

Design, Composition, and Performance

Rich Hickey

Figure 1: 00.00.00 title page

Hi. Thanks for coming. I'm very excited about this conference. It's always great, and I would like to thank the organizers for inviting me today to talk about design, composition and performance. So we start with a legal disclaimer prepared by lawyers.

We're going to have some fun with analogies today and, the cool thing about analogies is, they're as much fun when they're wrong as they are when they're right.

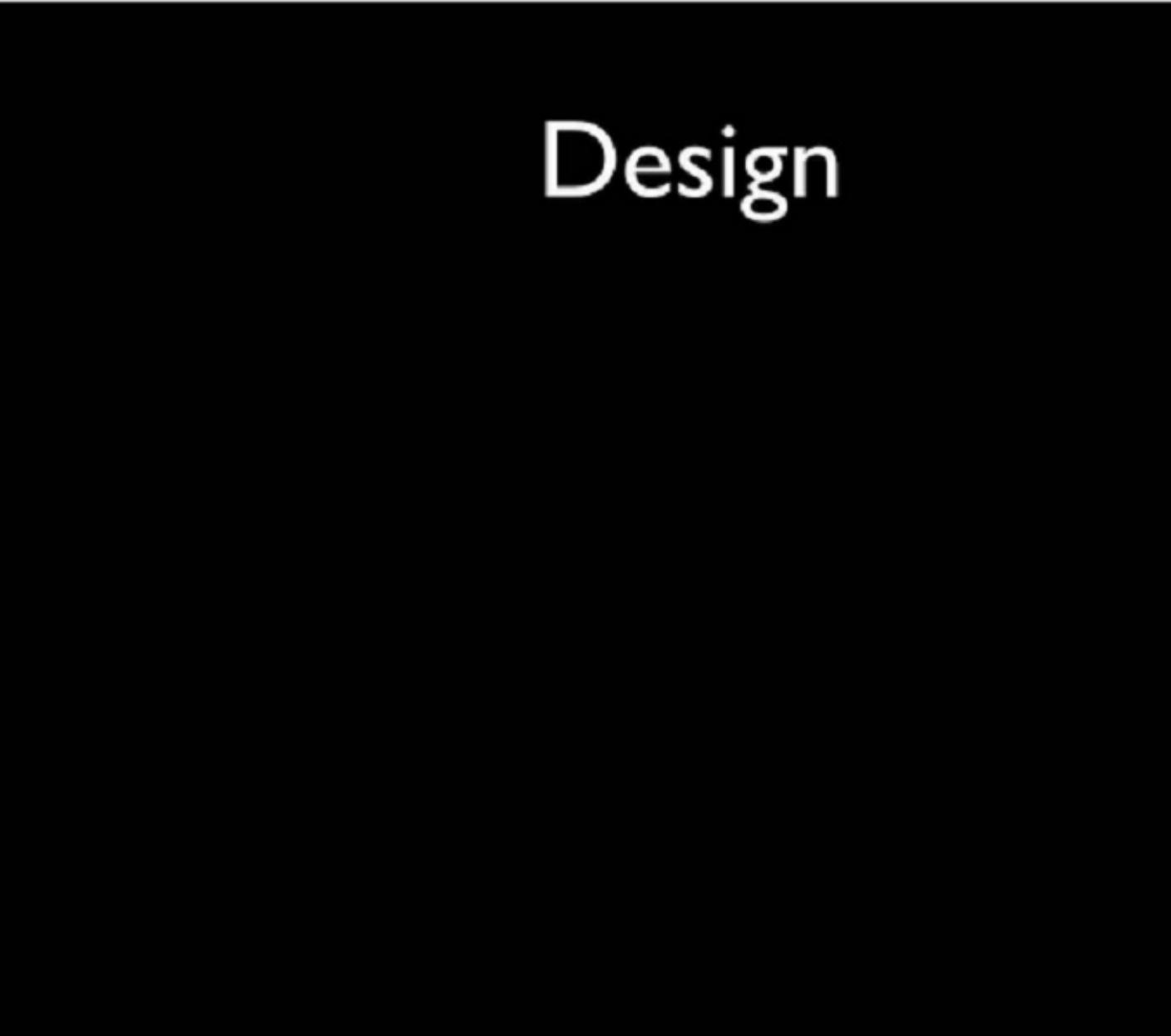
So, design is something we talk about a lot in software development.

But I think it is something that's somewhat beleaguered these days, not because people don't do it, but because I think people are in a hurry and they're trying to get things done. And I often get developers asking: I'd like to be able to work at the next level and talk about, you know, the design of things before I just code up solutions.

So, what does it mean to design something? And as you all know, all I do to prepare these talks is go to dictionary.com and look stuff up. So I looked up design, and one of the definitions is this, which is really

Analogies are like equivalencies, except when they are not

Figure 2: 00.00.18 Analogies



Design

Figure 3: 00.00.30 Design

Design

'to prepare the plans for (a work to be executed), especially to plan the form and structure of'

Figure 4: 00.00.35 Design - build slide

Design

'to prepare the plans for (a work to be executed), especially to plan the form and structure of'

'decide upon the look of'

Figure 5: 00.01.32 Design - build slide

There's another definition, which is to decide what the look of something is. And there's nothing wrong with that kind of design. I just want to say this talk is not about that at all. Never when I say design do I have this meaning in mind.

And, of course, we go to the roots and see that the root is in to mark stuff out, and that matters. So there are really sort of two things here: We want to make a plan, and we want to write something down.

And, of course, here's where everybody is like, oh, you know, we did this. Right?

We did this in the '80s, and we had all this stuff, and it was terrible.

We had these phonebook-sized specifications and nothing got done, and it was all awful. So we already write down code. Is that enough? Do we still need designs if we do this?

And the answer is yeah because that's not a plan. That's just what you did.

Can we generate docs from implementation? The same thing, right? That's not representing a plan to do something.

Design

‘to prepare the plans for (a work to be executed), especially to plan the form and structure of’

‘decide upon the look of’

designare - to mark out

Figure 6: 00.01.45 Design - build slide

Design

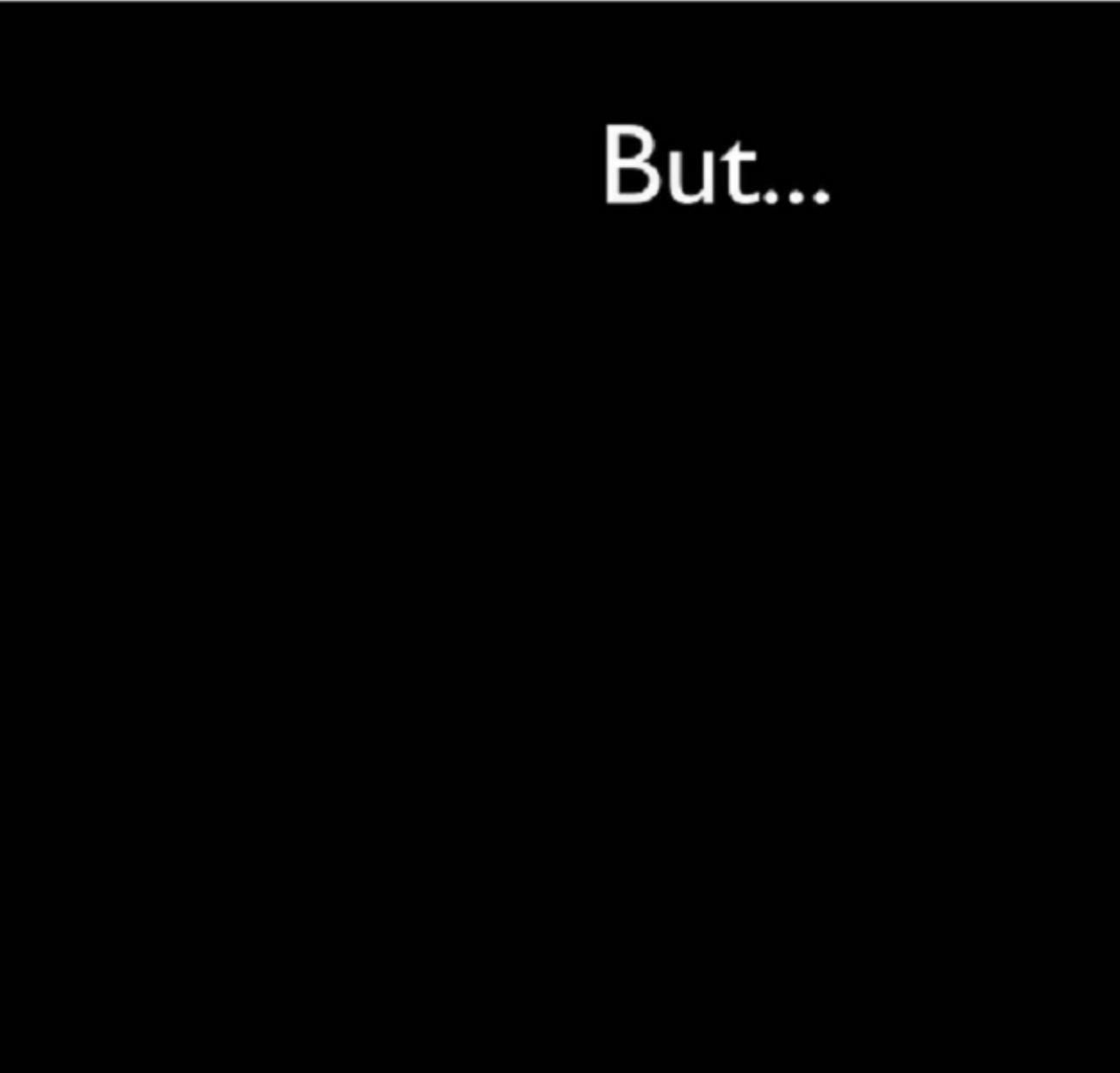
‘to prepare the plans for (a work to be executed), especially to plan the form and structure of’

‘decide upon the look of’

designare - to mark out

make a plan, write it down

Figure 7: 00.01.53 Design - build slide



But...

