

# How to Design for Augmented and Virtual Reality

## Getting in the space (3D UX)

Usability of virtual environments is essential. **Users should never have to figure out how to interact with VR interfaces.** While today's immersive experience design is a new skill for many practicing UX, anyone with a foundation of usability can easily transfer 2D thinking and skills to learn 3D UI design.

Contrary to what many developers, designers and UX people think, **much is known about 3D interface usability.** While new hardware is pushing new boundaries, there are usability principles and patterns that apply to VR regarding how to approach building effective navigation, collaboration and presence, for example.

To be clear, the goal of VR/AR UX is to **expand the “superpowers” of perception or imagination** (for both designers and users) and allow new ways to see, hear, feel and think about information, tasks and human experiences.

VR/AR extend users' imagination.

3D interaction Design involves a 1st person exploration/narration /perspective, with real-time interaction. We are co-authoring. (normally it's 3rd person, and the users is following what was prepared for them)

<https://www.foundry.com/industries/virtual-reality/vr-mr-ar-confused>

Vision of VR = story inside you. Our experience must transform the user.

MR = mixed reality

They all imagine something that is not there

AR (least immersive), it's extending and enhancing what's there, overlay visualisation with real world)

MR (imagination) is manipulating it, extends what's here or not, enhance what's there within the physics of what's there.

VR (most immersive) is co-authoring interaction/narrative, imagine extend/enhance what's not there,

**Augmented reality** is an overlay of content on the real world, but that **content is not anchored to or part of it.** The real-world content and the CG content are not able to respond to each other.

**Mixed reality** is an overlay of synthetic content on the real world that is anchored to and interacts with the real world—picture surgeons overlaying virtual ultrasound images on their patient while performing an operation, for example. The key characteristic of MR is that the **synthetic content and the real-world content are able to react to each other in real time.**

with AR/VR we leave the world of logic and enter imagination.

Start with presence: you need to feel like you are somewhere.

**Immersion** is how deep you are AR > MR > VR

**Presence** is how "pulled in" you feel...It's the feeling that you are there, even when one is physically situated in another.

It needs place illusion and plausibility illusion.

You can quantify, measure your presence index.

**Factors that can impact presence:**

degree of control

immediacy of control  
anticipation of event  
mode of control  
physical environment modifiability  
sensory modality (it can't only be visual, you need more), **better if it is multi modal** (gesture, movement, speech, sounds) this adds a level of reality.

Fear is the easier feeling to trigger to motivate people.

**Augmented:** having a meshed relationship with virtual and real

- maintaining contact with real space
- using real space as a canvas
- working around the physics of physical spaces
- user objects/experiences feels meshed or fully augmented

### First 30 seconds experience

B2B: business to business experience - it doesn't have to be boring

Narrative can focused attention.

Getting the first 30 seconds (F30) experience right. It's critical . Users will loose the plot or the interaction co-authorship. with VR/AR, the character is YOU.

Avoid: disorientation, low engagement and lack of affordance.

You need to stimulate the curiosity

### Exploring spatial interfaces

Less is more: don't use the whole canvas, focus the users attention.

Users should know what to do without help (**affordance**)

Designing for 360° could lead to neck stiffness, so need to be tested

Big icons floating on an overlay is simple and usually well received

### Think of the scene as an affordance canvas

Menus, Dialogs, Visualisation pieces, affordance cues.

Just because you can doesn't mean you should use 360°

Study: audiences with a 90° range of vision could recall nearly every event in the story.

The more field you use, the less comprehension.

**Foveated rendering:** focus the user on a 96° viewing angle, and within this gives a higher resolution to the fovea angle (about 20° in the middle)

If you don't do that:

HDM limitation : having access to foveated rendering or inside out tracking

You should make sure your affordance Canvas is focused (less is more) and not 360 or always 360 (unless you want your user to look behind them)

### Storytelling essentials

Story - Improvisation - imagination

Using narrative to **unfold the scene** design / affordance canvas

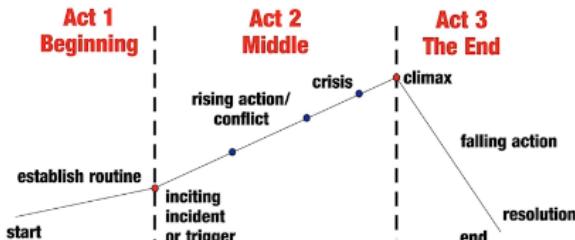
Narrative as the **task flow / story flow** guidance system

Using narrative mechanics to **shape the experience**:

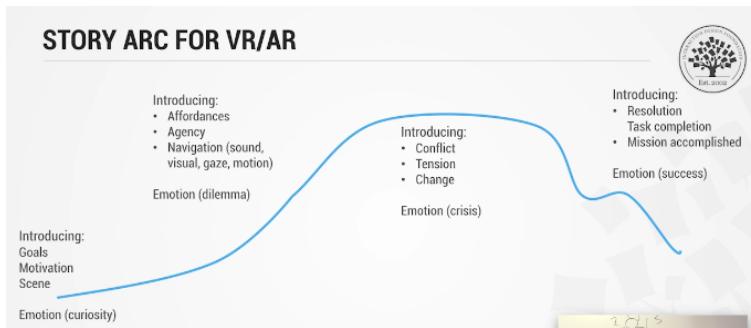
- give cues
- spark emotions
- guide discovery
- induce immersion

This leads to **presence**

# Story Arc



## STORY ARC FOR VR/AR



**What:** Design with storytelling (spatial, narrative, emotional)

Story as Design tool = narrative mechanics (impacting story flow, navigation and engagement).

**How:** story-sketching; improvisation

**Start with brainstorming sessions** (note cards, quick sketches and push pins) - capture first thoughts, ideas, images, and feelings about the story/experience you are creating.

Story sketch that up.

### Improvisation essentials

**Yes, and** - meaning an actor accepts whatever is given to her by her fellow actor, at face value, **without changing it**, negating it, or disagreeing with it. She then turns around and **adds something** of value to what she was given. In an improv scene, this is how an actor creates stimulating action.

Complimentary + Open communication

Fluid listening and creating ...

Fluid (any direction) vs Flexible

**Bodystorming:** improvising everyday user scenarios (performances)... relies on interaction designers translating observational data to a simulated environment.

- get in the context where the task is performed. Use environment as a prop.
- acting out - with or without (participatory Design)

**Embodied Design improvisation**, which alternates rapidly and fluidly between storyboarding, Wizard of Oz physical prototyping, domain expert improvisation, video prototyping and crowd sourced experimentation.

- hands-on prototyping in your physical space
- act it out (have users walk through your scene)

Designers cannot design an experience in a literal sense. Rather, designers create an **experience frame** for people to shape their own experiences. This kind of framework acts as guidance for the participant to follow through with its affordances, constraints, goals, and mechanics.

### Improv tips:

- withhold judgment (yes and...)
- build on the ideas of others
- generate a large quantities of ideas (like a design studio)
- free-wheel (= fluid - play "presents" game - designer pass an object generating alternative uses for a familiar object)
- identify a leader (facilitator or improv coach) - like a focus group
- brainstorm structure and place (use warm up improv exercises ; take breaks to review; focus on group dynamics not location, do it in any location)

Using improvisation can enhance the effectiveness of brainstorming and imagineering.

