Manual for VisiSonics' RealSpace3D Audio Unity Plugin

Beta Version

This simple manual outlines how the RealSpace3D Audio Unity Plugin can be used to create 3D audio in Unity applications.

Both the engine and manual are under continuous development.

Please feel free to email VisiSonics for support (support@visisonics.com).
Suggestions for improvements are always welcome.

VisiSonics Corporation

11/17/2015

Meta Platforms, Inc.
Exhibit 1084
Page 001

VisiSonics RealSpace3D Audio Unity Package Setup Instructions

Welcome to the RealSpace3D Audio Unity package setup and use instructions. The guide will walk you through setting up the VisiSonics' RealSpace3D Audio Unity package. We will use a new Unity project as a demo environment to which RS3D Audio sound will be added.

We assume you are familiar with Unity and how to navigate around in the Unity Editor. Also, the RealSpace3D Audio Unity package is for Unity 5.2 and higher.

You should have obtained the *realspace3d_v#.#.#_unity5.2+.unitypackage* from the RealSpace3D Audio web page download. If you have not you can obtain from www.realspace3daudio.com. You will also need to obtain a registration license key (registration is on the web page).

Note: RealSpace3D Audio operates over headphones, any brand or kind will do. Be sure to have the left and right ear pieces properly placed.

From here on RealSpace3D Audio will be referred to as RS3D Audio for brevity.

Let's get started…

1 Setup RS3D Audio

1.1 Requirements

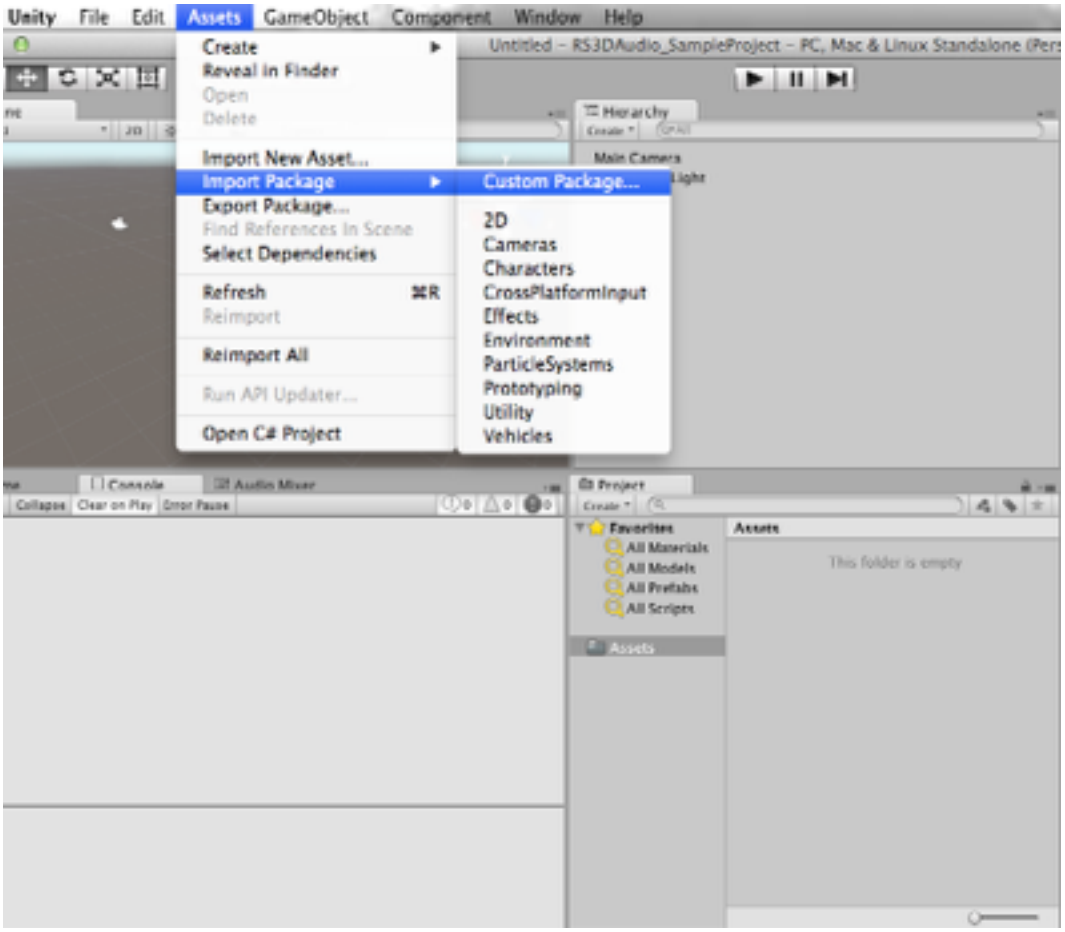
* Unity 5.2 or higher
* RS3D Audio unitypackage
* RS3D Audio registration license key
* Joy and excitement

1.2 Importing RS3D Audio

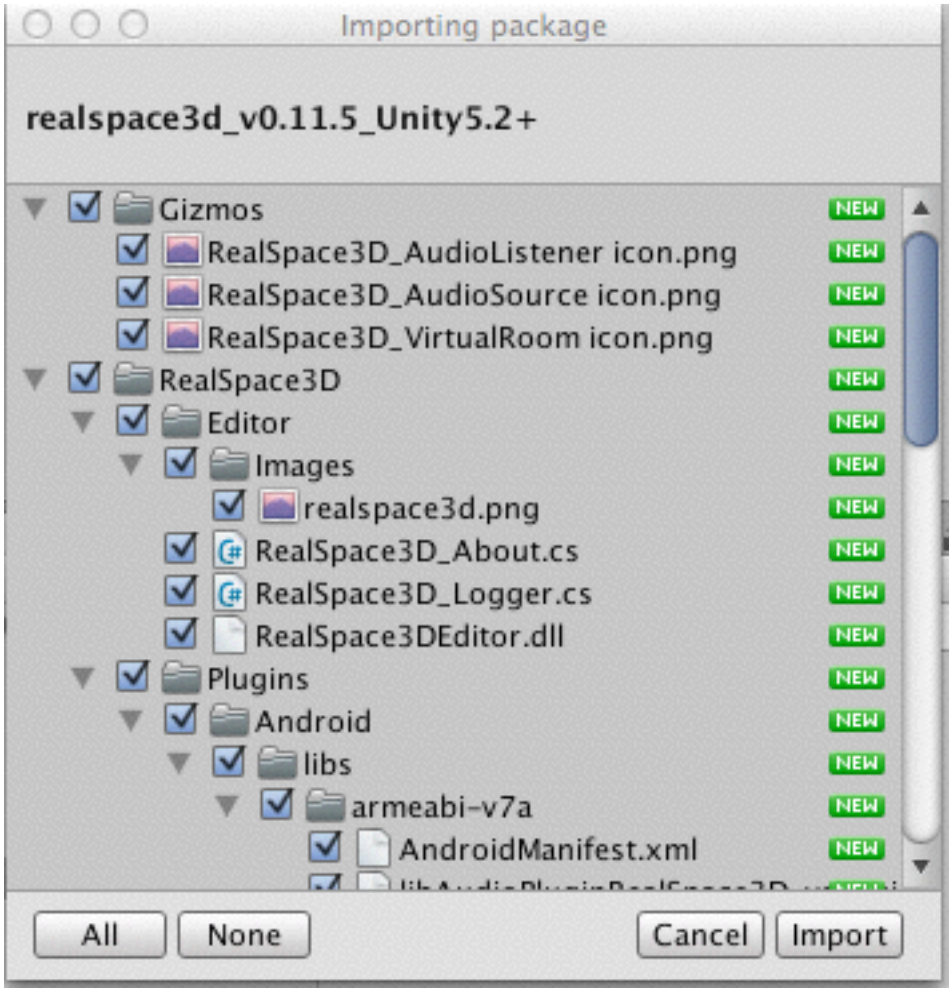
The following instructions are for a fresh install into a new or current project that does not contain RS3D Audio. The sample will use a new project.

1. Open Unity

2. Go to the 'Assets' menu and choose *Import Package* > *Custom Package*

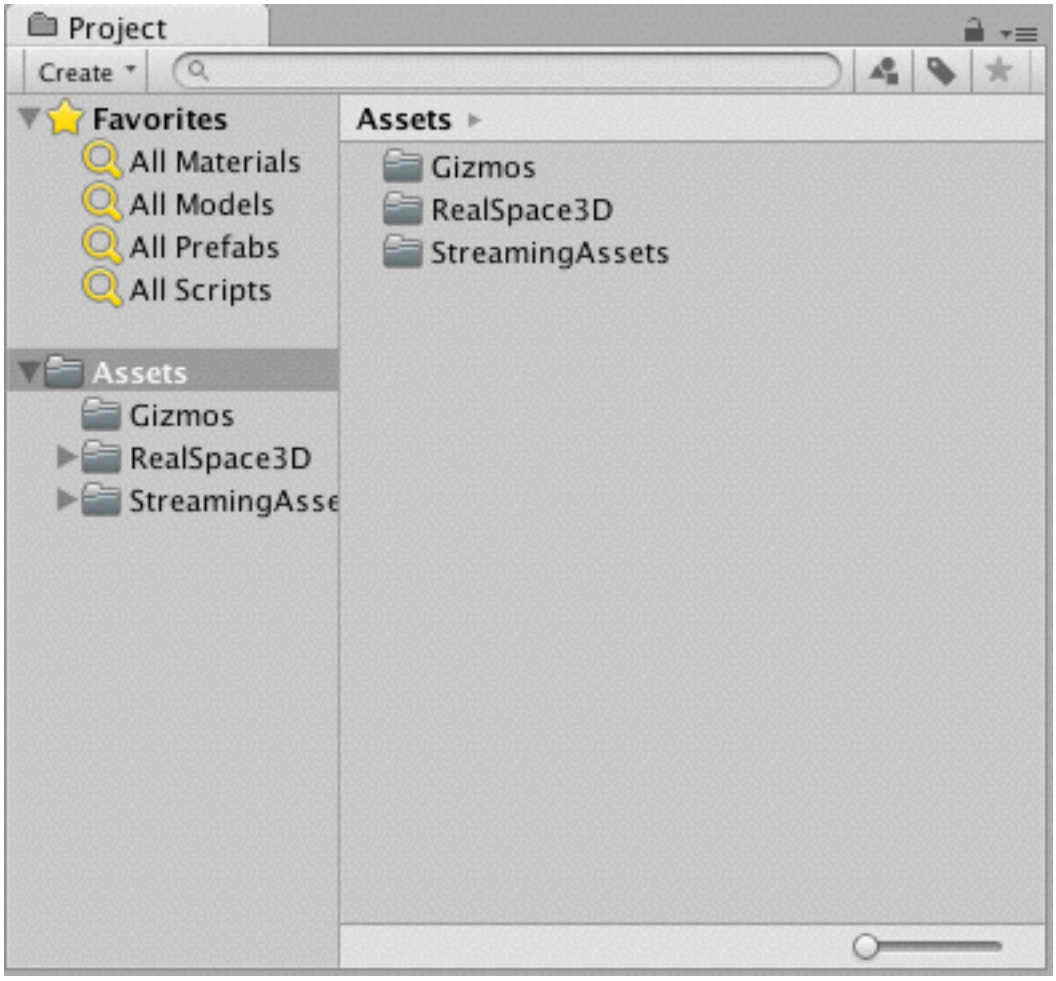


3. Navigate to where you saved the RS3D Audio unity package, *realspace3d_v#.#.#_unity5.2+.unitypackage* and select it. You should see the following window…