Figure 8: 00.01.59 But...

But...

We already write down code

Figure 9: 00.02.04 But... - build slide

But...

We already write down code

- do we still need designs?

Figure 10: 00.02.16 But... - build slide

But...

We already write down code

- do we still need designs?

Generate docs from implementation?

Figure 11: 00.02.19 But... - build slide

But...

We already write down code

- do we still need designs?

Generate docs from implementation?

- not a plan

Figure 12: 00.02.28 But... - build slide

But...

We already write down code

- do we still need designs?

Generate docs from implementation?

- not a plan

Monolithic designs, ugh, been there

Figure 13: 00.02.41 But... - build slide

They are top down. They're waterfall model, et cetera, et cetera. We did that already. And it's true that happened, and they were plans, but they weren't good plans.

And so what I want to talk about today is a little bit about what do we want out of a design and when we encounter in the world, what do we see?

So I think that a simple idea behind design is to look at it in terms of taking things apart.

This is the opposite notion we typically have. Typically people think about design, and they say design is, you know, making this big, involved plan that's going to solve every issue that the system is supposed to address. But I think that's not what you do when you're trying to get a design that's going to survive and live over time. I think, instead, what you want to do is break things apart in such a way that they can be put back together.

And that's fundamentally what design is about: taking things apart so you can put them back together because obviously taking things apart and walking away is not really going to help.

The other thing you find in good designs is that they're always about one or very few things. Designs that survive, designs that really foster reuse are about a single thing, generally. And then you put them together.

But...

We already write down code

- do we still need designs?

Generate docs from implementation?

- not a plan

Monolithic designs, ugh, been there

- plans, not good ones

Figure 14: 00.02.53 But... - build slide



Good Design

Figure 15: 00.02.58 Good Design

Good Design

Separating into things that can be composed

Figure 16: 00.03.05 Good Design - build slide

Good Design

Separating into things that can be composed

Each component should be ‘about’ one or a few things

Figure 17: 00.03.40 Good Design - build slide

Good Design

Separating into things that can be composed

Each component should be ‘about’ one or a few things

Composing them to solve a problem

Figure 18: 00.03.54 Good Design - build slide

Good Design

Separating into things that can be composed
Each component should be ‘about’ one or a few things
Composing them to solve a problem
Iterative

Figure 19: 00.04.05 Good Design - build slide

And there's nothing about this that's in conflict with iterative methods for developing software. Right? This can be an iterative process. And all that happens then is that you get feedback during development to your design.

So, what kinds of things would we take apart? There are a whole bunch of things that we could take apart and, in fact, you're constantly finding more things. You can take apart the requirements for a system. You can take apart the order in which things happen, who is going to talk to whom, information parts of your system for mechanism parts, and you can actually take apart different solutions to assess their merit. So let's just look at each of these in turn.

Taking apart requirements: This is something we do not do often enough. Somebody says I want a system that does X. I need Y. You know, it's got to do Z. We get these feature lists, and the first thing that we should do when we're handed that is to break them apart and try to find, in the set of requirements, in the set of features or desired things or needs, the actual problems. And it's only by doing that that you can start to move forward and say, okay, I've broken your need into problems that you have, and then we can try to make things that solve those problems.

The other thing you're going to do initially with requirements is divide them up. The simple way to take them apart is to say these are things I know how to do and these are things I don't know how to do, so your known from your unknown.

Design is taking things apart

requirements

time/order/flow

place/participants

information/mechanism

solutions

Figure 20: 00.04.19 Design is taking thing apart

Take apart requirement

Move from want/need

- to problems

knowns/unknowns

domain-side/solution-side

cause/symptom

unstated

Figure 21: 00.04.41 Take apart requirements

You're going to take apart requirements that are domain side - the system must do this to satisfy this business thing - from solution side things like we need to run on AWS or something like that. Often you get requirements, especially for systems that already exist, that are about - it's not working, and everybody has heard that, you know. How do you fix it? It's not working.

The first thing you have to do when you're trying to fix what's not working is to separate out what's the cause of this problem from what's the symptom of this problem. Somebody says my screen is black. You're

Take apart time/order/flow

queues

idempotency

commutation

transactions

Figure 22: 00.06.42 Take apart time/order/flow

Other things, just completely different dimension of things we can take apart when we do design, which is time. Right? You can take apart the order of things, how things are going to flow from one to the other. You can break systems apart, so there's less direct calling. You can use queues to do that. You can support redundant activity with idempotent approaches. Commutation is a very important concept that's going to be more and more prevalent as we try to build systems that are highly distributed, which says I can make a system order-independent by supporting operations that are all commutative. Then I don't care how things

Take apart place, participants

Figure 23: 00.07.34 Take apart place, participants

We can take apart place and participants, and there's a certain sense in which design is always about this. But, you know, there's this old adage, right? You just add indirection.

But here we're talking about possibly the whole process of building something. Right?

Having a design is a thing that let's two teams work independently or people work in two independent languages. Taking apart things is what facilitates the participants, the authors, as well as the participants, for instance the systems. By breaking things apart you're able to say, well, run this on this machine here, or run this in this tier, or we'll put that on the Web.

This one is kind of interesting because I don't see it talked about often enough, which is to separate information versus mechanism. So there's always information that our system manipulates. For instance, your system may have the notion of the set of users who are logged in. That's an idea that enumerated set is a piece of information, and then you have, like, you use the set class, a collection class from your favorite framework library to put the logged in users.

And one of the problems I think we have in software development is we use the same stuff for both of these things, but these are two very, very different things. One is sort of this device into which you stick stuff and you can go back later, and it's kind of a little bit of a place. And the other is a piece of information, which you should really not treat that way at all. So pulling these things apart, talking about your system and

Take apart place, participants

“All problems in computer science can be solved by another level of indirection”

Figure 24: 00.07.40 Take apart place, participants - build slide

Take apart place, participants

“All problems in computer science can be solved by another level of indirection”

Also authors

- independent development etc

Figure 25: 00.07.45 Take apart place, participants - build slide

Information vs Mechanism

Set of logged-in users

Set collection class/construct

Figure 26: 00.08.12 Information vs Mechanism

Take apart solutions

Benefits
Tradeoffs
Costs
Problem fit

Figure 27: 00.09.15 Take apart solutions

And then, finally, once we think we have an answer, we have a potential solution, we haven't implemented it yet, but we're looking at it, or maybe we have implemented some of it. You want to take those apart to see not just the benefits, right? Those are pretty evident usually. But also the tradeoffs: What part of this is not going to work? How much is it going to cost to run? And does it eventually fit the problem because a lot of times what can happen is you can adopt a solution that is larger than your problem, and then what do you have? You have two problems, right? You have your problem and now you have this thing that was too big, too big for it. So it's not just about getting answers. It's about breaking things apart in a coherent way.

So I'm a big fan of design. I think that we need to do a lot more of it, we need to talk about it more, and we need to spend more time on it. But I think it's pretty easy to rationalize why we need it.

The first is so that we can understand the system, right? A design is hopefully smaller than the code that implements it, and so it's easier to get our head around what it's about. The other thing, as I was talking about, is design is fundamental to coordination.

If you don't have some plan, you can't just send two people off to write. You write one-half a system; you write another half of the system. And that's the end of the conversation. What's going to happen? Well, they're going to wonder which half of the system they're supposed to write, right, because there's no plan. So there's no way to have coordination and to have multiple groups working on something without a design.

Why Design?

Comprehension

Coordination

Extension

Reuse

Testing

Efficiency

Figure 28: 00.09.57 Why Design?

Design also facilitates extension and extensibility. People are always like, oh, I want to make something extensible. But the easiest way to make something extensible is this breaking it apart thing because, when you've broken it apart, you end up with two separate things. You end up with pieces that are meant to connect to other pieces, which means there will be connecting points on those pieces. Therefore, when you want to do something new, you can make a new extension, and it can leverage that connecting point because it had to be in place because the things were separate.

The flipside of that is this reuse aspect, which is, when you've broken stuff up into separate pieces that have nice interconnecting points, you can pull them out of one context and put them in another context. And that's how you get reuse. These are not like magical things, and they're not attributes of APIs, necessarily. They mostly fall out of this decomposition.

Finally, testing is greatly facilitated by design. Ideal testing takes some design constraints, some specification and turns it into tests as opposed to sort of embodying design inside tests. That's inside out. But again, that's something we have to work more at. Stems like Quick Check are interesting because you're basically starting with propositions about your system, which reflect the design and saying you write the tests, computer.

And, finally, I think the thing that's often most readily pulled out as an argument against design is: I don't have time. This is going to slow us down. And in fact, I think it's the opposite. In particular, you know, there are all these adages about when is it easiest and least expensive to fix a bug, right? Not out in the field. If you've already shipped it, it's the most expensive. People are like, oh, we should fix it in QA, or we should fix it in our code and do test-driven design. But the thing is, you can keep moving back. It's most - it's easiest to fix your problems OmniGraffle. You just say, ooh, that is not going to work, and you move some boxes around, and it's fixed. It's much cheaper than fixing the software.

But even after you shipped, I think that there's a lot more efficiency in systems that have been designed because you're going to be able to go back to something. And usually the answer to your problem in the field is: I have just insufficiently broken something down, and so the solution I'm going to need is just breaking it down more. And that's less expensive than: I created this giant ball of everything and I need to untangle it. So I do think, in the end, it's more efficient. So that's design.

The talk is about design, composition, and performance, and so I'm going to take composition and performance together.

And one of the beautiful things about dictionaries is there's more than one meaning for each word. And so there's more than one meaning for composition, which of course we think about composing systems out of pieces like I was just describing, and we think about performance in systems usually as, you know, how fast do they run?

But when I think about composition, I often think about Bartok. And when I think about performance, I often think about Coltrane. And so these are two musicians. Now, Bartok is a Hungarian composer, but he was also a performer. He was a pianist and taught piano. And Coltrane is a famous saxophonist and great performer, but was also a composer, so I'm not trying to pigeonhole these guys. But we're going to use Bartok to stand in for the composer and Coltrane to stand in for the performer and talk about two different notions of composition and performance and maybe how they might inform software.