### Imagineering essentials

imagine + engineer = creative visualisation technique  
intentional approach to creative engagement and delight  
use of sound and motion  
interact back with the user

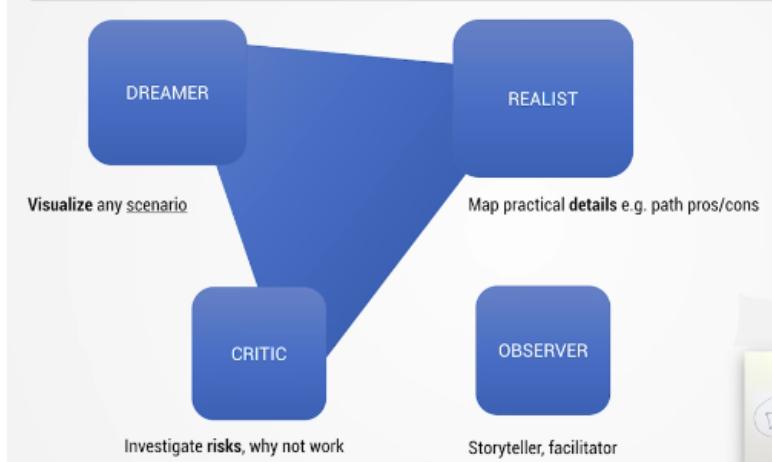
### Imagineering with immersive and mixed reality

**What:** Design with imagination (spatial, narrative, emotional)  
design for aid imagining (impact clarity, engagement and surprise)

**How :** use the Disney triangle (...) ... imagine what users will feel (map the emotions) that will delight, stop users, move them along.

Map the affordance need to help users move forward. Apply the Story Arc to the user scenario

### DISNEY'S TRIANGLE



## Getting familiar with 3D UI's

### Specifying your experience design plan

what is the goal of the experience (for you, for your user)  
what are your HEART metrics  
who is the audience (who are your personas)  
what is the basis of your content experience  
what can your users achieve  
what are limits / boundaries imposed or technical that compromise or limit their experience, how will you cover for it  
what's the narrative  
what is the intended emotional experience, how are emotional interactions used  
what's the intended social experience, how are social interaction or self identity used  
how deep is your presence



## HEART FRAMEWORK

	GOAL	SIGNALS	METRICS
HAPPINESS	For users to feel like the site is unique	A satisfaction rating from a survey	<ul style="list-style-type: none"> <li>▪ Satisfaction</li> <li>▪ Perceived ease of use</li> <li>▪ Net promoter score</li> </ul>
ENGAGEMENT	For users to keep discovering more content	The amount of time people spend viewing from analytics	<ul style="list-style-type: none"> <li>▪ Number of videos watched per user per week</li> <li>▪ Number of uploads</li> <li>▪ Number of shares</li> </ul>
ADOPTION	For users to use the site or app	The number of signups per day from analytics	<ul style="list-style-type: none"> <li>▪ Upgrades to latest version</li> <li>▪ New subscriptions</li> <li>▪ Purchases by new users</li> </ul>
RETENTION	For users to continue to use the site or app	The number of return customers from customer data	<ul style="list-style-type: none"> <li>▪ Number of active users</li> <li>▪ Renewal rate</li> <li>▪ Repeat purchases</li> </ul>
TASK SUCCESS	For users to accomplish their goal	The number of successful completes from a study	<ul style="list-style-type: none"> <li>▪ Search result success</li> <li>▪ Time to upload</li> <li>▪ Profile creation completion</li> </ul>

Google Ventures

### The reality of your user's brain in 3D

Multi-modal interactions win.

Research shows:

- overloading one sensory system is a bad idea
- users perform better with multi-sensory UI's
- error handling and multitasking are easier with shared sensory inputs

### Design for input methods:

speech, gaze, gesture, 6-dof controllers (degree of freedom) - gloves or direct interaction (leap motion controller)

can give a more intuitive and idrect connection with virtual objects.

### 3D space can overwhelm: (from the oculus research guidelines)

Gaze as a cursor but ... in testing, implementations of gaze selection without a cursor or crosshair have been reported as more difficult to use and less grounded.

Gaze as a cursor but with movement... this can allow the user to lose the interface and not realise it is still available and consuming their input, which can further result in confusion when the application doesn't handle input as the user expects (because they do not see a menu in their current view).

### Think of users point of view.

#### Some questions to ask:

- is the user sitting, reclining, standing, or walking while using your experience?
- how does your content adjust to different positions?
- can the user adjust it?
- will the user be comfortable using your app?

#### Best practices

- the user is the camera and they control the movement, let them drive
- if you need to virtually transport the user, be sensitive to issues around vestibular discomfort
- users will react to large menus coming at them
- use shorter animations
- animate from down/left/right or fade in instead of Z
- slow down timing
- allow user to see the world in the background

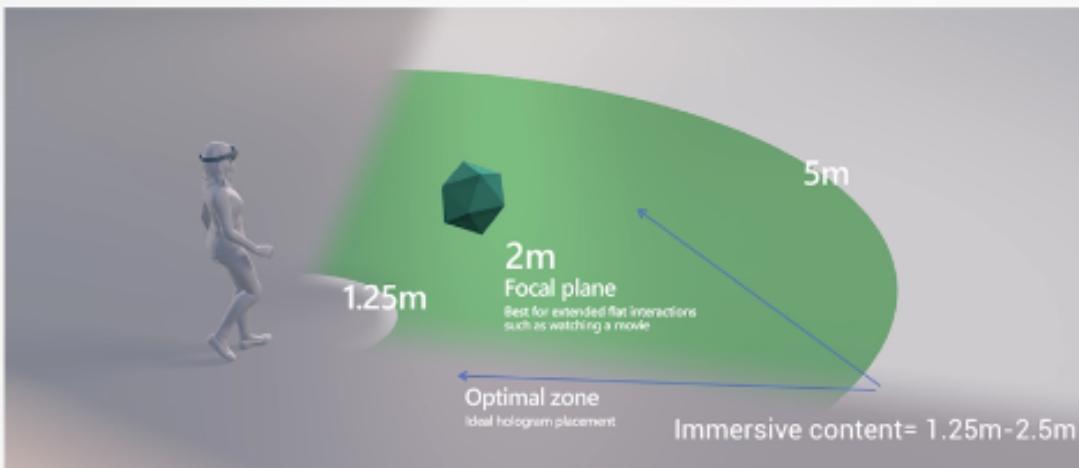
#### What to avoid

- don't shake the camera or purposely lock it to 3Dof (only orientation no translation) it can make the users feel uncomfortable
- no abrupt movement. If you need to bring content to or from the user, move it slowly and smoothly toward them for maximum comfort.
- users are sensitive to acceleration (both angular and translational). Do not accelerate or turn the user's camera

### Fit the field of view

- On hololens, holograms feel real when they fit with the field of view they don't get cut off.
- Users will move in order to see the bounds of a hologram within their field of view.
- Simplify your UI to fit within the user's field of view and keep your focus on the main action.
- For immersive headsets, it's important to maintain the illusion of a persistent
- You can use arrows, light trails, character head movement, thought bubbles, pointers, spatial sound, and voice prompts to help guide the user to important content in your app,

## HOLOGRAM PLACEMENT



### Locomotion and self motion

- always put the user in control of their movements; unexpected self motion is particularly problematic
- humans are very sensitive to the direction of gravity. Therefore, non-user-initiated vertical motions especially should be avoided.

