Grassroots Educational YouTube Videos: Exploration of a New Genre
Master Thesis

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Even though educational videos made by people who are not professional educators are immensely popular with millions of views on YouTube, very little research has been done into this genre of videos. In this study, I explored the different elements of these grassroots educational YouTube videos. Through a qualitative study I described what choices the creators of these videos make. The main findings are presented in two categories being 1) the presentation of educational content and 2) the maintenance of para-social relationships. I find that even though creators of these videos present the educational content in a traditional way, they maintain a relationship with their viewers as if they are a personal friend.
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“To me, the most interesting communities of learners that are growing up on the internet now are on YouTube, and admittedly, I’m biased. [...] I’m here to tell you that these places exist, they still exist. They exist in corners of the internet, where old men fear to tread” (John Green, 2015).

Introduction

Since its launch in 2005, YouTube has become one of the biggest platforms for sharing videos. YouTube hosts different types of educational videos, such as recordings of lectures or demonstrations of chemistry experiments. Some of these videos are immensely popular, with millions of views. These videos are not only popular with a general audience. Kousha, Thelwall, and Abdoli (2012) researched the use of YouTube in academic publications and showed that an increasing number of scholars are referencing YouTube videos in their academic papers, mainly to demonstrate real-time scientific phenomena or experiments. However, even though scholars do use these videos, the videos on this website have elicited very little academic research.

I notice and argue that there is a separate niche of educational videos that requires more research. The present study is meant as a first study into this specific type of videos: grassroots educational YouTube videos.

First, I will explain some of the characteristics of the videos I aim to study. The videos are made by people who are not experts at either making videos or films, or at the content they are teaching. The creators often profile themselves as people who started making videos for YouTube as a hobby, which then grew to be their job. The creators thus go off the beaten path and choose a new and unexplored way to educate. This way lies outside of the formal and generally accepted manner of educating. In this article I will call the videos I aim to research “grassroots educational YouTube videos”. This is because of the motivation of the creators of the videos: rather than being in formal environments that tell them to make a video about a certain subject, these creators decide to do it themselves. Because of an evolving digital world, the creators have access to the materials needed for making and sharing these videos. As a natural consequence, these grassroots educational videos are made for a general audience (rather than for “Ms. Jones’ chemistry students” or for “medical students”). Furthermore, these videos are made for YouTube specifically, and thus are a part of “the YouTube community”, which is an important characteristic I will explore later.

The creators of grassroots educational YouTube videos don’t use a prescribed curriculum. Thus, the creators have to ask themselves questions about how to present the material they want to cover in the video. These questions might be “what tools do I use to convey my message?”, “how much time do I spend on the topic?” or “what information is most important?”

Although videos have been used as classroom aids for a while, there has been a relatively new trend of videos aimed at a general public outside of the classroom, made by “amateur” film creators and educators. The viewers of these videos watch them on their own volition. After searching in academic databases concerning education, sociology, psychology, media, communication science, and information science, I came to the conclusion that little to no research has been done on grassroots educational YouTube videos. This is a surprising fact, since these videos are immensely popular. A quick search on YouTube shows that these videos get millions of views and that the channels that publish these videos have millions of subscribers.

Because this is such an important genre that is currently unexplored by scholars, I will propose to investigate grassroots educational YouTube videos. I propose that these videos are part of a new genre. To understand this new genre, I want to determine the qualitative characteristics these videos have. I aim to get a clear image of the choices the amateur video creators make to convey educational content. The outcomes of this study can generate important input for an understanding of the appeal and popularity of self-directed learning through these videos. Furthermore, because of their popularity, these videos might contribute to the popularization of science.

The remaining sections of this section are sorted as follows:

- To be able to understand the genre of the videos, it is important to understand what the meaning of ‘a genre’ is. In this article I will thus briefly discuss important considerations when describing a genre.
- An important aspect of this genre is that it is about educational videos. I will therefore present background information on educational instruction, and more specifically, digital educational instruction.
- Furthermore, it is important to understand what it means that these videos are created in a “grassroots” manner. I will thus explore literature on user-generated content and the emergence of “do it yourself” genres.
- Lastly, I will discuss the role of the audience and the relationship between the audience and the creator in the description of the genre.

Describing genres

As I pointed out in the introduction, we don’t know much about this type of videos yet. A genre analysis is a first step towards understanding these videos. J. R. Martin (1985) defines genre as follows: “Genres are how things get done, when language is used to accomplish them” (p. 249). This study thus focuses mainly on the language used in the videos,
and on describing how the language is used to accomplish the goals of the creators.

Describing genres has an important function. By identifying texts or other mediums that use language, the audience has an idea of what kind of work is being presented, which helps the audience to understand how to respond to the medium (Clarke, Lee, & Clark, 2017).

Bhatia (2017) reviews different perspectives on genre and discusses the commonalities in these perspectives. I will discuss some of these commonalities here briefly. The first commonality is that genres are defined in terms of their shared communicative purposes. Communicative purposes are important for the identification and interpretation of genres, according to the author. In the context of this article, the communicative purpose seems clear: To convey the educational content to the viewer. However, in the analysis, I will attempt to analyze whether this is really that simple or whether there are other communicative purposes as well. Furthermore, Bhatia (2017) states that genres are not static. Kramer (1999) argues the same thing, and adds that creators can change the boundaries of a genre through ‘innovation and experimentation’ (p. 34). This means that there is not always a static set of rules to describe a genre, which also means that with every addition, the genre might change (Kramer, 2009). This way of understanding genre is very applicable to genres in online media. Online culture and technology are rapidly changing in and of itself. When trying to understand the genre of grassroots educational YouTube videos, it is thus important to keep in mind that this genre is also dynamic and ever changing.

So what does a genre analysis in this context concretely look like? Genre can be described by very different characteristics, such as content, form, tone, styles, audiences, reactions of the audience, how it is produced, and what the medium is communicating (Clarke et al., 2017). To cover all of these in this article would be too ambitious. Therefore I choose to limit this article to the two biggest common denominators in the grassroots educational YouTube videos: 1) the creators present educational content, and 2) the creators cater the videos to an audience on YouTube. In the the following sections I will discuss educational content and audiences on YouTube to get an understanding of these common denominators.

Educational instruction

The previous section pointed out the importance of communicative goals in describing genres. As the videos are advertised as educational videos, one of the main communicative goals seems clear: To convey content in such a way that viewers learn from it. In this section I explore some considerations creators should take into account when creating educational content. There is an abundance of literature on educational instruction. Since this paper focuses on the choices creators of grassroots educational YouTube videos make, I will focus on literature on choices or considerations educators have to take into account when designing a lesson.

Gagne and Briggs (1992) state that it is not common for instructors to fully design the materials they use in their instruction themselves. Rather, they go through a process of selecting suitable materials and adapting them to fit the course material. In this process, it is important for instructors to take into account multiple considerations on several levels (Gagne & Briggs, 1992). In this section I will explore some of these levels: I first take a broad approach by briefly discussing the abstract cognitive processes that are important during learning and instruction. Then, I will discuss the more concrete (but still general) parts of a lesson. Lastly, I will discuss the specific principles of digital audio-visual instruction, as well as concrete techniques that were proven to be effective in the literature.

Cognitive processes. Clark and Mayer (2016) see learning as “a process of active sense-making” and teaching as “an attempt to foster appropriate cognitive processing in the learner” (p.79). The cognitive processing they mention in this definition is based on three principles: 1) dual channels, 2) limited capacity, and 3) active processing. The dual channel principle means that learners learn through two ‘channels’: the auditory channel and the visual channel. Especially in videos this is a relevant principle, because creators can manipulate these channels easily by writing and preparing the video and through video editing. The limited capacity principle means that learners can only process so much information at a time. Each of the two channels described before should contain a limited amount of information to optimize learning. The active processing principle means that learners go through processes where they actively organize the information they are presented with. These are processes like paying attention, mentally organizing the information, and integrating it with prior knowledge (Clark & Mayer, 2016).

In making educational videos, creators make certain choices regarding these three topics (consciously or subconsciously). For example, they need to decide what to present auditorily and what to present visually. They need to decide how much to present at once and they need to present and organize the information in such a manner that the learner is able to make sense of it. In this study, we consider these decisions in more depth in the analysis.

Parts of a lesson. Clark and Mayer (2016) (among others) recommend breaking a lesson into parts, and many studies focus on what the different parts of an instruction should be. For example, Gagne and Briggs (1992) distinguish nine ‘events of instruction’ in a traditional instruction setting:

1. Gaining the learner’s attention
2. Informing the learner of the objective
3. Stimulating recall of prerequisite learning
4. Presenting the stimulus material
5. Providing learning guidance
6. Eliciting the performance
7. Providing feedback about performance correctness
8. Assessing the performance
9. Enhancing retention and transfer

This is a very comprehensive and widely used list of different events in a lesson. These events are generally relevant for digital instruction as well. For example, Clark and Mayer (2016) distinguish three e-learning goals: inform, perform procedure, and perform task. These three goals can all be found in the list by Gagne and Briggs (1992).

However, in grassroots educational YouTube videos, the fifth through ninth events are less relevant, because of the asynchronous nature of the videos. In online instruction, the interaction between the instructor and the learner is asynchronous, which means that the learner and the instructor are not in the same place at the same time. Because of this there is no direct interaction between the creators and the learners, and eliciting or assessing performance is not immediately possible. Creators of grassroots educational YouTube videos seem to be able to solve this lack of interaction between educator and learner by using strategies that are specific to YouTube. I will further discuss this in the section on YouTube and learning.

Audio-visual digital instruction. In this section, I focus on literature on audio-visual digital instruction because this is the most relevant to grassroots educational videos. In the literature, multiple principles for effective audio-visual instruction arise. In this section, we will discuss some of these.

Clark and Mayer (2016) state that there are some guidelines for instruction for digital learning. First, they recommend using the multimedia principle. This means it is beneficial to use words and graphics rather than words alone. In order to create meaning for the learner, words and pictures should work together in instructional design (Clark & Mayer, 2016). “Multimedia presentations can encourage learners to engage in active learning by mentally making connections between the pictorial and verbal representations” (p.71). Thus, using graphics can be effective, but it is also important to match the type of graphics with the type of information being taught.

Next, they discuss the contiguity principle. One reason for a video format to be successful, is the contiguity principle (Clark & Mayer, 2016). This principle means that the graphics should correspond with the text. Making text and graphics correspond is easy to do in a video; easier than on a web page or a physical page.

The modality principle means that learning can be enhanced when the learner gets presented graphics that accompany spoken words. Horvath (2014) shows that “dividing attention between nonlinguistic visual and linguistic auditory tasks should engender little to no impairment for either stream: in fact, sensory integration may improve overall comprehension and retention”, whereas “dividing attention between text and speech typically impairs comprehension and retention for both stimuli streams” (p. 139). Creators should thus use image-based visuals rather than text-based visuals accompanying their spoken words.

This is most true when material is complex for the learner as well as fast-paced.

The redundancy principle states that redundant materials hinder learners in their learning process. This means that when information is presented, the creator should choose to either present it visually or to present it verbally: Presenting both can cause the learner to not be able to focus on one of them.

The coherence principle means that creators should avoid lessons with extraneous audio, graphics, words, etc. The capacity of human memory is limited, and learners will thus be benefited by lessons that do not have extraneous materials.

The personalization principle advises to use “conversational styles and virtual coaches”. This way the creator can engage the learner by engaging them in a conversation-like lesson.

According to the segmenting principle creators should break their content up into segments. Complex information especially should be broken into smaller parts, and the parts should be presented one at a time.

The pre-training principle is making sure learners “know the name and characteristics of key concepts” (p. 212). When learners know the basic names and characteristics before they are presented with more complex processes this can prevent the learner’s cognitive system from getting ‘overwhelmed’.

All in all, these principles give a comprehensive idea of how a creator should handle the information he is presenting to the audience (Clark & Mayer, 2016).

Before, I discussed the possible benefits of using both words and visuals. Research shows that using video for the visuals might even be a more effective means of instruction than static images (Moreno & Ortega-Ortiz, 2008). However, according to Clark and Mayer (2016) it is important to distinguish learning goals in choosing whether to use video instead of static images: “it appears that static visuals might be most effective to promote understanding of processes, whereas animated visuals may be more effective to teach hands-on procedures” (p. 86). In the case of grassroots educational YouTube videos, the subjects taught are more heavily geared towards processes than to hands-on procedures, which means video might not be the most effective
way to teach the materials. In this study, I investigate what decisions creators make regarding the use of animation or video and static images within their videos.

Other than adapting the presentation of educational content to the learning goals, it is important to keep the target audience in mind too. Clark and Mayer (2016) state that using both words and graphics is particularly useful when teaching novices rather than experts. Experts learn equally as well when there are both words and graphics or words alone. The authors explain this by stating that experts are able to form their own mental images of the material and don’t need the physical images for that anymore. This is called the ‘expertise reversal effect’. For grassroots educational YouTube videos, the instructors are not sure about who their viewers/learners are. However, it can be assumed that the viewers are novices.