Composition, music composition and other kinds of art creation is about addressing constraints.

It's about addressing problems, but not real world problems, right? Art doesn't solve real world problems, in general. And if it does, it's more than art. It's something else. So it's quite interesting that the first thing that composers tend to do when they have a blank page - they could do whatever they want - is make up a bunch of problems for themselves. They actually create a bunch of self-imposed constraints. And that's true of all the other art forms. Right? In general, you're going to see this.

And composition is designed for performance, so we saw that definition of design on the first slide. And it said, "To be executed," and that's what composition is. You're writing something. You're anticipating someone is going to perform it or do it later, and it's the same thing. Screenwriters presume people are going to act it out. Choreographers presume somebody is going to dance it, so it's designed, you know, solving constrained problems by creating your own constraints, and you're designing with something to be executed. So it's very much a design problem.

Composition and Performance

Figure 29: 00.13.22 Composition and Performance



Bartók

Coltrane



Figure 30: 00.13.28 Bartok and Coltrane

Composition

Figure 31: 00.14.20 Composition

Composition

Self-imposed problems/constraints

- like other art forms

Figure 32: 00.14.30 Composition - build slide

Composition

Self-imposed problems/constraints

- like other art forms

Design for performers

- ditto screenwriting, choreography...

Figure 33: 00.15.00 Composition - build slide

Composition

Self-imposed problems/constraints

- like other art forms

Design for performers

- ditto screenwriting, choreography...

Organization challenge

- a plan or design addressing those challenges

Figure 34: 00.15.30 Composition - build slide

Specificity and Scale

Figure 35: 00.15.40 Specificity and Scale

And it's quite interesting that, when you look at music composition, you end up immediately seeing a tremendous variety in the specificity of compositions and the scale of them. And it's telling that software sort of straddles these two things.

The first is you see fully orchestrated music. It's fully arranged. All the notes are written out for every part. This is typical at a larger scale, so bigger compositions, orchestral compositions, operas and things like that tend to have full orchestration.

And then smaller compositions, you might have only a melody written out and the chord changes for, say, a song. We'll call it a song, but we're going to not talk about words today. And, in those compositions, you have a lot more latitude for performers because you're not saying you must play this note or this register on this instrument at this time, this loud. You just said this is the melody and have at it. So there's more responsibility for performers, so there's this whole spectrum.

I think that when people push back against design, they're afraid of this first one because, again, back in the '80s we had this stuff, and people had plans that you would draw pictures and push buttons, and it would write programs. Maybe people still have those plans, but they're conducting them in secret.

But I think programmers are like, you know, don't repress me, man. I don't want to see this big thing. But I think that, again, you're going to have the spectrum. You're going to need a lot more writing down,

Specificity and Scale

Fully orchestrated/arranged

- typical at larger scales

Figure 36: 00.15.52 Specificity and Scale - build slide

Specificity and Scale

Fully orchestrated/arranged

- typical at larger scales

Melody + changes

- increased latitude for performers
- increased responsibility

Figure 37: 00.16.12 Specificity and Scale - build slide



Concerto for Orchestra

Figure 38: 00.17.19 Concerto for Orchestra

So we can see two pictures of this here. I don't expect anybody to be able to read that, but on the left is the concerto for orchestra. It's a Bartok piece. And, you know, the parts are all written out for the strings, the percussion, and the winds, and it's all specified. Although it really isn't though. I don't know if you can tell, but there are red markings and some other things on here, which were notes taken by who? The conductor, because the conductors says - or, "I don't know what to do here. You didn't tell me exactly, exactly, exactly what to do, so I have to decide what the tempo is," or how to balance these two sections against each other. But, in general, that's pretty fully specified.

On the right, we have My Favorite Things, as it would appear in like a jazz real book. And, you know, this is the tune from Rodgers and Hammerstein, The Sound of Music. And this is all you would get if you're a jazz musician, right? Here are the changes, and here's the melody, and you move from there.

So I talked a little bit about constraints.

And, again, it's quite interesting to see how this lines up. So most compositions are about one or a few things. The same kind of thing: You're setting out. You're saying what is this piece going to be. You rarely say, oh, I'll just use these notes for a while, and then those notes for a while, and then those notes for a while, and then call it done. Never. You never do that. Composers come up with little motifs and things that they're going to reuse or transform in sort of riff on as time goes by. So there are all these ideas that you're going to set up as boxes in which you're going to work. And you have variations of those things, and

Constraints

Figure 39: 00.18.18 Constraints

Constraints

Most compositions are ‘about’ one or a few things

- melodic, harmonic, rhythmic, timbral ideas

Figure 40: 00.18.21 Constraints - build slide

Constraints

Most compositions are ‘about’ one or a few things

- melodic, harmonic, rhythmic, timbral ideas
- motif or theme
- variations
- resolution

Figure 41: 00.18.57 Constraints - build slide

And then the scale and the composition really just determines how many of these things that you have, and maybe how many different levels there are.

Right? So a big Bartok composition is going to have very, very fine-grained constraints about melodic motifs in a very particular part of the piece and then, at higher levels of structure, deal with big form kinds of decisions. But again, they’re self-imposed constraints.

When we move to the performer side of the coin, the improvisation side like Coltrane, I think it’s quite interesting. Again, it’s an interesting word. It means not foreseen or not provided.

And not provided means you didn’t have the answer upfront before you went and did it. Like you weren’t handed a complete plan before you went.

And so in the case of a jazz performer, you’re going to have melody and changes. Then you’re going to go and provide variations, make something up.

But I think that people have a tremendous lack of understanding of what goes behind improvisation. For instance, a lot of people think Coltrane is just this genius who is spontaneously emoting. They think that improvisation in music is just making stuff up off the top of your head. It’s just amazing. It’s like hacking, right? Just, I am so awesome. I’m so bright. I am just going to, like, make this up.

But it’s quite interesting to see, as we’ve gone back through the archives and had these new releases of old recordings where they put the alternate takes in there because you’ll see Coltrane. He had the solo. It

Constraints

Most compositions are ‘about’ one or a few things

- melodic, harmonic, rhythmic, timbral ideas
- motif or theme
- variations
- resolution

Larger works, more structural components

Figure 42: 00.19.00 Constraints - build slide

Improvisation

Figure 43: 00.19.27 Improvisation

Improvisation

improvisus - not foreseen/provided

Figure 44: 00.19.37 Improvisation - build slide

Improvisation

improvisus - not foreseen/provided

Melody + changes provide constraints

- Performer provides variations

Figure 45: 00.19.50 Improvisation - build slide

Improvisation

improvisus - not foreseen/provided

Melody + changes provide constraints

- Performer provides variations

Tremendous preparation, practice, study

Figure 46: 00.20.58 Improvisation - build slide

Improvisation

improvisus - not foreseen/provided

Melody + changes provide constraints

- **Performer provides variations**

Tremendous preparation, practice, study

Deep musical knowledge and vocabulary

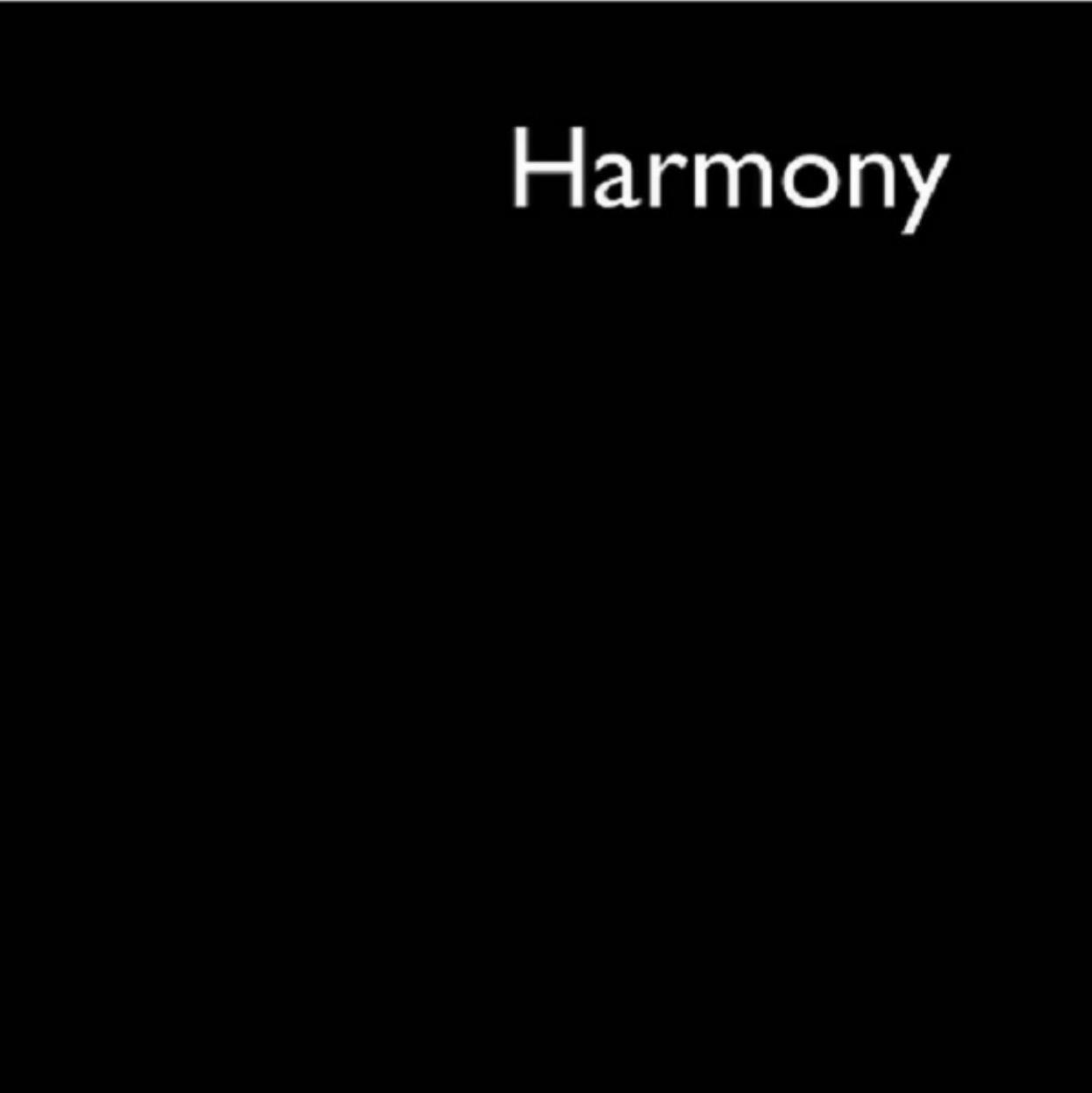
Figure 47: 00.21.29 Improvisation - build slide

And you have to have a lot of knowledge to do this and a lot of vocabulary to do it. It's just not something that you make up. And Coltrane was a genius at this preparing. He practiced more than anyone in order to seem as if he was making it up most fluently.