**For holographic devices** - give the impression they're moving a small object in the scene. This effect can be achieved as follow:

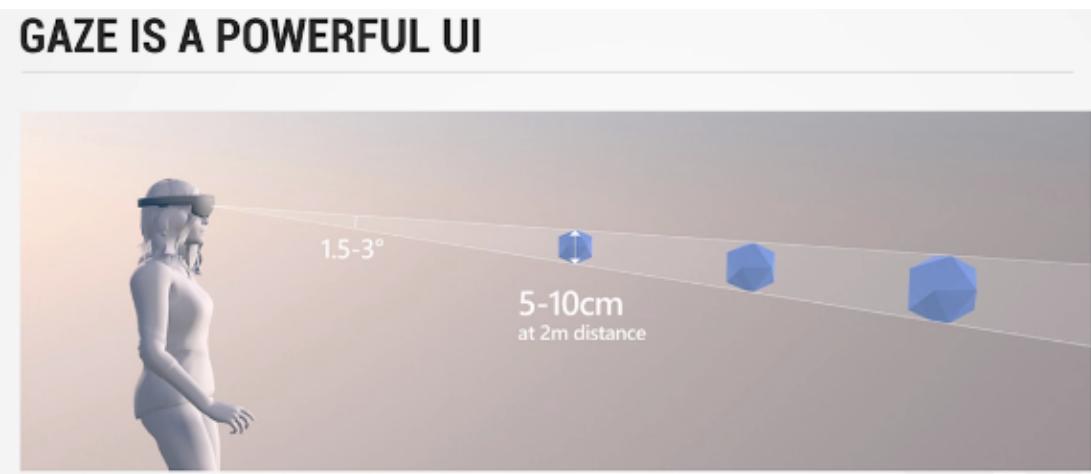
- provide an interface where the user can select a spot in the virtual environment where they want to move
- upon selection, shrink the scene rendering down to a disk around the desired spot
- while keeping the spot selected, allow the user to move it as though it were a small object.
- upon deselection, resume rendering the entire scene.

**For immersive devices** - mixed reality above disrupt immersion - instead: one trick for user locomotion in an immersive headset is the blink approach. This implementation provides the user with control over their motion and **gives a brief impression of movement**, but makes it so brief that the user is less likely to feel disoriented by the purely virtual self-motion:

- provide an interface where the user can select a spot in the virtual environment where they want to move
- upon selection, begin a very rapid simulated (100m/s) motion towards that location while quickly fading out the rendering.

- Fade the rendering back in after finishing the translation.

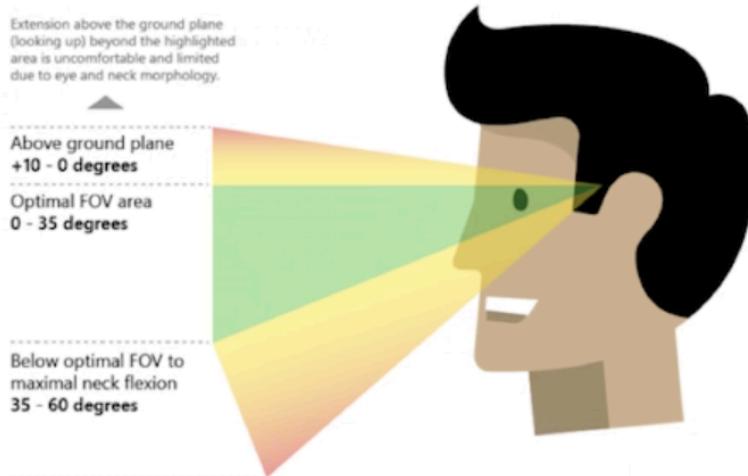
## The reality of your user's brain in 3D: Gaze and gesture



### Gaze guidelines:

- avoid gaze angles more than 10° above the horizon (vertical movement)
- avoid gaze angles more than 60° below the horizon (vertical movement)
- avoid neck rotations more than 45° off centre (horizontal movement)

The optimal (resting) gaze angle is considered between 10-20 degrees below horizontal, as the head tends to tilt downward slightly, especially during activities



### Gaze tips:

**highlighting** a gaze target: make affordance apparent, providing some salient cue that an element is "active" (that the user is targeting it) is extremely helpful - this can include treatment like visible "hover" effects, audio highlights or clicks, or clear alignment of a cursor with an element.

**Gesture:** keep it **very simple**, you don't want them to learn a new language

Watch out for '**arm fatigue**': muscle fatigue can accumulate when users are expected to keep a hand raised throughout the duration of an experience. It can also be fatiguing to require the user to repeatedly make air tap gestures over long durations.

We therefore recommend that experiences avoid requiring constant, repeated gesture input. This goal can be achieved by incorporating short breaks or offering a mixture of gesture and speech input to interact with the app.

Occulus touch: when touching the object, getting haptic and audio feedback adds to the immersion and creates a connection between the virtual and physical hands.

LeapMotion: hands as natural interaction.

### **Gesture tips:**

- the higher the person has to raise their arm to perform an interaction, the faster that interaction should be in order to avoid fatigue
- raising your arm high enough that your elbow is no longer in contact with your body can be tiring
- interacting with a moving interface (for example, a UI attached to the secondary hand, like a watch) can be challenging and should be primarily used for quick actions
- some people have trouble visually reading depth, and may need some time and practice in order to learn how far they have to reach out to manipulate objects in VR.
- when sitting, reaching out towards objects that are too close to your virtual body can be challenging
- hands that visually look realistic can be creepy. They give people a feeling of being inside someone else's body. They can also break the immersion when those same hands go through what appears to be a physical object, like a table
- a familiar object often communicates how it should be picked up, held and used. For example, people expect to use a gun-shaped prop to aim at things
- a physical object may need to have different physics when being held. If you're holding a pen and go through the table, you probably don't want the pen to hit the table and bounce, but rather go through the table with your hand
- people lose track of their real world physical surrounding when in VR. Hand gesture can result in them hitting a wall or throwing the controller away
- hand gestures are inherently social. When your friend is interacting with virtual objects in VR, having a visual indication of what they're interacting with removes the potential awkwardness of seeing their hands move in mid-air with no understanding of what they are performing

### **The reality of your user's brain in 3D: Voice**

voice UI - see it, say it

#### **How using voice can benefit the user**

- reduces time - it should make the end goal more efficient
- minimise effort - it should make tasks more fluid and effortless
- reduces cognitive load - it's intuitive, easy to learn, and remember
- it's socially acceptable - it should fit in with societal norms in terms of behaviour
- it's routine - voice can readily become an habitual behaviour

#### **Voice also has some weaknesses**

- fine grained control is one of them (for example a user might say "louder", but can't say how much. "A little" is hard to quantify. Moving or scaling things with voice is also difficult (voice doesn't offer the granularity of control)).
- voice can also be imperfect. Sometimes a voice system incorrectly hears a command or fails to hear a command. Recovering from such an error is a challenge in any interface.
- lastly, voice may not be socially acceptable in public places.

### **Voice UI tips:**

- use concise commands: choose keywords when possible. one syllable to avoid (not great for accent) two syllable or more.
- use simple vocabulary
- make sure commands are non destructive - make sure any action that can be taken by a speech command is non destructive and can easily be undone in case another person speaking near the user accidentally triggers a command.
- avoid similar sounding commands - avoid registering multiple speech commands that sound very similar.
- unregister your app when not in use - when your app is not a state in which a particular speech command is valid, consider unregistering it so that other commands are not confused for that one.

- test with different accents - test your app with users of different accents
- maintain voice command consistency - if "Go back" goes to the previous page, maintain this behaviour in your applications.
- avoid using system commands - the following voice commands are reserved for the system. These should not be used by applications.