Another important decision instructors make is what medium to use. An instructor can choose to use merely his voice, or present instruction on paper, or use digital tools like computers, projectors, or videos. Gagne and Briggs (1992) state that the computer is a useful instructional medium, because it is interactive by providing feedback to learners. Furthermore, they state that instructors as media “are the voice in delivering speech, and the action in demonstrating procedures” (p. 210). They also have the role of planning and managing the instruction. In this study, we investigate how they plan and manage the instruction in grassroots educational videos.

Gagne and Briggs (1992) suggest that media are best selected for specific purposes within a single lesson. They give the example that movies might be best for portraying historical events, but only if the teacher informs the learner of the objective.

Another interesting recommendation Clark and Mayer (2016) give, is using conversational styles in educational instruction. Using a conversational style rather than a formal style leads to a higher engagement of the learner with the material. A meta-analysis by Ginns, Martin, and Marsh (2013) confirms this recommendation and shows that a conversational style is highly correlated with effective cognitive processing in the learner.

**Benefits of using video for instruction.** Recently, both the use and the effectiveness of digital technology and new media for learning have been gaining attention in the literature. While the effectiveness of learning methods is not the focus of this paper, it demonstrates a need for more knowledge of different digital learning materials. There have mainly been many studies about the use of new media in classroom contexts. Most of these studies are optimistic about the use of new media and state that the use of new media can lead to higher involvement of students and better learning outcomes (e.g., Jaffar, 2012, and Brown, 2001).

There have also been authors who are pessimistic. For example, Azer, AlGrain, AlKhelaif, and AlEshaiwi (2013) study the quality of YouTube videos for anatomy education. They do this through analyzing several characteristics of the videos (e.g., length and title), content criteria (e.g., whether the creator is an authority in the medical field), and “pedagogical parameters” (e.g., whether the subject of the video is clearly presented and whether the video matches the target audience). The authors conclude that only a small number of the videos they analyzed were educationally useful.

Thus, findings have been ambiguous in a classroom context. However, it is not clear if these findings will generalize to outside the classroom because not many researchers have investigated educational material tailored to learning outside the classroom. While videos for classroom use are studied intensively, grassroots educational YouTube videos have received very little scholarly attention to date.

In the literature there is some evidence that instruction through digital technology and YouTube is in fact effective. One piece of evidence can be found in the process of self-directed learning. Self-directed learning is learning that happens when learners “take initiative related to their own learning with or without an instructor present” (Bonk, Mimi Miyoung, Xiaojing, Shuya, & Feng-Ru, 2015, p. 350). One of the unique aspects of self-directed learning is the sense of choice (Tan, 2013). YouTube provides an abundance of choice, which gives a first indication that YouTube has the potential to be a fruitful platform for self-directed learning. Other considerations regarding YouTube that are beneficial to self-directed learning are the following:

- Videos can be watched anywhere if someone has access to a (mobile) device and an internet connection.
- Students can rewatch the video when they do not understand, or skip parts when they do understand. One of the key points of effective instruction according to Lever-Duffy (1991) is no restrictions of location or time. Having instruction delivered to the learner through YouTube lifts these restrictions entirely.
- YouTube videos can be paused when the information given in the video overwhelms the student.
- The YouTube website allows for the videos to be watched at multiple speeds so when a complicated process is being shown, students can slow the video down.
- Content creators can add links and annotations to their videos at any point in time, so when new relevant videos are made, they can direct the viewers to them.
- Similarly, when new information about the subject comes to light, they can add this in the video.
- YouTube has the possibility to add subtitles, making the videos accessible to people who are deaf or hard of hearing or who do not speak the language.
Thus, there are some serious concerns with digital technology for learning, and creators need to think well about their decisions on cognitive and practical levels, but in general the medium looks promising.

Grassroots videos

Grassroots educational YouTube videos are closely related to a concept called user-generated content. When websites or other platforms allow their users to create their own content, such as diaries, photos, or videos, we call this user-generated content (UGC) (Leung, 2009). The same is true for grassroots educational YouTube videos: instead of content created by a professional or by an expert, the content is created by users of the platform.

User-generated content on the internet has been through many developments. When the internet started to become available for a bigger number of people, bulletin boards started gaining popularity. On these bulletin boards users could post their own messages and thus create the content. One could thus argue that UGC has been around since the 1990s. Over the years, many websites have gained popularity where people post their own content, whether it be stories, music, drawings, or videos. In all cases, the internet has provided a platform for people who are not necessarily experts to share their content. Web 2.0 however especially allows for users to “challenge the traditional sense of information control” (Xu, Park, Kim, & Park, 2016, p.106) by controlling it themselves. This has led to the possibility for users to make create and broadcast ‘do it yourself’ versions of media outlets that were previously only broadcasted by formal organizations.

The YouTube videos we talk about in this article are an example of a ‘do it yourself’ version. YouTube is a suitable environment for user-generated content. Holland (2016) argues that the way YouTube works removes technical barriers for spreading and sharing content online. Because of the simplicity of the website, people can view as well as upload, publish and now even live stream videos “without high levels of technical knowledge” (p. 1). Van Dijck (2009) for example says the following about YouTube: “Users contribute creative efforts outside of professional routines and practices” (p. 49). The necessary tools are no longer only available to professionals. Kim (2012) even states that traditional media have adopted strategies YouTube creators use, mainly because the interactive nature of YouTube helps create “the stability of loyal audiences” (p. 58).

Smith, Fischer, and Yongjian (2012) did a study on the differences between different social media (YouTube, Twitter, and Facebook) and concluded that YouTube is unique in the sense that the user-generated content on this medium is the most personal. There is similar information, but the focus in YouTube videos is very much on the person communicating the information rather than the information itself (Smith et al., 2012). This increased level of personal focus influences the relationship between creator and viewer, which we will discuss later on in the section ‘para-social relationships’.

An example of a study that has been done describing educational YouTube videos in a non-formal learning context, is one by Alston and Ellis-Hervey (2015). They studied educational YouTube videos about black natural hair. The authors analyzed YouTube videos qualitatively and gave an overview of choices the creators of these videos made. One of their main findings is that “online educators” use humor, humility and personal stories to connect to the viewers. Although the subject of the analyzed videos is not directly applicable to the present study, the study by Alston and Ellis-Hervey (2015) highlights the sense of community and the non-hierarchical relationship between educator and student.

YouTube audiences

YouTube is not the only platform where online education happens. Two examples of other platforms are TED Talks and Massive Open Online Courses, or MOOCs. In this section I will briefly explain what these platforms are, and how YouTube videos differ from them.

Sugimoto and Thelwall (2013) discuss the impact of the popular TED Talks platform (a platform where speakers can present their knowledge or ideas on different scientific topics through online video). Although these videos do not fall under the niche the present study investigates, TED Talk videos are also distributed through YouTube. The authors conclude that TED Talks have a bigger impact on non-scientists than on scientists, even though the TED Talks do address scientific topics (e.g., the universe, computer science). The authors thus conclude that TED Talks are “a highly successful form of popularizing discourse” (p. 673). This suggests that, like TED Talks, grassroots educational YouTube videos might also be beneficial to non-scientists and thus to science popularization.

Second, I will discuss Massive Open Online Courses, or MOOCs. These are courses that are only offered online. Several studies investigate the characteristics of MOOCs. For example, a study shows that shorter MOOC videos are more engaging than longer ones, as well as talking-head videos and tablet drawing style videos (Guo, Kim, & Rubin, 2014). Furthermore, high-quality pre-recorded classroom lectures are not found to be more engaging than MOOCs. Mackness, Mak, and Williams (2010) states that MOOCs have a high potential for effective learning due to the open, diverse and autonomous nature of the learning process.

All in all, videos like TED Talks and MOOCs seem to be very similar to grassroots educational YouTube videos. A commonality is that all three types of videos cater to non-formal education. Non-formal education is “more focused on the present, learner centered, less structured, and responsive to localized needs, and there is an assumed non-hierarchical
Para-social relationships. An important unique feature is a phenomenon called ‘para-social relationships’. Para-social relationships are a way of engaging the audience with the (contents of the) media. The reason that UGC videos are popular, can be explained by this phenomenon. Para-social relationships are one-sided relationships with media persona (Derrick, Gabriel, & Tippin, 2008). Para-social relationships are established through emotional connections and an analogy with social relationships (Claessens & Van den Bulck, 2015). By being exposed to said media persona for a prolonged period of time, people establish a sense of ‘shared’ experiences and interactions over time. Cummins and Cui (2014) state that creators of television shows help cultivate these para-social bonds with their viewers by directly addressing the viewer, as if they were speaking to them at home.

Para-social interaction in videos seems to affect the viewer. Lee and Watkins (2016) showed in an experimental study that para-social interaction in YouTube videos recommending certain brands leads to more positive perceptions of the brand and higher intent to buy products by the brand. Furthermore, these relationships even help people’s self-esteem (Derrick et al., 2008).

Do the effects of para-social interactions also occur when the viewer is a learner rather than a consumer? A study investigating the willingness of children to adopt robot-assisted learning systems showed that children were more willing to learn when there was a para-social relationship between the robot and the learner (Yoo, Kwon, & Lee, 2016). This indicates that para-social relationships may positively affect learners that learn through YouTube.

Even though the YouTube videos I discuss here are not live, Tolson (2010) states that the way YouTubers talk to the camera is to “construct co-presence and invite interaction” (p. 278). Tolson points out four characteristics of YouTube videos. The first of them is the creator directly addressing the viewer visually by looking into the camera. More importantly, this visual address is supported by talking to the viewers using the word “you”. Furthermore, the use of colloquial phrases is prevalent. The author also points out transparency about the process of production. For example, YouTubers draw attention to flaws like the battery of the camera running out.

An important point Tolson (2010) points out is the interactivity with the viewers. This is two-sided: on the one hand, the creator creates an environment where viewers feel like they can have a conversation. On the other hand, viewers are the ones who make use of YouTube’s possibility to leave comments on videos. These comments are informal (evidenced by spelling mistakes and non-standard punctuation and the use of smileys) and conversational (evidenced by the similar colloquial language).

Tolson (2010) furthermore says that there is a paradox: even though the YouTuber presents himself as ‘one of you’, they still have a certain authority on the subject at hand. To ‘solve’ this conflict (or dissonance), YouTubers use “hybrid forms of talk” (p. 283). This means that on the one hand, they use traditional forms of speech when someone is exerting their expertise. However, they also use markers of ‘the ordinary person’.

Next to the one-on-one relationship creators maintain (the para-social relationships I discussed in the previous paragraph), the creators also maintain a sense of community amongst the viewers as a group. This can be viewed as a form of a ‘collective para-social relationship’. I will refer to this as the “YouTube community”. According to McMillan and Chavis (1986), a sense of belonging to a community contributes to a sense of being a valuable being and to emotional safety. On YouTube, creators have the possibility to create a sense of community among their viewers by communicating with them. For example, creators commonly ask their viewers what they want to see and if they like the videos. Viewers can leave their comments on YouTube videos or interact with creators on social media. Moreover, they can interact with each other: They are more or less likeminded people who all have the same relationship with the creator. I believe this sense of community is an important factor contributing to the popularity of these videos.

Creators often actively try to form a community with each other and their viewers. They gather at different (annual) events where viewers can meet them and each other. Some content creators have nicknames for their collective of viewers. For example, people who watch the channel Vlogbrothers are part of the “Nerdfighter” community. Many creators give their viewers some sense of control over their channels by asking the viewers what type of videos they want to see. Furthermore, it is common practice to ask viewers about “daily” subjects (e.g., “what cereal do you like the best?”) and viewers leave their answers in the comment section underneath the video, where they can also discuss this with each other.

Thus, in studying grassroots educational YouTube videos, it is important to analyze how creators make the “YouTube community” salient in their videos.

Present Study

In the current body of literature, I see multiple indications that YouTube, as a digital, online technology, can be successful as a tool for self-directed learning. However, the existing body of literature mainly focuses on learning effects and attitudes of users, and lacks a description of videos that are
currently available through YouTube. In the present study, I want to describe characteristics of the genre of grassroots educational YouTube videos.

As a first attempt to describe the genre, I will answer the following research question: What characteristics do grassroots educational YouTube videos have when it comes to 1) presenting educational content, and 2) establishing para-social relationships and a community?

Since there are (to my knowledge) no studies yet concerning grassroots educational videos, I propose a qualitative study analyzing and describing these videos in an explorative manner.

Method

To answer the research question, this study analyzed videos that were uploaded to YouTube. The selection of these materials and the procedure of analyzing them will be discussed in this section.

Materials

For this study, I selected fifteen educational YouTube videos from five content creators (i.e., channels) who upload videos about the hard sciences, fitting the genre proposed in the introduction.

Because the popularity of these videos is a motivation for writing this article, I chose to analyze videos from five popular channels. As a first study on this subject, it is interesting to study popular videos, as they reach the highest amount of people. I chose five channels because I expect that these five channels provide this exploratory study with enough diversity to give a broad scope of the genre. After researching several educational YouTube videos and channels, I decided on including the five most popular channels I found. The popularity of the channels is evidenced by both the number of video views, and by the number of subscribers to the channel. The channels included in this study all have at least one million subscribers, as one million subscribers is often seen as a milestone for creators on YouTube. This is shown by YouTube sending creators that reach one million subscribers a golden plaque in the shape of a YouTube play button.

