# Wolf Avatar Blendshapes Review

## PART ONE: REVIEW OF SHAPES CURRENTLY USED IN HIFI

The selected shapes from this wolf fst are the shapes that Hifi currently drives. These are reviewed first.

```
jointIndex = RightShoulder = 24
bs = BrowsU_L = BrowsU_L = 0.5
bs = BrowsU_C = BrowsU_C = 0.5
bs = BrowsU_R = BrowsU_R = 0.5
bs = BrowsD_R = BrowsD_R = 0.7
bs = BrowsD_L = BrowsD_L = 0.7
bs = EyeBlink_L = EyeBlink_L = 1
bs = EyeBlink_R = EyeBlink_R = 1
bs = EyeOpen_L = EyeOpen_L = 0.5
bs = EyeOpen_R = EyeOpen_R = 0.5
bs = JawOpen = JawOpen = 0.5
bs = MouthSmile_R = MouthSmile_R = 0.6
bs = MouthSmile_L = MouthSmile_L = 0.6
bs = LipsFunnel = LipsFunnel = 0.5
bs = LipsUpperClose = LipsUpperClose = 0.5
bs = Puff = Puff = 0.5
bs = Sneer = Sneer = 0.5
bs = LipsUpperOpen = LipsUpperOpen = 0.5
bs = ChinUpperRaise = ChinUpperRaise = 0.5
bs = ChinLowerRaise = ChinLowerRaise = 0.5
bs = JawRight = JawRight = 0.5
bs = MouthRight = MouthRight = 0.5
bs = MouthDimple_L = MouthDimple_L = 0.5
bs = JawLeft = JawLeft = 0.5
bs = JawChew = JawChew = 0.5
bs = MouthLeft = MouthLeft = 0.5
bs = EyeDown_R = EyeDown_R = 0.5
bs = LipsPucker = LipsPucker = 0.5
bs = LipsStretch_L = LipsStretch_L = 0.5
bs = MouthDimple_R = MouthDimple_R = 0.5
bs = EyeSquint_L = EyeSquint_L = 0.5
bs = EyeUp_L = EyeUp_L = 0.5
bs = EyeOut_L = EyeOut_L = 0.5
bs = EyeSquint_R = EyeSquint_R = 0.5
bs = EyeOut_R = EyeOut_R = 0.5
bs = MouthFrown_L = MouthFrown_L = 0.5
bs = LipsLowerOpen = LipsLowerOpen = 0.5
bs = MouthFrown_R = MouthFrown_R = 0.5
bs = EyeUp_R = EyeUp_R = 0.5
bs = JawFwd = JawFwd = 0.5
bs = EyeIn_R = EyeIn_R = 0.5
bs = LipsStretch_R = LipsStretch_R = 0.5
bs = LipsLowerDown = LipsLowerDown = 0.5
bs = EyeDown_L = EyeDown_L = 0.5
bs = EyeIn_L = EyeIn_L = 0.5
bs = LipsLowerClose = LipsLowerClose = 0.5
bs = LipsUpperUp = LipsUpperUp = 0.5
```

This video goes through the shapes comparing current shapes to the original shapes in Wolf avatars from spring:

**wolf_blendshapes_compare.mp4**

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- JawOpen could be pushed a little further in the fst - try setting that scale factor from the current **0.3** to more like **0.5**.
- BrowsU_L, BrowsU_C and BrowsU_R might be helped by increasing the scale factor form **0.5** to **0.7.**
    - The shapes themselves are more isolated than the old shapes. The previous shapes had beautiful fall-off in the left and right brow raisers extending pretty far up the forehead.
    - The current shapes have a hard edge above that brow texture and don't move the edge loops above.
- The MouthSmiles look great on the new set.
- I'm not sure why the talking animation is reading as more muted now but I have a theory that the new funneler may also be part of the problem. If you compare old funneler and new, you'll see that the old one moved the jaw also - it partially opens the jaw/mouth when it fires. Our system uses the jawopen, funneler and mouthsmiles together to form the talking animation, so I think the new funneler not moving the jaw may be contributing to the more muted appearance.

## PART TWO: THE REST OF THE SHAPES

Since we are basing our supported shapes on the ARKit standard, this table compares **ARkit, FACECAP, Wolf,** and **Hifi**

I include the Face Cap App shape set because it also follows the ARKit standard, and uses the Iphone XS depth camera to capture face performance and export to fbx.

For evaluation and analysis I'll refer to the FACS names and action units (AUs) from this wikipedia page: https://en.wikipedia.org/wiki/Facial_Action_Coding_System

**General Authoring Best Practices:**

1. Each shape can have a large falloff but a steep S curve. This means that the vertices moved by the shape should be fairly specific to the AU, as described in the FACS page above, but the range of influence can be pretty large. This helps to keep the face feeling alive, and avoids the eerie perfectly-frozen-vertices effect that computer graphics tend towards.
    a. For instance, jawOpen moves vertices all the way up to and even a little bit around the eyes, but only just slightly.
2. When several shapes are intended to combine (all the brows up, smile+cheecksquint, sneering and snarling) they should be sculpted as a whole compressed angry snarling face and masked out to form the separate shapes.
3. Each shape that has an opposite should be sculpted in such a way that they flow back and forth into each other without big discontinuities.
    a. Brows up/down, mouthcorners in/out, smile/frown, mouth left/right.
4. All shapes should be bilateral. This isn't 100% supported by ARKit unfortunately (Puff) but wherever they do it, we should do it.

