stat sets, allowing for modular and reusable configurations. This is particularly useful if we have various kind of entities that share some stats but not all of them. For example, let's consider three entities: a deer, a ballista turret, and our hero character. The deer can take damage, move around, and cannot attack. The turret instead can take damage, deal damage, but cannot move. The hero can do all three things.

A first approach could be to create three distinct stat sets for each entity, but this would lead to a lot of redundancy since many stats would be repeated across the three sets. What if we decide to add a new stat that all three entities should have? We would have to remember to add it to all three sets, which is error-prone and inefficient. Alternatively, we could use a single all-embracing stat set that includes all the stats needed by all entities. However, this would lead to unnecessary complexity for entities that don't need all those stats, making it harder to manage and understand.

A better approach is to create modular stat sets that can be combined as needed. We can create three stat sets:

- `Damageable Stat Set`: includes stats like `Armor`, `Magical Defense`, `Dmg Reduction`, and so on
- `Damage Dealer Stat Set`: includes stats like `Physical Attack`, `Magical Power`, `Critical Chance`, and so on
- `Movable Stat Set`: includes stats like `Movement Speed`, `Jump Height`, etc.

Then, we can create three additional stat sets for our entities:

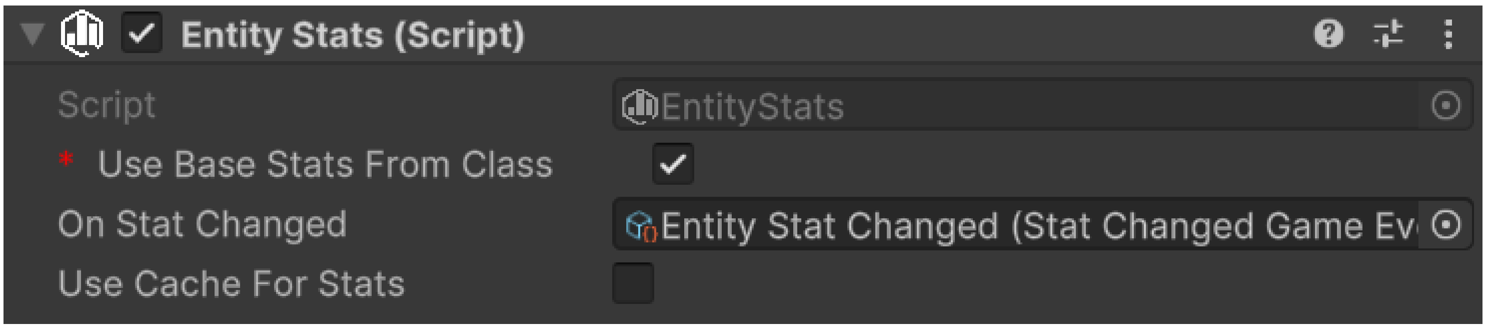
- `Pray Stat Set` for the deer, which includes only the `Damageable Stat Set` and the `Movable Stat Set`

- `Turret Stat Set` for the ballista turret, which includes only the `Damageable Stat Set` and the `Damage Dealer Stat Set`
- `Hero Stat Set` for our hero character, which includes all three stat sets: `Damageable Stat Set`, `Damage Dealer Stat Set`, and `Movable Stat Set`

This modular approach allows us to reuse stat configurations across different entities, reducing redundancy and making it easier to manage and update stats.

Add `EntityStats` to an Entity

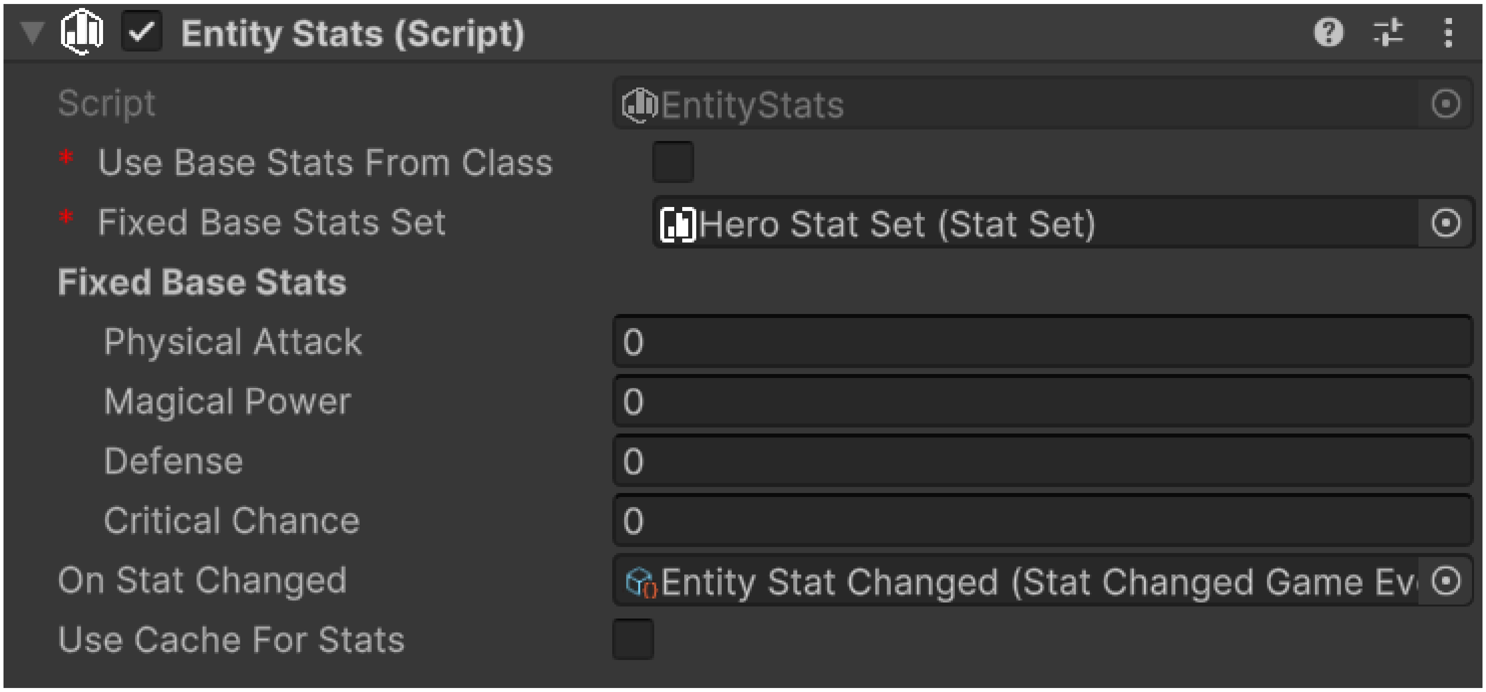
The next step is to assign the stat set we created to an entity. To do this, let's add the `EntityStats` component to our game object. The inspector will look like this:



An entity has base stats that can be either fixed or derived from a class. Additionally, stats can be modified through flat modifiers, stat-to-stat modifiers, and percentage modifiers.

`Use Class Base Stats` checkbox determines whether the base stats should come from the entity's class (if one is available) or from fixed values defined in the inspector. For now, let's leave it unchecked since we haven't added a class yet.

With `Use Class Base Stats` unchecked, we need to manually assign a stat set. Set the `Stat Set` field under `Fixed Base Stats` with our `Hero Stat Set`. This will reveal additional fields in the inspector where we can set the base values for each stat:



`On Stat Changed` event gets raised whenever any stat value changes due to modifiers. You can use this to update UI elements or trigger other game logic.

`Use Cache` enables caching of final stat values. This is useful for performance when you have many entities or complex stat calculations.

Understanding Stat Modifier Types

The framework provides three distinct types of stat modifiers, each serving different purposes and applied in a specific order during final value calculation. Understanding how each type works is crucial for creating balanced and predictable stat systems.

> **NOTE**
>
> **General considerations for stat modifiers**
>
> - If cache is being used: when adding modifiers through code, the attribute cache will automatically be invalidated to ensure the correct value is returned on the next access
> - When adding modifiers through code, the `OnStatChanged` event will automatically be raised if the final value changes.

Flat Modifiers

Flat modifiers add or subtract a fixed amount to a stat's value. They are the simplest type of modifier and are applied directly after the base value.

Use cases:

- Equipment bonuses (e.g., +5 Physical Attack from a sword)
- Temporary buffs (e.g., +10 Defense from a shield spell)
- Status effects that provide fixed bonuses or penalties

Code example:

```
// Add a flat +15 bonus to Physical Attack
entityStats.AddFlatModifier(physicalAttackStat, 15);

// Add a flat -5 penalty to Defense (negative values work too)
entityStats.AddFlatModifier(defenseStat, -5);
```

Calculation example:

- Base Physical Attack: 50
- Flat modifier: +15
- Result after flat modifiers: 50 + 15 = 65

Stat-to-Stat Modifiers

Stat-to-stat modifiers allow one stat to contribute a percentage of its value to another stat. This creates interesting dependencies between different stats and allows for more complex character builds.

These modifiers are applied right after the flat modifiers.

Use cases:

- Cross-stat synergies (e.g., 25% of Armor is added to Physical Attack).

> **WARNING**
>
> When using stat-to-stat modifiers, **only the base value and flat modifiers of the source stat are used** in the calculation. Stat-to-stat modifiers and percentage modifiers applied to the source stat are ignored. This ensures predictable and non-circular calculations.