A second condition for being included in the analysis, is that the videos are created primarily for YouTube, and that the videos have a non-specific target audience. This condition consists of two parts: first, the creator doesn’t address a (visible or invisible) audience other than the individual viewer. Second, the videos aren’t (visibly) affiliated with formal educational organizations. This condition was chosen to ensure the videos fall under the category described in the introduction of this paper.

The last condition was that the videos are under fifteen minutes long to avoid full length classes but to ensure that the videos are YouTube specific videos. As discussed in the introduction, YouTube videos are accessible to a big audience partly because of their short length. By analyzing videos and channels that conform to these conditions, I believe I will analyze a variety of videos that are representative for grassroots educational YouTube videos.

The channels chosen for analysis are listed below, followed by their respective channel descriptions. These are descriptions written by the owners of the channels and can be found on their YouTube channel under the header ‘About’.

- **Crash Course** (6.2 million subscribers)
  “Tons of awesome courses in one awesome channel! Nicole Sweeney teaches you sociology, Carrie Anne Philbin teaches you computer science, Craig Benzine teaches film history, and Mike Rugnetta is teaching mythology! Check out the playlists for past courses in physics, philosophy, games, economics, U.S. government and politics, astronomy, anatomy & physiology, world history, biology, literature, ecology, chemistry, psychology, and U.S. history. Help support Crash Course at Patreon.com/CrashCourse.”

- **CPG Grey** (3.0 million subscribers)
  No description

- **SmarterEveryday** (5.0 million subscribers)
  “I explore the world using science. That’s pretty much all there is to it. Watch 2 videos. If you learn something AWESOME, please subscribe if you feel like I earned it.”

- **Vsauce** (12.2 million subscribers)
  “Our World is Amazing. Questions? Ideas? Tweet me: http://www.twitter.com/tweetsauce. Vsauce was created by Michael Stevens in the summer of 2010. Vsauce is... Michael Stevens: Producer/Host of Vsauce1
  Kevin Lieber: Producer/Host of Vsauce2
  Jake Roper: Producer/Host of Vsauce3
  Eric Langlay: VFX for Vsauce1/2/3
  You: ‘Thanks for watching!!!’

- **MinutePhysics** (3.9 million subscribers)
  “Simply put: cool physics and other sweet science. ‘If you can’t explain it simply, you don’t understand it well enough.’ Rutherford via Einstein? (wikiquote) Created by Henry Reich”

To explore variety within each channel, I chose three videos from each channel, one from each of the following categories:

- A video about astronomy (a theme occurring on all channels)
- The video on the channel that has the most views (indicating popularity)
A video randomly chosen from all the videos on the channel through an automated program

This led to a corpus of fifteen videos. In Table 1 in Appendix A, some details of the videos are presented, such as the channel they were posted to, the category of videos they fall under, the title, the number of views (varying from 268,257 views to 49,156,402 views, indicating the popularity of these videos), the number of words spoken in the videos, the number of codes (from the list in Appendix B) assigned in the video, and the length of the video in seconds. Figures 1, 2, 3, 4, and 5 depict a screenshot of a video of each of the analyzed channels.

Procedure

Because research in this field is relatively new, there is not a large body of literature readily available, and the aforementioned research questions have not been answered or addressed before. This means that in this study, there is no theory to base the analyses on. For this reason, the analyses in this study were done using Grounded Theory Method (GTM) (P. Y. Martin & Turner, 1986) as the basis for analyzing the materials. This means that I did not use a specific theory to analyze the materials. Instead, I took the data (the videos) as a starting point and used the data to create an coding scheme. Analyzing data through GTM generally has two main characteristics: 1) it is inductive, and 2) it is iterative. Inductive in this study means that I strove to develop a theory based on the data rather than describe the data through a theory. Iterative in this study means that analyzing data changed the way of analyzing the data, which was a repeated cycle. Furthermore, the analyses were prompted by so called sensitizing concepts. The viewpoints of the researcher will thus strongly dictate the starting point of the analyses and the direction the analyses will take.

I will now describe the concrete steps I took for these ends.
Preparing coding scheme. First, I transcribed the speech in the fifteen videos without paying attention to intonation which led to fifteen documents. I read the documents carefully and wrote down what stood out in the context of the research questions. This means I paid attention to the presentation of the educational content as well as the way the creators made para-social relationships salient. I then made a preliminary coding scheme based on my findings. I divided the documents up into smaller segments. These segments were on average five sentences long. The divides between the segments were based upon natural speech pauses as well as transitions to new segments of the video or new topics. I started coding the first five documents with this preliminary coding scheme. I did this by listing which codes were prevalent in each segment. During coding, I added codes to the coding scheme that had not occurred to me in the previous stages. Over the course of coding the documents, this led to a coding scheme consisting of 39 codes. In the next step I started grouping codes together because I noticed some of the codes were too closely related and were not distinguishable. This led to a coding scheme consisting of 50 codes. This coding scheme also contained an explanation of when a coder is supposed to assign a code to a segment of the document.

A second coder was asked to code three randomly selected videos (out of the corpus of fifteen videos). This was done to examine the subjectivity of the coding. Furthermore, it was a test to see whether the codes and the descriptions of the codes were understandable and usable for an other person. I asked the second coder to make changes to the coding scheme if the codes were not understandable or usable, or if the second coder would feel the need for changing the coding scheme for other reasons. The second coder was given three transcripts with the original codes removed and then used the coding scheme to assign codes. During the coding of the three videos, the second coder added descriptions to the existing codes and made the wording of the descriptions more precise if the descriptions were unclear. The coder was also given the opportunity to remove, recategorize or add codes, however, the coder did not find this necessary.

By involving a second coder in this matter, we assume that the conclusions in this paper are based on methodology that is as reliable as possible. This process led to a final list of codes which can be found in Appendix B. I then re-did the coding for all the documents using this final list of codes, since the documents I coded in the beginning were not coded with codes that were added later or the codes that were adapted by the second coder.

To summarize: the development of the coding scheme was an iterative process, where codes were added and adapted by insights gained by analyzing more videos.

Visuals. After creating a coding scheme for the spoken words, I watched all the videos carefully and listed a general description of what I saw onscreen. Then, I categorized these descriptions in several types of visuals used in the videos, which I will describe in the results section. This article mainly focuses on the spoken words in the videos, which is why the analysis of the visuals is very brief.

Analysis. For the analysis, I used an approach based on the work by Beuving and De Vries (2015). These authors state that qualitative research does three things: 1) describe what people say, 2) interpret what people say, and 3) explain what people say.

This concretely means I took the following steps in the analysis: 1) For every code in the coding scheme in Appendix B, I analyzed and described carefully how the creator executed and worded this occurrence of the code. 2) I then searched for patterns, for example codes being used together, or codes only occurring in videos by certain channels. I considered what the motivations of the creators might have been and what effect the language acts of the creators might have on the viewers. By doing this, I attempted to interpret the language acts found in the data. For example, if a creator posed a research question, I asked myself the following questions: Where in the video is it done, how often is it done, why is it done, and how is the viewer affected by being presented with this research question? It is important to keep in mind that my views on the motivations and effects may not correspond with those of the creators and the viewers. I will discuss this further in the discussion section. 3) Lastly, I assigned meaning to the way codes were executed. This means that I placed the codes and their interpretations within the broader perspective of the genre as a whole. This led to a integrative exploration of the genre, which will be presented in the results section. For the visuals, I only did the first step of describing what is seen onscreen without assigning interpretation or meaning.

Results

This section is divided in three subsections. First, I will discuss the function of multimedia in the videos. Then, I will discuss in depth the language used in the videos. I will do this by discussing the presentation of educational content as well as the language used to maintain para-social relationships. In this section, I focus on the things I see in the data in general. In the last section however, I will discuss how the use of multimedia and language apply to different styles within the genre, where I will be more specific about what differences I found across channels.

In some instances I use examples from the data. These examples are accompanied with line numbers, which correspond with the line numbers in the data in Appendix C.

Visuals

As expected, the creators use both visual as well as audible material in the videos. However, an interesting observation is that the creators mostly do not use the visuals as
a vital part of conveying the educational content. If someone were to just listen to the video without looking at it, it would be understandable in all analyzed videos because the creators don’t rely on visuals to convey the story. Instead, the creators use the visuals as an aid supporting the spoken words. The spoken words are the core medium to convey the educational content. Because of this, the main focus of this section will be the spoken language in the videos. First, I will briefly discuss the different types of visuals used in the analyzed videos, after which I will discuss the language used in the videos in more depth.

- **Talking head.** A talking head is when we see the person talking in the video onscreen. It is quite literally a visible ‘talking head’. Seeing the person that is talking to the audience might contribute to the sense of ‘knowing the creator personally’ which I discussed before. Channels making use of this type of visuals were Crash Course, Smarter Everyday, and VSauce.

- **Blackboard.** The only channel making use of this type of visuals was MinutePhysics. Instead of filming himself, the creator of MinutePhysics uses the video frame as a black- or whiteboard where he writes or draws on. This imitates a typical school setting. However, with video editing, there are more possibilities than in a traditional school setting and MinutePhysics often uses this strategy in combination with other strategies (such as animations).

- **Animation.** In most of the videos, creators use animation to support explanations about difficult or abstract subjects. These animations are usually short in nature and temporarily serve to support the talking head shots. Every channel analyzed in this study made use of animations in at least one of the analyzed videos.

- **Still images.** In some instances, the creators use still images in their videos. One reason they do this is to show a picture of something they are talking about. Another use is showing graphs, tables, or timelines on-screen. Every channel analyzed in this study made use of still images in their videos.

- **Shooting on a location.** Some of the creators choose to leave their ‘set’ (which is sometimes not more than a bedroom) and go out into the ‘real world’. For instance, when interviewing experts they do this on location. Some creators choose to show science experiments outside. The channels that made use of this type of visuals were Smarter Everyday and VSauce.

- **Vlogging.** Some of the creators use a ‘vlogging’ style in their videos. Vlogging is short for video logging. It means the creators walk around in the world, filming themselves and their surroundings, while talking about what they are doing or seeing. The camera is thus typically handheld and ‘shaky’, contributing to the amateuristic feel to some videos (as explained in the negative ethos). The only channel that made use of vlogging was Smarter Everyday.

- **External footage.** In some instances, the creators use footage they did not create or shoot themselves. For example, in the videos about planets, most channels used NASA footage to support their stories. Every channel analyzed in this study made use of external footage, but not in many videos.

- **Text onscreen.** In almost all videos, creators use text onscreen. They either do this to display keywords, to bring focus to key concepts or signify a new section of the video. In the analyzed videos, adding text onscreen serves as a visual aid for what the creator is saying out loud.

**Spoken language**

**Presentation of educational content.** In this section I will discuss several techniques and language acts creators use to present educational content. Most of the topics the creators discuss are relatively complex materials. It is interesting to see how they guide their viewers through this material. A first observation I make about what creators do to guide their viewers is that they discuss what educational content they will present, rather than jumping right into the educational content itself. In other words, they help the viewers with complex content by preparing them. For example, they foreshadow topics that will be discussed later in the video. The viewers will thus be prepared for the topic. Another way to prepare the viewers is by asking questions. These questions can either be research questions, meant to be answered by the creator or questions meant to be answered to the viewer. Sometimes there is a fine line between ‘asking the viewer a question’ and ‘posing a research question’. The difference is that the first activates the viewer to think about the topic before the creator presents the actual information, whereas the second is a signal of what to expect forthcoming in the video, hence being more like stating learning goals than to asking a question. Interestingly, although (research) questions take on a rather classic form, the question that is actually asked is unique in the way that these questions are rather humorous. For example, example 1 talks about ‘ditching Pluto’. A more traditional research question would have been ‘Why do astronomers no longer think Pluto is a planet?’

(1) *Why do astronomers want to ditch Pluto?* (876-877)

Creators also state learning goals without asking questions; they simply state what the video will be about or what the viewers will learn from watching the video. This is generally not done by simply stating ‘the learning goals are ...’. 

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**Example 1:**

Why do astronomers want to ditch Pluto? (876-877)
Rather, the creators use more colloquial terms such as ‘I want to know a bit more about [topic]’, or ‘let’s talk about [topic]’. Interestingly, the creator in example 2 uses ‘we’re going to discuss’ rather than ‘I’m going to discuss’. This is indicative of forming a personal bond with the viewer, which will get back to in the section on para-social relationships.

(2) And today we’re going to discuss déjà vu. What is it, and why does it occur? (1202-1203)

Similarly, at the end of a part of the lesson or at the end of the video, creators often summarize what the video was about or what the viewers have learned. In example 3, the creator states the learning goals at the end of the video as a way of evaluating. Alongside this, sometimes creators end their videos or sections of the video with a concluding sentence or by in short answering a research question that was posed before. They thus reference back to what they talked about before, which is a way of guiding the viewer through the material.