NOTES from evaluating the shapes individually

| ARKit shapes | FACE CAP APP | Wolf shape set | HIFI FaceshiftConstants.cpp | WOLF NOTES |
|---|---|---|---|---|
| browDownLeft | browDown_L | BrowsD_L | BrowsD_L | Too isolated, doesn't move verts on forehead. Should flow from BrowsUp better. |
| browDownRight | browDown_R | BrowsD_R | BrowsD_R | |
| browInnerUp | browInnerUp | BrowsU_C | BrowsU_C | Too isolated, doesnt move verts above brows at all. |
| browOuterUpLeft | browOuterUp_L | BrowsU_L | BrowsU_L | all of these (brows up left, center, right) should combine well into a good result shape. |
| browOuterUpRight | browOuterUp_R | BrowsU_R | BrowsU_R | |
| cheekSquintLeft | cheekSquint_L | | CheekSquint_L | TODO |
| cheekSquintRight | cheekSquint_R | | CheekSquint_R | TODO |
| eyeBlinkLeft | eyeBlink_L | EyeBlink_L | EyeBlink_L | Good sculpt, There is a texture artifact on this character. See below. |
| eyeBlinkRight | eyeBlink_R | EyeBlink_R | EyeBlink_R | |
| eyeLookDownLeft | eyeLookDown_L | EyeDown_L | EyeDown_L | Good |
| eyeLookDownRight | eyeLookDown_R | EyeDown_R | EyeDown_R | Good |
| eyeLookInLeft | eyeLookIn_L | EyeIn_L | EyeIn_L | Good |
| eyeLookInRight | eyeLookIn_R | EyeIn_R | EyeIn_R | Good |
| eyeWideLeft | eyeWide_L | EyeOpen_L | EyeOpen_L | Verts move vertically rather than as though around eyeball, so a gap forms. See pic below. "Open" usually moves upper lid more (which does have muscle control) and is a slight change to lower lid, which does not have muscle control. |
| eyeWideRight | eyeWide_R | EyeOpen_R | EyeOpen_R | |
| eyeLookOutLeft | eyeLookOut_L | EyeOut_L | EyeOut_L | Good |

| | | | | |
|---|---|---|---|---|
| eyeLookOutRight | eyeLookOut_R | EyeOut_R | EyeOut_R | Good |
| eyeLookUpLeft | eyeLookUp_L | EyeUp_L | EyeUp_L | Good |
| eyeLookUpRight | eyeLookUp_R | EyeUp_R | EyeUp_R | Good |
| eyeSquintLeft | eyeSquint_L | EyeSquint_L | EyeSquint_L | Good - could move upper lids slightly. |
| eyeSquintRight | eyeSquint_R | EyeSquint_R | EyeSquint_R | |
| jawForward | jawForward | JawFwd | JawFwd | Good. Could move upper lid slightly - maybe expand falloff. |
| jawLeft | jawLeft | JawLeft | JawLeft | Good |
| jawOpen | jawOpen | JawOpen | JawOpen | Good. I'd try to clean up edge loops on this since it combines with a lot of othe shapes. |
| jawRight | jawRight | JawRight | JawRight | Good |
| mouthFunnel | mouthFunnel | LipsFunnel | LipsFunnel | Good. Could move jaw slightly. Hifi uses this as a talking viseme so some jaw motion would help hifi. |
| mouthPucker | mouthPucker | LipsPucker | LipsPucker | Good. Could move jaw slightly. |
| mouthStretchLeft | mouthStretch_L | LipsStretch_L | LipsStretch_L | Pretty good. When L/R combined they should stretch lips against teeth. Should flow from opposite shape Pucker. Nice falloff to skin on cheeks. |
| mouthStretchRight | mouthStretch_R | LipsStretch_R | LipsStretch_R | |
| mouthFrownLeft | mouthFrown_L | MouthFrown_L | MouthFrown_L | Too isolated. Should pull down slightly on lower nose and press lips against teeth. Optionally, could have response in neck since this is where muscle originates for this shape. |
| mouthFrownRight | mouthFrown_R | MouthFrown_R | MouthFrown_R | |
| mouthLeft | mouthLeft | MouthLeft | MouthLeft | Pretty good - maybe too isolated. Could have response in skin around eyes slightly. |
| mouthRight | mouthRight | MouthRight | MouthRight | |
| mouthSmileLeft | mouthSmile_L | MouthSmile_L | MouthSmile_L | These are nice. They do combine to lift the lips slightly too much but don't press lips against teeth. So when combined with some jawOpen, the lips don't wrap around teeth as you'd want.<br>Also, this shape incorporates some cheekSquint but it shoudn't. Those should be separate shapes. |
| mouthSmileRight | mouthSmile_R | MouthSmile_R | MouthSmile_R | |
| mouthRollLower | mouthRollLower | LipsLowerClose | LipsLowerClose | Lip rolls in, not a replacement for mouthClose |
| mouthRollUpper | mouthRollUpper | LipsUpperClose | LipsUpperClose | |
| cheekPuff | cheekPuff | Puff | Puff | good |
| mouthDimpleLeft | mouthDimple_L | MouthDimple_L | MouthDimple_L | should combine with smile for dimpled smile. These crash when combined. |
| mouthDimpleRight | mouthDimple_R | MouthDimple_R | MouthDimple_R | |
| mouthClose | mouthClose | | | TODO |
| mouthPressLeft | mouthPress_L | | | TODO |
| mouthPressRight | mouthPress_R | | | TODO |
| noseSneerLeft | noseSneer_L | Sneer | Sneer | should be bilateral |
| noseSneerRight | noseSneer_R | | | |
| mouthShrugLower | mouthShrugLower | | | TODO |
| mouthShrugUpper | mouthShrugUpper | | | TODO |

| | | | | |
|---|---|---|---|---|
| tongueOut | tongueOut | | | |
| mouthLowerDownLeft | mouthLowerDown_L | LipsLowerDown | LipsLowerDown | should be bilateral |
| mouthLowerDownRight | mouthLowerDown_R | | | |
| mouthUpperUpLeft | mouthUpperUp_L | LipsUpperUp | LipsUpperUp | should be bilateral |
| mouthUpperUpRight | mouthUpperUp_R | | | |
| | | | | Not in ARKit |
| | | | | Not in ARKit |
| | | | | Not in ARKit |
| | | LipsLowerOpen | LipsLowerOpen | Not in ARKit |
| | | LipsUpperOpen | LipsUpperOpen | Not in ARKit |
| | | JawChew | JawChew | Not in ARKit |
| | | | ChinLowerRaise | Not in ARKit |
| | | | ChinUpperRaise | Not in ARKit |

## FACECAP TESTS

- I record Jamil, Adam and myself running through some short emote performances with the facecap app on my iphone XS + video for a side by side comparison.
- The facecap shapes (gray face) are a good implementation of ARKit.
- I also include a mixamo shape set for comparison.
    - Note, mixamo's shape set has some huge omissions, but the shapes that are common to ARKit/mixamo can be compared. The rig I'm using here is mixamo resculpted and expanded by me, so all shapes are present, but it's not a complete rig yet. It's a WIP.