Code example:

```
// 25% of armor is added to physical attack
entityStats.AddStatToStatModifer(physicalAttackStat, armorAttribute, 25);

// Negative modifier: -10% of armor is subtracted from physical attack
entityStats.AddStatToStatModifer(physicalAttackStat, armorAttribute, -10);
```

Calculation example:

- Base Physical Attack: 50
- Flat modifier: +15 (from previous step)
- Current value: 65
- Armor value: 40
- Stat-to-stat modifier: 50% of Armor = 40 × 0.5 = 20
- Result after stat-to-stat modifiers: 65 + 20 = 85

Important notes:

- The source stat's base value + its flat modifiers is used for calculation
- Multiple stat-to-stat modifiers from different sources are additive, and order of calculation is commutative
- You can have the same source stat contribute to multiple target stats
- Circular dependencies can be defined, as the base values + flat modifiers are used for calculations

Percentage Modifiers

Percentage modifiers apply a multiplicative increase or decrease to the current stat value. They are applied last in the calculation chain. Because of this, they can have a significant impact on the final value.

Use cases:

- Powerful equipment bonuses (e.g., +25% damage increase)
- Character traits or talents (e.g., "Warrior's Might: +20% Physical Attack")
- Temporary powerful buffs or debuffs

Code example:

```
// Add a 25% increase to Physical Attack
entityStats.AddPercentageModifier(physicalAttack, 25);

// Add a 15% decrease to movement speed (negative percentage)
entityStats.AddPercentageModifier(movementSpeed, -15);
```

Calculation example:

- Previous value: 85 (from previous steps)
- Percentage modifier: +25% = 85 × 0.25 = 21.25
- Final result: 85 + 21.25 = 106.25 (rounded to 106 for integer stats)

Important notes:

- Multiple percentage modifiers are additive before being applied (e.g., +25% and +15% = +40% total)
- The percentage is calculated based on the value after flat and stat-to-stat modifiers
- Percentage modifiers can be negative to create penalties

Complete Calculation Example

Let's see a complete example with all three modifier types:

Initial setup:

- Base Physical Attack: 100
- Armor value: 60 (base + flat modifiers)

Applied modifiers:

1. Flat modifier: +20 (from weapon)
2. Stat-to-stat modifier: 75% of Armor = 60 × 0.75 = 45
3. Percentage modifier: +30% (from various sources)

Step-by-step calculation:

1. Start with base: 100
2. Apply flat modifiers: 100 + 20 = 120
3. Apply stat-to-stat modifiers: 120 + 45 = 165
4. Apply percentage modifiers: 165 + (165 × 0.30) = 165 + 49.5 = 214.5 → 214

Final Physical Attack value: 214

> ⓘ **NOTE**
>
> The framework does not provide a built-in tool for removing applied modifiers. It is up to you to define your own abstraction for buffs, debuffs, or other temporary effects that add and remove modifiers as needed. In the future, the SOAP RPG Modifiers extension for this framework will be released, which will include such abstractions thought to integrate seamlessly with the existing systems. Check the status of the extension for more details at https://electricdrill.github.io/

Retrieving Stat Values from code

Due to the relevance of retrieving stat values from code, the methods to do so are worth mentioning here.

To retrieve the final value of a stat, you can use the `Get` method:

```
// phyAtkStat is a reference to the Physical Attack Stat
int physicalAttack = entityStats.Get(phyAtkStat);
```

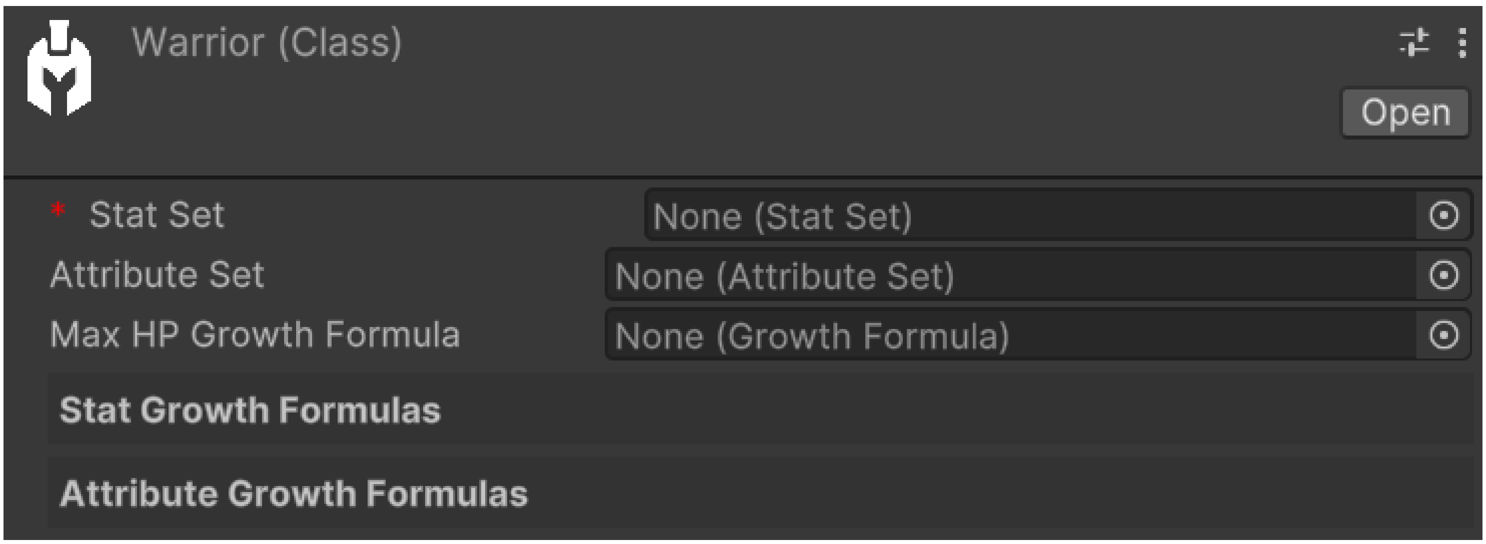
To retrieve the base value of a stat, you can use the `GetBase` method:

```
// phyAtkStat is a reference to the Physical Attack Stat
int basePhysicalAttack = entityStats.GetBase(phyAtkStat);
```

Create a class

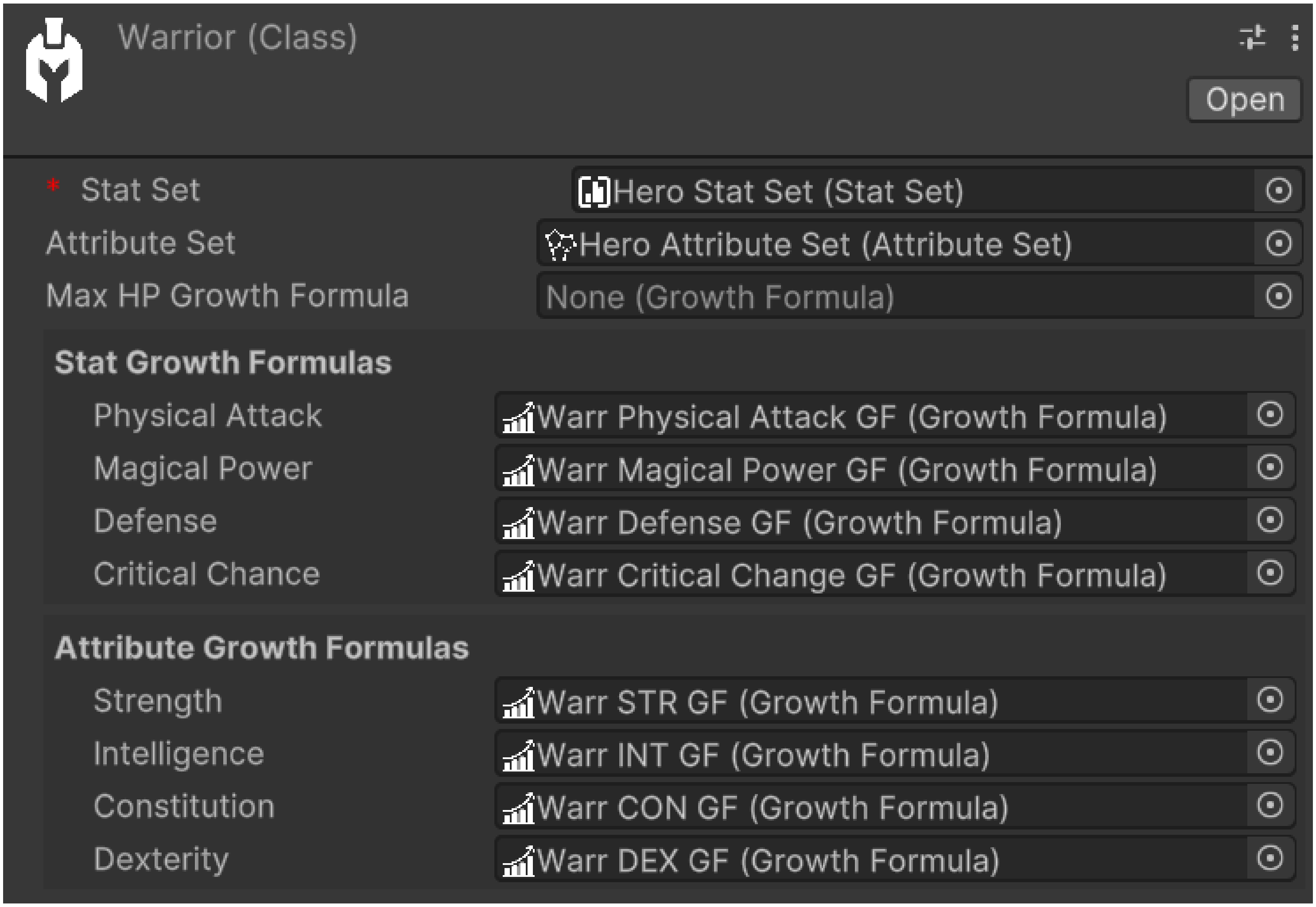
Relative path: `Class`

Let's create an instance of `Class` called `Warrior`. It should appear like this:



The only mandatory field is `Stat Set`. If we don't make use of attributes and Max HP, we can leave the `Attribute Set` and `Max HP Growth Formula` fields empty.