(3) Today you learned about how associative learning works, the essentials of behaviorist theory, the basic components of classical and operant conditioning, including positive and negative reinforcement, and reinforcement scheduling. (299-301)

Creators show other ways of guiding the viewer through the material as well. For instance, rather than listing separate facts, the creators provide more context and conceptual relationships between the facts. They do this by comparing and contradicting concepts with one another. This leads to a more memorable, logical, and coherent narrative. For example, Crash Course in example 4 compares foragers to agriculturalists. In the video, the viewer already was taught about agriculturalists. By comparing the characteristics of the new concept of foragers with the known concept of agriculturalists, the creator puts the new information in a familiar context.

(4) While we tend to think that the life of foragers were nasty, brutish and short, fossil evidence suggests that they actually had it pretty good: Their bones and teeth are healthier than those of agriculturalists. (350-352)

A contrasting technique to contradicting and comparing is enumerating. Creators often enumerate characteristics of the discussed concepts. This feels counterintuitive: I just discussed how creators choose to put their content in a certain context, whereas it can be argued that enumeration is the opposite of that. However, enumeration is often used in contexts where the separate elements aren’t the main focus of what is being learned. They function as examples of the overarching concept.

Other than using examples in enumeration, the creators give other, more explicit examples as well. Creators use examples in two different functions: 1) to support the main point and 2) as a learning point on its own. In example 5 we see that the main focus is teaching the viewer about behavior. Crash Course uses the example in the second line to strengthen that point rather than using it as a learning point on its own. In example 6 we see that the example about how scientists have found exoplanets is actually a learning point on its own. In both cases, the creators enrich the “dry facts” with examples. These examples provide additional context to the facts.

(5) Punishment decreases a behavior either positively, by say, giving a speeding ticket, or negatively, by taking away a driver’s license. (266-267)

(6) The vast majority of exoplanets, have been found indirectly, by observing their effects on their parent stars. For example, a planet passing in front of a star will make that star darker for a little while. (480-482)

Another technique creators use to enrich facts is using imagery in language. Lots of creators use illustrations and analogies which enriches their content or makes a fact more clear. As stated before, the visuals of the videos are not a core element for understanding the videos. However, creators do use images in their spoken words which might create a mental image in the mind of the viewer. This is closely related to giving examples, but it is more explicitly aimed at a mental image. In example 7 the creator invites the viewer to picture the ballerina on the truck without actually showing them a picture like that in the video.

(7) But this rotation is no more connected to the orbital motion around the sun than a ballerina spinning on the back of a truck is connected to the truck’s cruising speed. Counting the number of ballerina turns to predict how long the truck takes to dive in a circle might give you a rough idea, but it’s crazy to expect it to be precise. Counting the days to track the orbit is pretty much the same thing. (954-959)

As I discussed before, language techniques that creators use when presenting educational content are often designed around guiding the viewer through complex material. Creators sometimes do this explicitly by calling the viewers’ attention to, for example, an important part of the lesson. Creators use their language to guide the viewer where to direct their attention. One way they do this is by using obvious signifiers such as ‘this is important’ or ‘pay attention’. Another way is more implicit. In examples 8 and 9 the creators use words as if they are in a conversation and the viewer is responding to what they are saying. Here, the question and answer sequence as well as the word ‘actually’ indicate that the
viewer did not expect this fact. This means they anticipate on what the viewer would be saying or thinking, which in these examples is surprise (about the period being days, and about the amount of planets we have seen so far respectively). The creators thus use colloquial techniques to draw attention to a surprising piece of information. This technique (colloquial and anticipating on the viewer’s thoughts) is related to a technique in which the creators anticipate on the thought process of the viewer to maintain a para-social relationship with the viewer. I will discuss this in more depth in the next section.

(8) The orbital period turns out to be just a little over 4.23 days. That’s right, I said days. (49-50)

(9) We must have seen planets around the same size as Earth, right? Yes. Yes we have. We’ve actually found hundreds of them so far. (122-123)

In videos that are meant to teach viewers something new, it is expected that the viewers will be introduced to new concepts. It is interesting to note how the creators choose to introduce the new concepts to the viewers. In some instances, like in example 10, the creators choose to first explain the concept and then give it a name. In other instances, like in example 11, the creators first name the concept and then proceed to explain it. A rarer form of introducing new concepts to the viewer is ‘mentioning it in passing’, like in example 12. Here, the maker inserts the concept in an ongoing story without explicitly explaining what the concept itself is.

Other than the timing of introducing the concepts, there is a different interesting distinction going on in the introduction of the concepts. In example 10 the introduction of the concept is pretty straightforward: ‘if x happens, it is called y’. However, in example 11 the creator phrases the phenomenon as something that is familiar to the viewer. Furthermore, the creator says the concept has a ‘fancy name’, which downplays the difficulty of the concept. These two stategies factor into the relationship with the viewer.

(10) But if one day the rat chow doesn’t come, that connection quickly dwindles, and the rat stops hitting the lever. This is a process called extinction. (282-283)

(11) You’ve probably experienced a similar phenomenon known as a hypnagogic jerk. That’s a fancy name for what occurs when you’re about to fall asleep and then all of the sudden you feel like you’re falling, or that you tripped, and your body jolts itself awake. (1247-1249)

(12) Scott’s about to do something no American has ever done, he’s about to ride one of these, which is a Soyuz capsule, up to the International Space Station for how long? (601-603)

**Para-social relationships and community.** In the data, creators make several choices that are related to para-social relationships. I will discuss both the way creators address the viewers (‘viewer focused’) as well as the way creators position themselves (‘creator focused’).

First, I will discuss the **viewer focused techniques**. A quite literal first strategy, as it is often the first thing being said in the video, is the creator welcoming the viewer. Sometimes creators accompany this with introducing themselves. For instance, a creator might say ‘Hi, it’s John, welcome back to Crash Course’. The way the creators phrase this indicates acknowledgment of the viewer and the fact that the viewer is watching the creator’s video.

Another way creators address the viewers is by asking them questions. I have discussed asking questions in the section about presenting educational content as well, but asking questions is related to para-social relationships as well. The creators will not always get an answer from the viewer (in for example the comment section), so asking questions might serve a different purpose than that. Perhaps it is to activate the viewer, but it also might be part of creating a sense of conversation between the creator and the viewer.

Another way creators create a sense of conversation between the creator and the viewer is by anticipating on the thought process of the viewer. Without having an actual conversation, creators in some instances choose to use a colloquial style to imitate a conversation. We already saw this in example 8, where the creator anticipates on the thought process of the viewer and ‘responds’ accordingly. In example 13 however, the creator addresses the viewer and explicitly assumes things about their knowledge and thus their thought process. The creator can’t know if what they say is actually true for every viewer, but assuming that for most viewers it would be, it is a phrase they ‘dare’ to utter anyway. The creator chooses to show that they know the level of expertise of the viewer. This might make the viewer more comfortable when watching the video, because it shows that the creator knows where the viewer is in their learning process.

(13) We need to first discuss a planet you’ve never heard of: Ceres. (895)

Beyond just talking to the viewer, the creator sometimes calls the viewer to action. These actions vary from being in the mind of the viewer (e.g., ‘think about this’) or in the physical world (e.g., ‘click on this link’). Another way of distinguishing different types of action is 1) action related to understanding the educational content better (which I discussed in the previous section), and 2) action related to strengthening a para-social relationship. The latter is an almost ritualistic phenomenon and more closely related to the YouTube community genre as a whole than to the more specific educational genre. For example, creators ask viewers to subscribe or to leave a comment on the video. The viewer is being invited to
be more than a passive recipient of the video, but to also be a voice in the community or in the para-social relationship with the creator.

(14) If you want to guess at the phrase of the week, you can do so in the comments. You can also suggest future phrases of the week. And if you have a question about today’s video, please leave it in the comments where our team of semi-professional quasi-historians will aim to answer it. (468-471)

The creators sometimes reassure the viewer that the material they are explaining is not difficult. In example 15 the creator of Smarter Everyday acknowledges that the phrase ‘rocket science’ is used for something that is very difficult, and he assures the viewer that that is not the case in this video. The creator anticipates that the user will think it is difficult and addresses this by reframing it in a more approachable light. This might contribute to a para-social relationship because to the viewer it might feel like their teacher is reassuring, comforting or encouraging them. Another way of encouraging viewers I found is when creators talk about the fun in learning. In example 16 we see that the creator points out that it would be ‘cool’ to have a normal conversation with an astronaut. It is interesting to note here that the creator points out that what makes it fun, is having a ‘normal person to person conversation’. This is characteristic for this genre of videos: The creators use strategies to make their videos seem like normal conversations, and here they make that preference explicit as well.

(15) So today on Smarter Everyday we’re gonna talk about rocket science, and it’s really not that hard, I promise. (589-590)

(16) How cool would it be to actually get inside this Russian rocket and have just a normal person to person conversation with a guy that’s about to do this? (595-597)

Now, I will discuss the creator focused techniques. Throughout all the videos the creators sometimes use non-scientific language. By ‘non-scientific language’, I mean the use of words that are more ‘popular’ than what is to be expected in for example a scientific paper. Related to using non-scientific language is the use of evaluative or subjective language. It might seem that these are the same, because being subjective is by definition non-scientific. However, by subjective language I mean giving opinions about the educational content, whereas by non-scientific I mean the kind of words they use. Examples of non-scientific language and subjective language can be found in example 17. Saying a certain categorization (after explaining scientists disagree on this) is best is an objective evaluation, but it is not non-scientific use of language. The word stuff is not scientific, but it is not subjective. Both these strategies tie in to establishing a para-social relationship. The use of non-scientific language makes the text feel more colloquial which brings the creator ‘down’ to the level of the viewer. The opposite happens with the use of evaluative language: It establishes the creator as an entity that has the power to have an opinion on the matter at hand.

(17) For the time being the best way to categorize the stuff in our solar system is into one star, eight planets, four terrestrial, four gas giants, the asteroid belt, and the distant Kuiper belt, home to Pluto. (927-929)

Other than evaluations of the educational content, creators also show other aspects of themselves, such as their personality, personal interpretations, attitudes, or profile themselves simply by stating their name or channel name. It is interesting to see that sometimes the creators establish themselves as someone with the necessary expertise, and on the other hand they establish themselves as someone who also still needs to learn. We saw this paradox in example 17 where the use of subjective and evaluative language could give off opposing views of the expertise of the creator. Creators are sometimes vocal about this themselves. Looking back at example 14, we see that the creator uses the terms ‘semi-professional’ and ‘quasi-historians’ to describe himself and his team. It is interesting that the creator chooses these words, because the creators are the ones who convey the content to the viewers, which is why it would make sense that they are experts. The creator in this instance however quite explicitly states that they are in fact not necessarily experts. The creators do this in other ways too, which are not quite as explicit. For example, in example 18 the creator at the same time shows that he knows what a Hohmann Transfer is, but also uses language indicating that he is not the expert (“make sure I got this right” and the definition of the Hohmann Transfer given in the form of a question to an ‘actual’ expert). Sometimes creators also ‘downplay’ their own expertise by introducing other, ‘actual’ experts in the video. Example 18 shows this as well, because the creator asks the interviewee a question while it is clear that the creator himself knows the answer to the question as well. By doing this, he defers expertise to the interviewee. This also plays into the idea that the creator as a person is on the same level as the viewer: Interviewing an expert indicates that the creator’s relation to the expert interviewee is the same as that of the viewer to the expert interviewee.

(18) Interviewee: The first two are just gonna be a straight up Hohmann Transfer.
Creator: Okay gotcha. Let me explain that. A Hohmann Transfer, make sure I get this right, a Hohmann Transfer is like if you’re in a circular orbit, and you want to go to a larger or smaller circular orbit, you draw an ellipse between the two circles,
right?

Interviewee: That’s right. (672-675)

Not only do they show this type of language when it comes the presentation of the educational content, they also do it when it comes to the process of creating the video. In example 19 we see that the creator talks about the process of recording the video the viewer is watching at that moment. Through this, they give the viewer a sense of what is like creating the video. The videos aren’t necessarily ‘slick-looking’ end products that the viewer can consume, rather, the viewer more or less knows how the creative process works and might thus be more on the same level as the creator than if the creator would not talk about this.

(19) I brought special lights and a special macro lens so we can record it at first 1500 frames per second and then ramp it up to 3200 frames per second. (830-831)

Creators put themselves on the same level as viewers, by anticipating on their interests. An interesting technique is that the creators sometimes reference something from pop culture without further explaining it. This is not explained, and viewers who are not aware of the reference might miss that this happens altogether. Viewers who do understand the reference might feel like the creator is their peer because they have similar interests. This also rings true for the reference in 20: The creator references Star Wars, a beloved franchise in pop and nerd culture. In example 21, the maker uses the word ‘haters’. The word ‘hater’ is not new, but to have haters is recently developed slang in pop and internet culture. These examples are examples of language that the creators use in these videos which would usually be used in a friendship. References that are also used in friendships are ‘inside’ references: This happens when friends over time develop their own jokes and habits as a group. These references are usually unclear to outsiders. The same happens in the videos by the creators I analyze in this study. In example 22 the creator of Crash Course does this by using slogans that he uses in all his videos. In this example, ‘hometown’ is code for ‘people who watch my videos’, and the slogan ‘Don’t Forget To Be Awesome’ has become widely used in their community (which also extends outside educational videos, to for example vlogs, music bands or online forums), by both creators and viewers. In example 23 the creator also explicitly talks about a tradition in his videos, which is closing the video with the phrase ‘as always, thanks for watching’. Using these inside references and traditions might add to the feeling of a para-social relationship, because if someone points out how they always greet you in a certain way, it implies that you know the person, and moreover, that you have known them for a while.