Do not modify anything on the import window. Select "*Import*" with all the defaults.

Your project window should now look like the following…

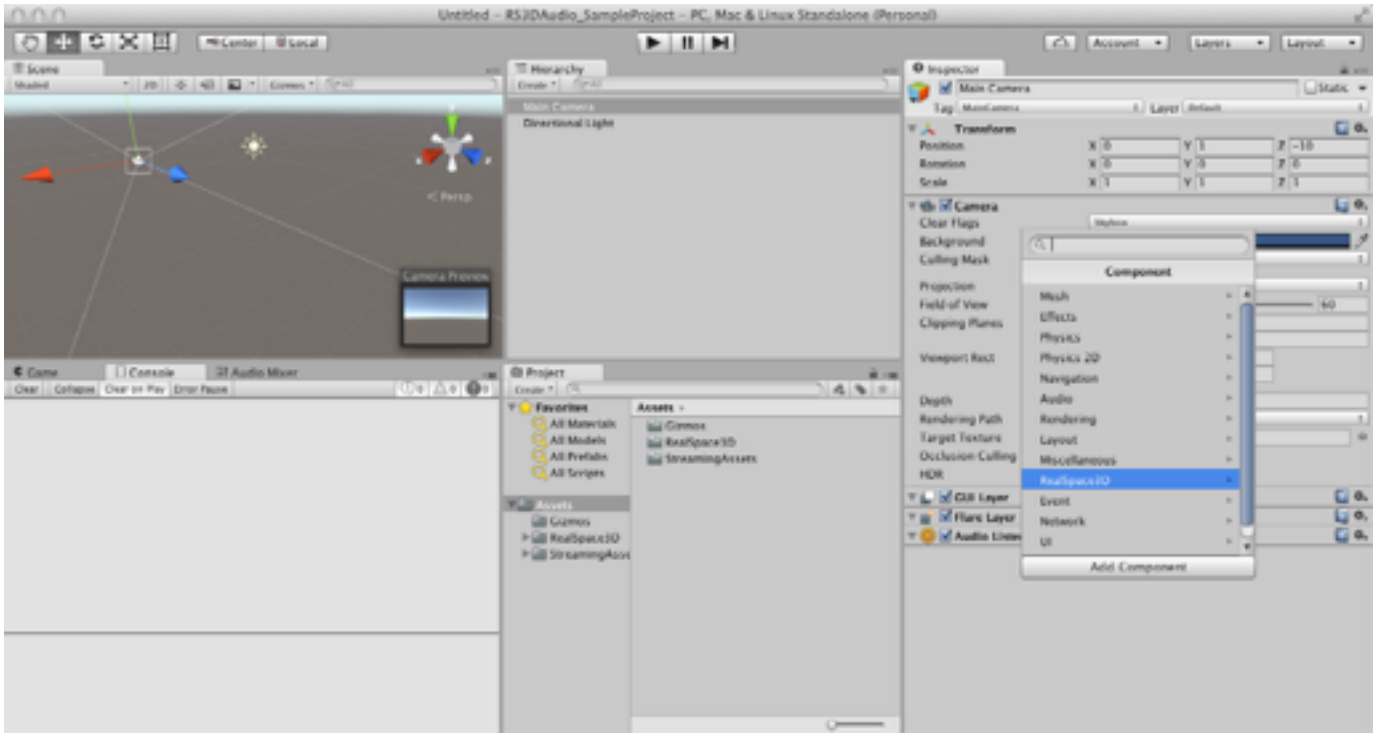


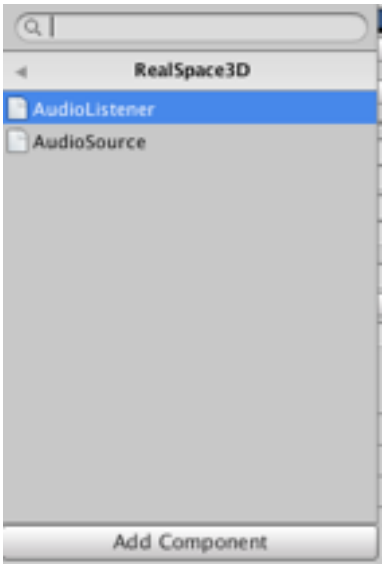
Note: To verify that your import has imported properly you can select the Unity menu Help > RealSpace3D > About the versioning dialog window should display. Also, if you are importing an upgrade of RS3D Audio on Windows the DLL does not get released so we suggest that after the import you close Unity and reopen it to set the new DLL. Again you can check the import is correct by selecting the RS3D About and seeing that the version number has changed.

2 Using RS3D Audio

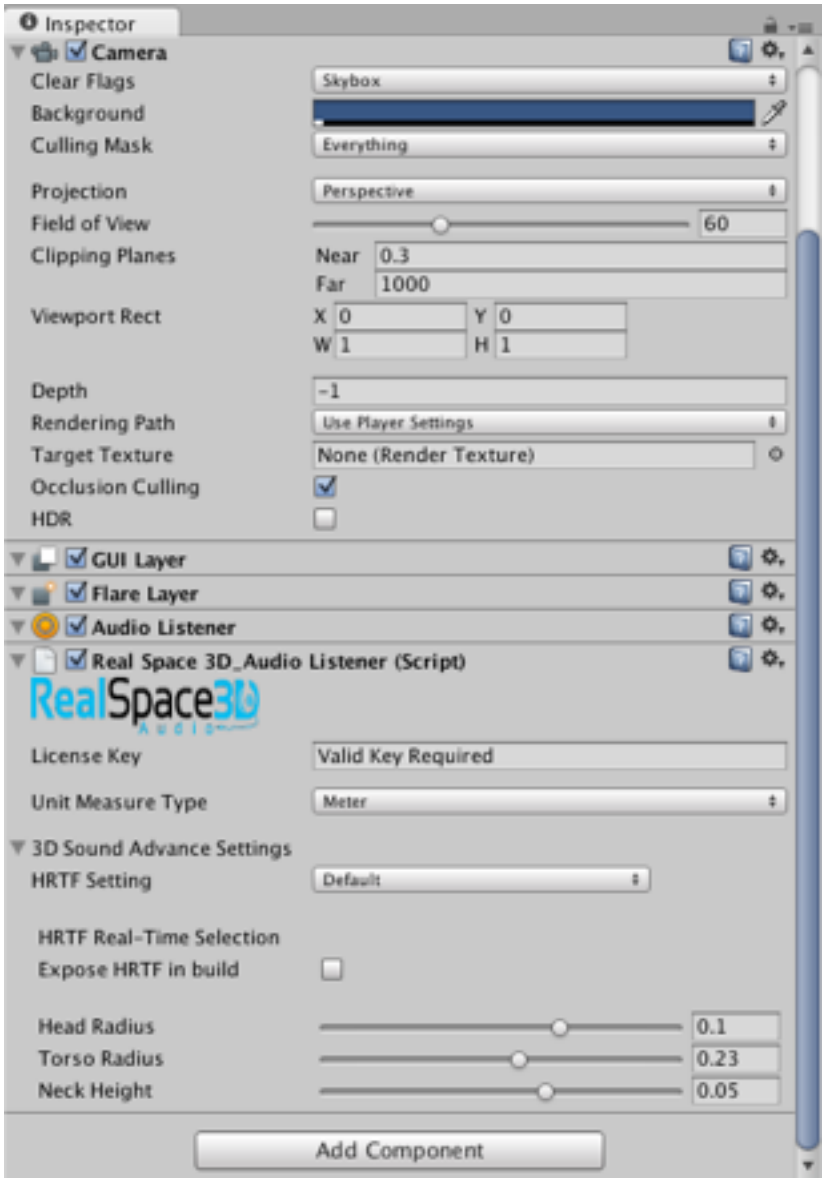
Now you are ready to put RS3D Audio into your application and it is only going to take you THREE simple steps (used to be two steps but, Unity 5.2 has added one more, see step 3.)

2.1 Select the Main Camera in the Unity Hierarchy window. Select the "Add Component" button in the Inspector window. Select RealSpace3D > AudioListener.