### The reality of your user's brain in 3D: What you (designer) need to know

Believability is a core design principle in Mixed Reality

Less is more (depending on your PCT (persona, context, task))

1. discovery (not too much)
2. menu density (less)
3. less movement
4. less visual input
5. less multi tasking

### 3D interaction designer bias

- your comfort vs your users
- your familiarity vs your users
- the same UX rules still apply

(Never assume; user data to decide ; Empathy as guide; test, test, test)

### Transitioning From 2D UI's to 3D UI's

#### 2D → 3D

1. Goals	1. Goals
2. Affordances	2. Affordances
3. Flows	3. Narratives
4. States	4. Episodes
5. Emotions	5. Emotion inducing Moods
6. Navigation	6. Spatialized navigation
7. Tools	7. Body or World locked
8. Non-Diagetic	8. Diagetic UI's

The big shift is also moving from 3rd person experiences to **1st person experiences**

In 3D there is no canvas, no frame, no keyboard/mouse

Sound as part of the environment

Speech

space has relationship

no familiar spaces (or are there?)

view change (based on user's head movement) and different requirement for user comfort (based on the properties of the devices and the human using them)

### VR/AR emotions - common:

Surprise is the number 1 emotion

discovery - intrigue , excitement

suspense, thrill

delight, pleasure

**Tag along tool** that stays with you is possible in VR, or **body lock tool**.

non-diagetic UI = overlay (soundtrack, narration (feels 3rd person))

**diagetic: embedded** (into world, story, task) - increase immersion (feels 1st person) (for example footsteps or birds flying or voices)

**a diagetic UI:** a UI element that gets fully integrated with the fictional setting.

For locomotion, provide an interface where the users can select a spot in the virtual environment where they want to move.

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## Design 3D story flows

### Storytelling in VR & MR: 7 Essential Musts

- craft your story arc
- use story structure
- determine agency limits (god or not?)
- develop empathy (allow the user to deepen in)
- determine immersion with story vs world/hologram (using space wisely)
- focus on intentional interactions
- design deliberate first person vs third person experiences

### Empathy vs interactivity

(TED talk : How VR can make the ultimate empathy machine)

I felt most empathy were ones where I'm merely witnessing a scene unfold as if I were a ghost because there's a different quality of experience when I'm being directly addressed as a character in the story.

There is a tradeoff between interactivity and empathy. Not having my ego involved in the story does indeed allow me to receive the story of other characters without worrying how I should respond. There's nothing to do but just receive the story in an "observant passive / ghost without impact" experience.

### Story arc fundamentals

**Plot** is defined as the events that make up the story, particularly as they relate to one another through cause and effect

**Arc** is defined as an extended or continuing storyline. In other words, the driving force that runs throughout the book

The purpose of a **story arc** is to move a character or a situation from one state to another, in other words, to effect change

Where you have **change**, you have **conflict**. Something happens to ignite that change.

### Developing your story arc:

5W's Who, what, why, where, and when + change

Interaction Design essential for story flow:

**goal orientation:** What do they need to know

**procedure orientation:** how do I make the story unfold

**feedback:** confirmation of progressive or regressive actions

### Use Narrative Essentials

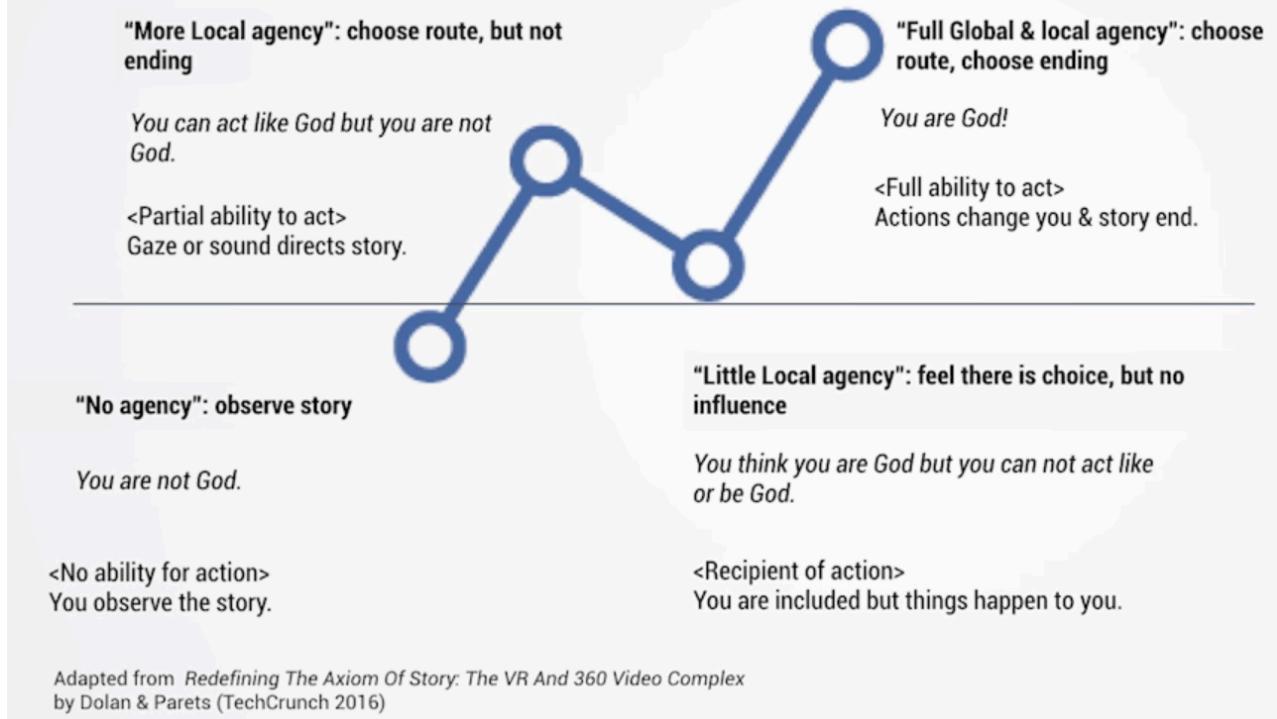
Gaze Voice Gesture, for Presence Immersion and Engagement

need to level the Agency (how much control the user has) and Diagetic (how immersive the narrative action/character are)

**Agency**: is like letting users adjust the room temperature (impacting the whole house or a room)  
**Global agency** means impact an episode; Local means impact a scene.

## STORY AGENCY- DESIGN CHOICES

### Participation in Story Events & Outcomes



consider the story beat (something is changing (action-reaction))  
every affordance should be there to support user expectation.

### Plotting Asynchronous Narrative

Don't assume it's a big flow, as the user might be interrupted in the 'real' life.

- AR by its "reverse immersion" can mean story-telling skips a beat from scene/action to scene/action
- AR may have short "hits" and tends to not sustain episodes (time length)
- MR is changing this but still, careful not to absorb users too much or they might get into physical or social danger

Black outs / gray outs in VR: game can crashed or bug

### Developing Your Personas

One thing that is important is to use role-based personas and define spatial characteristics  
Personas provide empathy, insights and design direction, to get in the user's brain in 3D

# PERSONA-SPATIAL CHARACTERISTICS

MR/VR: Lives in a *narrated space* along a time continuum (inhabits the space and interacts by narrative).

Affordances are *spatially contexted*.

Navigation utilizes spatial opportunities.

MR: Takes advantage of real world depth cues.



The UI is a world (not a screen).

Story flow is the key interaction design "meta-affordance".

Tools & Controls appear as needed in space.

Real edges and implications of actions on real world are considered.

Emotions appear along the way; and a collection becomes a mood.

The user is the actor or the observer...God or not.

Body or world locked...

Sound, emotion, movement clarify nav.

Gaze as cursor.

## 3D PERSONA - TEMPLATE



User type: [ Consumer; Business] Patient  
Familiarity with VR/AR: [New, Some, Moderate, Advanced]

Emotional sensitivity: [context specific- know your user context]  
Emotion target:  
Mood goal:

Role:

Presence goal: feeling in space [Passive, Active, Other]

User Goals:  
User Tasks:

Story Arc:

Agency (specify) [Start, Middle, End, Everywhere]  
Diagetic events:  
Sound events:  
Movement events:

## Designing Around Hardware and Technology Limits

To meet hardware limits, Interaction Designers should pay attention to the platform constraints and follow UI style guides

## A WORD ABOUT HARDWARE/SOFTWARE/ PERIPHERAL LIMITATIONS

(And why the material in this course is designed to be timeless i.e., you can use it for the next 15 years at least)

VR, AR & MR at the "new" beginning. They are on a maturity curve estimated in 2016 to reach acceptable maturity by 2026-2028. All hardware/ software and peripherals are undergoing radical transformation (every 8-16 months).