(20) Star Wars seem a lot closer to home than being in a galaxy far far away. (117-118)

(21) Skinner had a lot of haters. (245)

(22) Thanks for watching, and as we say in my hometown: Don’t Forget To Be Awesome. (471-472)

(23) It is just crazy to think that there is so much out there in the world, in the universe, that we don’t know, that we don’t understand, that we haven’t yet discovered. But yet that very feeling of familiarity for what we do know can’t always be trusted. About the only constant seems to be: As always, thanks for watching. (1276-1279)

Lastly, the creators use language that creates a sense of inclusion with the viewer. In examples 24 and 25 we see that the creators explicitly place themselves in the same group as the viewer. This adds to a para-social relationship in the same way as I have discussed above.

(24) People just like you and me have wondered about this for thousands of years. (6)

(25) Astronauts are just people, like me, like you. (593-594)

Discussion

In this study, I attempted to describe characteristics of the genre of grassroots educational YouTube videos. I addressed the following research question: What characteristics do grassroots educational YouTube videos have when it comes to 1) presenting educational content, and 2) establishing para-social relationships and a community? While I do not want to claim that I gave a full overview of all possible characteristics, I do believe that the findings will shed some light on what is going on in these popular videos.

Visuals

The creators mostly do not use the visuals as a vital part of conveying the educational content. This is an interesting finding, because in the discussion of the literature I discussed how videos like those on YouTube are an excellent medium to teach through a mixture of audio and visuals. The principles for digital instruction as posed by Clark and Mayer (2016) for the cooperation of audio and visuals are thus mostly not followed in this genre. An exception is the redundancy principle: This principle states that information should be conveyed by either visuals or audio, and not both.

The creators do apply the redundancy principle, but the question remains why most creators choose to mainly present it through their words and not through the visuals.

The creators do put effort into the visuals: in the analyzed videos we see several different types of visuals (such as a talking head, vlogging, or a blackboard) and creators usually use multiple types of visuals within a single video. This
study only briefly analyzed the visuals and further research is needed to investigate the use and the functionality of the visuals.

It is interesting to note here that even though the visuals onscreen are not a vital part of the story the creators tell, the creators do use imagery in their language. For example, they talk about concepts that illustrate the abstract concept they are explaining (without always putting this illustration onscreen as well).

**Presentation of educational content**

The analysis showed that creators generally take a traditional approach when it comes to presenting educational content. In general, these findings seem in line with both literature on traditional instruction and literature on digital instruction. Most principles for online instruction that I discussed in the introduction section were adhered to.

In some instances they do use non-scientific, informal or subjective language. This is in line with the recommendations by Clark and Mayer (2016) and Ginnis et al. (2013). Furthermore, sometimes they intertwine the content with jokes. This is in line with the study by Alston and Ellis-Hervey (2015), which showed that creators on YouTube use humor to support their educational content.

Most of the language acts that stood out regarding the presentation of educational content were focused around guiding the viewer through complex materials. The creators use several different strategies for this, for example by stating learning goals (which is related to the pretraining principle) or by summarizing information at the end of the video. Furthermore, creators make ‘dry’ materials more accessible by using illustrations or examples.

The main conclusion regarding the presentation of educational content is that creators do use traditional techniques that are overall in line with the literature. They give this their own personal twist by intertwining it with jokes and non-scientific and non-formal language.

**Establishing para-social relationships**

In this section I discuss the main findings regarding para-social relationships. In general, the characteristics Tolson (2010) described in his article (addressing the viewer visually as well as in spoken words, the use of colloquial language, and the transparency about the production process) are all prevalent in the data in the present study. Building upon these findings, we see two levels of maintaining para-social relationships. The first level is viewer focused: this means that the creator uses his language to instigate change within the viewer or to address the viewer. I find that addressing the viewer happens in several different ways, which is in line with the work by Cummins and Cui (2014). He showed that television creators cultivate para-social bonds with their viewers by directly addressing the viewer, as if they were speaking to them at home. For example, in my analyses I see that the creators encourage the viewer, call the viewer to action or ask the viewer a question. They usually do this with colloquial language, which simulates a conversation with the creator. This might contribute to the sense of a para-social relationship.

The second level is creator focused. This means that the language the creator uses is focused around positioning himself as a personality viewers can recognize and resonate with. We see the same types of personal stories Alston and Ellis-Hervey (2015) discussed in the videos analyzed in the present study. Examples of such personal stories are mentioning personal preferences, introducing themselves, and discussing how they created the video (rather than presenting a ‘slick’ end product).

An interesting technique creators use to position themselves is portraying themselves as learners. This is similar to the non-hierarchy Taylor (2008) discussed. This sometimes clashes with the educational techniques they use, because those techniques make them appear to be experts, whereas the technique to portray themselves as learners has the opposite effect.

Thus, in general, I distinguish two styles that creators can take on: 1) the creator that is an expert, and plans and scripts the educational content and then ‘reads’ it to the viewer, and 2) the creator that goes out into the world and discovers the world alongside the viewer. The main difference between these two styles can be summarized as a difference in portrayal of expertise: In the first style the creator exerts himself as the expert whereas in the second style the creator portrays himself as someone who is learning through the video, too. Keep in mind that one creator can take on both styles, sometimes between videos, and sometimes within a video. It is also possible that a creator switches these styles rather quickly within a video. For example, Smarter Everyday conducts interviews with experts, in which he asks them questions as if he is in the same learning process as the viewer. However, in the same sentence he can turn to the camera to explain a concept to the viewer himself, showing that he is actually an expert as well. This is an example of the paradox and the hybrid forms of talk Tolson (2010) found in his study as well.

Because the contents of the lesson seem similar to other types of (digital) instruction, I argue that the most distinguishing characteristic of grassroots educational YouTube videos is the establishment of the para-social relationships.

**Limitations and recommendations for future research**

In this study, there are some limitations that should be addressed in future research. First, there are some limitations regarding reliability. The material was chosen based on conditions (such as the minimum amount of subscribers and the maximum length of the videos) that I am not sure will influ-
ence results, and if so, in what way. Furthermore, the channels chosen in this study were all theoretical, while there are many videos on YouTube that teach practical things. Future research should aim to analyze a greater body of videos from a wider variety of channels to get a broader understanding of grassroots educational YouTube videos.

Because the materials were analyzed by only one researcher, the analyses are prone to sensitizing concepts. I tried to counteract the effect of this as much as possible by involving a second coder, who made changes to the coding scheme. This made the coding scheme used for the analyses more applicable, clear and reproducible. More research in the same manner is needed to be able to conclude whether the findings in this study are reproducible.

In the introduction, I mention the existence of TED Talks and MOOCs and contrast them to educational videos on YouTube. However, in my analyses, I do not compare these types of videos with the educational videos on YouTube. This is a gap in my reasoning regarding the unique characteristics of grassroots educational YouTube videos, because it is possible that the same techniques regarding educational content and para-social relationships can be found in TED Talks and MOOCs. It is important to keep in mind that according to Kramer (1999), genres may overlap and videos can belong to more than one genre at the same time. Therefore, in future research, it would be of great added value to compare the characteristics of different platforms against each other and to explore or even push the boundaries of the genre.

There are also some limitations regarding the interpretation of the results. In this article, I made some assumptions about what effect some of the creators’ actions have on the viewer. For example, I argue that addressing the viewer gives the viewer the feeling of personally being talked to. However, this is not something I measured in this study. For now these are merely assumptions and future research should investigate whether these effects really take place. Furthermore, the para-social relationships I describe in this study might not exist solely because of the videos I analyzed. There are other forms of communication between the creators and the viewers, for example through social media such as Twitter and Instagram, as well as interactions in the comments on the videos, or even ‘in real life’, for example during meet-and-greets and performances during conventions. Future research should investigate these complicated interactions and research what the unique role is of the videos on YouTube. Lastly, I only briefly discuss the visuals in the videos. I argue that the visuals don’t play a vital part in the understanding of the videos, but that doesn’t mean there is nothing interesting going on in the visuals. Future research should investigate the role of the visuals in more depth.

Implications

The videos described in this study reach and therefore possibly educate millions of people throughout the world. It is still unclear what the societal impact of these videos are, but videos with viewer counts that high should not be ignored by scholars. YouTube videos have characteristics which promote learning, such as interaction, engaging learners in a personal way and the possibility for the use of multimedia. However, we first need to understand what characteristics these videos have. This study narrows a gap in the current body of literature regarding that understanding. It gives us information about strategies used by creators of online materials for self-directed and/or non-formal online learning. It gives a clear picture of the structural elements of grassroots educational YouTube videos. This information can be used to build upon and to further research the actual effects of these videos on the learning process. It will give way for researchers to study the quality of these videos, to compare them with formal ways of teaching, and to research attitudes of users. Furthermore, this study will possibly give a new perspective on the popularization of science. The establishment of para-social relationships found in these videos can be an interesting starting point for understanding and predicting why big numbers of people watch these videos about science.

Conclusion

I started this article with a quote by one of the creators whose videos I analyzed. This quote makes it clear that the creators see their videos as noteworthy, and judging by the millions of viewers all over the world the viewers feel the same way. This study was a first attempt at understanding what the characteristics of these videos are. Even though the creators use traditional strategies to present the learning materials, they are able to maintain relationships with their viewers. Across videos we see differences in how many jokes creators make, how they start and end the video, to what degree they place themselves on the same level as the viewer, etcetera. The common thing we see across all videos is, intertwined with precise reasoning, the use of non-scientific and non-formal language. Furthermore, in one way or another, creators maintain a para-social relationship with the viewer as an individual, which I argue is the most distinguishing characteristic of the genre of grassroots educational YouTube videos.

References

about physical examination of the cardiovascular and respiratory systems. *Journal of medical Internet research, 15*(11).


Table 1

<table>
<thead>
<tr>
<th>#</th>
<th>Channel</th>
<th>Category</th>
<th>Title of video</th>
<th>Views</th>
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<th>Codes</th>
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<td>Exoplanets: Crash Course Astronomy #27 How to Train a Brain - Crash Course</td>
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</table>
Appendix B - Final code scheme

1. **Addressing the viewer**
The creator directly addresses the viewer by saying 'you' (which cannot be replaced by the word 'somebody' or a different general indicator) or indicates that they are speaking to the viewer in another way.
Example: Thank you for watching, You will notice this in the following videos.

2. **Answering a question**
The creator answers a question that was previously posed (implicitly or explicitly). This excludes interview questions.
Example: But what could cause these processes, dealing with the same information, to get temporarily out-of-sync like that? Well, it’s probably a neurological abnormality, possibly an epileptic episode where neurons all fire in sync.

3. **Predicting the thoughts of the viewer**
The creator indicates that they know something about the viewer’s thought or learning process.
Example: By now you are getting the picture.

4. **Calling the viewer to action**
The creator tells the viewer to take action, for example to think about a topic or to subscribe to the channel.
Example: Think about this.

5. **Comparing**
The creator compares two or more concepts to each other. This can be done either explicit or implicit.
Example: Compare that to a planet that is further away.

6. **Making a conclusion**
The creator ends a segment with a concluding sentence.
Example: So, to conclude: [...].

7. **Contradicting**
The creator explains a concept by contradicting it to another.
Example: Unlike Great Britain, the United Kingdom is [...].

8. **Having a conversation**
The creator has a conversation with another party without it having the structure of an interview.

9. **Giving other parties credits**
The creator mentions other parties or thanks them for participating.
Example: My friend Nick from Yeti Dynamics put this together.

10. **Implying the material is not difficult**
The creator states that the learning process is easy or that the material is not difficult.
Example: Sounds easy, right?

11. **Enumerating**
The creator lists two or more facts, parts, names, examples, etc.
Example: The planets are wildly diverse — big, small, airless, rocky, gaseous, hot, cold, and more.

12. **Evaluating**
The creator evaluates information they present in a seemingly subjective way.
Example: This is really bizarre.

13. **Giving an example**
The creator gives an example of a concept he is talking about.
For example, a planet passing in front of a star will make that star darker for a little while.

14. **Explaining**
The creator further builds on a piece of information that was introduced before.
Example: This means that [...] or so, [...], or in other words, [...].

15. **Foreshadowing**
The creator talks about a subject that will come later in the video or even in a later video.
Example: But before we discuss today’s topic, think about this.

16. **Implying the fun in learning**
The creator points out that the material or the learning is enjoyable by using words like “fun”, “awesome”, or “interesting”.
Example: How cool would it be to see that up close?