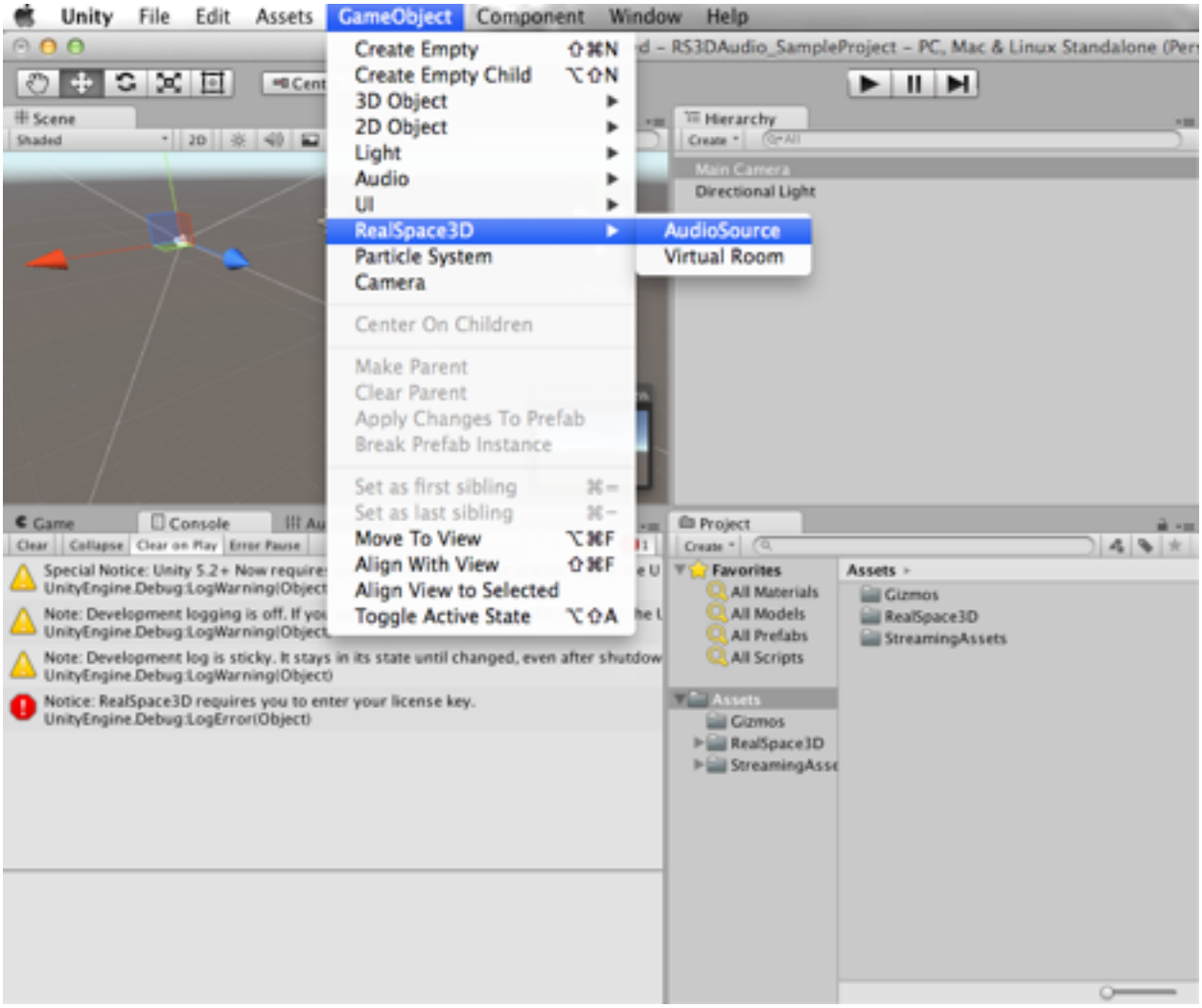


A dialog box will pop up notifying you that you need to supply a RS3D Audio license key (that you should have received when registering). You will now have the RS3D AudioListener on the Main Camera (it is probably a good practice to add the RS3D AudioListener to the same location as the Unity AudioListener).
Enter your obtained license key in the “License Key” text entry box.

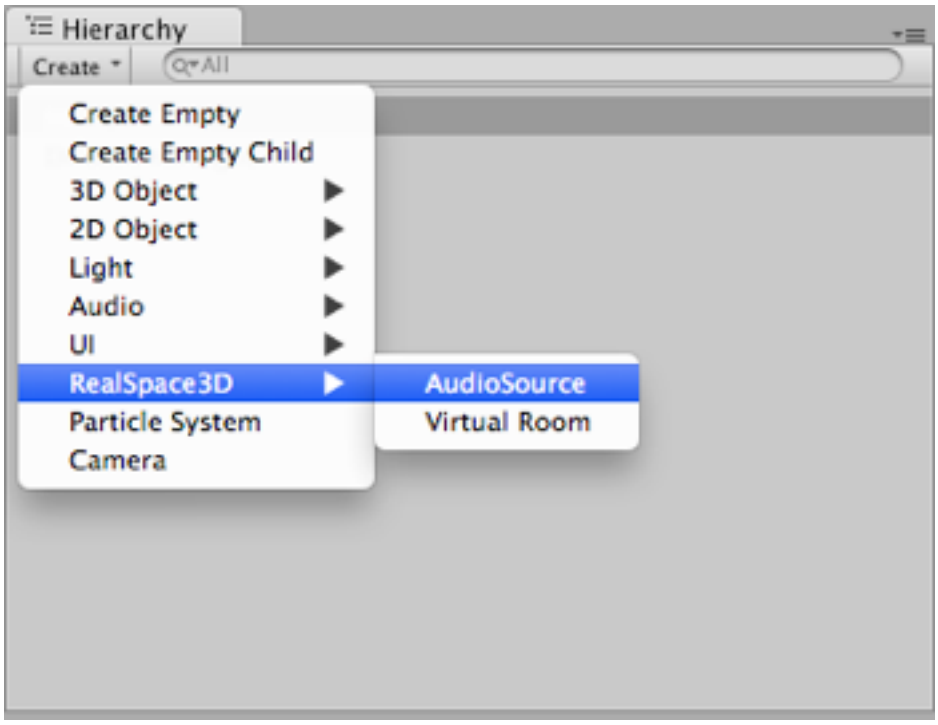


Note: If you are using Oculus SDK or some other plugin HMD camera be sure to place the RS3D AudioListener on the camera. In the case of Oculus place on the middle camera.

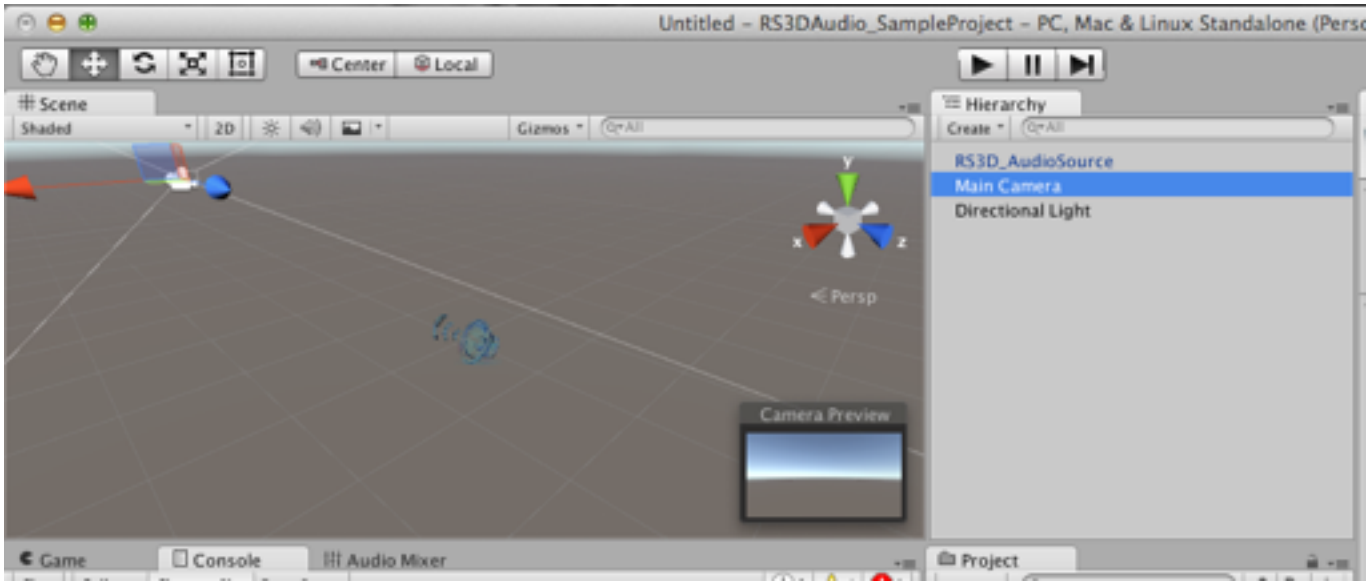
2.2 Navigate to the Unity menu and select GameObject > RealSpace3D > AudioSource.



Or from the Hierarchy > Create > RealSpace3D >AudioSource.