Another thing that sort of crosses the lines in composition and performance in music is this notion of harmony.

Again, we get this nice word for it, which is a chord or congruity - how do things line up?

Again, there's this lining up notion and the simultaneity associated with harmony. Right? So we have melody is sequential and harmony is parallel. Music did all this before we had computers. And so this is, how do things work together at the same time? If I played these three notes at the same time, what will happen? Or for Coltrane, if I played this note while these chord changes or this set of notes while these chord changes are happening, what will that be like? Bartok had to imagine, when the strings are doing this and the winds are doing that, what will it sound like all together.



Harmony

Figure 48: 00.21.48 Harmony

Harmony

‘accord, congruity’

Figure 49: 00.21.55 Harmony - build slide

Harmony

‘accord, congruity’

‘simultaneous combination (of tones)’

Figure 50: 00.22.02 Harmony - build slide

Harmony

‘accord, congruity’

‘simultaneous combination (of tones)’

‘the art or science concerned with the structure and combinations (of chords)’

Figure 51: 00.22.38 Harmony - build slide

Harmony

‘accord, congruity’

‘simultaneous combination (of tones)’

‘the art or science concerned with the structure and combinations (of chords)’

Harmonic sensibility is a key design skill

Figure 52: 00.22.48 Harmony - build slide

And I'm going to contend that harmonic sensibility is a super critical design skill. This is the thing that you want to nurture in yourself. And it may be a little bit hard to see how the mapping works from music to software, but it's fundamentally what a good designer has. They know if they make this choice in this context, that's going to go together, and those two things are going to work well together. And they know that because of their experience and the study that they've done of working systems.

So I think both Bartok and Coltrane are interesting, even though they're in completely different genres of music, in that they were both masters of harmony.

If nothing else, you can say the two are similar because they totally mastered harmony.

In fact, what was interesting about both of them was that they were students of harmoniousness, if you will. That the thing I think that they were most interested in was what makes things work together well.

Bartok studied obviously the classical tradition, but his music was not compliant with those rules, and it's because he brought a whole bunch of influences in from studies he had done of folk music of Hungary. And what he studied in that music was the sonority that was possible in these tunes that didn't follow the classical rules, but they still worked. And so he pulled out what worked about that and wrote pieces that are hard to really recognize as being completely tonal, but they are tonal, and they're satisfactorily consonant as tonal music is, which is quite, quite astounding.

Bartók and Coltrane

Figure 53: 00.23.17 Bartok and Coltrane

Bartók and Coltrane

Masters of harmony

Figure 54: 00.23.21 Bartok and Coltrane - build slide

Bartók and Coltrane

Masters of harmony

Students of harmoniousness

- Beyond the rules

Figure 55: 00.23.37 Bartok and Coltrane - build slide

Bartók and Coltrane

Masters of harmony

Students of harmoniousness

- Beyond the rules

New systems that preserve/explore harmonic essence

Figure 56: 00.24.41 Bartok and Coltrane - build slide

So I think that what was cool about both these guys is that they both sort of developed new systems that preserved what was essential about things being harmonic or being consonant.

And then the other thing that's quite interesting is that, on both halves, whether you listen to a Coltrane improvisation or the most beautiful, engaging piece of Bartok, what's behind this is a tremendous amount of intellectual effort and activity. I mean you can listen to this Bartok piece and be stunned by it, just blown away by the emotional content. Then you go study the score, and there's like all these fibonacci numbers and ratios in it. And you're like: oh, my God! This was the constraint he set for himself before he wrote this thing that seemed or was so emotionally powerful. So there's a lot to appreciate in both of them.

But what does this have to do with anything that we do? In particular, what does it have to do with languages and libraries, which is really what I want to talk about today: languages and libraries?

Is a language like Clojure or any other language? It doesn't matter. This isn't really about Clojure.

Is it like a song? Are languages like songs? Are they like small compositions? Are they like big compositions? I don't think so.

I think that languages and tools, to me, if you're going to map this analogy, are more like instruments, so let's talk about instruments.

That happens to be one of my favorites. I have that one.

Bartók and Coltrane

Masters of harmony

Students of harmoniousness

- Beyond the rules

New systems that preserve/explore harmonic essence

Towering intellectual effort, while totally rocking

Figure 57: 00.24.51 Bartok and Coltrane - build slide

What does this have to do with our Langs and Libs



Figure 58: 00.25.26 Langs and Libs

What does this have to do with our Langs and Libs?



Is Clojure like a song?

Figure 59: 00.25.38 Langs and Libs - build slide

What does this have to do with our Langs and Libs



Is Clojure like a song?

Is it like a symphony?

Figure 60: 00.25.46 Langs and Libs - build slide

What does this have to do with our Langs and Libs



Is Clojure like a song?

Is it like a symphony?

More like an instrument

Figure 61: 00.25.52 Langs and Libs - build slide

Instruments



Figure 62: 00.26.00 Instruments

Excitation



Figure 63: 00.26.06 Excitation

Excitation

Most instruments are 'about' one thing



Figure 64: 00.26.15 Excitation - build slide

And there's a sense in which most instruments are about one thing.

You pluck a string. You cause vibration on a reed by blowing on it. You strike strings with the mallets of a piano or you hit drums or things like that. And what's quite interesting is that very few instruments are about more than one kind of excitation. Most instruments are about one kind of excitation. It's quite rare to see the other.

Then this is combined with some sort of control or interface or technology on instruments and saying then there's an interface, right? So there's excitation. Then there's this interface for people to go and shape the excitation.

And, finally, there's an aspect of an instrument, which is sort of its fundamental goal in the world, which is to take that excitation and direct it at a problem. And the problem for most instruments is how is somebody going to hear this. How do we get the sound across the room so somebody can pick it up? And so instruments are about directing the force or energy of the excitation out to the audience. They're directed at an outcome, so there's a little piece of design work associated with an instrument.

Instruments also have this other interesting aspect, which is resonance. When you design an instrument, especially something like a violin, a guitar, or anything that has a vibrating body to it, the body itself is going to interact with the excitation. So the excitation of the string is going to vibrate, whatever, and the

Excitation

Most instruments are ‘about’ one thing
Pluck, vibrate, strike...