17. **Illustrating**
The creator uses imagery in his language. For example, he illustrates a topic by referring to images on-screen or by making an analogy or by placing the abstract material in a more concrete situation.
Example: Imagine two kids, one big and one small, facing each other. They clasp hands and start to spin around. As they do, the little kid, who weighs less, will make a big circle, and the bigger kid will make a small circle.

18. **Signifying the importance of a part of the video**
The creator points out that something is important or
uses words to draw attention to an important part of the video.
Example: *This is important because [...]*, or *Now mind you, [...]*

19. **Giving an inside reference**
The creator says something that isn’t clear for everybody to understand.
Example: *You might recognize these people.*

20. **Giving an interview answer**
An interviewee answers a question that was asked to them.

21. **Asking an interview question**
The creator asks someone else in the video a question.

22. **Introducing a new concept**
The creator gives the definition of a concept or gives a name to an already explained process/phenomenon/etc.
Example: *You’ve probably experienced a similar phenomenon known as a hypnagogic jerk.*

23. **Introducing an other party**
The creator introduces the audience to an other party (for example experts) to have them be a part in the video.
Example: *This is astronaut Scott Kelly.*

24. **Making a joke**
The creator says something to provoke amusement with the audience.
Example: *According to British tradition, all power is vested in God and the Monarch is crowned in a Christian ceremony. God, however, not wanting to be bothered with micromanagement, conveniently delegates his power.*

25. **Stating the learning goals of the video**
The creator states what the viewer will learn or has learned from watching the video.
Example: *Today you will learn about how associative learning works.*

26. **Talking about learning on a meta level**
The creator talks about the learning process of the viewer.
Example: *You now understand some rocket science.*

27. **Talking about science on a meta level**
The creator talks about the science or scientists that are behind the topic the creator is talking about.
Example: *It’s difficult to scientifically study déjà vu because there’s no reliable way to cause it to happen in people’s heads in a laboratory.*

28. **Talking about the video on a meta level**
The creator explains the viewer something about the process about creating the video the viewer is watching at that time.
Example: *Hi there, camera two, it’s me, John Green.*

29. **Using non-scientific language**
The creator uses words that are more ‘popular’ than to be expected in the scientific genre.
Example: *They were like, you know what would be awesome: more food.*

30. **Showing the creator’s personality**
The creator talks about a personal preference, characteristic, personal interpretation, attitude, their name, or any other aspect of his/her personality.
Example: *That’s one of the reasons I think it’s so important to study history.*

31. **Referencing pop culture**
The creator talks about something from a movie, music, internet culture or anything else related to popular culture.
Example: *We’ve even seen planets orbiting binary stars, making Star Wars seem a lot closer to home than being in a galaxy far, far away.*

32. **Promoting an other party**
The creator encourages the viewer to look at a different party’s website, YouTube channel or other medium.
Example: *This video is brought to you in part by Audible.com, The leading provider of audio books.*

33. **Asking the viewer a question**
The creator asks the viewer a question, either to answer in the comments, or as a prompt to think about a certain topic. This is more colloquial than a research question.
Example: *Sound familiar?*

34. **Referencing back in the video**
The creator refers to something he discussed earlier in the video.
Example: *Back to Pluto.*

35. **Posing a research question**
The creator asks a question that indicates what the subject of (a part of) the video will be.
Example: *Pluto: Planet or not?*

36. **Summarizing**
The creator summarizes the content that has been discussed so far by using words like ‘in short’, ‘in sum’, or by listing several key points.
Example: *Let’s summarize: [...]*. 
37. **Portraying the creator as a learner**
The creator indicates that he/she is learning as well.
Example: *Not really sure how this is gonna work out but I want to know a little bit more about tattoos.*

38. **Referencing the visuals**
The creator says something that can not be disconnected from looking at the video.

Example: *If we take this diagram and adjust for the correct sizes of the planets it looks like this.*

39. **Creating a sense of inclusion with the viewer**
The creator signifies that they and the viewer are ‘the same’.
Example: *We (which can not be replaced by ‘they’ or a general ‘people’, or People like you and me.*
### Appendix C - Data and coding

<table>
<thead>
<tr>
<th>Line number</th>
<th>Text spoken in video</th>
<th>Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>When you look up at the night sky, and if you happen to live far from city lights, you can see thousands of stars. It seems like the sky is crammed shoulder to shoulder with them. And you’re only seeing the tiniest fraction of stars there are; billions more exist that are too faint to see with just your eyes. As you ponder this incredible number, a natural thought arises: Are there planets circling those stars, too? And are any of them like Earth?</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>People just like you and me have wondered about this for thousands of years. And right now, today, we can answer that question. And the answer is: yes. Our Sun is orbited by a lovely array of planets. And they’re wildly diverse — big, small, airless, rocky, gaseous, hot, cold, and more.</td>
<td>39, 2, 12, 11</td>
</tr>
<tr>
<td>10</td>
<td>That makes you think that maybe forming planets is easy, with so many varieties to choose from. Even if making planets is hard, there are so many stars in the sky that it’s hard to believe our Sun is the only one that’s been able to pull this trick off. Astronomers have fretted over this for a long time, but trying to find such planets is hard. The biggest problem is, any such planets would be faint, far away, and sitting right on top of their parent star. Being able to see one in a telescope would be like trying to spot a firefly sitting next to searchlight. So if you can’t spot a planet like that directly, maybe you can spot it indirectly.</td>
<td>3, 27, 17, 11, 7</td>
</tr>
<tr>
<td>18</td>
<td>Imagine two kids, one big and one small, facing each other. They clasp hands and start to spin around. As they do, the little kid, who weighs less, will make a big circle, and the bigger kid will make a small circle. The same would be true of a star and planet. As the planet orbits the star, it makes a big circle (or ellipse). But the planet has gravity, too, and it tugs on the star. That means the star will make a small circle—what’s called reflexive motion. For a long time, astronomers looked really hard for this motion in nearby stars. But it turns out that indirect effect is also too small to see. There were a few false alarms, but no real planets.</td>
<td>17, 22, 27</td>
</tr>
<tr>
<td>26</td>
<td>Then, in 1992, everything changed. Astronomers Aleksander Wolszczan and Dale Frail made a shocking announcement: They found not just one planet, but two orbiting a pulsar, the dead remnant of a star that had exploded. This was really bizarre: When a star explodes, it’s a catastrophic event that should destabilize any orbiting planets. It’s the last place anyone would have thought to find them. However, follow up work quickly confirmed that the planets did indeed exist, and in fact a third one was found a few years later. The first true alien planets had been found. Officially, we call them exoplanets, which, you have to admit, is pretty cool.</td>
<td>7, 27, 12, 22, 3, 1</td>
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<tr>
<td>34</td>
<td>While this was an incredible discovery, it was still a little unsatisfying. For one thing, pulsars are really weird, and for another it looked like those planets may have formed around the pulsar after the supernova explosion, from the material left over from the catastrophe. That’s nothing at all like our own solar system. And that still left the question open: Are there exoplanets orbiting sun-like stars?</td>
<td>12, 29, 39, 29, 35</td>
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<tr>
<td>39</td>
<td>We didn’t have to wait long to find out. In 1995, Swiss astronomers Michel Mayor and Didier Queloz made a big announcement: They had found a planet orbiting the star 51 Peg, a star very much like the Sun just 50 light years away. How did they do it? Well, remember those two kids holding hands and circling each other? Even though the wiggling back and forth of the star is too small to measure, that doesn’t mean the effect is undetectable. As the host star of the exoplanets makes its little circle, sometimes it’s headed toward us, and sometimes away. That means that its light will undergo a Doppler shift, and that can be detected. It’s not a big shift, and takes some pretty fancy equipment to see it, but it’s measurable.</td>
<td></td>
</tr>
<tr>
<td>48</td>
<td>That’s how Mayor and Queloz found their planet. And the planet they found, called 51 Peg b, is weird. For one thing, the orbital period turns out to be just a little over 4.23 days. That’s right, I said days. That means the planet is seriously close to its parent star, just 8 million km out. Compare that to Mercury, which is on average 55 million km from the Sun. Not only that, but the amount of Doppler shift in the star is related to the mass of the planet; a more massive planet pulls harder on the star, making it move more quickly. They found the planet was at least half the mass of Jupiter, and probably more. That was a problem. According to planetary formation models, that wasn’t possible! You can’t form a planet that big that close to a star.</td>
<td></td>
</tr>
</tbody>
</table>
| 57   | Well, it turns out the models are probably right. The planet didn’t form that close. It probably formed farther out, just like Jupiter did. And like Jupiter, it then moved, migrated inward toward the star as it interacted with the disk of planet-forming material around the star. In our solar system, Jupiter didn’t get very far in its inward motion — it’s thought that interactions with Saturn put the brakes on that, and pulled Jupiter out to where it is now. Apparently 51 Peg b didn’t have its own version of Saturn pulling on it. Its inward spiral continued until it ran out of disk material to interact with, which was very close indeed to the star. We call planets like that “hot Jupiters”.

Once 51 Peg b was found, other teams began looking for short-period planets, and within a few years several more had been found, many of them hot Jupiters just like 51 Peg b. Now mind you, at first there was a lot of doubt and skepticism in the community about these exoplanets discoveries. A lot of other phenomena could masquerade as planets, like starspots, or pulsating stars, or background stars messing up the measurements. Scientists discussed these possibilities vociferously — as well they should. Science is all about not fooling ourselves. A good scientist wants other scientists to try to poke holes in their ideas. It’s disappointing to be wrong, but if we are we want to know.

That all changed in 1999. A planet called HD 209458b had been discovered on a very short orbit around its star, taking just 3.5 days. As luck would have it, from Earth we see the planet’s orbit edge-on. That means once per orbit it passes directly in front of its star. This event is called a transit, and when the planet transits the star it blocks a little bit of the star’s light, and that means we can detect a dip in the star’s brightness. And sure enough, that dip was found. HD 209458b was the first independent confirmation of an exoplanet, and pretty much everyone was on the bandwagon after that.

The beauty of transiting exoplanets is that the amount of starlight blocked tells you how big the planet is; a big planet blocks more light. If we know the planets’ mass from the star’s Doppler shift, we can use the planet’s size to calculate its density. This is important: A gas giant like Jupiter has a low density, and a rocky metallic planet like Earth has a very high density. Without even being able to see the planet directly, we can already start to determine what it’s like physically.

In 2009, NASA launched a space-based telescope named Kepler, designed specifically to stare at 150,000 stars to detect that telltale dip in light indicating exoplanet transits. And oh my, did it work. By early 2015, Kepler found its 1000th confirmed exoplanet, and there are 500 more confirmed from ground-based telescopes. That’s more than 1500 planets! And we have well over 3000 more candidates from Kepler awaiting confirmation. All these planets have been found using indirect methods. |
What about actually seeing them, getting photos of them? That’s hard, because planets are so faint. But it’s not impossible. In 2004, the first picture of an exoplanet was released: 2M1207b, a planet with five times the mass of Jupiter. It orbits a brown dwarf, a peculiar kind of low mass star that we’ll learn more about in a future episode. It’s a young system, which makes it easier to see: The planet is still glowing hot from its formation, and it appears a lot brighter using a telescope that can see in the infrared.

About a dozen other planets have been seen this way, too. My favorite is the planet orbiting the star Beta Pictoris. It has seven times the mass of Jupiter, and orbits the star in about 20 years—and we’ve actually seen it move! Images taken a few years apart actually show the planet in different positions around the star, confirming its orbital motion. That is incredible. Taking photos of these planets is still a daunting task, which is why so few have been seen. But we’re getting better at this, and as new technology comes along we’ll get more pictures of exoplanets and learn even more about them.

The sheer variety of exoplanets is staggering. Hot Jupiters are the easiest to find, because they’re massive and fast, making their signal easier to detect. But as the techniques have improved, planets of lower mass have been seen; the smallest exoplanet found is smaller than Mercury, and not much bigger than Earth’s Moon. We’ve seen planets bigger than Earth but smaller than Neptune, called “Super Earths”. About 500 multiple planet systems have been found, too, including one with seven planets. We’ve found them around every kind of star, too.

Exoplanets have been detected around stars like the Sun as well as tiny, cool red dwarfs; hot, massive blue stars; and even red giants, stars nearing the ends of their lives. One exoplanet system announced in 2015 is incredibly old; the host star is 11 billion years old! When our solar system was just beginning to form, these planets were already over six billion years old—older than our solar system is now. We’ve even seen planets orbiting binary stars, making Star Wars seem a lot closer to home than being in a galaxy far, far away.

We’ve seen so many exoplanets now that we can extrapolate a bit and get some numbers. The results are staggering: In our galaxy alone, there may be hundreds of billions of planets. In fact, planets may outnumber stars in the sky. Now, if we’ve seen planets as big as Jupiter, and as small as Mercury, then we must have seen planets around the same size as Earth, right? Yes. Yes, we have. We’ve actually found hundreds of them so far. It looks like making planets the same size as ours is pretty easy for stars to do.

But Earth-sized is one thing. Earth-like is another. How many of these planets might actually be habitable? That is, at the right distance from their star to have Earth-like conditions, where liquid water could exist on their surface? We’re not sure. But from what we’ve seen so far, it looks like the galaxy may have more than 10 billion Earth-like planets. Ten. Billion. And maybe a lot more than that.