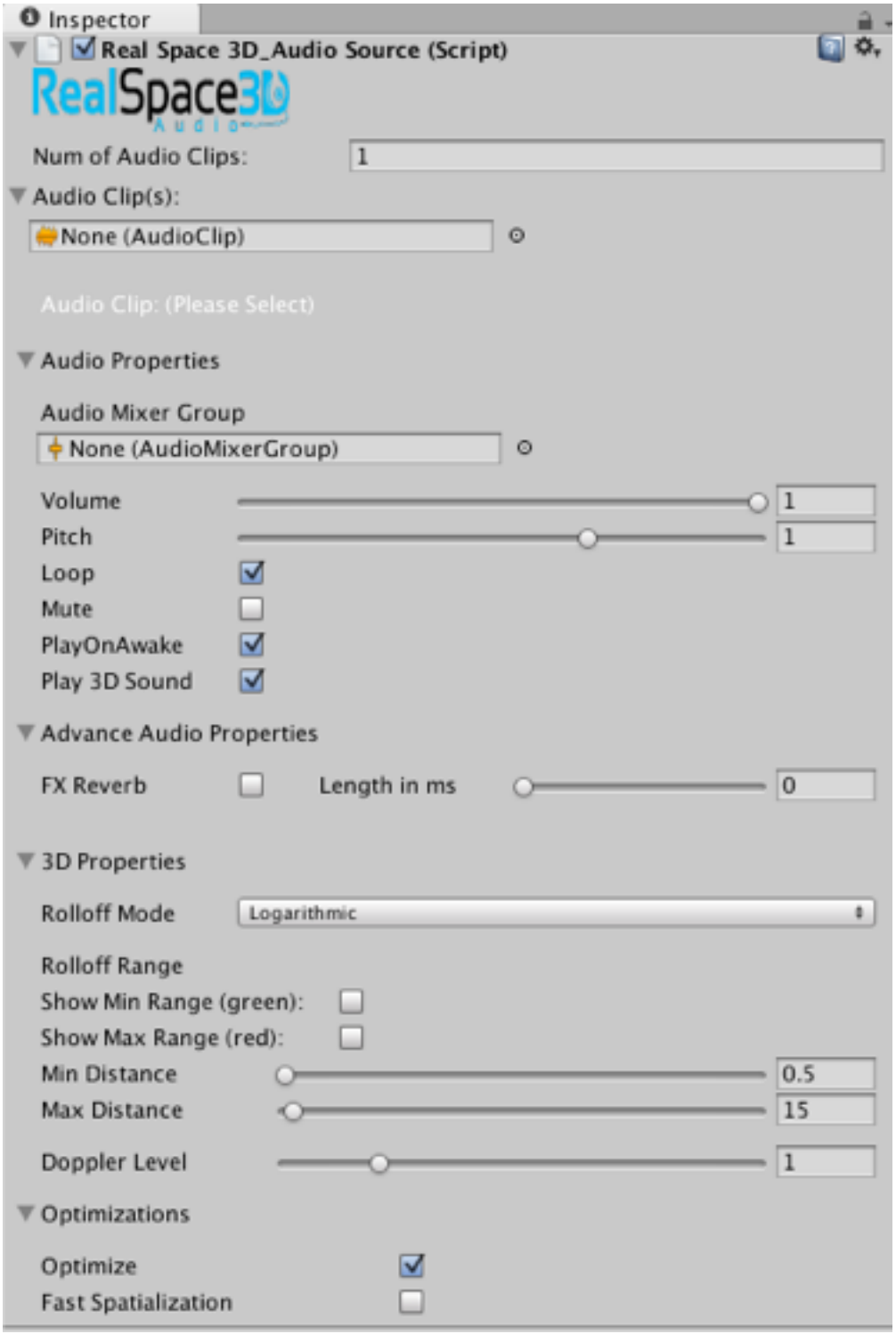


You now have a RS3D Audio game object in your scene, it is identifiable by an icon that looks like a speaker.

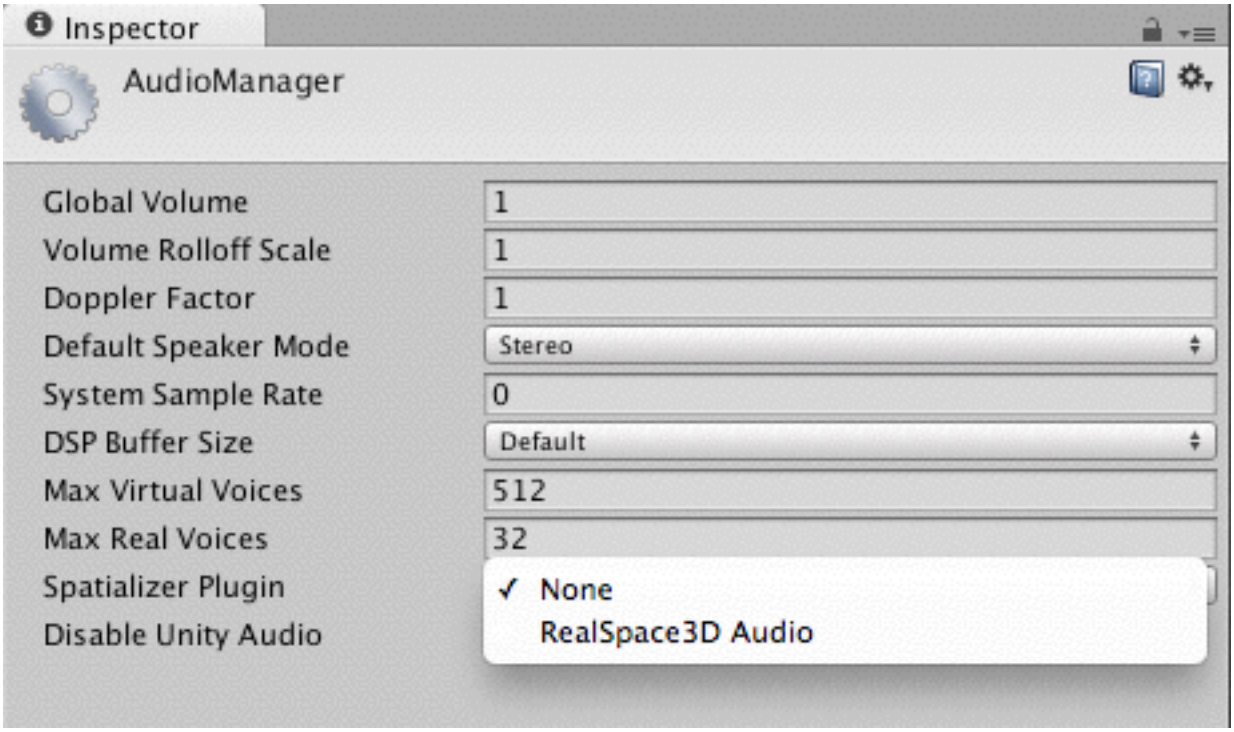


Note: RS3D AudioSource can also be added to a GameObject in the Inspector via the "Add Component" button.

With the RS3D_AudioSource selected in the Hierarchy window you should see the component below. Enter an audio clip and you are ready to hear 3D audio in your project.



2.3 Unity 5.2 introduced the Audio Spatialization Plugin Architecture. This now allows 3D audio spatializers to process the audio streams much faster and efficient. To turn on the 3D Audio Spatialization go to the Unity menu and select Edit > Project Settings > Audio. In the Inspector window you will see a drop down selection "Spatializer Plugin." Choose "RealSpace3D Audio" you can now select the play button in the Unity editor and manually move the camera or the RS3D AudioSource around and hear your audio clip in 3D sound.



3 RS3D Audio Components/GameObjects

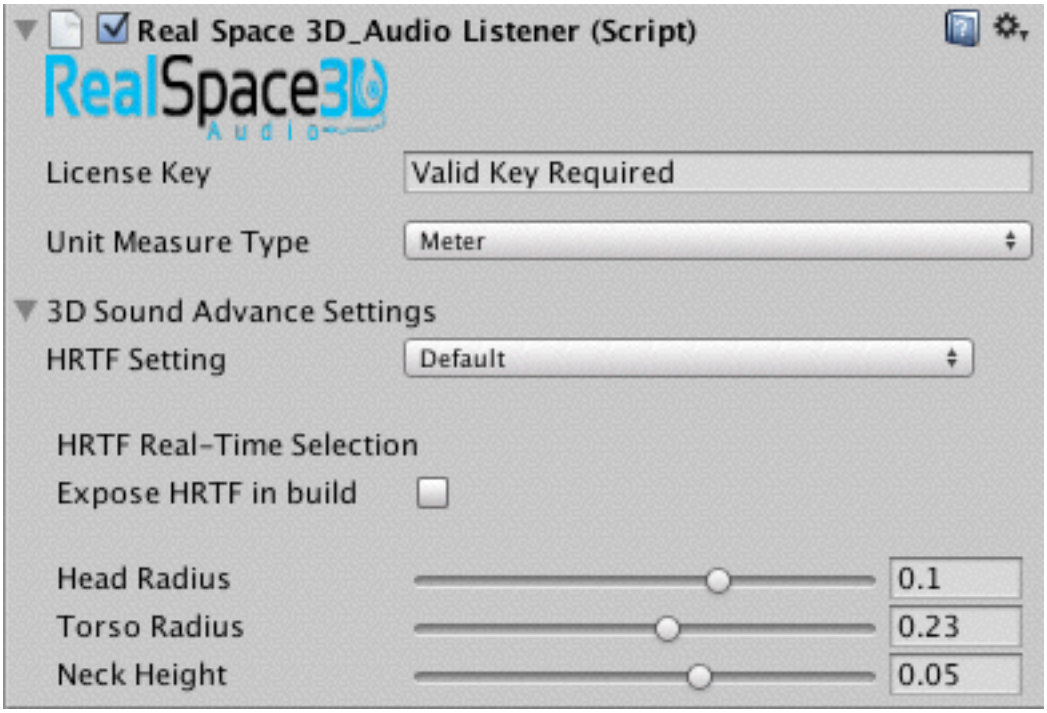
3.1 RS3D AudioListener

A single instance of the RS3D AudioListener must be added to the main camera or a camera that controls the player (see **2.1)**. If you are using a Head Mounted Display (HMD) camera that has left, middle, and right cameras, it is best to place the RS3D AudioListener on the middle camera. If a stereo camera with left and right, either camera will do.

Let's take a deeper look at the RS3D AudioListener…

Properties

* License Key: Enter the license key received from VisiSonics (if you do not have one you can easily obtain by going to www.realspace3daudio.com and registering. You will receive a license at the email address you registered.) RS3D Audio will not play 3D sound without the license key.



* Unit Measure Type: Defaults to Meter (Unity default game unit). Other selections are Centimeter or User Type.

* 3D Sound Advance Settings:

- HRTF Setting: A selection to choose from different types of HRTFs. HRTFs are used to spatialize the sound so that you hear audio in 3D.

Try them out and select the best that works for you. The Default is what works for 80% of the population.

Default — an HRTF set that has been found to work well for majority of users.

Bassy_LG_Ear — an HRTF set from a larger eared person. Bass boosted.

Bassy_SM_Ear — an HRTF set from a smaller eared person. Bass boosted.

Thin_LG_Ear — an HRTF set from a larger eared person. No Bass boost.

Thin_SM_Ear — an HRTF set from a smaller eared person. No Bass boost.

- HRTF Real-Time Selection/Expose HRTF in build: Selecting this option allows a dialog box entry for the end user to select the HRTF they wish to use and not the one you selected to use. If you do not choose this option the user of your final product will hear 3D audio through the HRTF you selected.