In our case, let's assign our `Hero Stat Set` to `Stat Set` and `Hero Attribute Set` to `Attribute Set`. This way, the `Warrior` will have access to all stats and attributes from the assigned `Stat Set` and `Attribute Set`. As we fill these two fields, we'll see that the `Stat Growth Formulas` and `Attribute Growth Formulas` sections will automatically populate with the stats and attributes from the assigned `Stat Set` and `Attribute Set`. Let's proceed to create all the growth formulas for the warrior's stats and attributes. Follow the steps outlined in the [Growth Formulas](#) section to create the growth formulas for the warrior's stats and attributes.
Once all growth formulas are assigned, the `Warrior` should look like this:

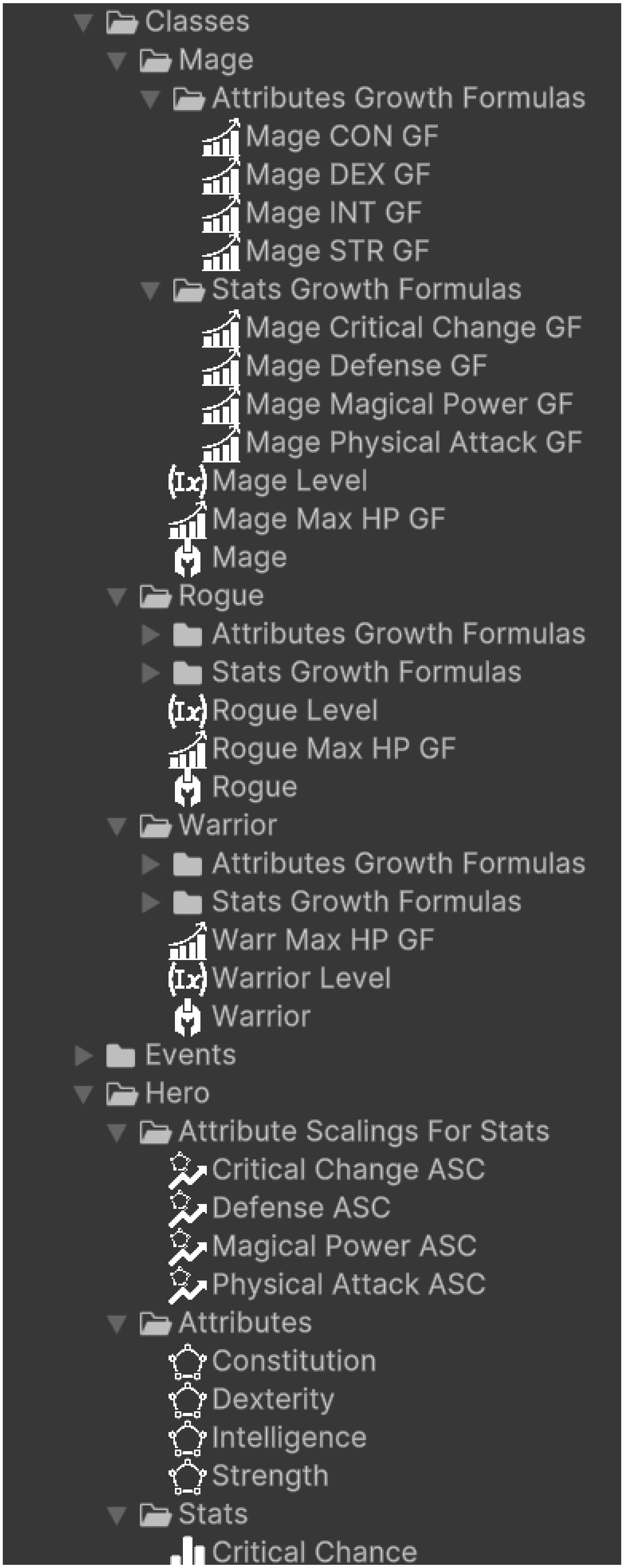


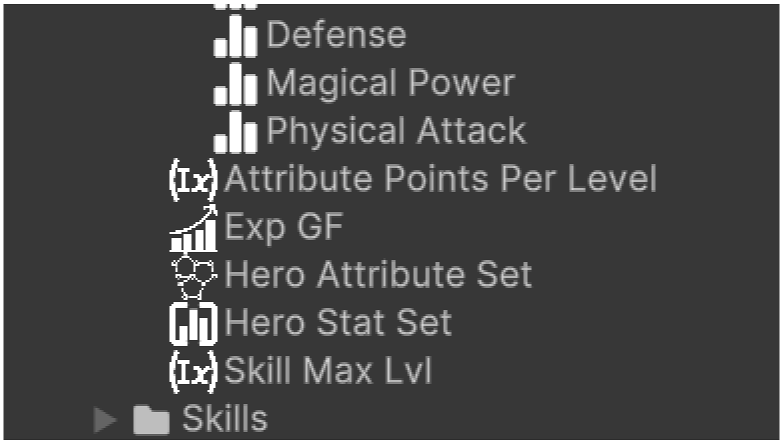
`Max HP Growth Formula` allows specifying how the Max HP value grows as levels change. In our example, we'll leave it empty. The presence of this field for hit points might be surprising since this module of the framework isn't focused on health management. Indeed, damage and health are managed by the *Health&Dmg | Soap RPG Framework* module, which will be released in the coming months. However, this field is positioned here since the scaling of base max hp still depends on the class.

Keeping the hierarchy clean

By now you should have a lot of assets in your hierarchy. To keep it clean, you can create a folder named `Classes` and move the `Warrior` class inside it. You can do the same for the `Attributes` and `Stats` growth formulas inside the `Warrior` folder. This way, you can keep the hierarchy organized and easily find the assets.
Similarly, the `Hero Stat Set` and `Hero Attribute Set` could be placed in a `Hero` folder, that is common to all the classes. This way, you can have a single set of stats and attributes for all the classes that will be created in the future.

This is how your hierarchy could look like:

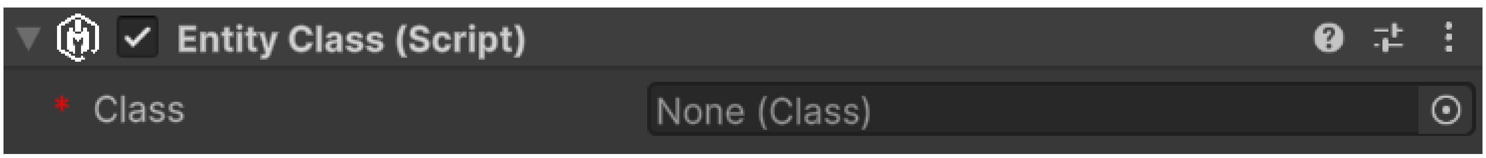

Classes
Mage
Attributes Growth Formulas
Mage CON GF
Mage DEX GF
Mage INT GF
Mage STR GF
Stats Growth Formulas
Mage Critical Change GF
Mage Defense GF
Mage Magical Power GF
Mage Physical Attack GF
Mage Level
Mage Max HP GF
Mage
Rogue
Attributes Growth Formulas
Stats Growth Formulas
Rogue Level
Rogue Max HP GF
Rogue
Warrior
Attributes Growth Formulas
Stats Growth Formulas
Warr Max HP GF
Warrior Level
Warrior
Events
Hero
Attribute Scalings For Stats
Critical Change ASC
Defense ASC
Magical Power ASC
Physical Attack ASC
Attributes
Constitution
Dexterity
Intelligence
Strength
Stats
Critical Chance



Obviously this is just a possible organization of the assets. Feel free to organize it as you prefer.

Add `EntityClass` to an entity

To assign a class to an entity, we need to add the `EntityClass` component to it. The inspector will look like this:



All we have to do now is just assign the `Warrior` class we created earlier to the `Class` field.

Switching to class-based attributes and stats

We can now check the `Use Class Base Attributes` and `Use Class Base Stats` checkboxes. By doing this, the entity will use the base attributes and stats defined by the class. The `Fixed Base Attributes` and `Fixed Base Stats` fields will be disabled, and the values will be automatically retrieved from the class growth formulas.