**doug_emotes_facecap.mp4**

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**facecap_tests_jamil_maleFitA.mp4**

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NOTES:

- Surprise
    - wolf **overcombines a lot in mouth** area
    - most of this comes from **funneler not working well with open mouth**
    - **brow creases**
- Smile
    - **wolf mouth corners don't move** much
    - **no pressers**
- Eyelook directions
    - wolf soft eyes are pretty understated
    - wolf **blink shows texture artifacts**
- Pursed lips
    - wolf doesn't support this - no pressers
    - facecap app doesn't really drive this correctly
- Mouth articulation
    - wolf **does not have mouthClosed** shapes
- Sneer, compressed angry face
    - Sneer should be bilateral
    - Sneer could be bigger - there isn't much range.
    - Need left/right lip raisers to support sneer with snarl, and they should combine well with sneer.

### ANGRY : furrow brows, tighten mouth, lip raisers, sneers, widen eyes or squints

**rig_angry_frown.mov**

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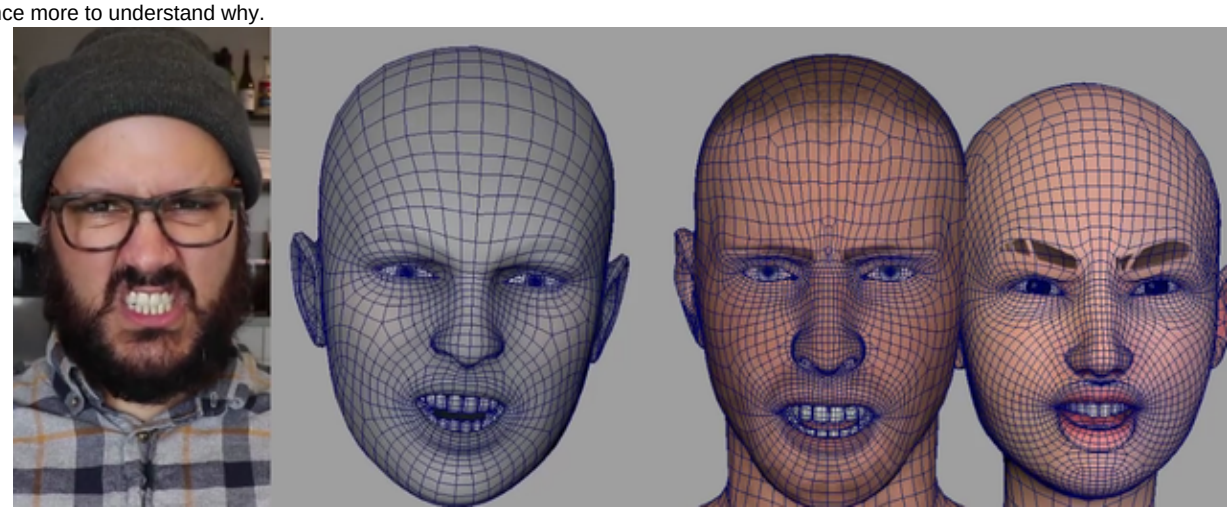
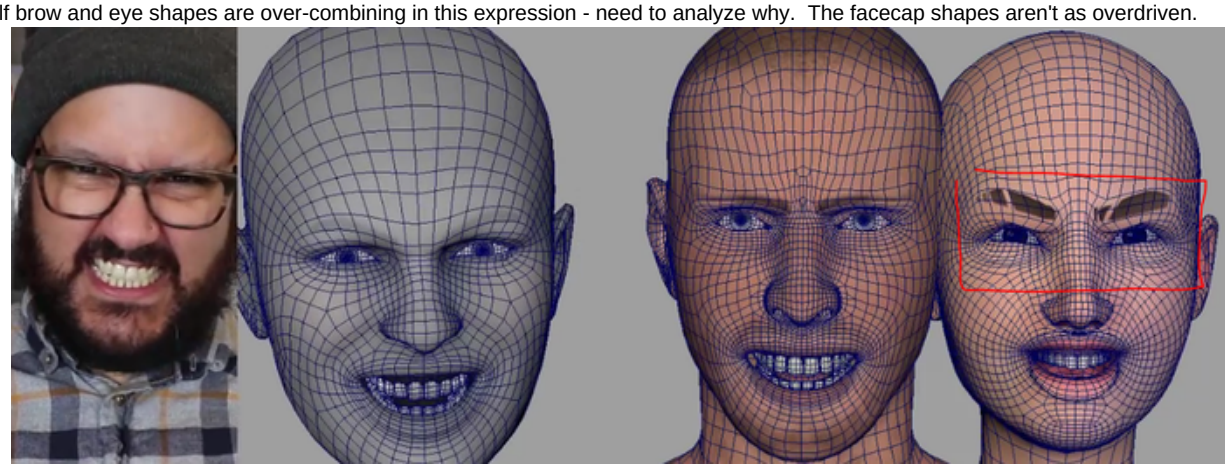
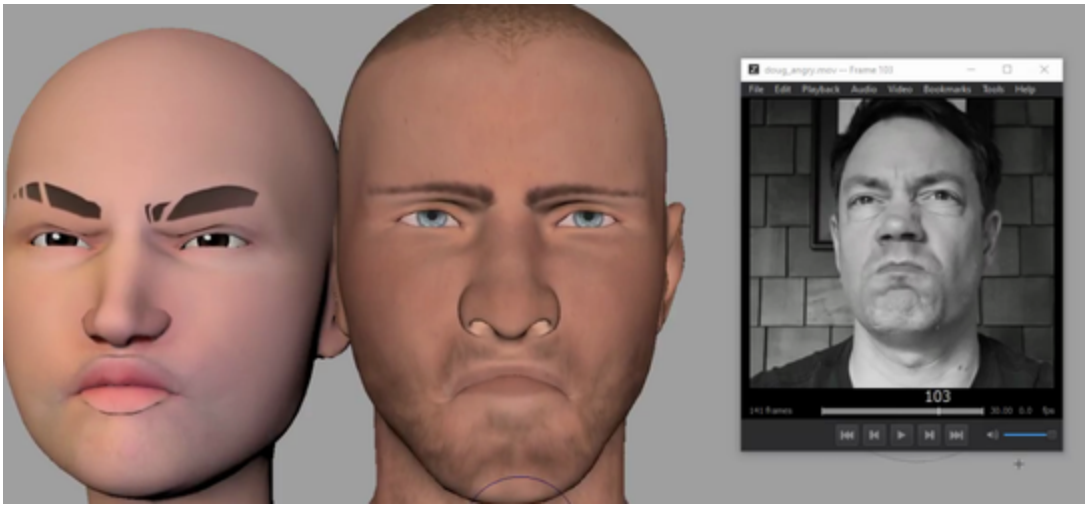
Notes