Knowing your platform limits is crucial, but from a UX perspective your Interaction Design choices will always fit around those.

# How to wireframes 3D interactions

## Developing Your Interaction Models for VR, MR, AR

### INTERACTION CANVAS

Scene (intro, world, environment)



Spatial (real world, distance, edge, direction)



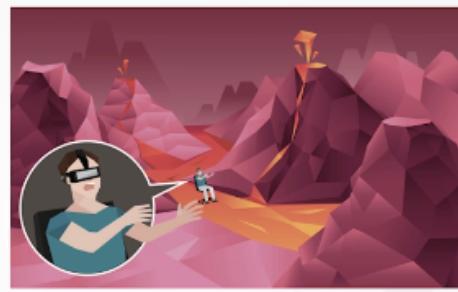
Affordances (navigate, choose, take action)



How the scene opens, what users can do and how the world or narrative fits the space, is what is important in designing 3D interaction.

### OPENING SCENE FOR 3D INTERACTION

- Like a Lead Character in a movie (protagonist)
- Subtlety, intuitively, powerfully
- Hypnotic engagement (cat mesmerized)
- Focal Area (visual gathering place or destination)
- Goal (Action path)
- Narrative triggers- start story
- Task triggers (or any of the above as the kindling)



### DEVELOPING SCALABLE INTERACTION MODELS

#### 1. Consider User View\*:

- Land locked
- Bird's Eye
- Guided Route
- Open Discovery



#### 2. Define Agency Points

- None
- Local +-
- Local +-+
- Full

Remember this is the interaction lever! (for FOV and 1<sup>st</sup> vs 3<sup>rd</sup> person)

### DEVELOPING CHARACTERS

First or Third person (or blended)?!

Camera angles matter!

Direction of sound matters!

Inciting Incident (moment story starts- becomes aware of external goal)

External Goal (what spend time trying to achieve)



#### CHARACTER CHECKLIST:

- **Protagonist** (establish with Position, Light, Dialogue)
- **Antagonist** (both want same thing in good narratives)
- **Internal Goal** (protagonist wants most deeply)
- **Conflict** (engine of the story)

#### CHARACTER CHECKLIST:

- **External Story** (external journey- clear external goal)\*\*essential
- **Internal Story** (internal journey of protagonist- what they need; weakness fix)
- **Internal Flaw** (inner weakness of protagonist must overcome)- unaware at start
- **Character Arc** (how P changes over course of story) eg grows-develops-realizes
- **Resolution** (revelation- answer to the problem protagonist solving)

## Holographic Interface Storyboarding Techniques

4.2 à faire + video 22min

### Wireframing Immersive Interactions 4.4 1h

The 3 factors that deepen **immersion** are: **emotion, sound and movement**.

**Get physical for concepting.** Gives you a better feel for the space for example. Walk the scene, use props, move around.

Do some **quick testing** with users:

- give the user scenario
- ask them to perform the task
- think aloud
- observe and incorporate in your prototype

Get out of your comfort space

## PROTOTYPING TIPS

### TEST:

Because errors in the spatial mapping data may strongly affect your user's experience, we recommend that you test your application in a wide variety of environments.

### IN DIFFERENT LOCATIONS:

Don't get trapped in the habit of always testing in the same location, for example at your desk. Make sure to test on various surfaces of different positions, shapes, sizes and materials.

Similarly, while synthetic or recorded data can be useful for debugging, don't become too reliant upon the same few test cases. This may delay finding important issues that more varied testing would have caught earlier.

### WITH REAL USERS:

It is a good idea to perform testing with real (and ideally un-coached) users, because they may not use the HoloLens or your application in exactly the same way that you do. In fact, it may surprise you how divergent people's behavior, knowledge and assumptions can be!

### Emotion:

pros: aids immersion, deepens presence, diagetic (presence) narrative aid, story arc essential, mood inducing

## EMOTION IS A TOOL AS WELL AS AN OUTCOME

**Affective Artifacts\***: (emotions) Design tools that you use to help users progress through the Story Arc.

**Surprise** is the biggest tool you need to design for (it is the key emotion) (Desmet).

### Sound:

pros: can be a navigation aid, aids mmersion, deepens presence, diagetic, ambiance, believable, mood inducing

cons

### 3D spatial sound:

- important for immersion
- deepens presence

- important for navigation
- cheap UI aid for graphics trade off

### Movement:

pros: part of navigation (eg teleportation), immersion (walking), change of direction, 6 DOF

## VR INPUT FOR MOTION

- 6 DOF manipulation
- Pointing
- Hand Controls
- Ambient Invocation



- Within Reach
- Reach and Beyond
- Actuation (point and manipulate), Swiping
- Infrequent, Indirect

### Haptic feedback (force on a glove for example)

- can anchor body awareness
- touch controller feedback eg vive controller (like mouse over - press release)
- help improve spatial awareness (give a little bump when you land after jumping, or vibrate when something is bad..)
- free up or focus auditory and visual channels
- trigger a "pulse" (rythm)
- vibrate like a phone

### 3D Wireframing Tools

## WIREFRAMING TOOLS

#### Analog:

- Scissors and tape
- Whiteboard
- Improv

#### Getting into VR:

- Google Blocks
- GoProVR viewer (360 views)
- Aframe VR
- SketchBox VR
- SketchUp
- MakeVR
- Blocksmith- Vrigami
- Sketch then use Framer (for animations and interactions)
- Unity VREditor
- Unity- VRTK and Newton VR Toolkits\*
- Sketch template (source: sketch-to-VR on GitHub)
- \*Add in the Oculus Avatar SDK to visualize Touch hands.

#### AR animations:

- Animvr
- Limitless
- Storyboard VR
- Quill (Oculus)
- Tiltbrush (Google)

## Social VR and collaborative virtual environments

### Important Social UI Characteristics

**social signifiers:** is either created or interpreted by people or society. Signifying social activity or appropriate social behaviour. This is different to an affordance. Bookmarks



**social focus:** informal coordination point. Consider the role of focal points in coordinating behaviour. No rule or enforcer. Set expectations of cooperation, informal organisation. This differ to orientation or focal points.

**social behaviours:** do something with social consequences for example cloak or invisible to that user, profile like interest, follow or unfollow, fly together, anywhere chat (any space or anytime, trade contact token, indicate mood (glow orange), shared context (artefacts), awareness of others (status), negotiation and communication (avatar gesture, gaze, eyebrow, head nod), flexible and multiple viewpoints (role-switching)

**social tasks:** do something for the community (get points) do something together, indicate understanding via collaborating, get help from info point or another, help another,

**social presence:** being together with another, avatar (seeing each other gives social sense), enhance with intimacy (eye contact and physical proximity) and immediacy (psychological distance between sender and receiver), verbal and non verbal communication, feeling want to or safe to socialise, privacy in VR.

## Communication, Coordination and Collaboration

**Communication:** social effects, what group effect or social behaviours accompany an activity. What are natural social behaviours?

**Collaboration:** emotion effects: what makes a task compelling, how can the group or team solve a problem, achieve a goal and sense of accomplishment?