Retrieving class-based values from code

With a class we can access:

- attributes values: `GetAttributeAt(Attribute attribute, int level)`
- stats values: `GetStatAt(Stat stat, int level)`
- Max HP values: `GetMaxHpAt(int level)` For example:

```
// hero is a reference to the EntityCore component of the hero
EntityClass warriorClass = hero.GetComponent<EntityClass>();
// hero.Level is of EntityLevel type, but it is implicitly be converted to an int
int level = hero.Level;
int strengthAtLevel5 = warriorClass.GetAttributeAt(strengthAttribute, level);
```

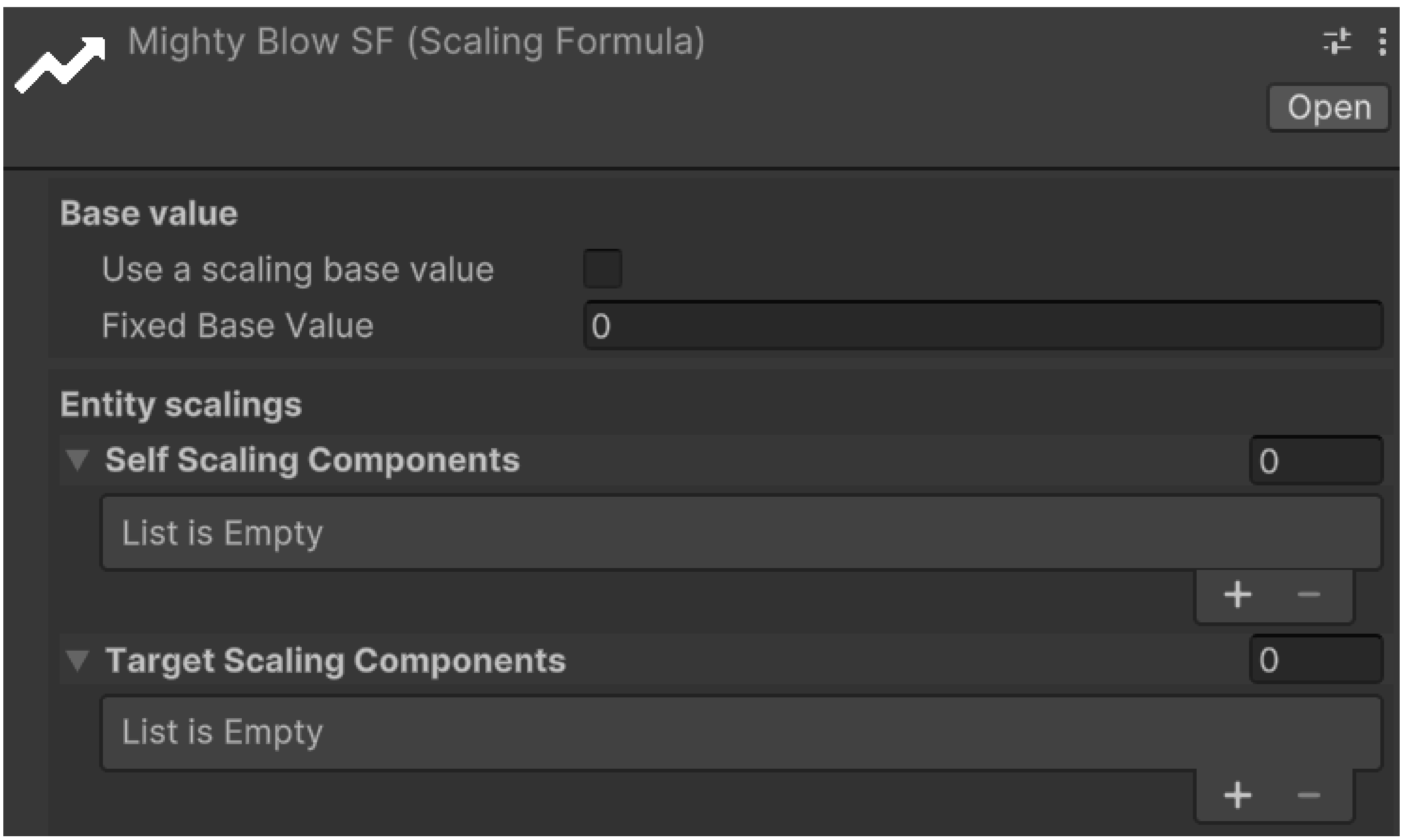
```
int physicalAttackAtLevel5 = warriorClass.GetStatAt(phyAtkStat, level);
int maxHpAtLevel5 = warriorClass.GetMaxHpAt(level);
```

Create Scaling Formulas

Keyboard shortcut: `Alt + Shift + S` *Relative path:* `Scaling -> Scaling Formula`

We already saw how to create an `Attribute Scaling Component` for stats. On top of such usage, scaling components, and more in general scaling formulas, can be used for much more situations. For example, they can be used to define the damage of an ability, to define the bonus granted by a piece of equipment, or to define the damage of a weapon. In general, they can be used to define any kind of scaling that can be expressed as a function of one or more variables.

For example, let's create a `Scaling Formula` called `Mighty Blow SF`. It should look like this in the inspector:

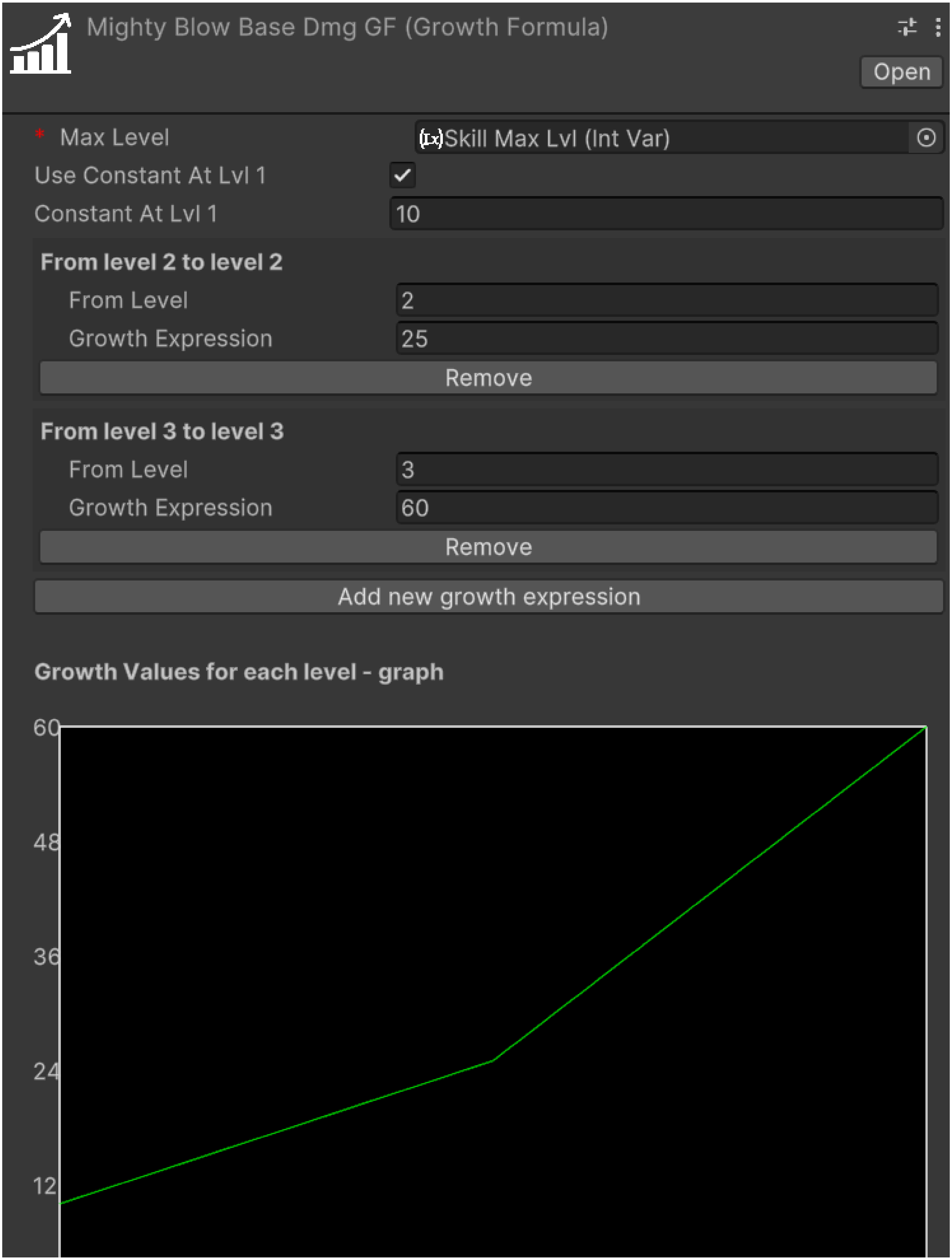


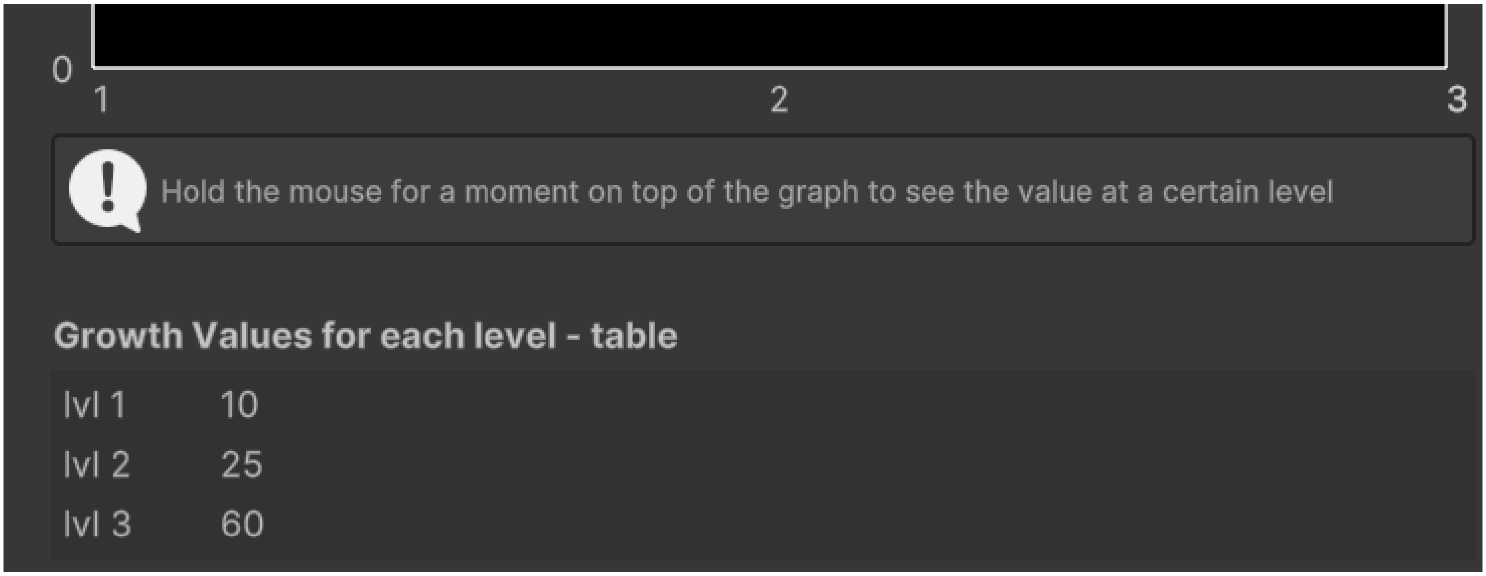
`Base Value` determines the starting point for the scaling formula. It can either be a fixed constant value or a value that scales with levels (e.g., the level of the Mighty Blow skill). If the latter is chosen, a `Growth Formula` must be provided to define how the base value changes as levels increase.

This scaling formula will be used to define the damage of a skill called `Mighty Blow`. The scaling formula will be defined as follows:

- Base damage: 10 at lvl 1, 25 at level 2, 60 at lvl 3
- Damage scaling: 1.5 * Physical Attack + 0.5 * Constitution

Since we want a base value that varies as level grows, let's check the `Use a scaling base value` checkbox and create a `Growth Formula` named `Mighty Blow Base Dmg GF`. The `Mighty Blow Base Damage GF` should look like this:


Mighty Blow Base Dmg GF (Growth Formula)
Open
* Max Level
Skill Max Lvl (Int Var)
Use Constant At Lvl 1
Constant At Lvl 1
10
From level 2 to level 2
From Level
2
Growth Expression
25
Remove
From level 3 to level 3
From Level
3
Growth Expression
60
Remove
Add new growth expression
Growth Values for each level - graph
60
48
36
24
12



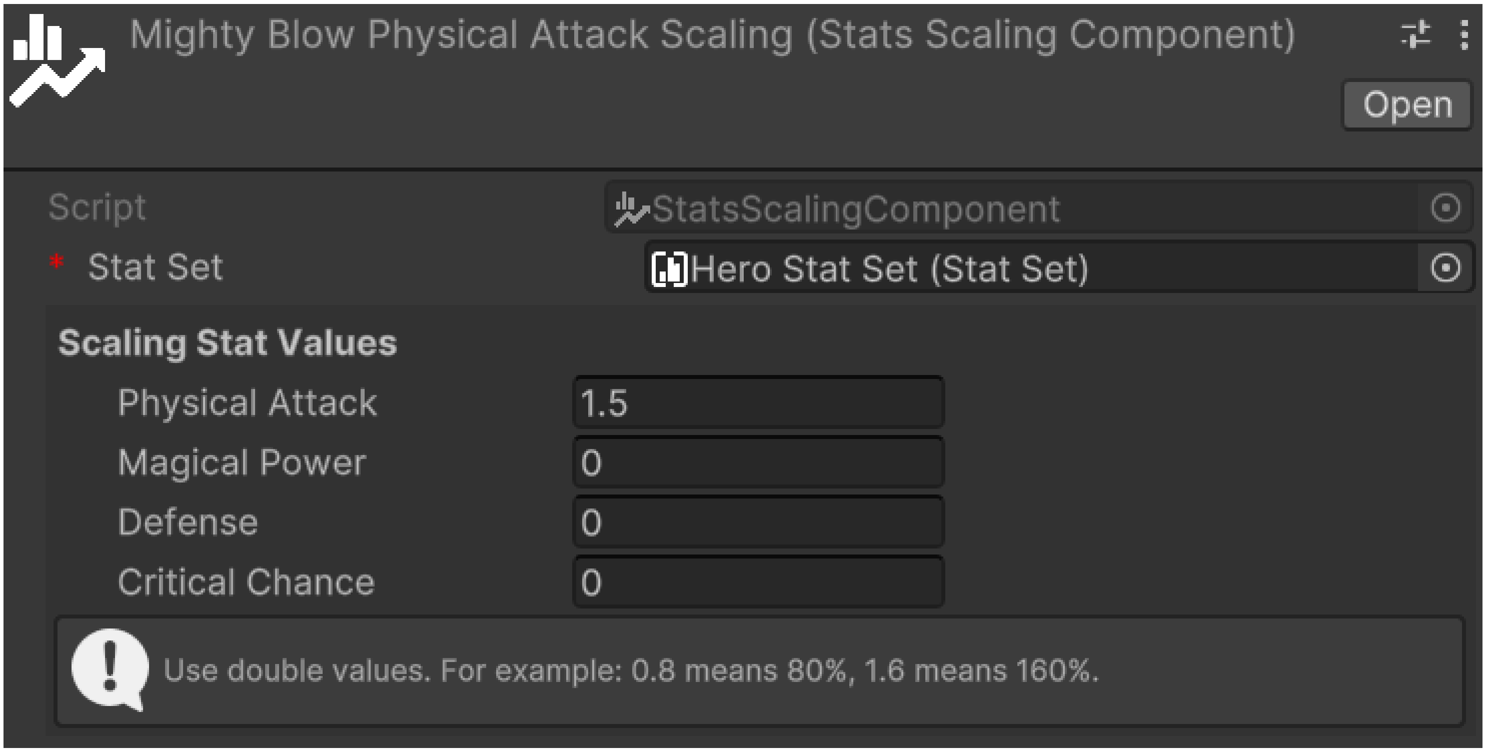
Notice that a new Skill Max Lvl has been created and assigned to `Max Level`. This is necessary as the skill max level is not related to the max level of our hero.

We can now assign this growth formula to the `Base Value` field of the `Mighty Blow SF` scaling formula.

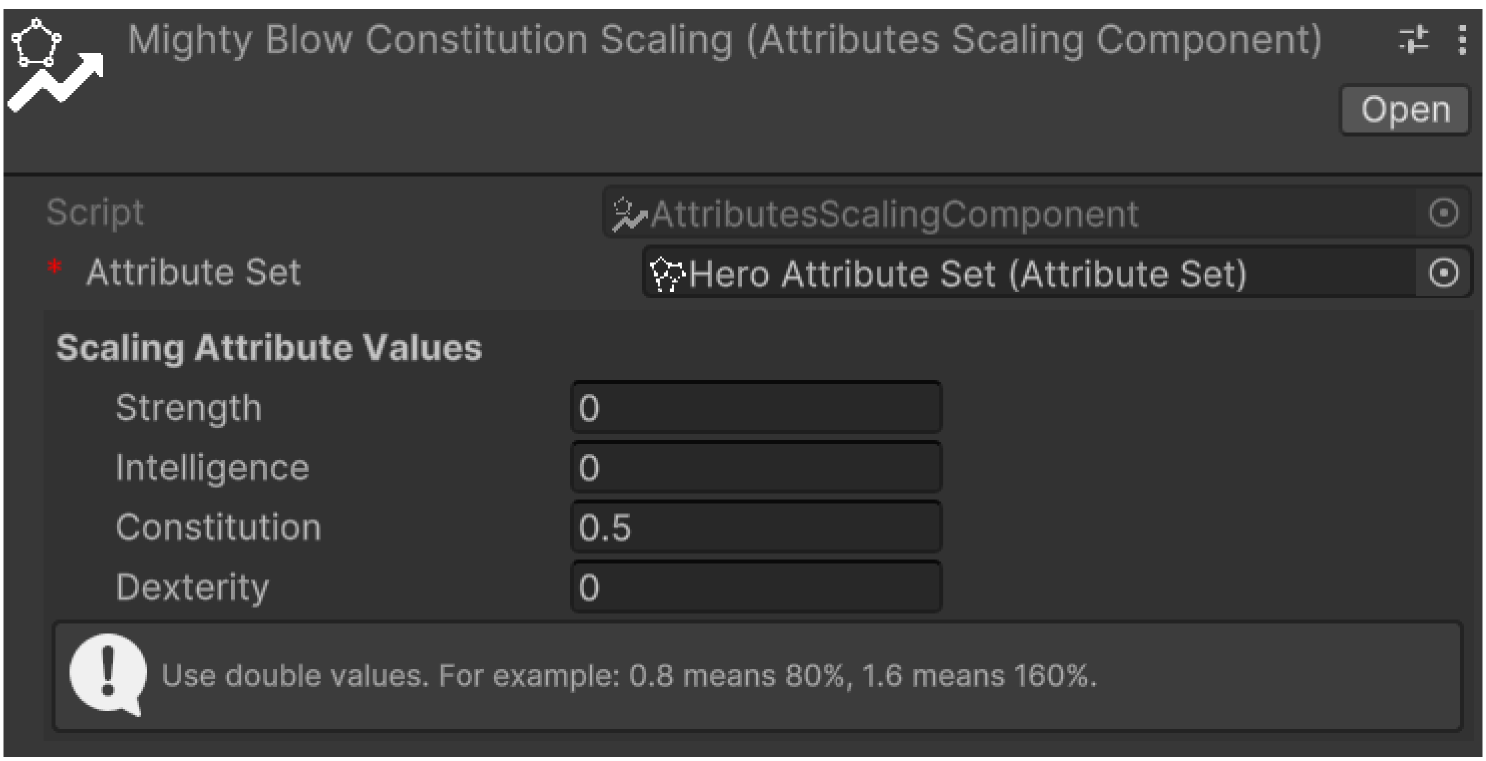
Under `Entity Scalings` we have `Self Scaling Components` and `Target Scaling Components`. The former are used to define the scaling of the entity itself, while the latter are used to define the scaling of the target of the ability. In our case, we will only use `Self Scaling Components`, so we can leave `Target Scaling Components` empty.