- Without wrinkle maps it's really hard to sell a good sneer.  The facecap app isn't detecting much nose-wrinkler on jamil, possibly because of his glasses.  Wolf shape set is missing the cheek squints and mouth pressers here.
- Anger really distorts the face - the sneer shapes should be bilateral.  Facecap/ARKit specify left/right versions for sneer - we should follow.
- ARKit is missing mouthNarrowers, which is too bad.  They would be used here.  Jamil's mouth compresses and narrows, but the ARKit shape set can't follow that.
- Facecap isn't posing correctly for clenched teeth, but it's sort of close.  The wolf shapes miss this by a lot.  I need to analyze the difference more to understand why.
- 
- The wolf brow and eye shapes are over-combining in this expression - need to analyze why.  The facecap shapes aren't as overdriven.
- 
- Missing mouth shrug or frown shapes in the wolf set makes it impossible to really hit an angry pout or compressed, upset angry lower face.




- Both rigs need mouth shapers.  It was hard to get the lips to compress and press together.
- ARKit has simplistic brow control.  I'd like to have pushed the brows together as you get when the mentalis and corrugator fire together and pull against each other.  But the ARKit shape set doesn't have a way to push the brows in and together.
- Wolf's sneer also furrows the brow but it shouldn't.  The brows should be controlled independently from the sneer.

### DISGUST - sneers, squints, compression of face, lip raisers, lip tighteners

**rig_disgust_sneer.mov**

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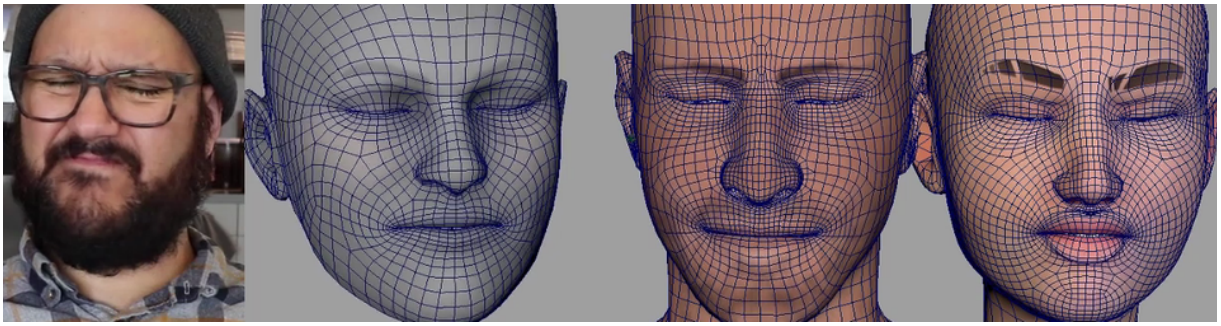
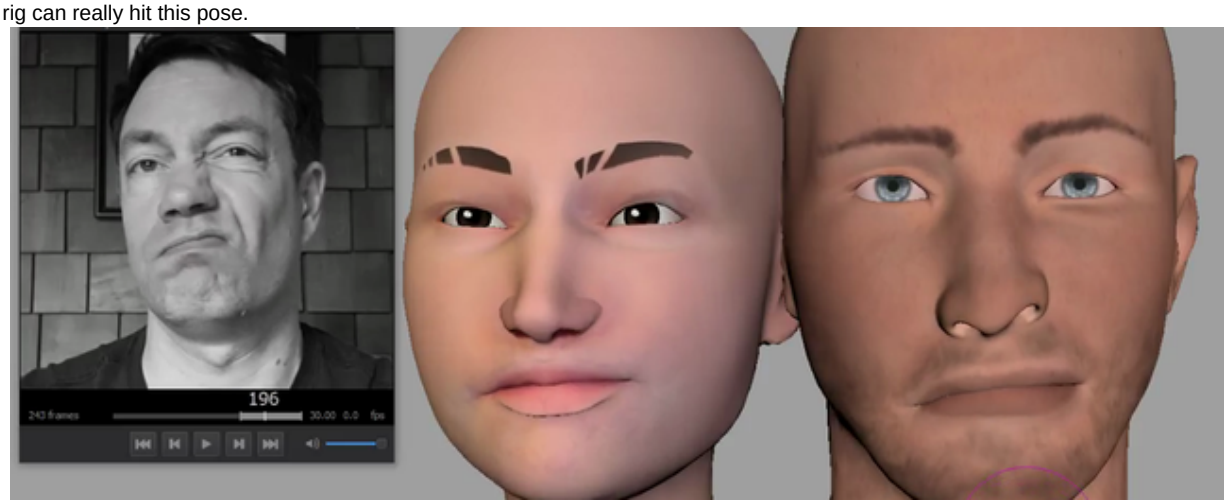
Notes

- Disgust requires bilateral lip raisers and nose wrinklers.  It's a difficult shape to support in a rig, and it too would typically require wrinkle maps on a mesh of this resolution.
- Wolf is missing pressers, so can't compress the mouth much.  The facecap face is doing better.  The mixamo face is best around the mouth.