Now I want to be careful here: We don’t know what kind of atmospheres these planets will have, or what they’re composed of. Do the planets have magnetic fields strong enough to prevent solar wind from eroding away their atmosphere? Do they even have an atmosphere, let alone liquid water? We don’t know. But still, there are a lot of planets out there. There could very well be a twin of Earth orbiting a star not too far away. And over the whole galaxy? We could be part of a very large family.

After all this time, we finally have an answer to one of the biggest questions we’ve ever asked in astronomy: The sky is filled with planets. Today you learned that planets orbiting other stars exist and can be detected with a variety of methods. Nearly 2000 have been found so far. The most successful method is using transits, where a planet physically passes in front of its parent star, producing a measurable dip in the star’s light. Another way is to measure the Doppler shift in a star’s light due to reflexive motion as the planet orbits. Exoplanets appear to orbit nearly every kind of star, and we’ve even found planets that are the same size as Earth. We think there may be many billions of Earth-like planets in our galaxy.
| 145 | Crash Course Astronomy is produced in association with PBS Digital Studios. Head over to their YouTube channel to catch even more awesome videos. This episode was written by me, Phil Plait. The script was edited by Blake de Pastino, and our consultant is Dr. Michelle Thaller. It was directed by Nicholas Jenkins, edited by Nicole Sweeney, the sound designer is Michael Aranda, and the graphics team is Thought Café. |
| 146 | Video #2  
Crash Course  
How to Train a Brain - Crash Course Psychology #11 |
| 148 | So if the name Ivan Pavlov rings a bell, it’s because his experiments are among the most famous in the history of psychology. His work contributed to the foundation of the behaviorist school of thought that viewed psychology as an empirically rigorous science focused on observable behaviors and not unobservable internal mental processes. Even though today we view psychology as the science of both behavior and mental processes, Pavlov’s influence was tremendous. His research helped pave the path for more experimental rigor in behavioral research, right up to the present day.  
Born in 1849 in Russia, Pavlov was never much for psychology. After giving up on his original aspirations to become a Russian Orthodox priest like his father, he instead earned a medical degree and spent nearly twenty years studying the digestive system, earning Russia’s first Nobel Prize in his mid-50s for his research expanding our understanding of how stomachs worked. He didn’t study human stomachs though, cause the procedures were terrible and cruel, he studied dog stomachs. And while researching those dogs, he noticed how the animals would salivate at a mere whiff of their dinner. At first he found all that slobber annoying, but soon started to suspect that this behavior was actually a simple but important form of learning.  
For us scholars of psychology, we can define learning as the process of acquiring, through experience, new and relatively enduring information or behaviors. Whether through association, observation, or just plain thinking, learning is what allows us to adapt to our environments and to survive. And as Pavlov began to discover, it wasn’t only humans who learned. Soon enough he was turning out his famous series of experiments, in which he paired the presence of meat powder - yummy - which got the dogs to drooling, with lots of different neutral stimuli - things that wouldn’t normally make you drool, like a certain sound, a shining light, or a touch on the leg. Then Pavlov observed, after several of these pairings, a dog would start to drool just at the sound or the light or the touch, even if there wasn’t any slobber-inducing meat powder around.  
Animals, he found, can exhibit associative learning. That’s when a subject links certain events, behaviors, or stimuli together in the process of conditioning. This may be the most elemental, basic form of learning a brain can do. But that doesn’t mean that the processes behind conditioning are, or ever were, obvious. Or, for that matter, simple. In fact, the research that’s gone into how we’re conditioned by our environments has helped shape the science of psychology, from a still-kinda-subjective-thought-exercise into the more rigorous discipline we know today. And it also starred some of psychology’s most notable, and often controversial, figures, including Pavlov, B. F. Skinner - aaaand that guy who trained kids to be terrified of furry animals...  
OK, I’m not a licensed dog-trainer - do they license dog trainers? But I can break down for you the sequence of steps in Pavlov’s famous experiment, to help you get a sense of how conditioning works: First, before conditioning, the dog just drools when it smells food. That smell is the unconditioned stimulus, and the slobbering, the unconditioned, or natural response. The ringing sound, which at this point means nothing to the dog, is the neutral stimulus, and it produces no drooling. During conditioning, the unconditioned stimulus - that food smell - is paired with the neutral stimulus - the bell sound - and results in drooling. This is repeated many times until the association between the two stimuli is made, in a stage called acquisition. |
By the time you get to the after-conditioning phase, that old neutral stimulus has become a conditioned stimulus, because it now elicits the conditioned response of drooling. Sounds super simple, right? If you have a dog, you’ve probably seen it tapdance at the sight of a leash, but in Pavlov’s day, this whole series of steps hadn’t really been studied in a lab setting, or thought about in scientific terms. Pavlov’s work suggested that classical conditioning - as this kind of learning came to be known - could be an adaptive form of learning that helps an animal survive by changing its behavior to better suit its environment. In this case, a bell means food, and food means survival. So get ready!

Not only that, but methodologically, classical conditioning shows how a process like learning can actually be studied through direct observation of behavior, in real time, without all those messy feelings and emotions. This was something Pavlov especially appreciated given his disdain for “mentalistic” concepts like consciousness and introspection championed by Freud.

Behaviorist psychologists, like Pavlov’s younger American analogues B.F. Skinner and John B. Watson, also embraced the notion that psychology was all about objective, observable behavior. In his 1930 book Behaviorism, he argued that given a dozen healthy infants he could train any one of them to be a doctor, artist, lawyer, or even a thief, regardless of their talents, tendencies, or ancestry. Whoa there, Watson! Thankfully no one gave him any infants.

In his most famous and, yes, controversial experiment, Watson conditioned a young child, dubbed “Little Albert,” to fear a white rat. Maybe that doesn’t sound so bad, but he accomplished this by pairing the rat with a loud, scary noise, over and over and then demonstrated that the child’s terror could branch out and be generalized to include other furry, white objects, like bunnies, dogs, or even fur coats. So yeah, that’d never fly today, obviously, but Watson’s research did make other psychologists wonder whether adults, too, were just holding tanks of conditioned emotions - and if so, whether new conditioning could be used to undo old conditioning. Like, if you’re terrified of roller coasters, but you made yourself ride one ten times a day for two weeks, would your fears fade?

For the record, recent exploration has revealed that the boy known as Little Albert sadly died a few years after these experiments, while Watson eventually left academia and got into advertising, where he put all that associative learning to lucrative use.

So that’s classical conditioning. But we’ve also got another kind of associative learning: operant conditioning. If classical conditioning is all about forming associations between stimuli, operant conditioning involves associating our own behavior with consequences. The kid who gets a cookie for saying please, or the aquarium seal that gets a sardine for balancing a ball on its nose, they’ve both been trained with operant conditioning.

The basic premise here is that behaviors increase when followed by a reinforcement, or reward, but they decrease when followed by a punishment. And the most well-known champion of operant conditioning is American behaviorist B.F. Skinner. He designed the famous operant chamber, or “Skinner Box” - a confined space containing a lever or button that an animal could touch to get some sort of reward, typically food, along with a device that keeps track of its responses.

Okay, time for a debunking break! Other than maybe Freud, no other figure in psychology seems to be as shrouded in lore and misinformation as B. F. Skinner. So I’m just going to tell you straight that, no, Skinner never put any kids in this box. And no, he didn’t raise his children without love or affection, and his daughter didn’t hate his guts until the day she committed suicide. Deborah Skinner is alive and well, and she loved her dad plenty.

Skinner did, however, invent something called an air crib - a climate controlled box with a window on the front that was meant to keep babies warm and safe while moms ran around doing their 1950’s-lady thang. ‘It’s not exactly where I’d like to spend the night, but it wasn’t remotely the same as the Skinner Box. No one knows where all of these myths came from, but being a somewhat controversial guy, Skinner had a lot of haters, some of whom were probably happy to perpetuate misinformation.
But back to the rat in the box. Basically, the box provided an observable stage to demonstrate Skinner’s concept of reinforcement, which is anything that increases the behavior that it follows. In other words, you push the lever, you get a snack, and then you want to keep pushing the lever. But most rats aren’t going to push a lever for no reason. I mean, there aren’t food-dispensing levers in a natural environment, so operant-conditioning behavior requires shaping. Maybe you give the rat a nibble of food each time it gets closer to the bar, then only when it touches the bar, until little by little, in a series of successive approximations to the desired behavior, you only reward them only when they do what you’re trying to shape them to do.

In everyday life, we’re all continually reinforcing, shaping, and refining each other’s behaviors, both intentionally and accidentally. We do this with both positive and negative reinforcement. Positive reinforcement obviously strengthens responses by giving rewards after a desired event, like the rat snack after a lever push, or getting a cookie when you say please. Negative reinforcement is a little trickier. It’s what increases a behavior by taking away an aversive or upsetting stimulus. Like, say, you get in your car and it does that infernal beeping thing until you fasten your seatbelt. The car is reinforcing your seatbelt-wearing by getting rid of that horrible beeping. And it’s good, because you should wear your seatbelt.

It’s important to recognize here that negative reinforcement is not the same as punishment. Punishment decreases a behavior either positively, by say, giving a speeding ticket, or negatively, by taking away a driver’s license. But negative reinforcement removes the punishing event to increase a behavior. So, painkillers negatively reinforce the behavior of swallowing them by ending the headache.

So by now hopefully you’re getting the picture. There are things that we want and things that we don’t want, and we can be taught by way of those impulses to behave certain ways. But it’s worth pointing out that conditioning is way more complex than just the cookie and the beeping car. For one thing ending annoyance or getting a cookie, are types of primary reinforcers - you don’t have to learn that, they just make innate biological sense. Beeping is annoying, cookies are delicious.

But there are other kinds of reinforcers that we only recognize after we learn to associate them with primary reinforcers. Like, a paycheck is a conditioned reinforcer-we want money because we need food and shelter, which are still the primary drivers. Plus, just as there are different kinds of reinforcers, so are there various reinforcement schedules. Like, those boxed rats were getting continuous reinforcement when they got a treat every single time they hit that lever, so they picked it up pretty quickly.

But if one day the rat chow doesn’t come, that connection quickly dwindles, and the rat stops hitting the lever. This is a process called extinction. And it is important, because that’s how real life works. Outside of a Skinner box, you’re not gonna get continuous reinforcement. All of life is a series of partial, or intermittent reinforcements, that occur only sometimes. Learning under these conditions takes longer, but it holds up better in the long run and is less susceptible to that extinction.

So, say a cafe gives out a free cup of coffee for every ten you buy, while another shop pours a free double shots every Tuesday morning, and yet another has a free-coffee lottery that customers win at random. These are all different kinds of intermittent reinforcement techniques that get customers coming back for more.

Now, Pavlov, Watson, and Skinner’s ideas were definitely controversial - as well as the whole scary-rat experiments. Plenty of folks disagreed with their insistence that only external influences, and not internal thoughts and feelings, shaped behavior. It was clear to many of the behaviorists’ rivals that our cognitive processes - our thoughts, perceptions, feelings, memories - also influence the way we learn. We’re going talk about how these other things factor into learning next week when we look more at conditioning, cognition and observational learning - and yeah, also watch kids beat the face off blow-up dolls.
Today you learned about how associative learning works, the essentials of behaviorist theory, the basic components of classical and operant conditioning, including positive and negative reinforcement, and reinforcement scheduling.

Thanks for watching this, especially to all of our Subbable subscribers, who make this whole channel possible. If you'd like to sponsor an episode of Crash Course, or get a special Laptop Decal, or even be animated into an upcoming episode, just go to Subbable.com. This episode was written by Kathleen Yale, edited by Blake de Pastino, and our consultant is Dr. Ranjit Bhagwat. Our director and editor is Nicholas Jenkins, the script supervisor is Michael Aranda, who is also our sound designer, and the graphics team is Thought Café.

Hello, learned and astonishingly attractive pupils. My name is John Green and I want to welcome you to Crash Course World History. Over the next forty weeks together, we will learn how in a mere fifteen thousand years humans went from hunting and gathering...

Mr. Green, Mr. Green! Is this gonna be on the test? Yeah, about the test: The test will measure whether you are an informed, engaged, and productive citizen of the world, and it will take place in schools and bars and hospitals and dorm-rooms and in places of worship. You will be tested on first dates; in job interviews; while watching football; and while scrolling through your Twitter feed.

The test will judge your ability to think about things other than celebrity marriages; whether you'll be easily persuaded by empty political rhetoric; and whether you'll be able to place your life and your community in a broader context. The test will last your entire life, and it will be comprised of the millions of decisions that, when taken together, make your life yours. And everything — everything — will be on it. I know, right? So pay attention.

In a mere fifteen thousand years, humans went from hunting and gathering to creating such improbabilities as the airplane, the Internet, and the ninety-nine cent double cheeseburger. It's an extraordinary journey, one that I will now symbolize by embarking upon a journey of my own... over to camera two. Hi there, camera two, it's me, John Green.