*Note: Refer to the "**3.4 HRTF Real-Time Selection"** section in the manual to see how to expose and use this option.*

Each HRTF can be further customized by setting the "Head, Torso, and Neck" parameters for a particular listener. The default values hold for an average listener. To personalize you need to enter some basic sizes of the listener and enter.

* the specific head radius: between 0.06 - 0.12 meters. Default 0.10
* torso radius: between 0.12 - 0.32 meters. Default 0.23
* neck height of the listener: between 0.00 - 0.08 meters. Default 0.05

Note: If your Unit Measurement Type is "Centimeters" the scale for the head, torso, and neck will automatically adjust.

3.2 RS3D AudioSource

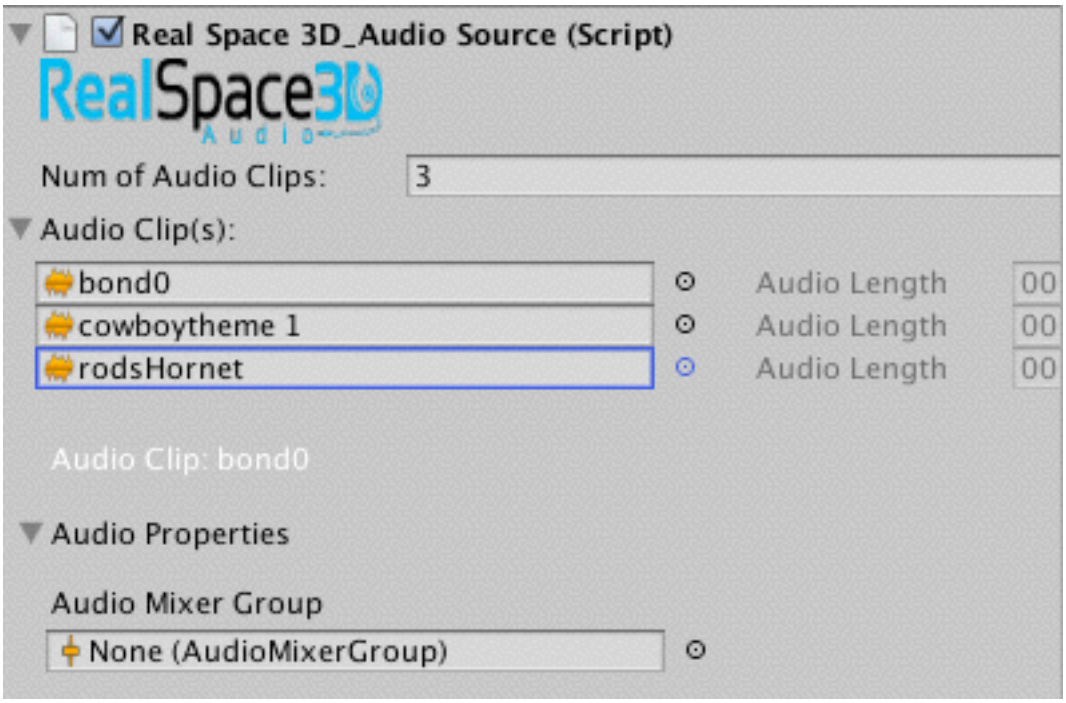
The RS3D AudioSource is the component that you will place on game object that you wish to emit 3D audio from (see **2.2)**. You can also just place a RS3D AudioSource into a scene without it being associated to an objet; this is a good approach for ambient sounds or sounds you just do not wish to associate with an object. The choice is yours.

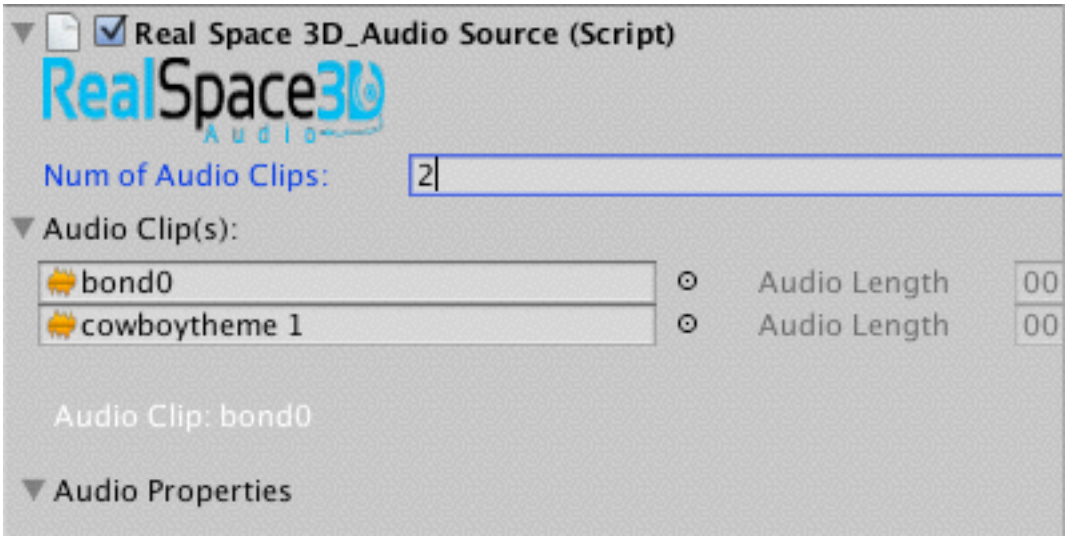
RS3D AudioSources can be selected via the component menu or the game object menu.

Properties

* Num of Audio Clips: Enter the number of audio clips you wish the object to play. RS3D AudioSource allows you to set a list of audio clips to have the object emit, that you then control through scripting. By default the first audio clip in your list will play. Through scripting you can choose which audio clip to play (see the *RealSpace3D Audio API manual).* To delete audio clips re-enter the number of clips you wish to have and the audio clips will be removed from the list in reverse order. For example if you originally entered “3” for the number of audio clips, and then re-entered “2”, the 3rd audio clip will be removed.

* Audio Clip(s): Click on the audio clip selector and select the “.wav” file to be attached to the object. Based on the number of audio clips you entered in the “Num of Audio Clips” entry box you will select those many clips.





Each audio clip has the following settings:

* Volume: Sound volume, 0.0 = off, 0.5 = half volume, 1.0 = original volume. *Note: setting volume to zero should not be used as a way to turn off the sound source — this will entail unnecessary processing.*

* Pitch: Speeds up or slows down the audio clip. Normal playback is 1.

* Loop: The sound source will play continuously. When the audio clip reaches the end, it will restart and play again.

* Mute: Turns the volume down to 0 but the sound is still playing, and thus processing so do not use mute to stop sound sources.

* PlayOnAwake: On start of the application the sound source will begin to play.

* Play 3D Sound: Allows you to toggle between RealSpace3D audio and Unity's audio. *Note: Unity's audio will play in 2D without panning or attenuation. If you would like full capabilities of Unity audio then you must use a Unity AudioSource.*

* Advance Audio Properties:

- FX Reverb - Toggles on the feature, which if set reverbs the last energy in the audio for the length entered in milliseconds. *Note: In order to hear the reverb be sure there is audio energy at the end of the audio clip. The tail of the audio clip is what gets reverberated.*

* 3D Properties

- Rolloff Mode: The sound attenuation type. Logarithmic gives a smooth reduction in volume the further away the listener gets from the source and cutoff is the Max Distance that is set. Linear cuts the sound off immediately at the Max Distance. Custom is user supplied scripting rolloff method.

- Rolloff Range:

Show Min Range - Allows for the toggling on/off of the visual indicator of the sound range minimum distance. This indicator is shown as a green wire sphere around the RS3D AudioSource. When you change the minimum distance via the slider the green wire sphere will increase or decrease in size depending on your inputs.

Show Max Range - Allows for the toggling on/off of the visual indicator of the sound range maximum distance. This indicator is shown as a red wire sphere around the RS3D AudioSource or object that has a RS3D AudioSource. When you change the maximum distance via the slider the red wire sphere will increase or decrease in size depending on your inputs.

- Min/Max Distance: The sound source in a real world often propagates for much longer distances than the environment designer may care for. To control this behavior, we provide two regions around each source. The first — Min Distance — is the distance till which the sound volume increases as one approaches the source. To prevent an increase beyond what the designer wants, the source volume does not

increase if one comes closer. The second — Max Distance — is the distance at which the sound volume goes to zero.

- Doppler Level: How much doppler effect will be applied to the audio source. 0 is no effect applied.

* Optimizations:

- Optimize: The sound processing will be turned off completely when the sound source is out of the listener set range (explained above Min/Max Distance). This should be set on sound sources where continuous play is not important. If this option is selected the next time you come into range of the sound source it will play from where it was when the listener went out of range. This option greatly reduces the overheard of processing sounds out of range. Sound sources without this option do not play when out of range but, their sound source current position does have to be continuously updated so that when the user returns within listening range the sound source is playing at the position in the sound stream where it should be, i.e., a conversation or speech on the sound source if "Optimize" is not selected will have progressed when the listener is back in range. If "Optimize" was set the conversation or speech will resume from where it was. It is up to the user whether they want to select "Optimize" or not but, keep in mind that it greatly reduces the computational load. The "Optimize" option defaults to on.