- This expression suffers from lack of mouth-narrower support in ARKit.
- Neither rig can really hit this pose.




- Both need sneer to go further.

- Wolf falls short because it's sneer isn't bilateral
- Wrinkle maps would really help sell expressions that compress the face like this.

### FEAR - raise brows, widen eyes, sneers, lip pressers

**rig_fear.mov**

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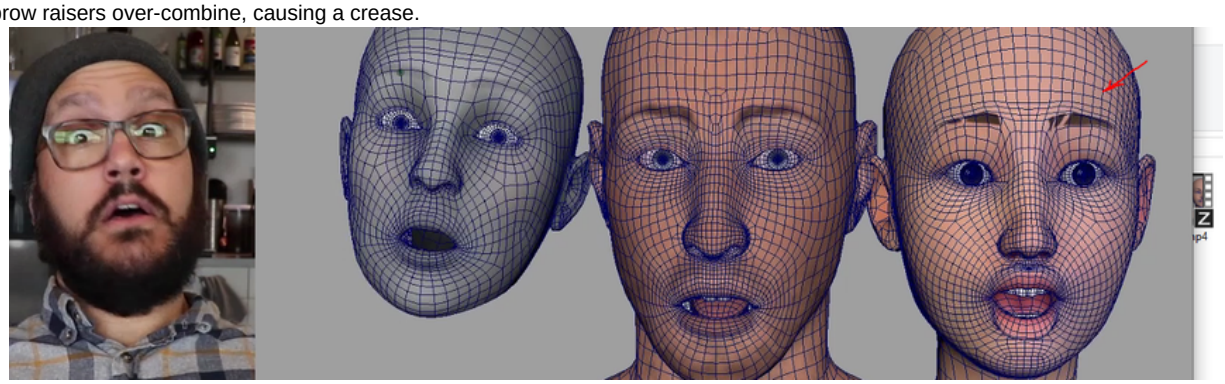
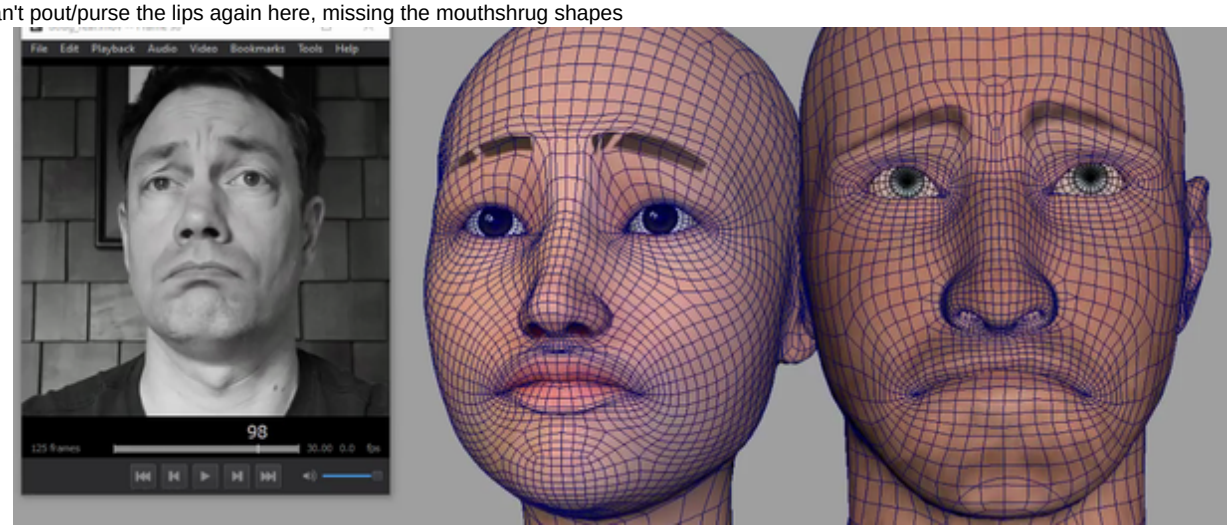
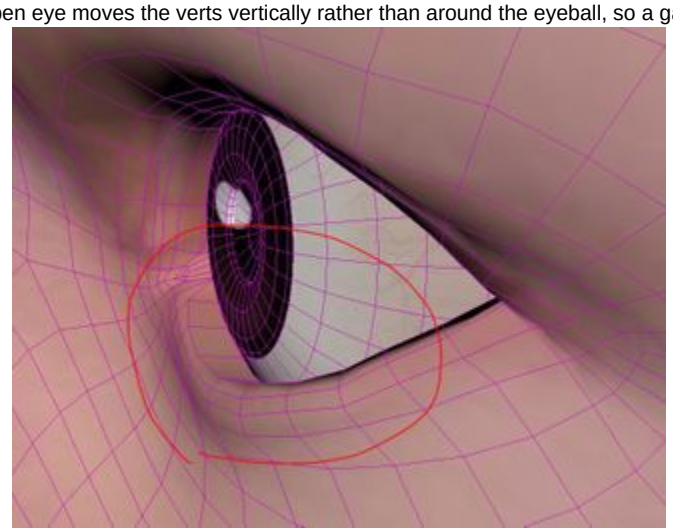
Notes