We can now proceed to create the scaling components for the `Physical Attack` stat and the `Constitution` attribute.

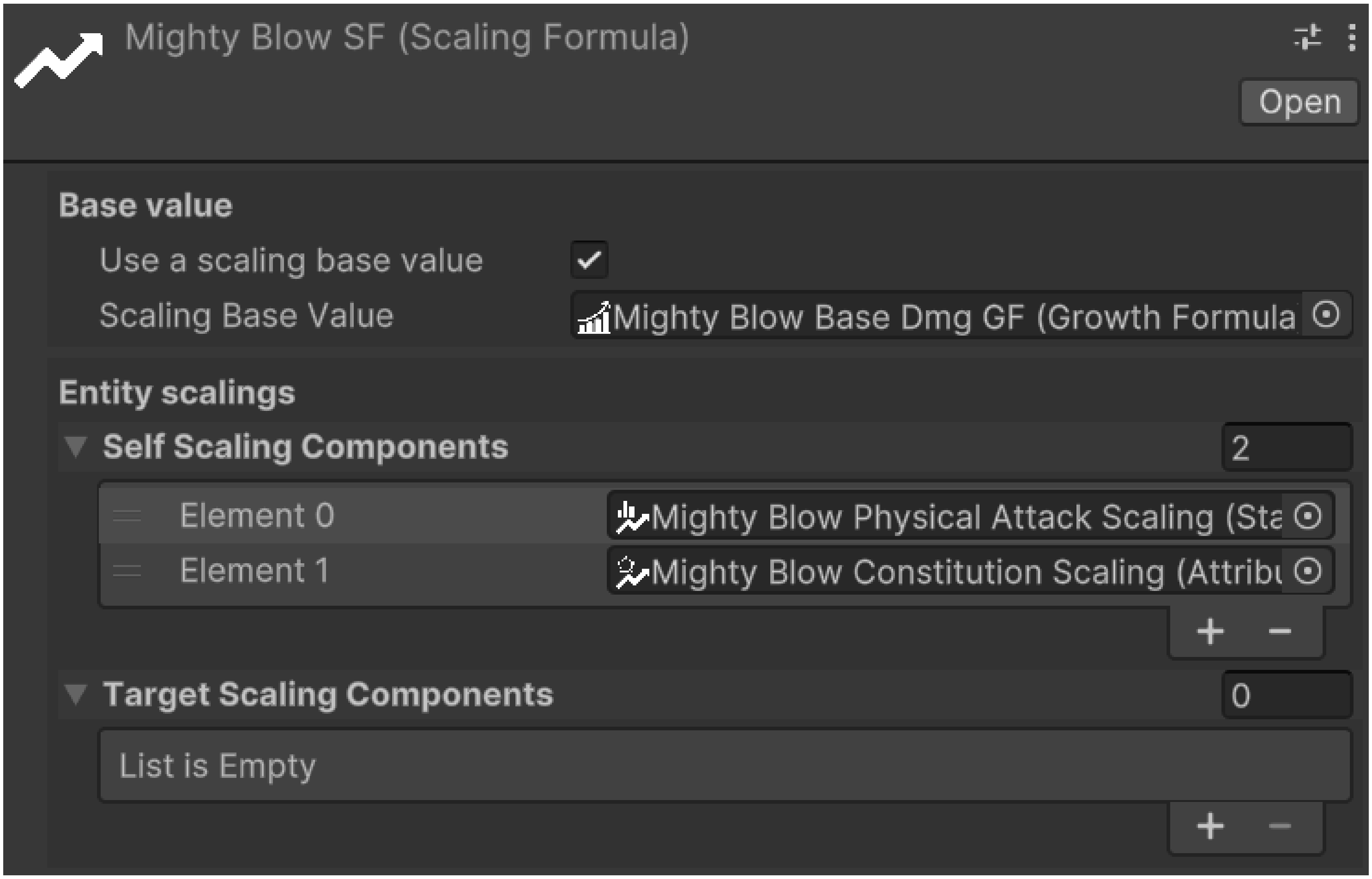
Let's create a new `Stat Scaling Component` called `Mighty Blow Physical Attack Scaling`. Assign the `Hero Stat Set` to it and set the scaling of the `Physical Attack` stat to `1.5`. The scaling component should look like this:



Next, we will create a similar `Attribute Scaling Component` for the `Constitution` attribute called `Mighty Blow Constitution Scaling`. Assign the `Hero Attribute Set` to it and set the scaling of the `Constitution` to `0.5`. The scaling component should look like this:



Finally, let's press on the `+` of `Self Scaling Components` and assign the two scaling components we just created. The `Mighty Blow SF` should look like this:



Using scaling formulas in code

First of all, `ScalingFormula`s expose two code-only properties: `List<ScalingComponent> TmpSelfScalingComponents` and `List<ScalingComponent> TmpTargetScalingComponents`. These properties can be used to add scaling components to the scaling formula at runtime. This is useful when you want to dynamically change the scaling components based on certain conditions or game states, without changing the original serialized scaling formula asset. For example, the character could get a temporary buff that makes the, let's say, `Mighty Blow` skill scale also with the `Intelligence` attribute. In this case, we can add a `Attribute Scaling Component` for the `Intelligence` attribute to the `TmpSelfScalingComponents` list of the `Mighty Blow SF` scaling formula.

If the buff wears off, we can remove the scaling component from the `TmpSelfScalingComponents` list.

There is also a method for resetting all the temporary scaling components: `ResetTmpScalings()`. This method can be useful, for example, when the player completes a room and advances to the next stage or area of the game, and you want to clear all temporary buffs the character received during that stage.

Moreover, there are four more methods that are worth mentioning:

- `long CalculateValue(EntityCore self)`: Calculates the value of the scaling formula by summing the value returned by each self scaling component (calculated on the entity itself values), there must not be any target scaling components.

- `long CalculateValue(EntityCore self, int level)`: If the scaling formula has a base value that varies with levels, this method calculates the value of the scaling formula for the entity itself, and adds the base value at a specific level. Again, there must not be any target scaling components.
- `long CalculateValue(EntityCore self, EntityCore target)`: Calculates the value of the scaling formula by summing the value returned by each self scaling component (calculated on the entity itself values) and each target scaling component (calculated on the target entity values).
- `long CalculateValue(EntityCore self, EntityCore target, int level)`: Calculates the value of the scaling formula by summing the value returned by each self scaling component (calculated on the entity itself values) and each target scaling component (calculated on the target entity values), and adds the base value at a specific level.