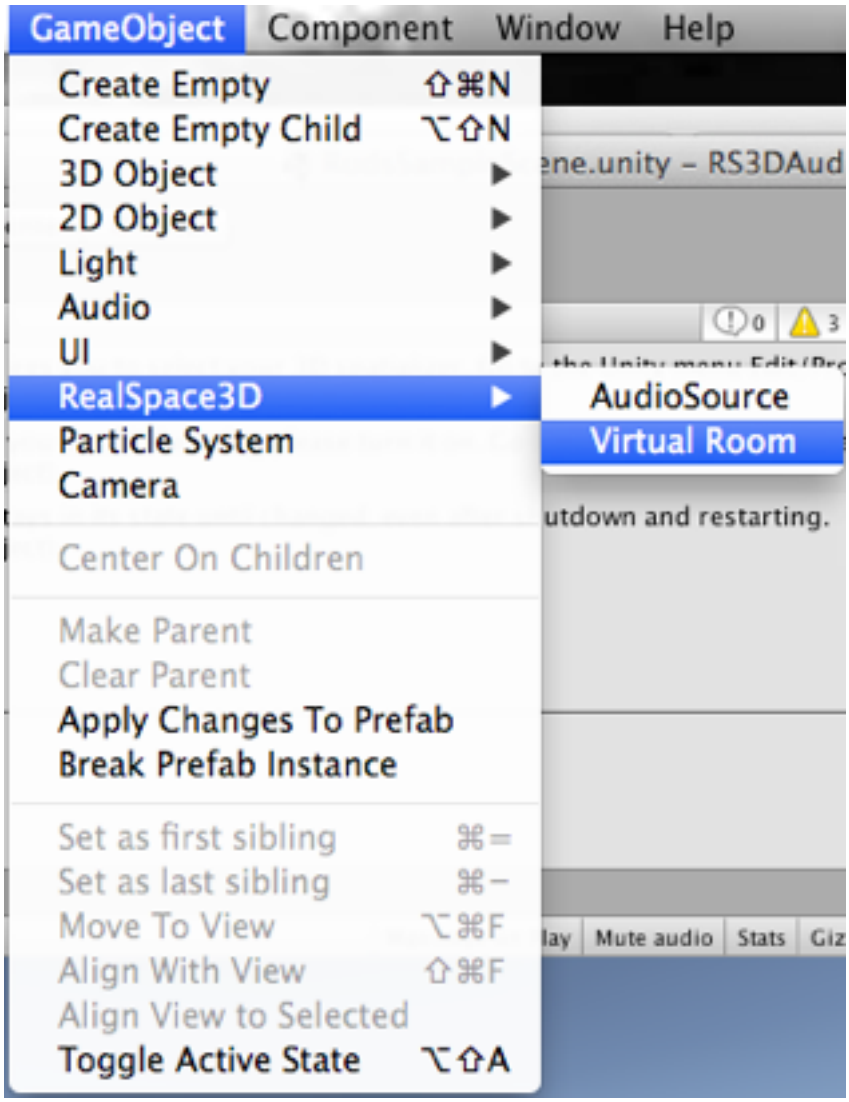
- Fast Spatialization: This option defaults to "off" on console platforms (Mac, PC, and Linux), and defaults to "on" on mobile platforms (Android and iOS).

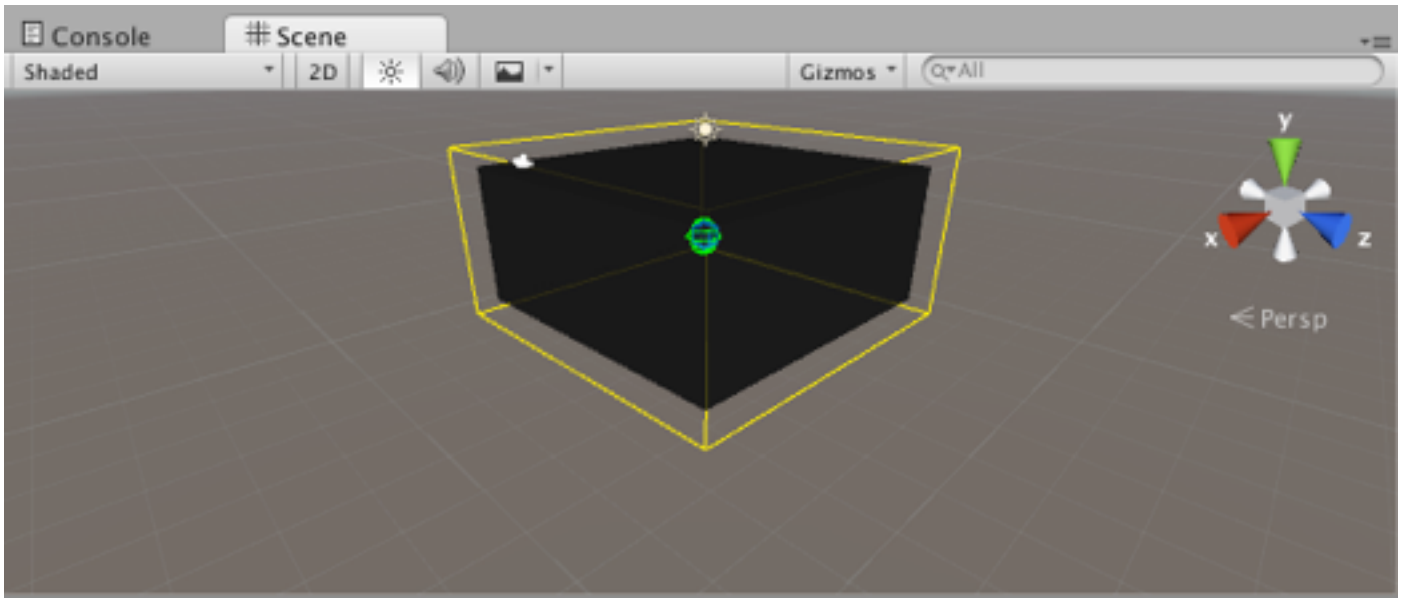
Fast Spatialization allows for faster processing on mobile devices allowing user to play more RS3D Audio sound sources simultaneously. *Note: Fast Spatialization defaults to the sound sources spatialization to not be heard after the listener is 7.5 meters away from the sound source. The attenuation rolloff is logarithmic. Fast Spatialization is "point directional" and no reflections so Virtual Rooms have no affect. Scenes*

can have some sound sources as regular 3D spatialization and others as Fast Spatialization.

3.3 RS3D Audio Virtual Room (RS3D_VirtualRoom)

The RS3D_VirtualRoom is used to provide acoustic properties to the RS3D AudioSource. In order to get a RS3D_VirtualRoom into your scene you can either select it from the Unity menu GameObject > RealSpace3D > RS3D_VirtualRoom or drag the prefab from the /Assets/RealSpace3D/Resources folder into the scene.




Console
Scene
Shaded
2D
Gizmos
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y
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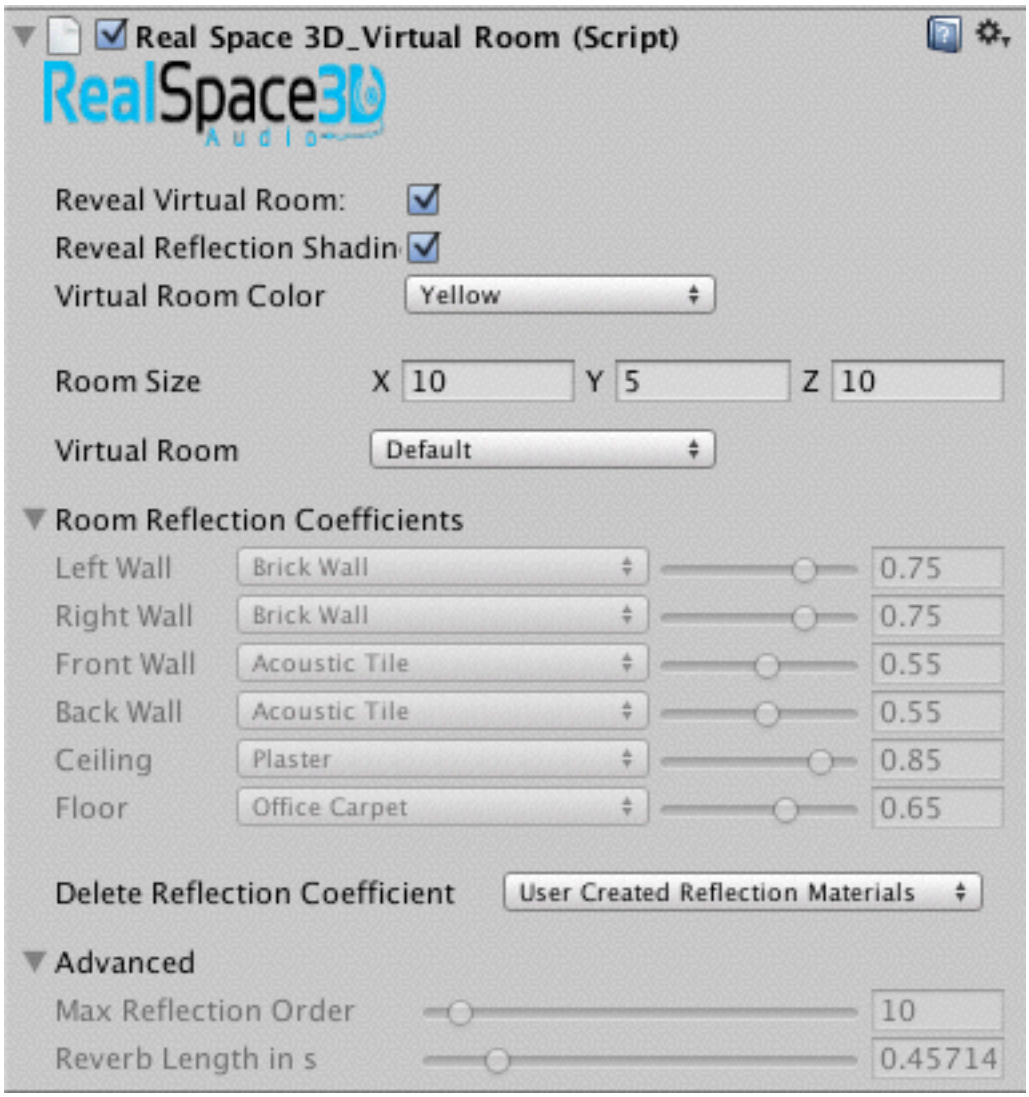

Real Space 3D_Virtual Room (Script)
RealSpace3D
Audio
Reveal Virtual Room:
Reveal Reflection Shadin
Virtual Room Color
Yellow
Room Size
X 10
Y 5
Z 10
Virtual Room
Default
Room Reflection Coefficients
Left Wall
Brick Wall
0.75
Right Wall
Brick Wall
0.75
Front Wall
Acoustic Tile
0.55
Back Wall
Acoustic Tile
0.55
Ceiling
Plaster
0.85
Floor
Office Carpet
0.65
Delete Reflection Coefficient
User Created Reflection Materials
Advanced
Max Reflection Order
10
Reverb Length in s
0.45714

Properties

* Reveal Virtual Room: Toggles the virtual room on/off in the Unity Editor Scene. The virtual room does not show up in the Game window or final build, it is strictly to aid in editing.