Figure 65: 00.26.20 Excitation - build slide

Control/Interface



Figure 66: 00.26.44 Control/Interface

Projection

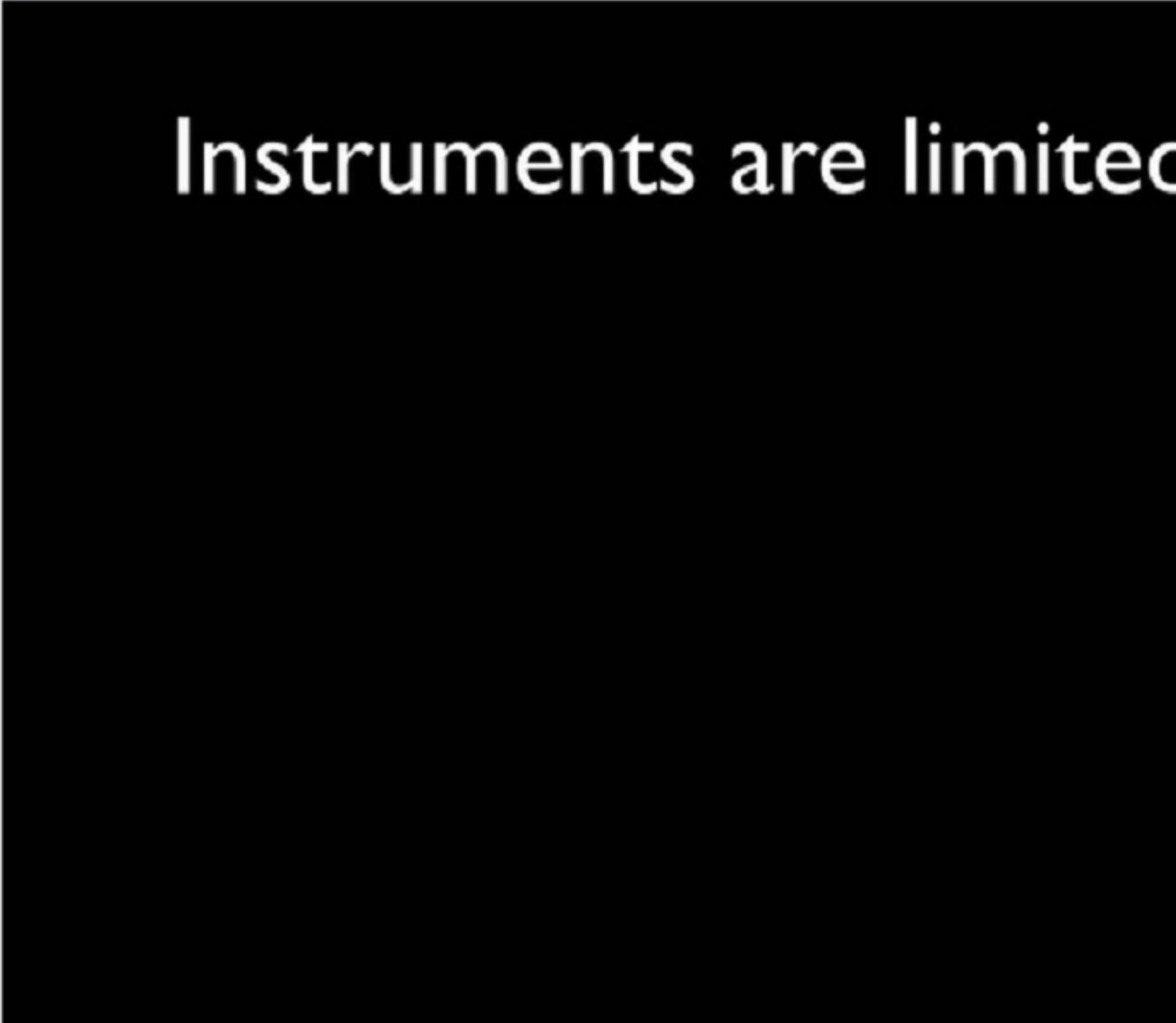


Figure 67: 00.26.55 Projection

Resonance



Figure 68: 00.27.22 Resonance



Instruments are limited

Figure 69: 00.28.09 Instruments are limited

But instruments have a lot of other characteristics, and one of them that's quite striking is that instruments are limited. They're very limited.

Piano - can't play any in between notes. It can only play specific notes: the 12th root of 2 all the way across or maybe you stretch it a little bit, but there's no in between notes.

Saxophone can only play one note at a time. This is awful.

[Audience laughter]

I mean, and these things have been around for hundreds of years. I mean they didn't have GitHub, but somebody should issue a pull request.

[Audience laughter]

And, like, fix this! Right?

Instruments are limited

Piano

- no in-between notes

Figure 70: 00.28.16 Instruments are limited - build slide

Instruments are limited

Piano

- no in-between notes

Sax et al

- one note at a time

Figure 71: 00.28.28 Instruments are limited - build slide

Instruments are limited

Piano

- no in-between notes

Sax et al

- one note at a time

Minimal, yet sufficient

- no missing notes

Figure 72: 00.28.46 Instruments are limited - build slide

Piano

- no in-between notes

Sax et al

- one note at a time

Minimal, yet sufficient

- no missing notes



Figure 73: 00.29.05 Instruments are limited - build slide

But, not all of them will, right? Blues harmonica doesn't have all the notes. Right?

There's a kind of musical DSL, right? It's like you don't need all the notes. You're just a businessperson. I can give you just the blue notes. That's all you get.

And so, you know, is this something to fix? There are all kinds of limits, not just in the notes they can play, but the registers they can play and things like that. Why haven't these all been fixed? Why can't every instrument do everything?

And there's a sense in which the players can overcome this. How many people here play piano? Right? So what do you do to deal with the fact that piano can't play the in between note? What do you have? You have grace notes and trills and mordents and stuff that give you all that sort of feel around the note thing.

John Coltrane famously became so adept at the saxophone and had such physical prowess and muscle memory and combined it with this gargantuan knowledge of harmony that he could play these scales so fast that he could imply not only chords, but entire tonalities, superimpose entire tonalities over chord changes by just playing sheets of sound, is what they called it, over music. So it's not necessarily the case that the shortcomings of these things need to be fixed in an instrument. Right? There may need to be room for the performer to do it.

Instruments are limited

Piano

- no in-between notes

Sax et al

- one note at a time

Minimal, yet sufficient

- no missing notes



Figure 74: 00.29.10 Instruments are limited - build slide

No one wants to
choose-a-phone

Figure 75: 00.30.31 Choose-a-phone



Figure 76: 00.30.45 -image-

So some people do want to play a choose-a-phone.

[Audience laughter]

This is Keith Emerson sitting in front of a Moog modular synthesizer back in the day, and that was just, wow! You could make it do anything if you plugged in the wires the right way.

So I'll take a step back and say maybe some people do want to play choose-a-phone, but no one, I bet, wants to compose for a choose-a-phone ensemble.

Just imagine that you are sitting in front of an orchestra and everybody in the orchestra had one of these in front of them.

Right? And they put the wires in and whatever. And you're the conductor, and you went like this [raising hands up in the air], and when you say go, what is going to happen? You have no idea. You have no idea of what even could possibly happen.

If you're sitting in front of an orchestra, there's a certain category of things that you think might possibly happen, but you can kind of get your head around what that might be. And so the problem here is that where you try to build a bigger system out of something with as much, let's say, parameterization, as these

No one wants
compose for
choose-a-phone
ensemble

Figure 77: 00.31.05 choose-a-phone ensemble

Compl

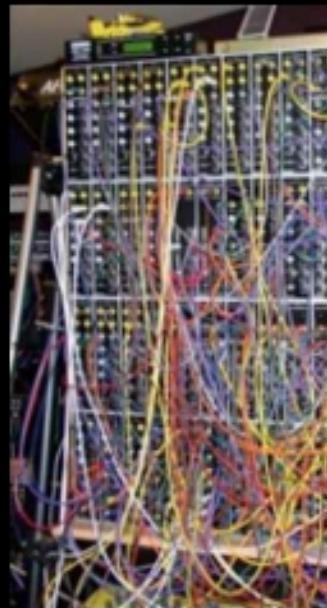
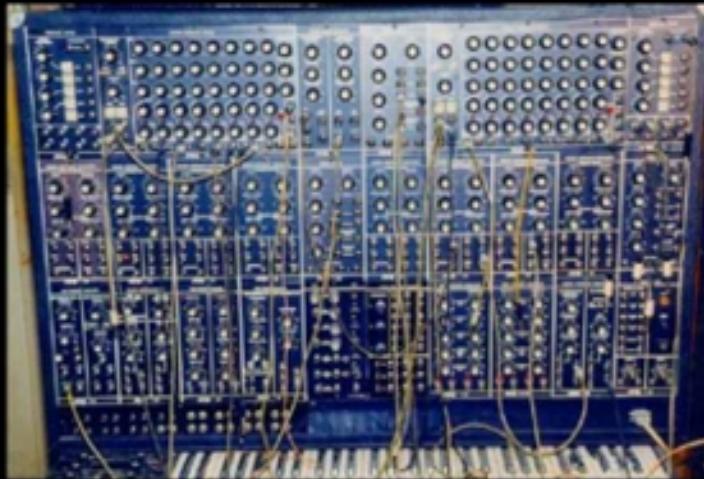


Figure 78: 00.31.10 Complex target

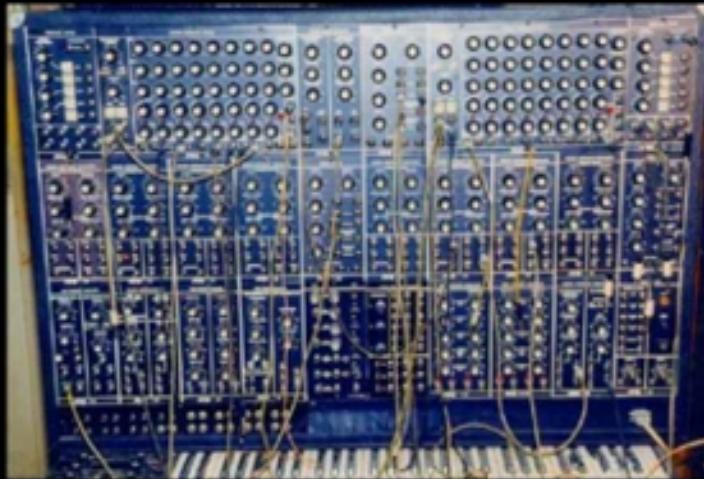
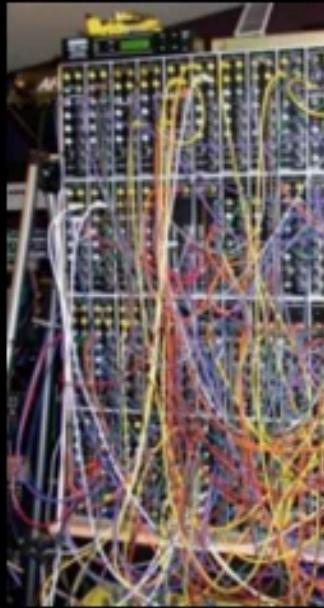
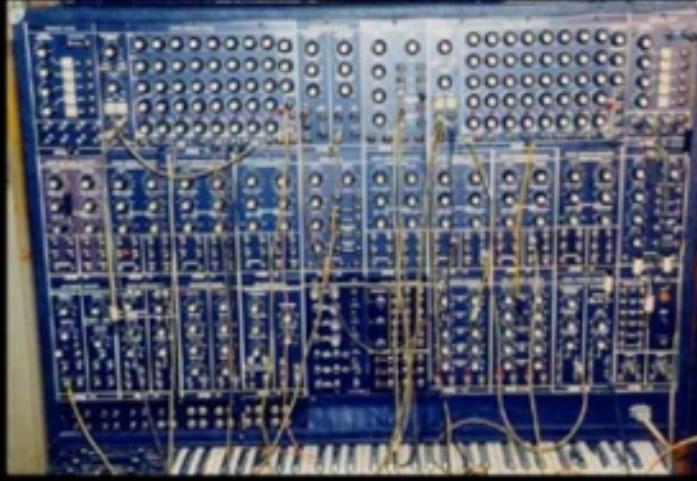


Figure 79: 00.31.13 Complex target - build slide



Nested design problem

Figure 80: 00.31.57 Complex target - build slide

And there's a sense in which this is just the wrong way to go about things because you've got this design problem that's actually multilevel, and it's nested. What happens when you say go? Well, it's the sum of what happens for each person.