- Wolf's brow raisers over-combine, causing a crease.
- 
- Wolf can't pout/purse the lips again here, missing the mouthshrug shapes
- 

- Wolf nostrils could flare in mouth compress shapes.  They don't respond at all right now.
- Wolf open eye moves the verts vertically rather than around the eyeball, so a gap forms.
- 

## LAUGH - smile, open mouth smile, cheek squint, eye squint, brow raisers

**rig_laugh.mov**

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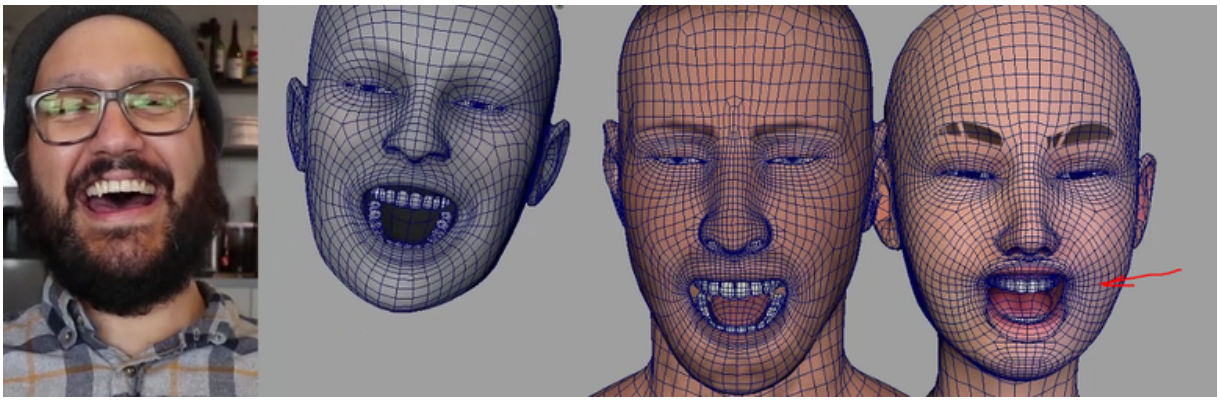
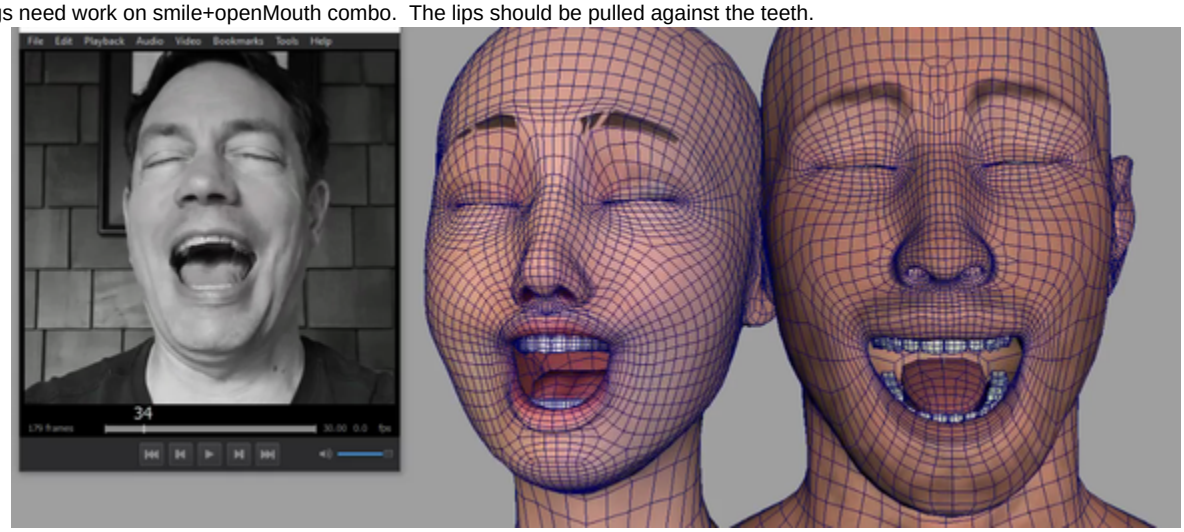
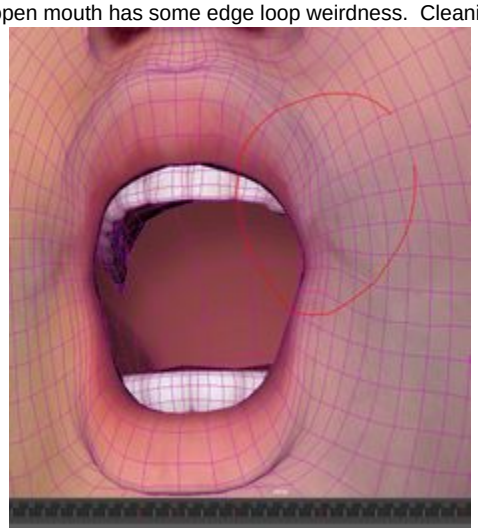
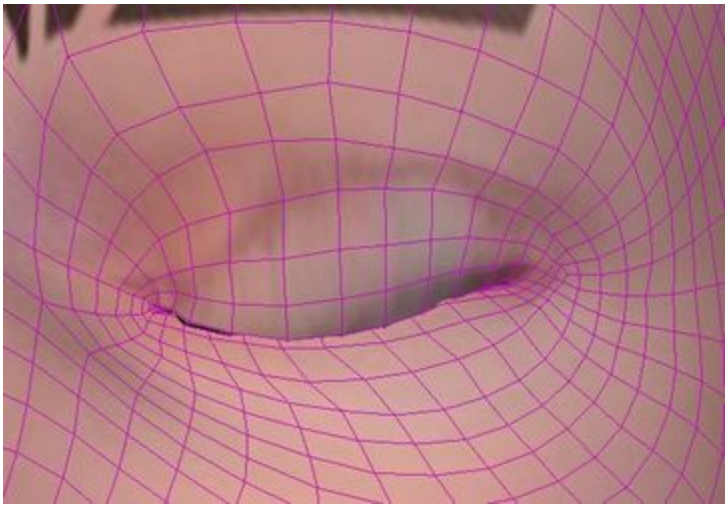
Notes