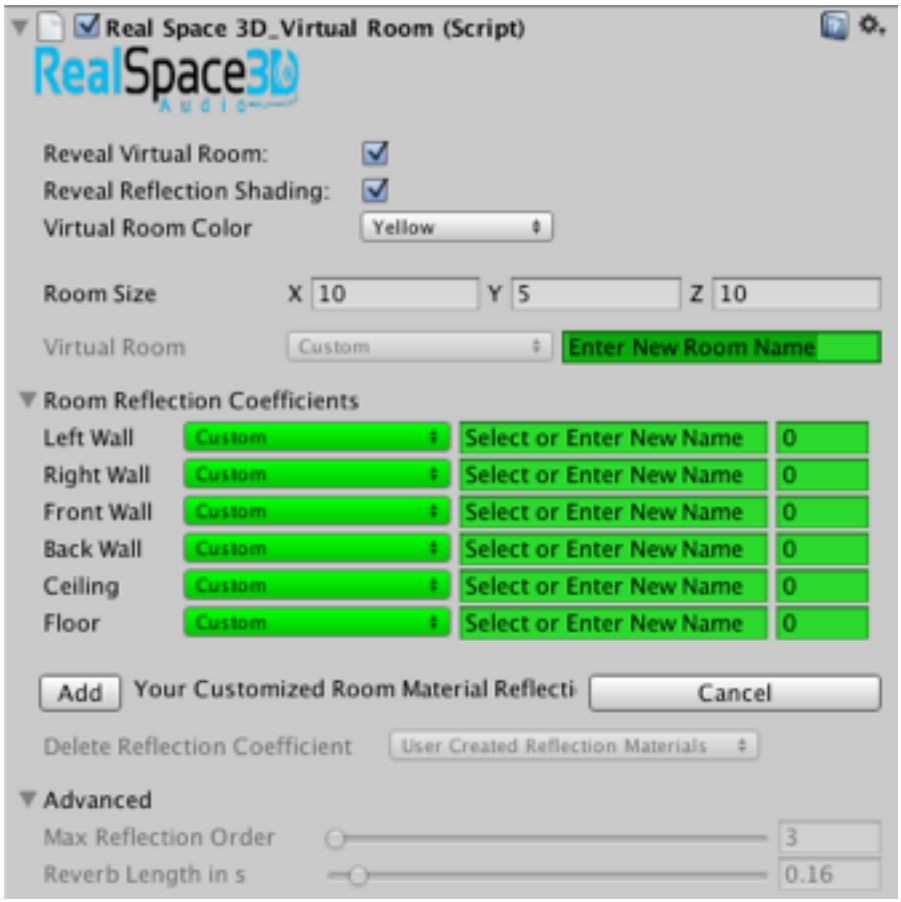
* Reveal Reflection Shading: Toggles the virtual room material wall reflection coefficient shading. The shading represents the wall, ceiling, and floor material selected reflecting radiant energy.

* Virtual Room Color: Allows users to select different colors for their virtual rooms to easily identify them when scenes are cluttered with other game objects. *Note: This only changes the color of the virtual room's wire frame and not the "Reflection Shading."*

* Room Size: The size of the virtual room.

Note: RS3D AudioSources will reflect the material reflection coefficients of the virtual room they reside in. A sound source translating outside of the virtual room into another virtual room will take on the reflective properties of the newly entered room, or if it exits to open space (no virtual room) the sound source defaults to an "Outdoor" reflecting radiant energy setting.

* Virtual Room: Presets that can be chosen that automatically set the wall, ceiling, and floor "Reflection Coefficients." VisiSonics' provides four presets; Default, Cathedral, Office, and Outside. Selecting the "Custom" preset allows users to create their own preset(s) (see image below). User created presets can be saved, edited, and deleted.



The user enters a name for their virtual room preset and can choose from the wall, ceiling and floor drop down for already defined material and reflection coefficients or create their own by entering a name for the material and entering a floating point number for the reflection coefficient in the range of 0.0 to 0.95. The lower the number the less radiant energy and the higher the number the higher the radiant energy.

* Room Reflection Coefficients: The walls, ceiling, and floor can be edited and saved. Buttons to do these will automatically appear to give the user control when changes are detected. When running in the Unity editor users can switch presets and materials in realtime to see how they sound. Changes while running are not saved.

Note: Switching presets in realtime will incur a brief interruption transitioning the changes.

So, what exactly are “Reflection Coefficients?”

The walls of the virtual room are reverberant, and the interaction of this reverberation and the HRTF gives RS3D Audio its ability to localize sound. Good default values of these coefficients are already selected. The order of the walls is as follows (w.r.t. initial listener position), left, right, front, back, ceiling, and floor.

However, you can change the characteristics of a listening environment significantly by changing the presets which change the material properties. Materials with high coefficients (max value 0.95), makes the room very reverberant, while materials with low values (min value 0), makes the room approximate an anechoic space. For a good perception of source distance, some reverberation is recommended.

* Delete Reflection Coefficient - Allows user(s) to delete material reflection coefficients they have created.

Note: Material reflection coefficients deleted the are used on other presets will automatically be deleted in those presets and replaced with default “custom” material with a reflection coefficient of 0.0, it is up to the user to replace the “custom” reflective material or the wall, ceiling or floor with “custom”default will not have reflective radiant energy. Only user created presets and materials can be edited and/or deleted. VisiSonics’ Presets and Material Reflection Coefficients appear greyed out indicating they are unchangeable.

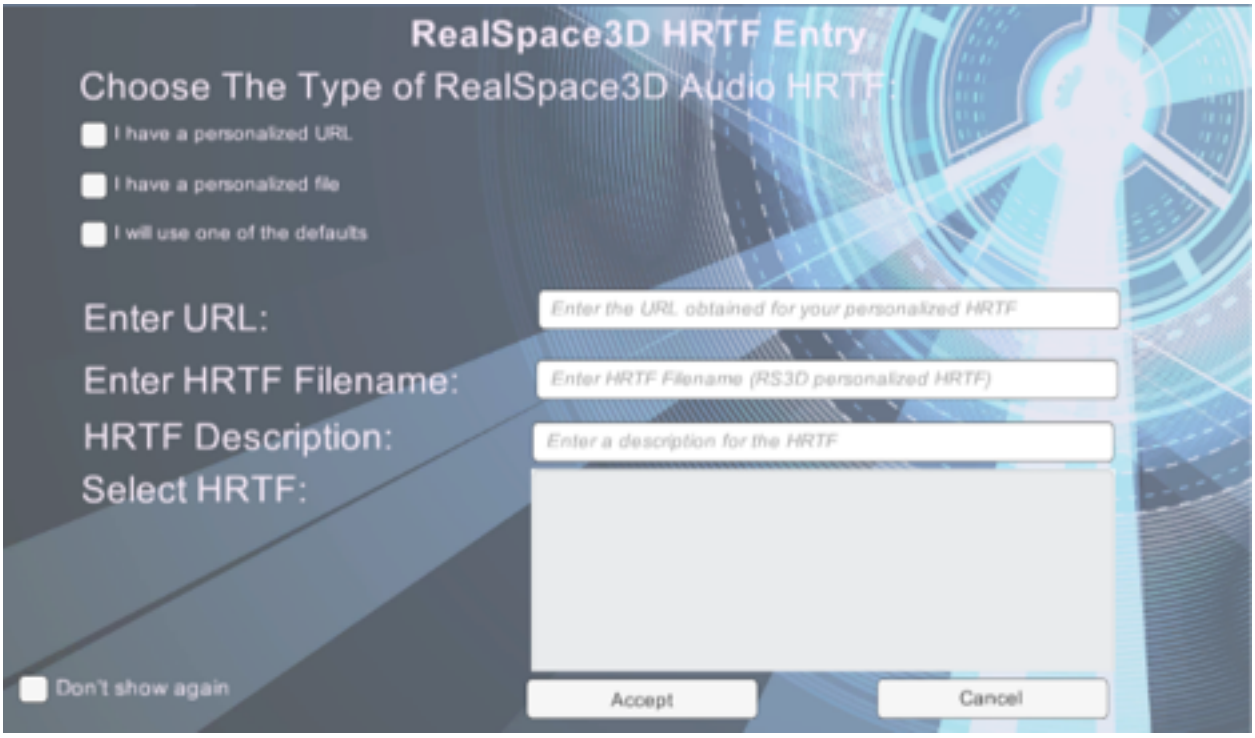
* Advanced: The amount of reverb processed has a strong bearing on the perception of 3D sound. We have exposed two “advanced” settings which are set to values which are automatically set to reasonable values, based on the environment size and the wall reflection coefficients. These parameters are:

— Max Reflection Order

— Reverb Length in s (seconds)

If you wish to change them the interface provides you with an ability to change them. Generally larger values would lead to better perception, at the cost of greater CPU load. You may want to experiment with the setting that provides the best trade-off. These values are also automatically calculated based on the walls, ceiling, and floor material selected.