What happens for each person? Well, it depends on where they put the wires and what happens, you know, what determines what happens when you put the wires. Well, each module has a different thing that it does. It may be a filter. It may be a sound generator, something like that. So each, there's a level.

There's a set of levels at which there must be design. I must design the modules. I must design the sound, that patch that hooks them together, and then maybe I would try to take on a piece with all of this. But unless there was a way to talk about one of those arrangements and get your head around what it implied, you could never build up higher.

So another stunning thing about instruments, which is just, again, it's astounding that the world has continued, is that instruments are made for people who can play them, who can already play them. I don't know. Hasn't everybody heard of, like, "Explain it to me like I'm five," or whatever? We're not supposed to do this anymore. We're supposed to make everything for beginners.

But instrument makers don't do that. They don't make anything for beginners. They make everything for experienced players. Instruments are made for people who can play them - 100% of the time.

Instruments are players



Figure 81: 00.32.43 Instruments are for players

Beginners are not players

Figure 82: 00.33.19 Beginners

players

Should cellos...

Figure 83: 00.33.34 Beginners - build slide

So we should fix this, right? Because we're technologists, we know how to do this.

We start with the cello. Should we make cellos that auto tune? Like, no matter where you put your finger, it's just going to play something good, play a good note.

[Audience laughter]

Like, you're good. We'll just fix that.

Should we have cellos with, like, red and green lights? Like, if you're playing the wrong note, you know, it's red. You slide around, and it's green. You're like, great! I'm good. I'm playing the right song. Right?

Or maybe we should have cellos that don't make any sound at all. Until you get it right, there's nothing.

[Audience laughter]

And then - then you get it. So, I mean, do we need to fix this?

Here we go. We have a bunch of children, young children being subjected to cellos. There's nothing different about these cellos. These are regular cellos, and they're all sitting there. They're out of tune, it hurts their hands, and it's just awful. I think somebody took off, took away their shoes until they get it right.

[Audience laughter]

Beginners are not players

Should cellos...
auto-tune?

Figure 84: 00.33.40 Beginners - build slide

Beginners are not players

Should cellos...

auto-tune?

have green/red lights when you are
of tune?

Figure 85: 00.33.47 Beginners - build slide

Beginners are not players

Should cellos...

auto-tune?

have green/red lights when you are
of tune?

not make any sound until you play
entire piece correctly?

Figure 86: 00.33.58 Beginners - build slide



Figure 87: 00.34.13 - image-

Players wanted

<rant>

</rant>



Gu



Harp

Doub

Figure 88: 00.35.10 Players wanted

So we need players. I would rant here, but I won't. But look at this guitar player with blisters. A harpist has blisters, a base player with blisters. There's this barrier to overcome for every musician. Imagine if you downloaded something from GitHub and it gave you blisters.

[Audience laughter]

Right? The horrors! And yet how many people here play an instrument or have at one point in their lives? Yeah, a lot of programmers do. And for how many people did you just pick it up and it was awesome? How many wished, like, something could have made it more straightforward to get started with and, like, just made it easy? And how many would have believed after that that they could play it later? No, not at all. This is - it's actually quite important. The level of engagement that's required is quite important.

So we shouldn't sell humanity short. Humans are incredible. In particular, they're incredible learners.

One of the things that's really cool is you give a five-year-old or, I don't know, eight, maybe, a cello and some decent instruction, and they will learn how to play cello if they spend enough time doing it. In fact,

Humans are Incredible

Figure 89: 00.36.03 Humans are Incredible

Humans are Incredible

Learners

Figure 90: 00.36.06 Humans are Incredible - build slide



Figure 91: 00.36.24 Humans are Incredible - build slide

And we're also really good teachers, in general. So I don't think we need to go to our tools and our instruments and make them oriented towards the first five seconds of people's experience because that's not going to serve them well. It's especially not going to serve anyone well who wants to achieve any kind of virtuosic ability with the tools. No one would become a virtuoso on the cello if they had red and green lights when they started.

So neither of these two things is effort free, but we shouldn't be in a game to try to eliminate effort because we are novices, right?

There's a sense in which we're only going to briefly be novices.

You're only a complete beginning at something for an incredibly short period of time, and then you're over it.

It's like we should not optimize for that. But, on the flipside, we're always learners no matter how much time you spend on the violin. Who sits there and says, "I'm done. I've completed learning violin. I finished it"? That's awesome. I personally don't play violin at all, but I don't think there would be a player on earth, no matter how great they are, who would say, "Yeah, I finished violin and I moved on to something else." We're constantly. It's just the human condition to do this.

Things take effort. Just like we shouldn't target beginners, we shouldn't try to eliminate all effort. Look at these two guys. These two guys are experts.

Humans are Incredible

Learners

Teachers

Neither effort-free

Figure 92: 00.36.51 Humans are Incredible - build slide

We are novice

Figure 93: 00.36.55 Humans are Incredible - build slide

We are novice

Briefly

Figure 94: 00.37.00 Humans are Incredible - build slide

We are novice

Briefly

Permanently

Figure 95: 00.37.08 Humans are Incredible - build slide

Effort



Figure 96: 00.37.33 Effort

Effort



Is this the
when you
auto-c

Figure 97: 00.37.42 Effort - build slide

Instruments (and tools) are usually for one



Figure 98: 00.38.27 Instruments

Another interesting observation that's not really that important to this talk is that instruments and tools are usually made for one user at a time, like this whole notion of two guys on one keyboard to program. That doesn't happen in instruments.

Now you make ensembles of instruments. I'm doing this and you're doing that, and we're doing them together in the room, and it sounds great. We do that. But this, like, two people pulling on one tool, that almost never happens.

So I wonder if this pairing thing is just a way to keep us from typing all the time, to buy one person some time to think - a little bit. Whoever is not pulling has got an easy ride. Of course, this is pretty fast switch back and forth.

Instruments (and tools) are usually for one



Pairing?

Figure 99: 00.38.55 Instruments - build slide

Planning/Perform

Figure 100: 00.39.14 Planning/Performance

What ratio of time spent?

- compose/study/practice
- vs perform/record

Figure 101: 00.39.29 Planning/Performance - build slide

But is that, like, the way other things work? No! How about for an orchestral musician? How much time do they spend practicing versus at the concert? Way more time. Way more time. And do they go and say, "I practiced at college, so I'm done practicing"? No.

Why do we think that we can do this? We went to college or wherever we learned, whatever, and then, like, we just, like, we're going to go, and we're going to do it every day. We just do it from here on. Went to school; we're done.

I think that we do need to assess how much time we spend. How many people spend 10% of their time designing? 25%? 50%? I'm going up. No more hands are going to go up. No one spent 10%. It's quite sad.

But there's a sense in which -

[Audience laughter]

There's a sense in which - I mean, it is sad. It is. It's actually sad. It's not sad as a joke - sad. It's actually sad. But there's a sense in which it's like, all right, well, this is all so - it's so different, right? Coltrane couldn't build a website in a day. I could. You know, I could do that.

Actually, I personally couldn't, but I know other people who can. And that's where another rant would go about how important is that. Why do we put so much priority on, like, how fast can a beginner do something

Planning/Perform

What ratio of time spent?

- compose/study/practice
- vs perform/record

Why do we think we can just show up?

- unlike other creative people

Figure 102: 00.39.50 Planning/Performance - build slide

Planning/Perform

What ratio of time spent?

- compose/study/practice
- vs perform/record

Why do we think we can just show up?

- unlike other creative people

‘In order to be creative you have to know how to prepare to be creative.’

Twyla Tharp.

Figure 103: 00.40.00 Planning/Performance - build slide

But...

Coltrane couldn't build a web site in

Figure 104: 00.40.20 But...

But...

Coltrane couldn't build a web site in

<rant></rant>

Figure 105: 00.40.42 But... - build slide

Coltrane couldn't build a web site if

<rant></rant>

Software isn't made of wood or me

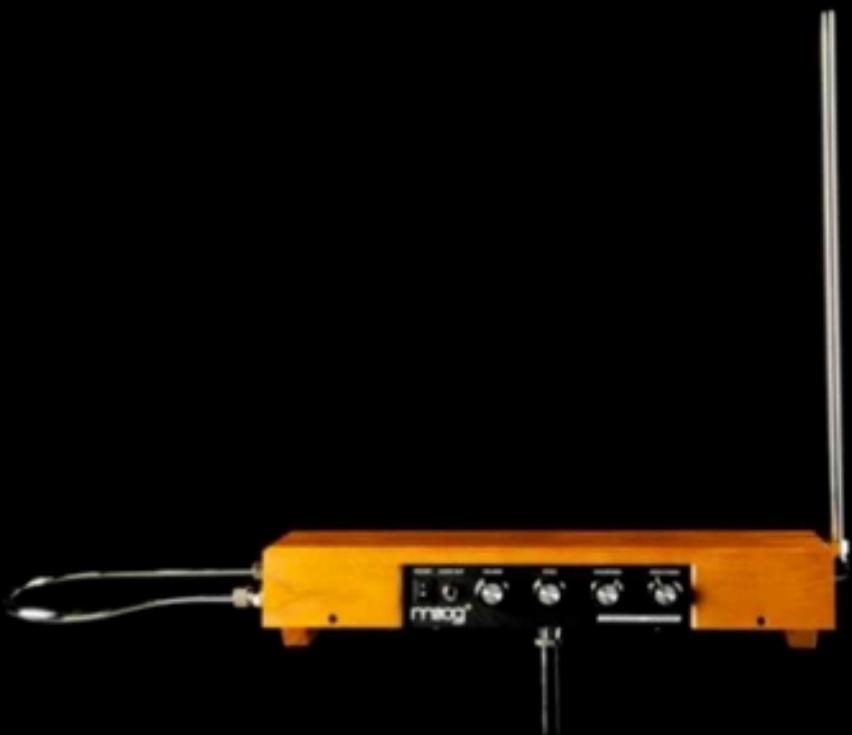
Figure 106: 00.41.00 But... - build slide

But it's a fair point that, you know, software is not like instruments. It's not made out of wood or metal, right? We have these ones and zeros. There are so many combinations. There are so many ones and so many zeros. It just seems so open. How is this connected?