**Coordination:** what tasks, artefacts or work are shared? what needs to be done and by whom and when>

Communication: chat, verbal, nonverbal, emotion, mood

Coordination: goal awareness, shared goals, tasks, problems, shared artefacts, shared status, story flow

Collaboration: clear boundaries, what input expects and from whom, when they had to expect it, when deliver output and timing, immersive collaborative story, use both speech and gesture rather than speech alone as the interaction modality for faster task times.

## Tips for Better Social UX

- 1- Match real world social behaviours, don't make it up.
- 2- Align with relevant social triggers. Find the social/emotional charge that is relevant to your field
- 3- support social interactions by design: be socially sensitive (don't be a creep), BigScreen's Personal social bubble avoid avatar collision (goes invisible when getting close)

**SDK:** software development kit.

---

## Bringing it all together

### Designing Your 3D Experience

#### 3D UX Checklist

- Experience Design Plan
- Heart Metrics
- Scene approach
- Scene as affordance canvas
- Menus
- Dialogs
- Visualisation pieces
- Affordance cues
- First 30 seconds experience
- Story Arc, story flow (narrative) story beat (action-reaction)

Give cues

spark emotions

guide discovery

induce immersion

#### Think about the users point of view

- is the user sitting, reclining, standing, or walking while using the experience?
- how does your content adjust to different positions?
- Can the user adjust it
- will the user be comfortable using your app

Define persona, context and tasks

Goals

Affordances

Narratives

Episodes

Emotion inducing moods

Spatialised navigation

Body or world locked

Diagetic UI's

#### 7 storytelling Musts:

- craft your story arc
- use story structure
- determine agency limits (god or not)
- develop empathy (allow the user to deepen in)
- determine immersion with story vs world/hologram (using space wisely)
- focus on intentional interactions
- design deliberate first person vs 3rd person experiences

Consider your physics (real and emotional) , sound and gaze

## **Interaction level**

direct interaction = direct manipulation (don't make me think principle)

indirect interaction = more steps

semi-direct interaction (blends)

## **Key questions:**

What is right for the task, for the flow ? for the story flow ?

## **Body movement:**

- Expansive body positions (open limbs) activate hormones
- Restrict movement or not? (diagnostic)
- How distracting is the movement to engagement, immersion, presence?
- ease neck strain

Remember hover, pointers and hints

Be forgiving with selecting an object (area where you can pick it or select it for example)

## **Quick 2D mock ups:**

### **in Illustrator:**

- make a canvas 360cm wide, 90cm tall
- put on canvas 50cm radius cylinder
- transparent background - rectangular image
- uses CSS3D transforms

Sketch but think spatially

## **Defining Spatial Interactions**

### **DEFINING SPATIAL INTERACTIONS**

- Movement (real, simulated or perceived).
- Manipulation of objects in space (expand, zoom, rotate etc).
- Destination or Exploration or to advance/enhance story mechanics.

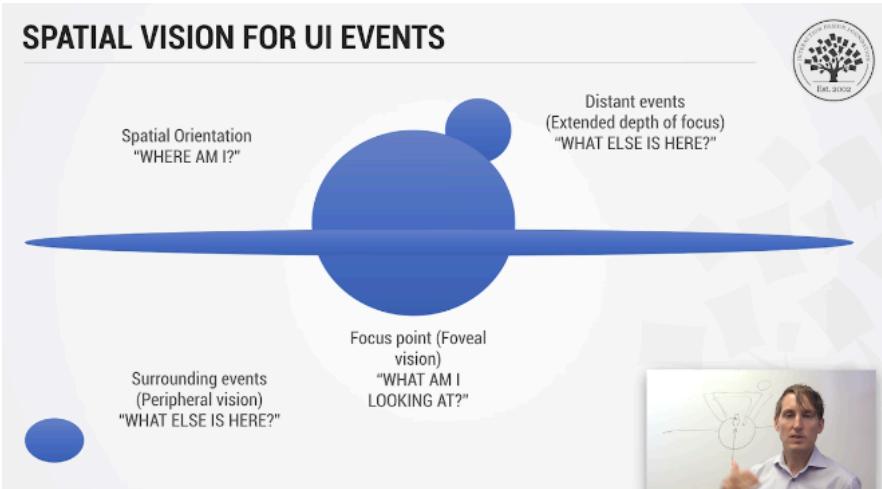


### **spatial orientation - basics**

Giving users cues in the space for navigation, manipulation and discovery will help user with spatial orientation in 3D.

- Spatial cues /perception
- spatial navigation
- impacted by gesture, gaze, action (tap, hold, manipulate)
- affordance (move or not)

## SPATIAL VISION FOR UI EVENTS



## SCALE QUESTION

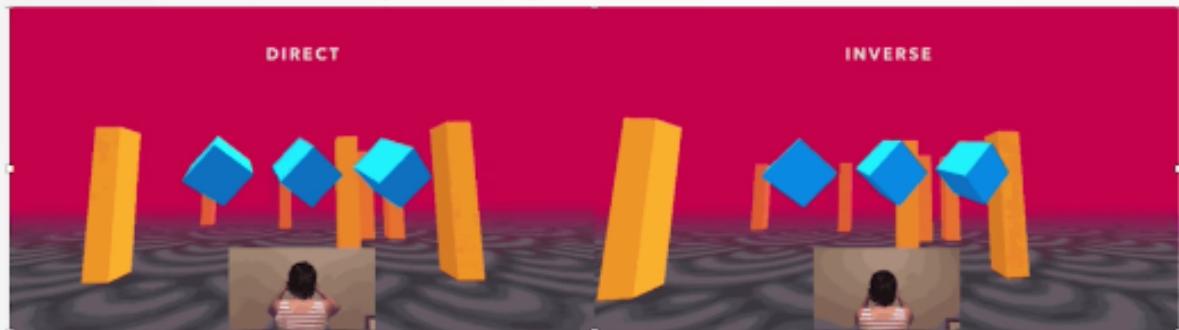
Scale: grow or shrink an object equally in all directions (ie. enlarge or shrink something).

- Room scale?: Standing or sitting?
- Scale and distance are difficult to perceive in VR (MR is easier, but...)
- Face the user? (Pinch and zoom eg reading)
- Shrink an object (or viewpoint)
- Guide eyes/mind (Depth context)
- Lighting/Shadows (object shape detection)
- Opacity (use Fresnel effect – if facing= less opaque)

Smooth surfaces will present a stronger Fresnel, totally rough surfaces will have no Fresnel.

## INVERSE SCALING

How do you look behind an object in VR if you can't walk around it?



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Direct means that when you look right, the right blue box comes towards you (use the above image as a reference). When you look down, you see the bottom of the blocks. It is as if your head is a direct controller of the boxes.

An inverse connection means that when you look right, the left box comes toward you. Looking down, you see the top of the blocks. It is as if you are walking around the object, looking at it as you move.

## SPATIAL UI TIPS

- Give information an anchor. Add visual and spatial cues to abstract information or functionality. A great example is how Fantastic Contraption's menu uses objects instead of buttons and text.
- You put a space helmet on your head to access the menu. This takes you to a new environment where physical objects serve as the actions you can take.
- Think 'Odd Ball.' If you want people to remember the location of an object in your environment without being explicit, place something odd around it. When people are presented something they didn't necessarily expect, that visual information can stick in memory better.

## SPATIAL UI TIPS

- Group similar objects. Be it items in a virtual menu, tool box, inventory, etc. People may forget the location of specific items, but if items are grouped together by higher level features they may be easier to find.
- Show people rather than tell them. Spatially organizing the steps in a workflow will support recognition rather than recall. This leaves the users' working memory free for completing the task rather than remembering the steps.
- Use depth and distance. A unique feature of VR is depth, or the ability to place objects in or out of peoples' reachable space. Things that are closer or more easily accessible will be viewed as more important.
- Don't forget about visual design. Use visual cues like colour, lighting, architectural style, etc. to spatially segregate parts of the environment that have specialized functions. Also, provide distinctive transitioning elements, like doorways, between these environments.