3.4 HRTF Real-Time Selection

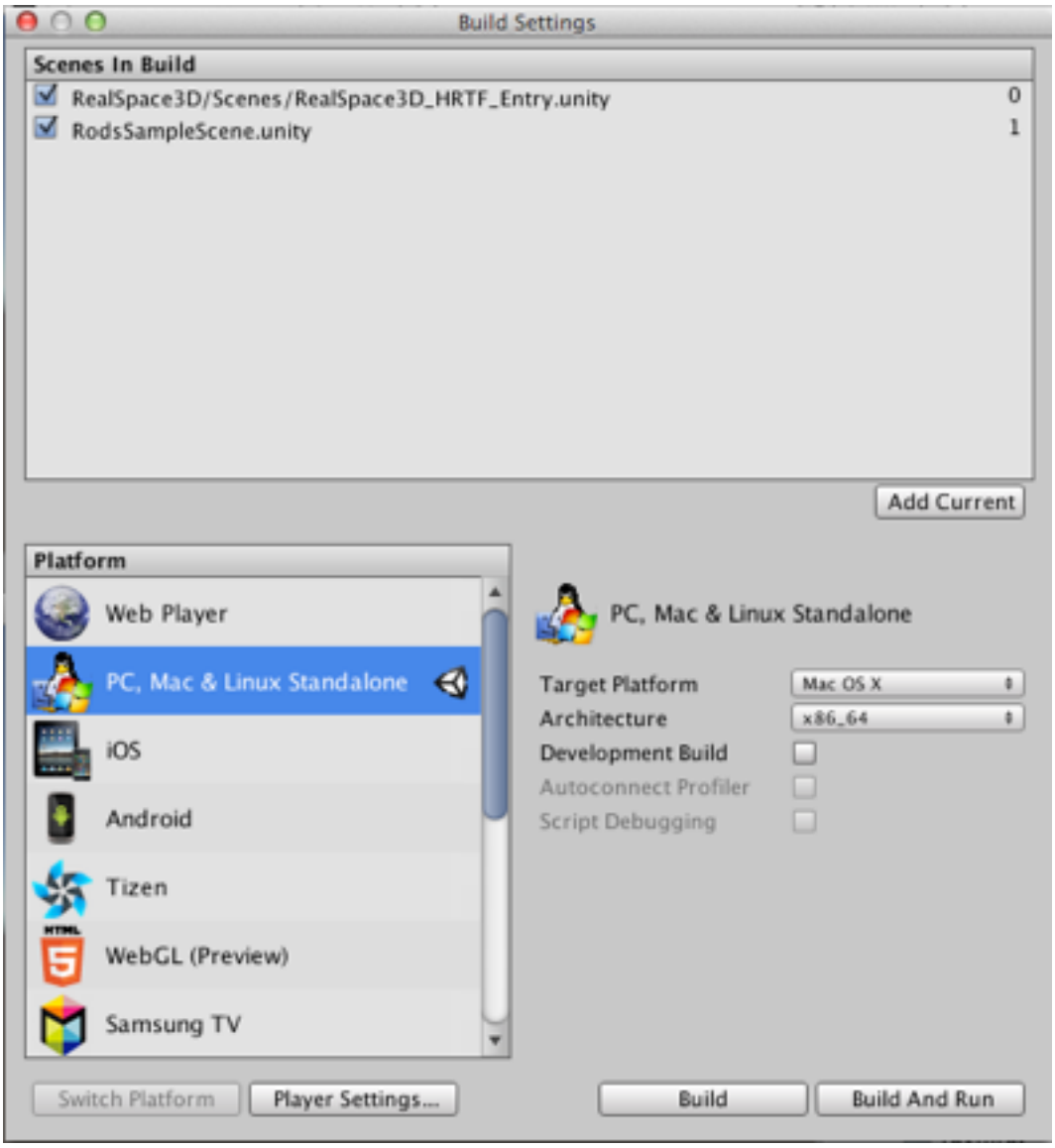


The RS3D Audio HRTF entry box enables developers to expose to their end-users the ability to choose the HRTF they wish to hear RS3D Audio with. The user can choose from the VisiSonics' set of HRTFs or if they have a personalized HRTF they can enter the file or url received from VisiSonics.

The end-user can choose not to show the dialog again by checking the "Don't show again" option. Choosing this option on the next play of the application the user is notified that they have 5 seconds to hit a key to

activate the entry dialog again, if not, the last selected HRTF will be used.

Developers must select the “Expose HRTF Entry in build” option on the RS3D AudioListener component, and manually add the RealSpace3D_HRTF_Entry.unity scene into their Unity Build Settings “Scenes In Build” at the level they wish to expose the dialog box (see image below). The RS3D Audio HRTF Entry scene can be found in the /Assets/RealSpace3D/Scenes folder.



Build your project and now the end-user will be prompted to choose the HRTF they wish to use.

4 RealSpace3D Audio API

All RS3D Audio components/game objects properties can be controlled via scripts. Please refer to the RS3D Audio API manual (separate) for more details. RS3D Audio also provides a "realspace3d_sample.unityproject" that has scripting examples that show most of the APIs in action. They can be found in the sample projects / Assets/RealSpace3D/Scripts folder.

5 Additional Information / FAQ

* When upgrading / importing a Windows RS3D Audio unity package into a project with a previous version of RS3D Audio you must import the package and then close the Unity editor and re-open in order for updates to truly take effect. Appears that Unity's Windows version does not release the .dll.

* I imported RS3D Audio package into a project and I am getting error "RealSpace3D_vsEngine.dll is defined multiple times for the Editor. Only one DLL can be assigned to the Editor." RS3D provides for Windows a x86 and x86_64 dll. Unity provides the plugin Inspector you must select the DLL for the platform you wish to use. Navigate to the which architecture on Windows you are building for 32bit or 64bit, the /Assets/RealSpace3D/Plugins/x86 or /x86_64 in the Project window. Click on the folder and then click on the dll in the Project window. The Inspector will show check boxes under "Select platform for plugin." Select "Editor" and "Standalone" on the architecture you wish and deselect all in the other.

* Do I have to write scripts to interact with RS3D Audio?

It is not necessary to write scripts in order to hear your sound objects emit 3D sounds. You can just set your sound objects in the scene and via

the Inspector enter the params you wish on the AudioSource and RS3D Audio takes care of the rest. Scripting allows the developers that wish to have more control take over how and when their 3D sounds will be heard or not.

* I do not hear any sound at all.

— RS3D Audio uses the Unity engine so there must be at least one Unity AudioListener in the scene. Normally, the Unity AudioListener is on the MainCamera. You can place the RS3D AudioListener on the MainCamera as well, it will not interfere.

— You may also have audio that has been generated at a sampling rate higher than 44.1 kHz. RS3D Audio does not currently spatialize audio with sampling rates higher than 44.1 kHz.

— Check the console window for any errors that may have occurred, RS3D Audio may have halted.

* I am using RS3D AudioSource but not hearing 3D sound.

If using Unity 5.2+ you must now select the spatializer plugin you wish to use. Go to Edit > Project Settings > Audio and in the Inspector window choose “RealSpace3D Audio” from the “Spatializer Plugin” drop down.

* How can I control the sound quality of RS3D Audio?

In the RS3D AudioListener you can set different HRTF settings or in the RS3D_VirtualRoom you can play around with the “Room Reflection Coefficients” and the “Advance” settings. You can also in the Unity Editor select the Project Settings > Audio > DSP Buffer Size and choose from the listed options of Default, Best, Latency, Good Latency, or Best Performance. RS3D Audio will read these options and provide the best quality available at these settings.

* I keep getting “Insufficient Threads” and a Unity crash.

This is usually a Unity error due to the user running multiple monitors on a PC. We have found the way to correct this is to open a command prompt and choose “Run As Admin.” Navigate to /Program Files (x86)/ Unity/Editor (or wherever you have installed Unity and find the Editor folder) and run Unity from the command prompt with the following command, “unity-force-d3d11.”

* Why can’t I play more than 4 RS3D Audio sounds?

You can. You just have to obtain a non-indie developer license. Send an email to *info@visisonics.com* and request a non-indie developer license.

* Why do I see “NullReferenceException” when I remove an AudioClip from a RS3D Audio sound source.

You are probably switching sounds on your audio source. This is Unity letting you know the sound source has no audio clip. You can ignore this message and assign your new audio clip.

* Please make sure that when you are building RS3D Audio for another platform that you remember to “switch platforms” in the Unity Build Settings window. Doing so will guarantee that Unity will find the proper RS3D Audio platform specific libraries needed.

* RS3D Audio provides a debug logger to help you during your development. If you wish to use it, navigate to the Unity menu Help > RealSpace3D > Development Log. A dialog box will prompt you to whether or not you wish to have the logger turned on. Clicking yes will turn it on. Another dialog box will appear and show you the location of where the log file will be written to. For Mac applications the log file is in the .app file. You must click “show application contents” and navigate to the Contents/Resources/Data/ StreamingAssets/RealSpace3D/DontTouch folder and see the rs.log file.

Note: Log files generated on Android and iOS devices will have to be obtained by whatever means the developer has on hand to access files on the devices, i.e., a file manager or some other tool.

* RS3D Audio provides a default AndroidManifest.xml file for Android device builds. There is nothing that RS3D Audio needs in the manifest file when running in other applications. You can simply use your AndroidManifest.xml file as is.

If problems should be encountered or you find errors in the manual please contact VisiSonics. Email to *support@visisonics.com* or if a dire emergency for immediate help email *rod.h@visisonics.com*

6 RS3D Audio Common Error Codes

When running RS3D Audio if a failure should happen errors are displayed in red in the Unity Console window, also as displays in the scene. The following are some common errors and possible solutions.

Code 52: RS3D Audio Not — Check to see if all the monobehaviour scripts in your project are set. Unity sometimes upon changes to the mono dlls drops the monobehaviour scripts and they have to manually be reset. To do so find the little circle next to the box in the Inspector that reads, “Missing MonoBehaviour” and a list of all the components and scripts will be displayed. Select the correct MonoBehaviour.

Code 614: Invalid License - You have an invalid RS3D Audio license. Contact *support@visisonics.com* or go to *www.realspace3daudio.com* to obtain a valid license.

Code 615: Invalid Platform - Your RS3D Audio project is running on a platform it has not been built for. Check your build settings in the Unity editor and make sure you are building for the correct platform.

Code 617: Expired License - Your RS3D Audio license has expired. Contact *support@visisonics.com* or go to *www.realspace3daudio.com* to obtain a valid license.

Code 618: Indie License Limit - If you see this error you have tried to create more than 4 RS3D AudioSources. Indie version licenses allow for only 4 RS3D sound sources. Simply remove the RS3D AudioSources that are causing the conflict.

7 Conclusion

RS3D Audio allows you to easily add immersive 3D sounds by using a physics, based model in your applications. As a user you can simply interact with the components or you can control it via scripts. Please read the RS3D Audio API documentation for further details.

Thank you for choosing RS3D Audio. Enjoy experiencing 3D audio in your application.

If you have any questions send email to *support@visisonics.com*