- Open mouth smile or laugh is really hard to support.  The facecap face does ok, mixamo a little less, and the wolf face over-combines causing some distortion.
  - 
- Both rigs need work on smile+openMouth combo.  The lips should be pulled against the teeth.
  - 
    
- Wolf's open mouth has some edge loop weirdness.  Cleaning this up would make it combine more predictably with other shapes.
  - 
- The way the selfie picture is masked against the face texture causes a weird ugly little artifact when blinking.  Looks kind of like a bruise.

- 

### SAD - mouth stretchers, pressers, lips raisers, sneers, furrow brows, squints

**rig_sad.mov**

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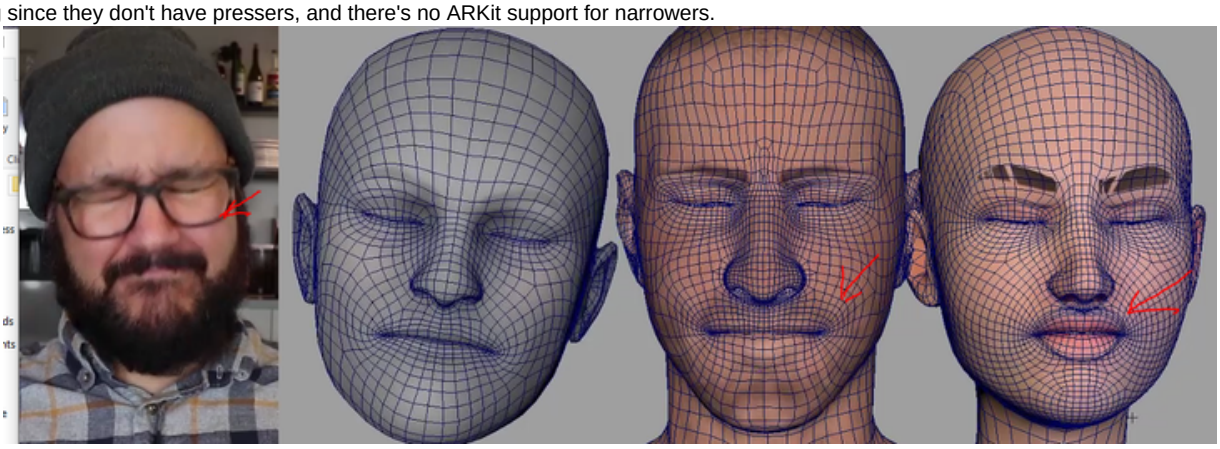
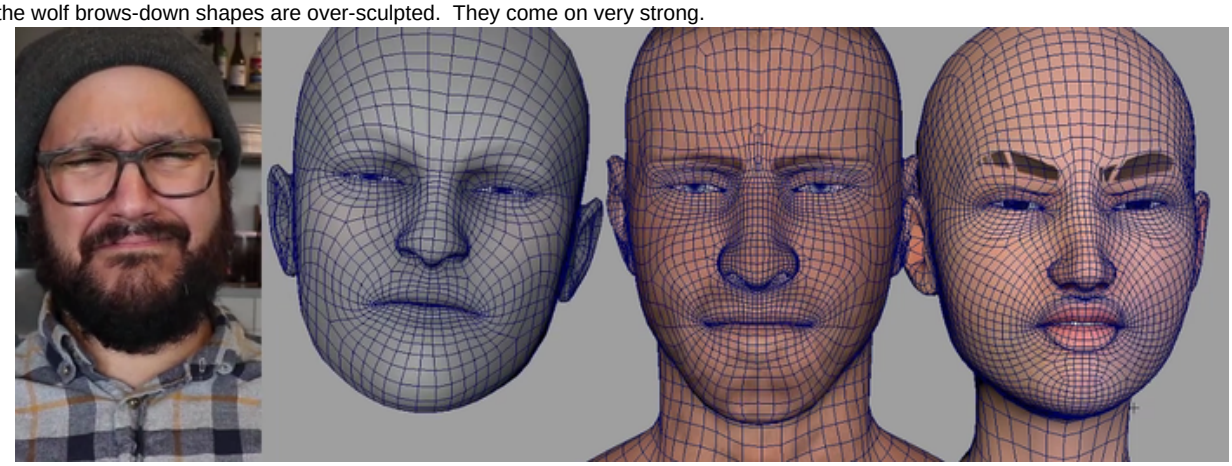
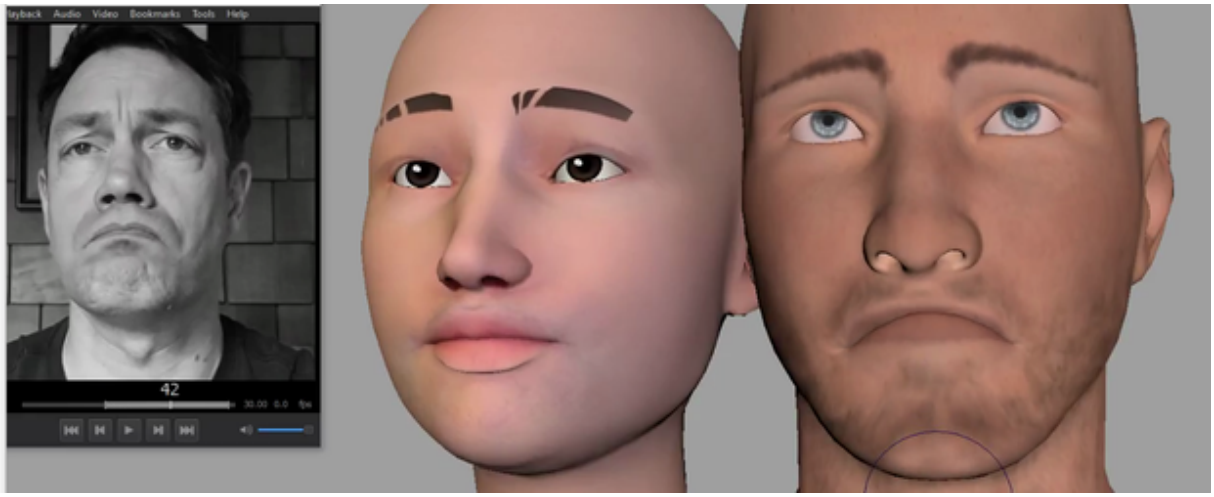
Notes