Game Events

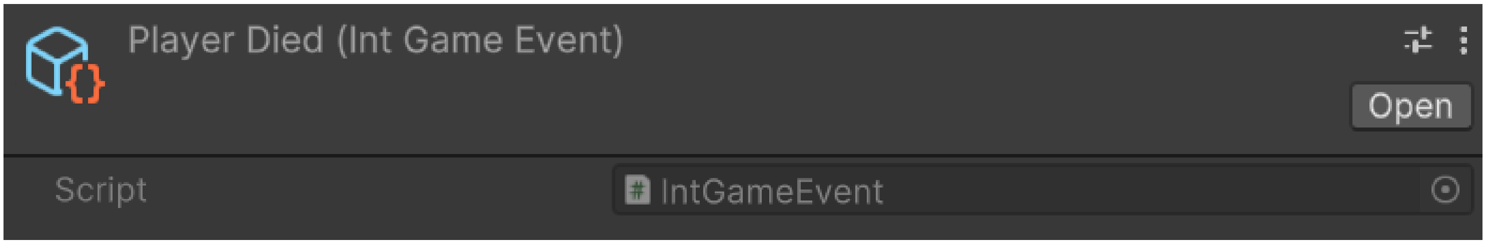
Relative path: `Events -> Game Event` *Relative path for custom game events:* `Events -> Generated -> *CustomEventName*`

At the beginning of this page we briefly mentioned the concept of game events as scriptable objects, and we have introduced the generic `GameEvent`. Such event is great for notifying actions that happen in the game, but it has limited flexibility as it is not carrying along any context information. For example, if we want to notify that a character has leveled up, we might want to pass along the entity that leveled up and the new level reached. In other cases it could be useful to pass along with the event a reference to the entity that triggered the event, so we would like to be able to pass a reference of type `EntityCore` as context parameter. And so on.
The framework comes along with some pre-defined game events:

- `IntGameEvent`: an event that carries along an `int` as context parameter
- `EntityCoreGameEvent`: an event that carries along an `EntityCore` as context parameter
- `EntityLeveledUpGameEvent`: an event that carries along an `EntityCore` and an `int` as context parameters, where the `EntityCore` is the entity that leveled up and the `int` is the new level reached
- `StatChangedGameEvent`: an event that carries along a `StatChangeInfo` context parameter, which contains:
  - A reference to the `EntityStats` component of the entity that has changed
  - The `Stat` that has changed
  - The previous value of the stat
  - The new value of the stat
- `AttributeChangedGameEvent`: an event that carries along an `AttributeChangeInfo` context parameter, which contains:
  - A reference to the `EntityAttributes` component of the entity that has changed
  - The `Attribute` that has changed
  - The previous value of the attribute
  - The new value of the attribute

Along with the game events, the frameworks provides the `*GameEventListener` counterparts, which are components that can be attached to a game object to listen for the events and execute a method when the event is raised. For example, `IntGameEventListener` listens for a specific `IntGameEvent` and executes a method that takes an `int` as parameter when the event is raised.

Let's suppose we need a game event for notifying, each time the player dies, how many times the player has died so far. In the inspector, create a new `IntGameEvent` called `PlayerDied`. It should look like this:



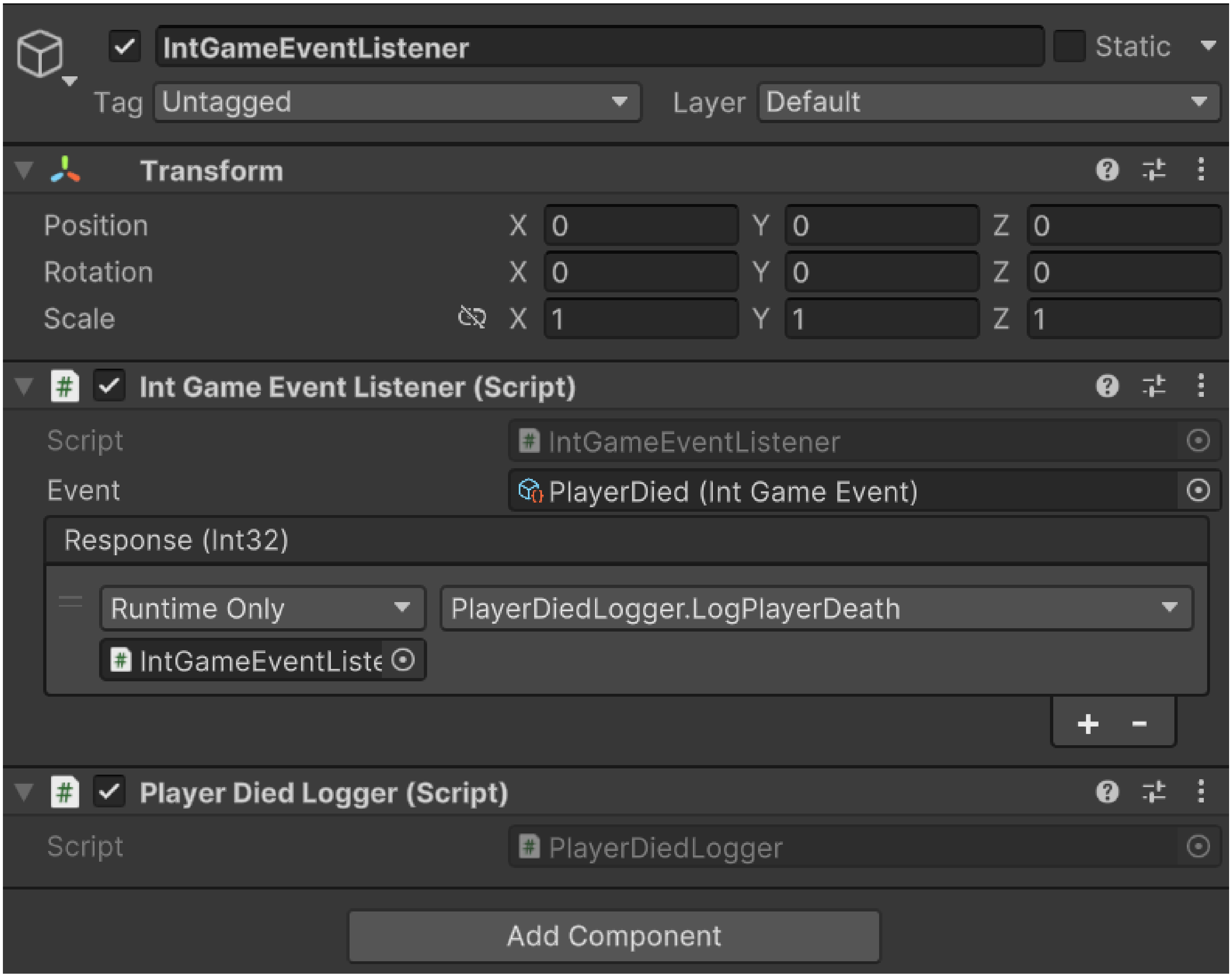
There are no fields to fill in the inspector. The integer to be passed as context parameter will be passed in the code that is responsible for raising the event.
The method to raise the event is `Raise(int value)`, which will raise the event and pass along the integer as context parameter. Therefore in a dedicated script you can call it like this:

```
public void OnPlayerDeath() {
    playerDeathCount++;
    // Assuming playerDiedEvent is a reference to the PlayerDied event
    playerDiedEvent.Raise(playerDeathCount);
}
```

Now let's create a listener for this event. Let's say that we want to show a message in the console when the event is raised. To do this, create a new game object in the hierarchy and add a script that defines a public method for logging an event, that takes an `int` as input parameter. It should be like:

```
public void LogPlayerDeath(int deathCount) {
    Debug.Log($"Player has died {deathCount} times.");
}
```

Now add the `IntGameEventListener` component to the listener game object and, in the inspector, assign the `PlayerDied` event to the `Event` field. Now drag the `Logger` script created before into the `Response`'s object selector. You should be able now to select the `LogPlayerDeath` method from the dropdown menu. The result should look like this:



This is a powerful mechanism that decouples the event producers from the event consumers, allowing for a more modular and maintainable codebase. And most of the setup is inspector-based. You just need to define the raising and the listening methods from code.

Game Event Generators

Relative path: `Events -> Game Event Generator`

> **WARNING**
>
> Game event generators are an experimental feature and may change in future releases.
> To avoid potential issues, it is recommended to back up or version control your project before renaming or moving the generated events to different folders.

Sometimes the pre-defined game events are not enough to cover all the use cases. In this case, you can create a custom game event generator. A game event generator is a scriptable object that lets you define a custom game events with up to four context parameters. You can choose the type of each parameter. Parameters can either be primitive types (like `int`, `float`, `string`, etc.) or more complex types (like `EntityCore`, `Stat`, `StatChangeInfo`, ..., or your own data types).

Game Event Generator setup

Let's create a custom game event generator to manage all the events related to the experience and leveling up of entities. Rename the newly created events generator `EntityLevelingEvents`. In the inspector, it should look like this:

With `Menu Base Path` we can change the path of the context menu where the generated events will be available for creation. By default, it is set to `Soap RPG Core -> Events -> Generated`, but we can change it to `Soap RPG Core -> Events/Generated/Experience` for the sake of organization.

With `Base Save Location` we can change the path where the source code files for the generated events will be saved. By default it is set to `Assets`, but for this example let's set it to `Assets/Events`.

Adding new events

Now let's create an event that will be raised when an entity grants experience to another entity. To do this, click on the `Add new event` button and fill in the fields as follows:

- `Event Name`: `EntityGrantedExp`
- `Documentation`: an entity granted experience to another entity
- `Parameters`: press the `+` button and add the following three parameters:
  - `Parameter Type` to `Mono Script`, `Mono Script` type to `EntityCore` (drag it from the Soap RPG Core folder)

  - `Parameter Type` to `Mono Script`, `Mono Script` type to `EntityCore` (drag it from the Soap RPG Core folder)
  - `Parameter Type` to `Native`, `Native type` to `long`

The first parameter represents the entity that granted the experience, the second parameter represents the entity that received the experience, and the third parameter represents the amount of experience granted.

Now let's press the `Generate Game Events` button to create the new event. We can now navigate to `Assets/Events/GeneratedEvents/EntityLevelingEvents` to find the following two folders:

- `GameEventListeners`: contains the source code for all the game event listeners generated by our `EntityLevelingEvents` game event generator.
- `GameEvents`: contains the source code for all the game events generated by our `EntityLevelingEvents` game event generator.