### Spatial UI Considerations

#### Space and UI orientation:

give affordance cues  
give directional cues  
give grounding elements (eg table)  
give controller guidelines  
give presence cues (mirror can be one)

#### Obstacle: judging closeness

figuring out how close object appear to the user  
what is your intended viewing distance  
what needs to be first and what is background  
what's in view and what's out of view

#### Spatial orientation

hologram behaviour  
game mechanics

#### WEB VR issues (Mozilla)

sitting or standing  
headset on/off / mouse / blend  
transitions between 2D and 3D content  
overwhelming users with web-made content  
caution of designing on the desktop can bias content / 3D UI

need to be responsive WebVR content creation is a must  
much more inclusive of any headset (some don't support it)  
design spatially sensitive content/ text

## 3D navigation

- break into zone of action
- way finding aids
- you are here maps or scaled view of large environments
- place landmark strategically
- minimize sickness inducing effects
- use characters to point the way
- use edges to deter travel
- use grid-like patterns for spatial organisation
- offer user placed markers (breadcrumbs) ; trail marking
- avoid showing legs (awkward movements)

Skeumorphism as default for navigating

don't overdo menus just because we're in VR

gaze time and fixation

sitting better for higher concentration (mousing, typing, math), problem solving, and memory

standing better for focused tasks (highly verbal tasks) insight/learning

transitions are important

Radial menus are ideal

## TEXT AND HIT SIZE GUIDELINES

- 1dmm = 1px (1 dmm = 1 mm or "x" as it scales into distance)

*Distance Independent Millimeter*

- 1 dmm = the perceived size of 1 mm when viewed from 1 meter away

### Text size

Headline	Regular 40dmm
Title	Medium 32dmm
Subheading	Regular 28dmm
Body 2	Medium 24dmm
Body 1	Regular 24dmm
Caption	Regular 20dmm
BUTTON	MEDIUM 24dmm

### Hit size

	Minimum 64x64dmm + 16dmm padding
	Comfortable 96x96dmm + 16dmm padding

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## SPATIAL AUDIO

- Object driven (GVR Audio Sources): Object passes by...
- Atmospheric sounds (GVR SoundField Sources): Head rotation.

### OTHER TIPS:

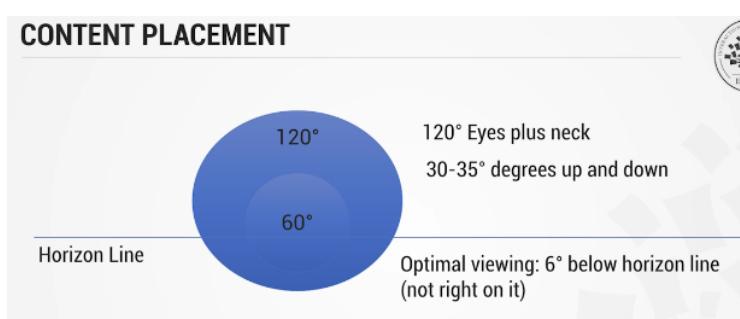
- Play the sound more than once (repeat the cue).
- Avoid overly quiet sounds, low frequency or simple tones.



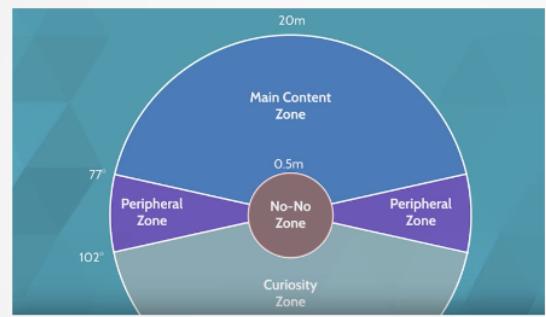
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Source: Google VR Guidelines

## Designing Immersive Content



### DEFINING CONTENT ZONES



give users context sensitive menus and controls (should only appear when needed)  
make UI decisions point mesh with story flow (or narrative mechanics)  
remember spatial tension can add or alter context

## 6.6 Holographic UI design - **not done**

### Gamification for Any Immersive Experience

**MOTIVATORS**

Behavior motivators...	Satisfy desires...
<ul style="list-style-type: none"> <li>• Points</li> <li>• Levels</li> <li>• Challenges, Trophies, Badges, Achievements</li> <li>• Virtual Goods</li> <li>• Leaderboards</li> <li>• Competitions</li> </ul>	<ul style="list-style-type: none"> <li>• Reward</li> <li>• Status</li> <li>• Achievement</li> <li>• Self-expression</li> <li>• Competition</li> <li>• Altruism</li> </ul>

## DESIRSES VS GAME MECHANICS

Game Mechanics	Human Desires					
	Reward	Status	Achievement	Self Expression	Competition	Altruism
Points	●	●	●		●	●
Levels		●	●		●	
Challenges	●	●	●	●	●	●
Virtual Goods	●	●	●	●	●	
Leaderboards		●	●		●	●
Gifting & Charity		●	●		●	●

Figure 1 illustrates the interaction of basic human desires and game play. The green dots signify the primary desire a particular game mechanic fulfills, and the blue dots show the other areas that it affects.

## Player-centred design

Know your user

Identify the mission

Understand human motivation (and your user's motivation specifically)

Apply mechanics

Manage, monitor and measure

## Validating your 3D experience

### Evaluating Your Design

#### usability testing:

- observe your users interacting with your design or concept
- TIP - recruit target user /players if Play testing (no down the hallway users!)
- remember emodied improv (bodystorming) test or video tape the scenario as part of prototyping - test as you go along
- TIP - if testing multi player (simulate the 2nd users or have two players to test)

#### top metric = ease of use

success rate - do they get the task

failure rate - do they not get it

partial success - do they get part of it

## TEST IN TARGET HEADSETS!

"No matter how closely I sketched out the scene in 3D, the actual experience in headset was almost never the same as the sketch. That's why it's important to test out the scene in the target headsets."

Hae Jin Lee  
(Microsoft UX Designer)



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## IMMERSION EVALUATION CHECKLIST

Immersion criteria:	Tasks	World	Story
Tactical elements pull user in (Things they can do or ways they navigate)	✓	✗	✓
Strategic elements pull the user in (Problem solving, decision making is enhanced or activated)	✓	✗	✓
Narrative elements pull the user in (Story flow and story arc both guide and lead the user toward or away from events and perceptions)	✗	✓	✗
Spatial elements pull the user in (Room or world, real or virtual compliment the discovery, navigation etc)	✓	✓	✓
Situational awareness pulls the user in (Goals are clearly defined, feedback is given to the user, status and progress indicators are offered)	✓	✗	✓



## Measuring Presence

### defining presence:

- presence is a matter of focus (where attention is directed)
- there are varying degrees of presence
- broad focus on all aspects of the environment necessary (versus focusing on one thing or area)
- more immersion = more presence

place illusion (feeling like you are in the place/narrative)

plausibility illusion (think what's going on is real: event refer directly to you even if you're not in control)

### Measuring presence

- Subjective measure (questionnaire)
- emotion / physiological (sweat, heartbeat)
- behaviour / performance

### What impacts presence:

presence is deepened with :

- degree of control (world, story arc)
- immediacy of control (action are apparent - delay in cause/effect = bad)
- anticipation (anticipate or predict)
- mode of control (acts like natural expected work, if learn new ways = diminished)
- physical environment modifiability (ability to modify objects as if real eg open door)
- sensory modality
- environment richness (lots of sensory stimulation)
- degree of movement perception
- meaningfulness of experience
- separation anxiety/disorientation

## MEASURING PRESENCE- KEY QUESTION

How compelling was your sense of moving around inside the virtual environment?