- Missing mouth pressers, it's hard to hit sad frown.  The mixamo shapes do ok, but don't have the range.  Wolf shapes can't really do anything since they don't have pressers, and there's no ARKit support for narrowers.
  - 
- I think the wolf brows-down shapes are over-sculpted.  They come on very strong.
  - 
  - Hard to drop the brows without furrowing brows on Wolf.
- Similar to fear - all the same comments apply.




- Cheek squint is needed for this one, which is missing from the wolf set.

### SMILE - lip corner pullers, open mouth smile, cheek and eye squints, brow raisers, pressers

**rig_smile.mov**

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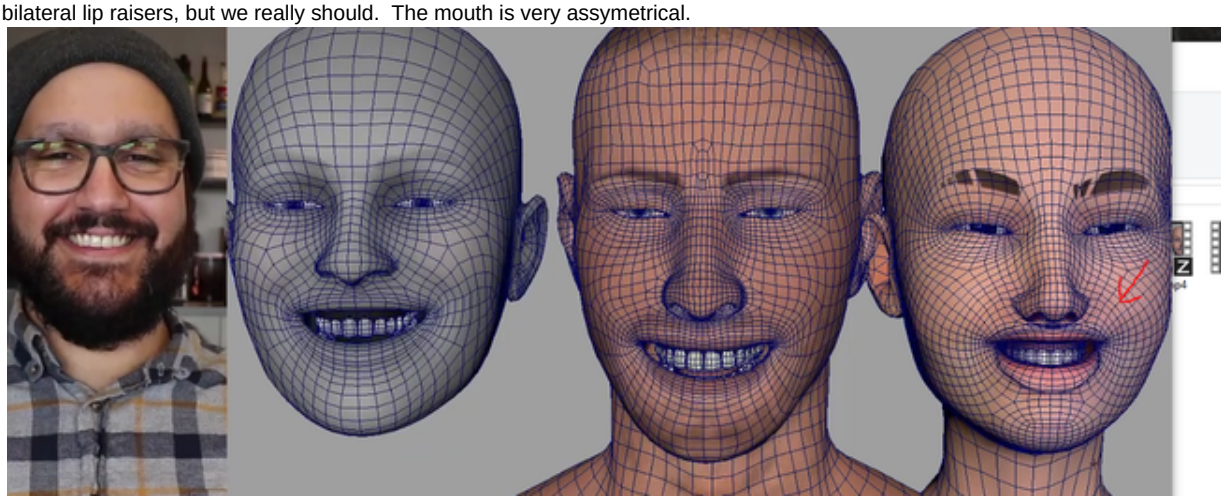
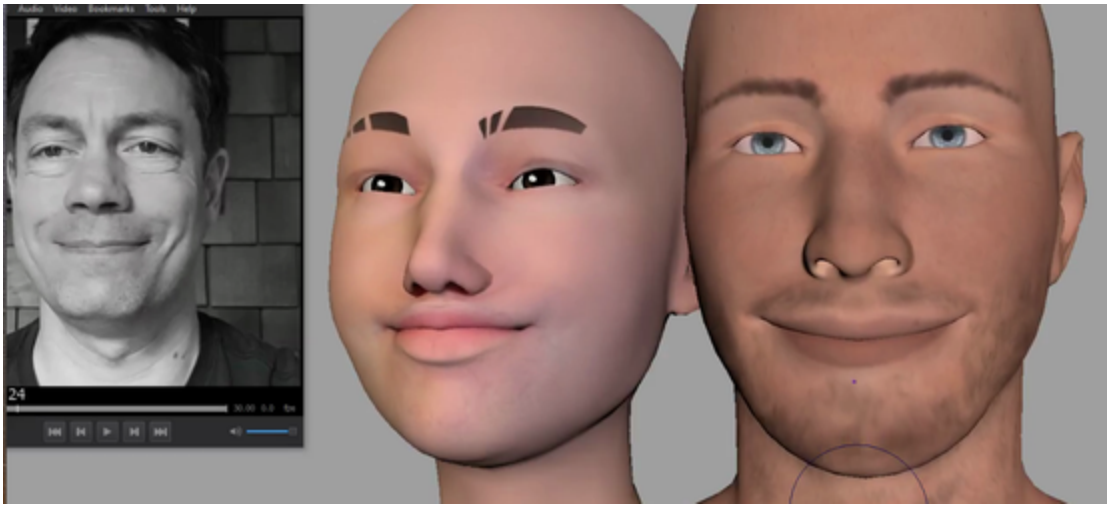
Notes

- Smile is what all of these shape sets do best.
- Face cap is firing lip raisers and it's creating an ugly effect on it's own face, but especially on wolf's shape set.  Wolf (and HIFI) do not support bilateral lip raisers, but we really should.  The mouth is very assymetrical.



- Wolf is missing cheek squint, or rather they combine smile and cheek squint so there's no opportunity to vary the timing of the expression across the face.

- 

- The brow sculpts isolation from forehead shows here too.