It ends up that there is this connection between instruments and things that are more technological, and they're technological instruments or electronic instruments. This one I want to share a picture of because I also have one of those. It's called a Theremin. No sooner did we have the ability to turn electrical signals into vibrating loudspeakers by having recorded stuff in order to send the signals through that somebody said I wish we didn't have to record stuff. I wish I could just make up an electrical signal and send it to the speaker. Let's cut out that performing and recording part and let's just do - let's just go right for the sound.

And so electronic music was born, and this is one of the first electronic instruments where you play this thing. It's two antenna, and the vertical one controls the pitch. The closer you get, the higher the pitch. The further away, the lower the pitch. And the one, the horizontal one controls the volume. The closer you are, the lower the volume, and the further away you are, the higher the volume. So you can silence it by touching it. You do that, and that's all you got.

You don't actually touch them at all, and the knobs just change the tambour a little bit, but really not very much. It's not really about that. This is an incredibly difficult instrument to play, but it was one of the first ones.



Theremin

Figure 107: 00.41.15 Theremin

Modularity

Figure 108: 00.42.28 Modularity



Figure 109: 00.42.29 Modularity - build slide

And now we're starting to see things more like we know, we understand. These are some of the first electronic instruments that were made. These are the pieces of that instrument you saw before. Each module does a particular thing. It might generate sound or generate certain wave shapes, or it might be a filter that trims off high frequencies from those shapes, or it might generate a low frequency oscillation you can use to modulate something else.

And one of the really cool things about this is not only do you see the first thing, you know, first, or not the first ones, but not only do you see examples of physical modularity, but you also see examples of control. So there are these little holes, these jacks on the front of these things, and they actually take in our output control voltage. It's just voltage. You send a voltage in and then, depending on the module, the voltage might control the pitch or the frequency of oscillation or something, or the frequency at which the filter kicks in, or the wave shape, or various things like that. And then the knobs are redundant things that sort of give a human interface to what you could have done through control voltage by plugging something into the jack.

And there's something incredibly interesting about this, and then you see behind these, there's a circuit, so we have the layers of effort.

But there's a really good lesson here about human versus machine interface. These things had a machine interface first. It was all control voltage. And then they put knobs on it. So you could patch the control voltages around and build customized things.

Imagine if someone had built something - SQL - without any machine interfaces - Unix.

Modularity



Control voltage!

Figure 110: 00.42.54 Modularity - build slide

Modularity



Control voltage!

Figure 111: 00.43.40 Modularity - build slide

Modularity



Control voltage!

Human vs m

Figure 112: 00.43.48 Modularity - build slide

Design stack



Figure 113: 00.44.44 Design stack

We're seeing this thing, this stacking that occurs. This guy, whose name I'm going to mess up, Yves Usson, is somebody who is awesome. He can work at all the layers of the stack. I think he's a biochemist or something. But in his spare time, when he's not a biochemist, he's a C++ programmer. In his other spare time he actually designs these modules. You see behind him a rack of these modules. But he designs the modules, so he can do the electronics work associated with building a module and building an analog filter, for instance, or an analog generator.

And then he obviously can compose them. He helps people make kits and then you can build them into racks. Then you patch them together. So then you're at another level of design where you're patching things together and setting them in odd positions and designing a sound or patch, they call them, but setting a sound out of the module. Then maybe sometimes there's a little keyboard next to them. Sometimes he gets to play the keyboard and make music with this. But it's all these layers associated to what he does and can do.

He happened to work with this company, Arturia, to produce an analog synth, which is rare these days.

Design stack



Figure 114: 00.45.49 Design stack - build slide

There will be no music today!

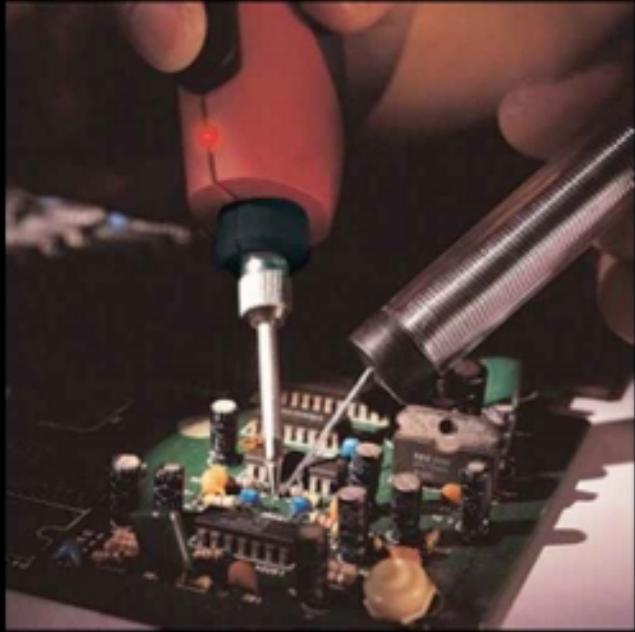


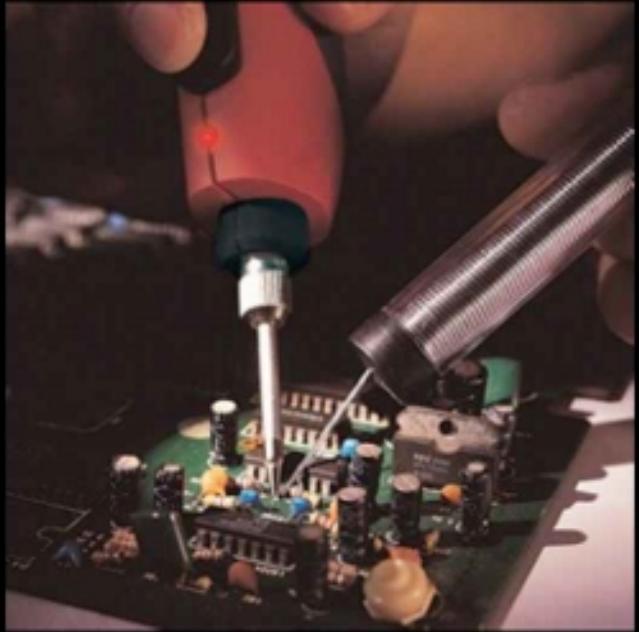
Figure 115: 00.46.38 no music today

And it's quite an important thing because, for him, he has different days. He has days when he's patching stuff together. Maybe he has days when he's playing his thing. And that's all fine, but days when he's soldering, he is not making music. And this is what happens to us.

This is what happens to us when we say you should use emacs. It's like somebody wanted to make music, and you gave them a soldering iron. It's like: here you go. Have at it. Start at the bottom.

And why does that happen to us? The reason is because, for us, it's the same stuff all the way down. In that space, it's very different. Designing an analog filter is a pretty tricky thing just from a mathematics perspective, and then there's also the componentry associated with the electronics aspect of it. Then there's actually being able to solder and put it together on a circuit board.

There will be no music today!



“You should use emacs!”

Figure 116: 00.46.52 no music today - build slide



Code all the way

Figure 117: 00.47.05 Code all the way down

Code all the way down

In software, same mechanism at every level

Figure 118: 00.47.50 Code all the way down - build slide

Essentially, we all do have soldering irons.

It's like any time you want to, you can start soldering. You're supposed to be up here doing this, but you could just start soldering.

And just because we had the soldering iron doesn't mean we're capable of doing things at all layers, but we just do because we can. We have got the iron in hand.

And I think it leads to a lot of distraction and expansion of scope of things. It's like, I was working on this, and then I realized if I rewrote the driver, I could be 10% faster. And now I'm doing something I shouldn't be doing.

There's a sense in which having so much control over so many parts of the stack, it gives us this paralysis. There's so much we could do at every point. So what are we going to do? And I think that we need to - of course, the problem space has some constraints, but we need to bring constraints of our own into play.

We have to do this for ourselves the same way composers do it for themselves or choreographers or directors do it for themselves. They bring constraints in to help them move forward.

Code all the way down

In software, same mechanism at every level

We all have soldering irons

Figure 119: 00.47.52 Code all the way down - build slide

Code all the way down

In software, same mechanism at every level

We all have soldering irons

Doesn't mean we can do filter design

Figure 120: 00.48.03 Code all the way down - build slide

Code all the way down

In software, same mechanism at every level

We all have soldering irons

Doesn't mean we can do filter design

Distraction, expansion

Figure 121: 00.48.13 Code all the way down - build slide

The paralysis of choice

Figure 122: 00.48.25 The paralysis of choice

The paralysis of choice

The impetus of constraint

Figure 123: 00.48.39 The paralysis of choice - build slide

The paralysis of choice

The impetus of constraint

Constraint is a driver of creativity

Figure 124: 00.48.52 The paralysis of choice - build slide

and agglomerating
and fiddling
and tweaking



Figure 125: 00.49.09 Quit fidgeting

So I think we need to quit fidgeting and glomming stuff on and fiddling around with things and tweaking. I mean, oh, my God. As an industry, we spend an inordinate amount of time focused on ourselves: build tools, automating this and that, and just crazy, crazy, crazy stuff. Talking about it any everything else, and we should just be focusing on what we're doing because what ends up happening is, when you keep fiddling with stuff, and when you have no limitations to scope, and no constraints, what happens?

This thing happens. And every one of those parts may be a good idea. They're probably all good ideas. But if you take every good idea, you end up with that.

I don't care if you configure this thing with spring; it's not playable.

[Audience laughter]

No one wants to play this. In fact, this particular one, no one does play. It plays itself.

[Audience laughter]

The actual patching of it is the composition, and it's got stochastic elements in it that cause it to generate novelty, and it plays itself in a museum. I mean, maybe we want programs like that, but maybe we don't.