Not  
Compelling

Moderately  
Compelling

Very Compelling

(7 point Likert scale)

## Distraction & realism factors

### Distraction factors:

- isolation (more the real world is blocked out more presence potentially) (MR potentially changes this)
- selective attention: user willingness to focus on task, world or room
- interface awareness: un-natural, clumsy or feature-heavy UI's hinder interaction and presence

### Realism factors:

- scene realism: core to presence (context, texture, resolution, light source, FOV)
- consistency of info with the objective world

## PRESENCE QUESTIONNAIRE 1/2

Use 7 point scale per above

- How much were you able to control events?
- How responsive was the environment to actions that you initiated (or performed)?
- How natural did your interactions with the environment seem?
- How completely were all of your senses engaged?
- How much did the visual aspects of the environment involve you?
- How much did the auditory aspects of the environment involve you?
- How natural was the mechanism which controlled movement through the virtual environment?
- How aware were you of events occurring in the real world around you?
- **How aware were you of your display and control devices?**
- How compelling was your sense of objects moving through space?
- **How inconsistent or disconnected was the information coming from your various senses?**
- How much did your experiences in the virtual environment seem consistent with your real-world experiences?
- **Were you able to anticipate what would happen next in response to the actions that you performed?**
- How completely were you able to actively survey or search the environment using vision?
- How well could you identify sounds?
- How well could you actively survey or search the virtual environment using touch?

See: Whitmer and Singer 1998

## PRESENCE QUESTIONNAIRE 2/2

- **How compelling was your sense of moving around inside the virtual environment?**
- How closely were you able to examine objects?
- How well could you examine objects from multiple viewpoints?
- **How well could you move or manipulate objects in the virtual environment?**
- To what degree did you feel confused or disoriented at the beginning of breaks or at the end of the experimental session?
- How involved were you in the virtual environment experience?
- How distracting was the control mechanism?
- How much delay did you experience between your actions and expected outcomes?
- **How proficient in moving and interacting with the virtual environment did you feel at the end of the experience?**
- How much did the visual display quality interfere or distract you from performing assigned tasks or required activities?
- **How much did the control devices interfere with the performance of assigned tasks or with other activities?**
- How well could you concentrate on the assigned tasks or required activities rather than on the mechanisms used to perform those tasks or activities?
- Did you learn new techniques that enabled you to improve your performance?
- Were you involved in the experimental task to the extent that you lost track of time?

See: Whitmer and Singer 1998

## Tools for Evaluating VR/AR Experience

### VR "JOY OF USE"

- Experience generates good feelings
- Experience sustains good feelings
- Experience puts a smile on users face
- Experience is fun to use, delightful, exciting
- Experience feels good, works well, joy to own
- Interface 'friction' is minimal
- Can sustain Presence
- Good use of Agency can intensify
- Part of 3D Storytelling ("Flow" or "cognitive absorption")

# TESTING TOOLS- QUANTIFYING UX



Emotion Measurement

Quantifies what most believe to be subjective and unmeasurable.

Non-Verbal\* instrument teases out bias.

Physiological emotion measurement (heart rate, Galvanic Skin Response, Facial expression)



EyeTracking

Quantify where users are looking (gazing, fixating and missing). Brings "hard science" to stakeholders.



Usability Testing

Low-fidelity vs High fidelity

Formative (concept validation) vs. Summative (stats on task performance)



Play Testing

Leveraging Game Design heuristics and testing



Score card

USE Scorecard

Evaluating strengths of features.

template to take notes:

## QUICK TEST- NOTE TAKER

Name:

Date:

Familiarity:

FIRST 30 SECONDS

WEIRD STUFF/ BUGS

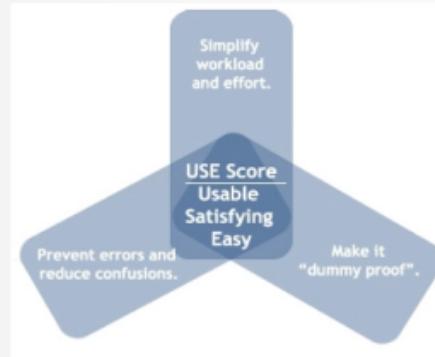
BEST THING

WISH IT HAD/ DID

FAVORITE PART

OVERALL IMPRESSION

## EVALUATING USE- SCORECARD



Purpose: Quickly evaluate usability of a feature with your team to gain priority and tease out usability issues.

test with 8 to 10 users, not just 5

## READ: VR/ MR UX GUIDELINES

- Oculus VR UI Guidelines
- Hololens: Microsoft Holographic - Mixed Reality UI Guidelines
- Meta 2 Guidelines
- Designing for Mixed Reality (Hololens)
- Microsoft Kinect for Windows Human Interface Guidelines v1.8.0 UX Guidelines
- Leap Motion UX Guidelines
- Unreal Engine VR UX Guidelines
- Unity VR UX Guidelines
- Google Cardboard VR UX Guidelines

## Inclusive Design: Accessibility, Gender, Localisation

Some people with mobility are very keen to use VR, so we need to think about this.

Caption for deaf can be challenging

VR is a good tool for people with mental issue like phobia, post traumatic stress

dyslexia could impact the experience, to be tested

avoid height bias (user can't reach some shelves (too high)

try to remove the limitations, include super powers

sounds as a navigation aid

**Gender**.... but I'm not convinced ;) try testing with various gender though

**Localisation:** not just translation, also culture)

- clarify your persona
- design for cultural sensitivity
- translation
- literacy
- test speech across accents
- gazing might not work with culture who are more private (Scandinavian for example)

**User research**

- conduct user research to learn about the domain, goals, tasks of your users
- get ideas by observing what works and what affordances or skeuomorphic ideas might translate
- find your story arc in your user's work, lives and struggles

**VR is an open door**

- choose your narratives carefully!
- bring your values to work

**To learn more:**

Pluralsight paths:

**3Ds max - Unity - ZBrush**

<https://app.pluralsight.com/paths/skill/3ds-max-environment-modeling>

<https://app.pluralsight.com/paths/skill/unity-game-development-core-skills>

<https://app.pluralsight.com/paths/skill/zbrush-core-skills>

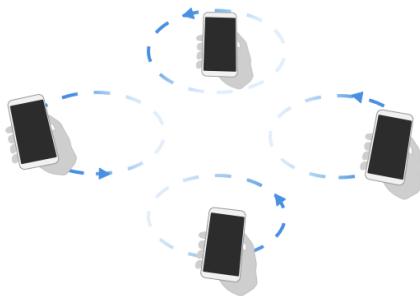
<https://uxdesign.cc/immersive-design-the-next-10-years-of-interfaces-16122cb6eae6>

# Plane Discovery & Object Placement

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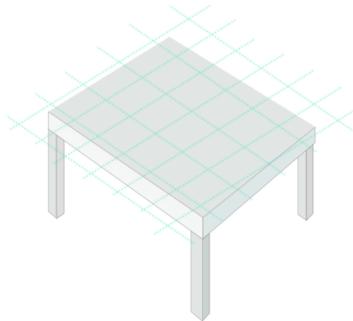
## Finding Surface - Instruct users to scan

- Animate movement
- Instruct users to take action
- Provide users feedback if there isn't enough lighting, fast movement, etc.
- Decide on device orientation support.



## Surface detection- Feedback

- Provide enough contrast in the UI
- Decide if the app will auto or manually place virtual object.
- Decide if the app will detect vertical and/or horizontal planes.



## Move object - visual feedback

- Create touch targets zones large enough for object manipulation.
- Drop virtual object with a CTA.
- State change - Object is selected
- Use lighting & shadows