Inside both folders, you'll find a subfolder named `3`. The Game Event Generators organize the generated events in subfolders based on the number of parameters they have. In this case, we have a game event with three parameters, so it is placed in the `3` subfolder.

However, more interesting is the fact that if we now use the context menu and navigate to `Soap RPG Core -> Events -> Generated -> Experience`, we can find the `EntityGrantedExp` event.
From here, you can follow the same steps as for the pre-defined game events to create a listener for this event, and to wire it up to the appropriate game logic.

If you need to create more experience related events, you can repeat the process of adding new events to the `EntityLevelingEvents` game event generator.

After having generated the source code for the game events, you can also click on the `Remove Event` button under each Game Event to remove it from the generator and delete the generated source code files. It might be necessary to refresh (right click on an asset folder and select `Refresh`) the asset folder containing the generated events to see the changes reflected in the Unity editor.

> **WARNING**
>
> Pay attention that renaming or moving the generated events to different folders will cause the game event generator to lose track of them. If you change the `Base Save Location` and then re-generate the events, the game event generator will first delete the old files and then create new source code files in the new location. This means that any references to the old files will be lost, so you will need to reassign them in the inspector or in the code. This can be highly disruptive if you have many references to the old files, so it is recommended to back up or version control your project before renaming or moving the generated events to different folders.
> To safely move files you should move them from the Unity editor and then update the `Base Save Location` field in the game event generator to match the new location of the generated events. This way, the game event generator will be able to find the generated events in the new location and will not attempt to delete/recreate them.
> Same applies if you rename the game event generator itself. If you want to rename it, you should do it from the Unity editor and then update the `Event Name` field in the game event generator to match the new name of the game event generator.

Limitations

- `OnStatChangedEvent` is risen only when modifiers are applied, not on level-ups/base stat changes
- `OnAttributeChangedEvent` is risen only when modifiers are applied and spendable points are assigned, not on level-ups/base attribute changes
- Currently, multi-classing is not supported. Each entity can only have one class at a time
- Stat modifiers are applied in the following order:
  1. Flat modifiers
  2. Stat-to-stat modifiers
  3. Percentage modifiers
- Stat-to-stat modifiers use the base value and the flat modifiers for the source stat for the calculations. This ensures that the modifiers are applied consistently and predictably, and that circular dependencies can be defined without issues.
- Attribute modifiers do not have a attribute-to-attribute modifier system. This was a design choice to keep the system simpler.
- Attribute modifiers are applied in the following order:
  1. Flat modifiers
  2. Percentage modifiers
- Only one event for stats changed, attributes changed, and entity spawned can be assigned to entities. However, multiple event listeners can be assigned for the same event type, allowing for multiple responses
- Custom game event generators support up to four context parameters. To work around this limitation, users can combine multiple pieces of data into a single user-defined class—a technique known as "parameter packing." This approach is extensible through inheritance and helps maintain a simple, user-friendly API by avoiding telescoping parameters.

Requirements

- Unity 2022.3.50f1 or later

Package Contents

The relevant content for you consists of the package samples and the "utility events" contained in the package folder (located in `/Packages`).

For more information about the samples, see the [Samples] documentation.

The "utility events" (Game Event Generators, source code of the generated events, and instances of the Game Events) have been intentionally placed outside the samples folder because they are used directly in the package's source code. Therefore, it would not be correct to place them in the samples folder, as omitting them during package import would cause the source code to not function correctly.

The Game Event Generators are located in the `Packages/SoapRPGFramework/Runtime/Events/EventGeneratorInstances` folder. Here you will find:

- `GeneralPurposeEventGenerator`: defines two game events: `EntityCoreGameEvent` and `IntGameEvent`.
- `AttributesEventGenerator`: defines `AttributeChangedGameEvent`
- `StatEventsGenerator`: defines `StatChangedGameEvent`

> **WARNING**
>
> Do not modify these Game Event Generators, as they are an integral part of the package's source code.
> If you want to add new events, create new Game Event Generators in your Assets and use those to define your custom events.

The source code for the events defined within the aforementioned Game Event Generators is located in the `Packages/SoapRPGFramework/Runtime/Events/GeneratedEvents` folder. The organization follows the rules mentioned in the [Adding new events] documentation.

The instances of the generated Game Events are provided with the samples of the package instead. Such objects are also used by the Sample Scene (always available in the samples folder). If you want to instantiate new Game Events of type `EntityCoreGameEvent`, `IntGameEvent`, `AttributeChangedGameEvent`, or `StatChangedGameEvent`, feel free to do so.

Samples

The samples folder contains 2 sub-folders:

- **utils**: contains some utility objects that can be used in your game.
- **examples**: contains resources that are used in the sample scene to showcase the package's features

Utils

The `Utils` folder contains 2 sub-folders:

- `EventInstances`: containing `Entity Attribute Changed`, `Entity Spawned`, `Entity Stat Changed`, and `On Player Level Up` Game Events. These are instances of the Game Events defined in the package's source code.
- `Player`: containing `Max Level`, `Player Hp`, `Player Max Hp`, and `Player Level` Int and Long variables. These are useful to use Scriptable Object variables in your game, as showcased in the [Workflows] documentation.

Examples

There are several objects in this folder. Let's start by the Sample Scene. Here we have two relevant game objects: `Heroes` and `HeroesHUD`. These wrappers contain the entity game objects and the GUI elements that are used to display the heroes' stats and attributes respectively. There are three heroes in the `Heroes` GO: `Warrior`, `Mage`, and `Rogue`. Each hero has its own game object, with the following components:

- `EntityCore`
- `EntityClass`
- `EntityStats`
- `EntityAttributes`

The objects in the `HeroesHUD` are not as relevant. Feel free to explore them, but they are not the focus of this documentation as they are just used to display the heroes' stats and attributes in the UI.

Along with the Sample Scene, there are a few sprites and UI scripts (in the `Sprites` and `Scripts` folders respectively), some prefabs in the `Prefabs` folder, a few events in the `Events` folder, and some more relevant content in the `Instances -> Classes` folder. Here, we have all the instances of the frameworks's scriptable objects for the Sample Scene.
For each class we have the following:

- Attributes growth formulas
- Stats growth formulas
- An Int var for the hero's level
- A Max HP growth formula
- The class itself All these objects are used in the Sample Scene to showcase the package's features.

Using the Sample Scene

The scene uses `Strength`, `Intelligence`, `Dexterity`, and `Constitution` as attributes, and `Physical Attack`, `Magical Attack`, `Critical Chance`, and `Defense` as stats. Each stat scales with the respective attribute:

- `Physical Attack` scales with `Strength`
- `Magical Attack` scales with `Intelligence`
- `Defense` scales with `Constitution`
- `Critical Chance` scales with `Dexterity`

If you now enter play mode in the Sample Scene, you'll see three heroes: the Warrior (left), Mage (center), and Rogue (right), each with their respective HUD displayed above them. You can use the arrow buttons (`<` and `>`) to toggle between viewing the heroes' stats and attributes.

The Sample Scene is designed to demonstrate how stats and attributes respond to changes made in the inspector.

For example, select the `Warrior` in the hierarchy and change its Level from 1 to 2 using the Entity Core component. You'll observe that the Warrior's `Physical Attack` increases from 28 to 29, and `Defense` rises from 24 to 25.

Increasing the level also grants the Warrior a spendable attribute point (visible in the `EntityAttributes` component). If you allocate this point to `Strength`, the `Physical Attack` will increase from 29 to 30.
If you revert the level back to 1, `Physical Attack` returns to 28 and the spent attribute point is removed.

Next, let's adjust how `Physical Attack` scales with the `Strength` attribute. By default, each point of `Strength` adds 1 point to `Physical Attack`. Suppose you want each point of `Strength` to contribute 3 points instead.
To do this, locate the `Physical Attack` stat instance in `Examples -> Instances -> Hero -> Stats`. Select the `Physical Attack` stat, then double-click the `Physical Attack ASC` object in the inspector. This Attribute Scaling Component controls how `Physical Attack` scales with `Strength`.
You'll notice the scaling value for `Strength` is set to `1`. Change this to `3`. Instantly, the Warrior's `Physical Attack` at level 1 jumps from 28 to 60, since the base value is 12 and the Warrior has 16 points of `Strength`: 12 + (16 × 3) = 60.
If you increase the Warrior's level to 2, `Physical Attack` becomes 61. Assigning the new attribute point to `Strength` further increases `Physical Attack` from 61 to 64.

After exiting play mode, inspect the modified objects. You'll see that the Warrior's level is reset to 1, `Physical Attack` returns to 28, and the `Physical Attack ASC` (ASC stands for Attribute Scaling Component) scaling for `Strength` is back to 1.
This happens because changes made to `ScriptableObjects` during play mode are not saved to disk when you exit play mode. This is intentional Unity behavior, not a package bug.
Persisting such changes would be risky. For example, if a debuff reduces the scaling of `Physical Attack`

from `Strength` to zero during play mode and this is saved, you would permanently lose the original scaling—even after restarting without the debuff.
`ScriptableObjects` in this package are intended to define your game's baseline mechanics. Any modifications during play mode are temporary and not meant to be saved. Fine-tuning these values is crucial in RPGs, and once you achieve the desired balance, you want to ensure those values remain intact.

You can also explore the other heroes and all their components in the scene. Play around with their levels, stats scalings, attributes and their spendable points, and see how they affect the heroes' stats and attributes in real-time.