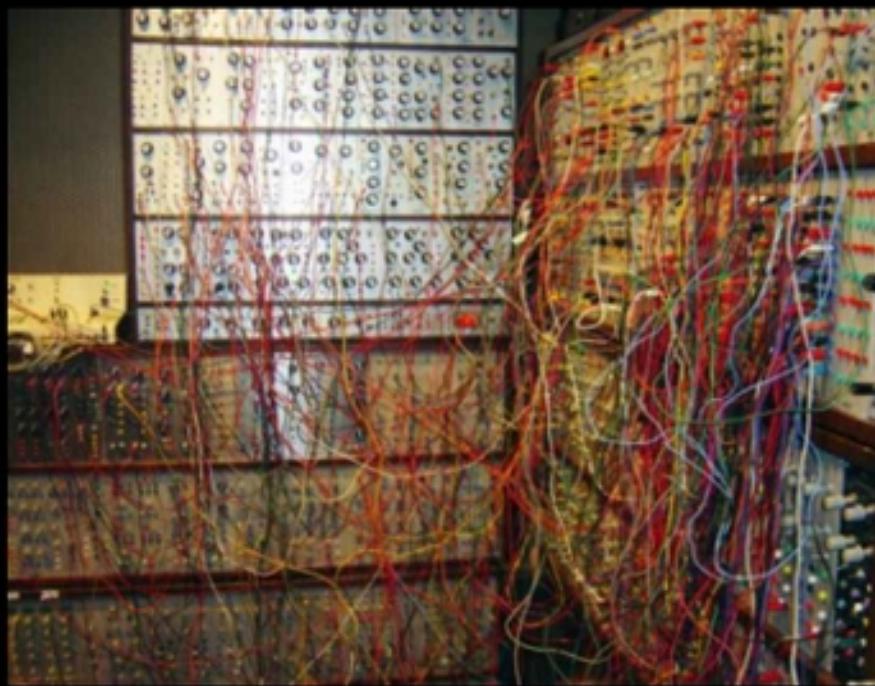


Figure 126: 00.49.38 - image -



Carolina Eyck

<http://www.youtube.com/watch?v=7I9YcewEumw>

Figure 127: 00.50.28 Carolina

Design is imagining

Figure 128: 00.51.18 Design is imagining

So what is design? If we take a step back and sort of merge all these things together, there's a sense in which design is imagining. If it's not just regurgitating something that's already happened before, you're facing some set of problems. You have to imagine potential solutions.

And the first thing you need to do is rush at the constraints. You don't want to be like, don't constrain me; I'm trying to design. It's the opposite of that. You're like, give me, give me, give me the constraints. I want to know about everything. And, if you haven't given me enough constraints, I'm going to make up some because I want this thing to work.

Design is imagining

Embrace the constraints

Figure 129: 00.51.36 Design is imagining - build slide

Design is imagining

Embrace the constraints

Be optimistic

Figure 130: 00.51.54 Design is imagining - build slide

Design is imagining

Embrace the constraints

Be optimistic

Imagine a lot

Figure 131: 00.52.22 Design is imagining - build slide

However, actually designing is about making decisions, which means you try to think up 100 times as many things as you actually use, way more things than you use.

You don't want to think of one thing and be like, okay, let's go do that. You want to think of ten things and then say this one is the one we want to do.

So you want to admit very little.

You want to be able to say no because the value that you convey in your design is strictly about the decisions you've made. When Yves helped make that synthesizer, he made a set of decisions. Are they perfect? No. Is it everything you want? No. Do I wish I could patch a wire from here to there? Yeah, sometimes I do. But you know what? I really appreciate the fact that this thing just works, and it sounds great, and I can do the next thing. I don't have to fiddle around with the inside of it.

So if you leave all the options open, you're not designing. That is not design. Everything configurable, that's not design. That's like do your own thing.

So performing is preparing. It's planning.

Design is making decisions

Figure 132: 00.52.26 Design is making decisions

Design is making decisions

Admit little

Figure 133: 00.52.45 Design is making decisions - build slide

Design is making decisions

Admit little

Value conveyed is in decisions made

Figure 134: 00.52.46 Design is making decisions - build slide

Design is making decisions

Admit little

Value conveyed is in decisions made

Leaving all options open is avoiding

Figure 135: 00.53.13 Design is making decisions - build slide

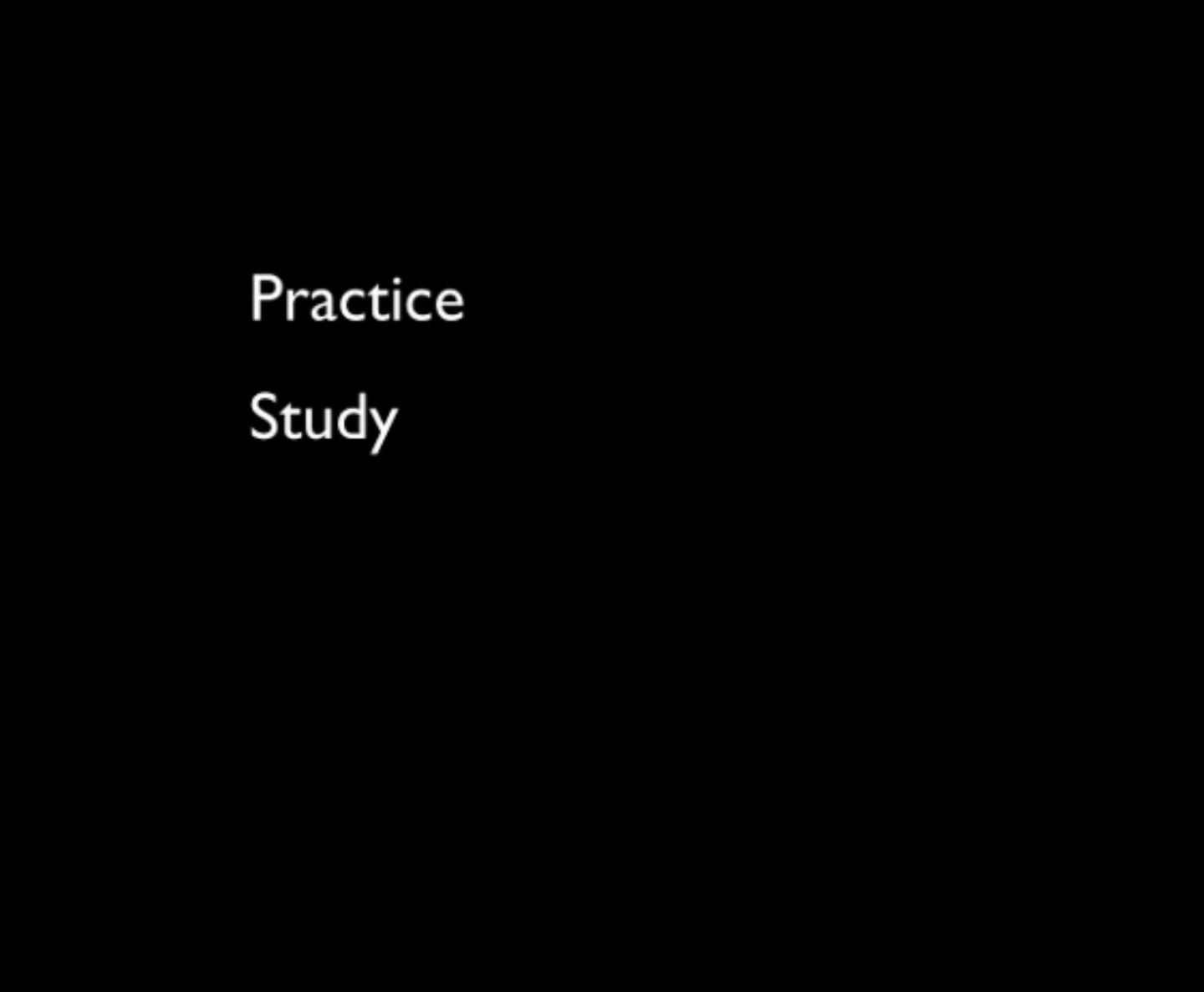
Performing is preparing

Figure 136: 00.53.23 Performing is preparing

Performing is preparing

Practice

Figure 137: 00.53.27 Performing is preparing - build slide



Practice

Study

Figure 138: 00.53.29 Performing is preparing - build slide

You have to study.

And, in the end, what you want to try to do is develop sensibilities that you can apply when you're trying to write code. If writing code is the performing part, you have to have patterns, techniques, knowledge about what works and what doesn't to apply to what you're going to do. You cannot just make it up as you go.

So design is taking things apart in order to be able to put them back together. And that's really all it is. Every time I encounter something, I can boil it back down to that. Every time I encounter something that I wish my design was better, I need to do more of this. It's over and over and over again. It's always this. I did not take it apart enough.

You want to design like Bartok. That is to say, you want to communicate very well. You want to be able to work at multiple levels.

And you want to code like Coltrane. You want to take preparedness and experience, real experience with doing things, not experience by doing the same thing over and over again. And bring them to bear in what feels like a more improvised thing. I'm encountering a new scenario in a programming project. I'm really not making it up. I'm really bringing my background into play to solve that problem.

I think you want to find and choose languages and libraries that are like instruments in all the ways I talked about in terms of being simple, directed at one thing, oriented around people that know how to use them and expressing and backing some fundamental excitation or idea. Those are going to be the most satisfying.

Performing is preparing

Practice

Study

Developing design sensibilities you can't teach
on the fly

Figure 139: 00.53.32 Performing is preparing - build slide



Take things apart

Figure 140: 00.53.52 Take things apart

Take things apart
Design like Bartók

Figure 141: 00.54.13 Take things apart - build slide

Take things apart
Design like Bartók
Code like Coltrane

Figure 142: 00.54.21 Take things apart - build slide

Take things apart

Design like Bartók

Code like Coltrane

Langs and libs like instruments

Figure 143: 00.54.43 Take things apart - build slide

Take things apart

Design like Bartók

Code like Coltrane

Langs and libs like instruments

Pursue harmony

Figure 144: 00.55.08 Take things apart - build slide



Figure 145: 00.55.19 Rock on

But thanks very much for listening, and I hope you enjoy the rest of the conference.

[Audience applause]