Let's start with that double cheeseburger. Ooh, food photography! So this hot hunk of meat contains four hundred and ninety calories. To get this cheeseburger, you have to feed, raise, and slaughter cows, then grind their meat, then freeze it and ship it to its destination; you also gotta grow some wheat and then process the living crap out of it until it's whiter than Queen Elizabeth the First; then you gotta milk some cows and turn their milk into cheese.

And that's not even to mention the growing and pickling of cucumbers or the sweetening of tomatoes or the grinding of mustard seeds, etc. How in the sweet name of everything holy did we ever come to live in a world in which such a thing can even be created? And how is it possible that those four hundred and ninety calories can be served to me for an amount of money that, if I make the minimum wage here in the U.S., I can earn in eleven minutes? And most importantly: should I be delighted or alarmed to live in this strange world of relative abundance?

Well, to answer that question we're not going to be able to look strictly at history, because there isn't a written record about a lot of these things. But thanks to archaeology and paleobiology, we can look deep into the past. Let's go to the Thought Bubble.
So fifteen thousand years ago, humans were foragers and hunters. Foraging meant gathering fruits, nuts, also wild grains and grasses; hunting allowed for a more protein-rich diet... so long as you could find something with meat to kill. By far the best hunting gig in the pre-historic world incidentally was fishing, which is one of the reasons that if you look at history of people populating the planet, we tended to run for the shore and then stay there. Marine life was: A) abundant, and B) relatively unlikely to eat you.

While we tend to think that the life of foragers were nasty, brutish and short, fossil evidence suggests that they actually had it pretty good: their bones and teeth are healthier than those of agriculturalists. And anthropologists who have studied the remaining forager peoples have noted that they actually spend a lot fewer hours working than the rest of us and they spend more time on art, music, and storytelling. Also if you believe the classic of anthropology, NISA, they also have a lot more time for skoodilypooping. What? I call it skoodilypooping. I'm not gonna apologize.

It's worth noting that cultivation of crops seems to have risen independently over the course of millennia in a number of places, from Africa to China to the Americas, using crops that naturally grew nearby: rice in Southeast Asia, maize in Mexico, potatoes in the Andes, wheat in the Fertile Crescent, yams in West Africa. People around the world began to abandon their foraging for agriculture. And since so many communities made this choice independently, it must have been a good choice... right? Even though it meant less music and skoodilypooping. Thanks, Thought Bubble.

All right, to answer that question, let's take a look at the advantages and disadvantages of agriculture. Advantage: Controllable food supply. You might have droughts or floods, but if you're growing the crops and breeding them to be hardier, you have a better chance of not starving. Disadvantage: In order to keep feeding people as the population grows you have to radically change the environment of the planet. Advantage: Especially if you grow grain, you can create a food surplus, which makes cities possible and also the specialization of labor.

Like, in the days before agriculture, everybody’s job was foraging, and it took about a thousand calories of work to create a thousand calories of food, and it was impossible to create large population centers. But, if you have a surplus agriculture you can support people not directly involved in the production of food. Like, for instance, tradespeople, who can devote their lives to better farming equipment which in turn makes it easier to produce more food more efficiently which in time makes it possible for a corporation to turn a profit on this ninety-nine cent double cheeseburger. Which is delicious, by the way. It's actually terrible. And it's very cold. And I wish I had not eaten it. I mean, can we just compare what I was promised to what I was delivered? Yeah, thank you. Yeah, this is not that.

Some would say that large and complex agricultural communities that can support cities and eventually inexpensive meat sandwiches are not necessarily beneficial to the planet or even to its human inhabitants. Although that's a bit of a tough argument to make, coming to you as I am in a series of ones and zeros.

Advantage: Agriculture can be practiced all over the world, although in some cases it takes extensive manipulation of the environment, like y'know irrigation, controlled flooding, terracing, that kind of thing. Disadvantage: Farming is hard. So hard in fact that one is tempted to claim ownership over other humans and then have them till the land on your behalf, which is the kind of non-ideal social order that tends to be associated with agricultural communities.

So why did agriculture happen? Wait, I haven't talked about herders. Herders, man! Always getting the short end of the stick. Herding is a really good and interesting alternative to foraging and agriculture. You domesticate some animals and then you take them on the road with you. The advantages of herding are obvious. First, you get to be a cowboy. Also, animals provide meat and milk, but they also help out with shelter because they can provide wool and leather. The downside is that you have to move around a lot because your herd always needs new grass, which makes it hard to build cities, unless you are the Mongols.
By the way, over the next forty weeks you will frequently hear generalizations, followed by "unless you are the Mongols". But anyway one of the main reasons herding only caught on in certain parts of the world is that there aren't that many animals that lend themselves to domestication. Like, you have sheep, goats, cattle, pigs, horses, camels, donkeys, reindeer, water buffalo, yaks, all of which have something in common. They aren't native to the Americas. The only halfway useful herding animal native to the Americas is the llama. No, not that Lama, two l's. Yes, that llama.

Most animals just don't work for domestication. Like hippos are large, which means they provide lots of meat, but unfortunately, they like to eat people. Zebras are too ornery. Grizzlies have wild hearts that can't be broken. Elephants are awesome, but they take way too long to breed.

Which reminds me! It's time for the Open Letter. Elegant. But first, let's see what the Secret Compartment has for me today. Oh! It's another double cheeseburger. Thanks, Secret Compartment. Just kidding, I don't thank you for this. An Open Letter to elephants.

Hey elephants, You're so cute and smart and awesome. Why you gotta be pregnant for 22 months? That's crazy! And then you only have one kid. If you were more like cows, you might have taken us over by now.

Little did you know, but the greatest evolutionary advantage: being useful to humans. Like here is a graph of cow population, and here is a graph of elephant population. Elephants, if you had just inserted yourself into human life the way cows did, you could have used your power and intelligence to form secret elephant societies, conspiring against the humans! And then you could have risen up, and destroyed us, and made an awesome elephant world with elephant cars, and elephant planes! It would have been so great! But noooo! You gotta be pregnant for 22 months and then have just one kid. It's so annoying! Best wishes, John Green.

Right, but back to the agricultural revolution and why it occurred. Historians don't know for sure, of course, because there are no written records. But, they love to make guesses. Maybe population pressure necessitated agriculture even though it was more work, or abundance gave people leisure to experiment with domestication or planting originated as a fertility rite - or as some historians have argued - people needed to domesticate grains in order to produce more alcohol.

Charles Darwin, like most 19th century scientists, believed agriculture was an accident, saying, "a wild and unusually good variety of native plant might attract the attention of some wise old savage." Off topic, but you will note in the coming weeks that the definition of "savage" tends to be "not me."

Maybe the best theory is that there wasn't really an agricultural revolution at all, but that agriculture came out of an evolutionary desire to eat more. Like early hunter gatherers knew that seeds germinate when planted. And, when you find something that makes food, you want to do more of it. Unless it's this food. Then you want to do less of it. I kinda want to spit it out. Eww. Ah, that's much better.

So early farmers would find the most accessible forms of wheat and plant them and experiment with them not because they were trying to start an agricultural revolution, because they were like, you know what would be awesome: more food!

Like on this topic, we have evidence that more than 13,000 years ago humans in southern Greece were domesticating snails. In the Franchthi Cave, there's a huge pile of snail shells, most of them are larger than current snails, suggesting that the people who ate them were selectively breeding them to be bigger and more nutritious.

Snails make excellent domesticated food sources, by the way because A) surprisingly, calorie B) they're easy to carry since they come with their own suitcases, and C) to imprison them you just have to scratch a ditch around their living quarters. That's not really a revolution, that's just people trying to increase available calories. But one non-revolution leads to another, and pretty soon you have this, as far as the eye can see.
Many historians also argue that without agriculture we wouldn't have all the bad things that come with complex civilizations like patriarchy, inequality, war, and unfortunately, famine. And, as far as the planet is concerned, agriculture has been a big loser. Without it, humans never would have changed the environment so much, building dams, and clearing forests, and more recently, drilling for oil that we can turn into fertilizer.

Many people made the choice for agriculture independently, but does that mean it was the right choice? Maybe so, and maybe not, but, regardless, we can't unmake that choice. And that's one of the reasons I think it's so important to study history. History reminds us that revolutions are not events so much as they are processes; that for tens of thousands of years people have been making decisions that irrevocably shaped the world that we live in today. Just as today we are making subtle, irrevocable decisions that people of the future will remember as revolutions.

Next week we're going to journey to the Indus River Valley - whoa - very fragile, our globe, like the real globe. We're going to travel to the Indus River Valley. I'll see you then.

Crash Course is produced and directed by Stan Muller. Our script supervisor is Danica Johnson. The show is written by my high school history teacher, Raoul Meyer, and myself, and our graphics team is Thought Bubble.

If you want to guess at the phrase of the week, you can do so in comments. You can also suggest future phrases of the week. And if you have a question about today's video, please leave it comments where our team of semi-professional quasi-historians will aim to answer it. Thanks for watching, and as we say in my hometown, Don't Forget To Be Awesome.

**Video #4**
**minutephysics**
**How to Find an Exoplanet**

It took Clyde Tombaugh half a year of manually looking at photographic plates, contains over two million stars before he discovered Pluto. and its in our own solar system. So how on earth, does one find a planet orbiting a distant star? You could just look, but stars are so far away, and so bright compared to their planets, that it's really hard to just look at one, and see a planet orbiting it.

Direct discovery of new exoplanets by just looking, is essentially limited to relatively nearby stars, with very large planets, very far away from them. Think 10 times the size of jupiter, and an orbit at least as big. The vast majority of exoplanets, have been found indirectly, by observing their effects on their parents stars. For example, a planet passing in front of a star will make that star darker for a little while. And the amount it darkens, will tell you about the size of the planet, relative to the size of the star.

Of course this only works if the planet's orbit is tilted perfectly to pass between us and its star. And on average less than 1% of earth like planets will have this convenient orbital orientation. We have managed to find a lot of exoplanets this way, by exhaustive satellite searches. But you could instead have a look at the effect planets have on the motion of stars.

As we know, planets don't orbit stars. Rather, both orbit around their combined centre of mass. Stars are so heavy, so often the centre of mass is inside the star, but the star will nonetheless be moving. That motion manifests itself as a teeny tiny wobble, in the velocity of the star relative to us, which we determine by carefully measuring the red or blue Doppler shift of the star’s light.

Both these indirect methods are most effective at finding big planets, close to their stars, because the speed's involved, and the amount of light blocked are greater, and also because close planets orbit more often so we don't have to wait as long to notice their effects.
There are other more complicated and fancy methods which can find planets which are harder to notice by a star wobbling or star light blocking and all of these together have helped to discover more than 1800 exoplanets as of 2014. Sorry Pluto, you've been x-ed out!

This video is brought to you in part by Audible.com, The leading provider of audio books across all types of literature, including fiction, non-fiction and periodicals. If you go to audible.com/minutephysics, you can try Audible out by downloading a free audiobook of your choice. I would like to recommend the book 'Foundation'. It's the opening act of Isaac Asimov's opening saga about the impending collapse of interstellar civilisation. You can download your free audiobook at Audible.com/minutephysics and I would like to say thanks to Audible for helping me continue to make these videos.

If the purpose of a telescope is to bring far-away things closer to us, then why do we send some of them so far away? The main reason to put a telescope into space is to avoid that perpetual troublemaker, the atmosphere, since astronomers haven't yet figured out how to get rid of it. And it's a big nuisance.

First off, the atmosphere plane gets in the way, what with its clouds and smoke and haze that can block light from distant stars or nearby planets. And even just the air in a clear sky blocks a huge range of the wavelengths of light, pretty much only letting through visible light, and a smattering of infrared and radio waves.

The atmosphere is also -hey! Stop that!-distracting at day, visible light from the sun bounces off of air molecules, and other small particles and completely overwhelms the light from any other star you might want to look at. At night, the light from the moon and from human sources bounces off the same particles and outshines the light from most distant and faint stars and galaxies, washing out their images. The atmosphere also messes things up.

Air is constantly moving, and just like a heat mirage, this turbulence blurs and distorts starlight, which causes stars to twinkle, and telescope images of stars to be blurry. We can avoid all of these nuisances by putting telescopes above the atmosphere, in space.

Plus, there are other benefits; A space telescope can make observations 24 hours a day, A space telescope can be put far enough away from the earth's infra-red warmth and then cooled down really cold so that it can take clean infra-red images, and a space telescope is a telescope we freaking put in outer space!

Of course, there are some downsides to space telescopes; It's hard and expensive to get them there, hard and expensive to fix them if they break or you want to upgrade to newer fancier parts, hard and expensive to take people there on tours, but really, How can you argue, with this and this and, this and this and this and even this and this and this. This too. And this.

Thank you so much for watching, This video was supported by the James Webb space telescope project at the space telescope science institute where they put telescopes into space so you don't have to deal with stuff like clouds, and rain. Thanks again for watching, and thank you again to the James Webb space telescope project for supporting this video.

Video #5
minutephysics
Why Do We Put Telescopes in Space?

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Air is constantly moving, and just like a heat mirage, this turbulence blurs and distorts starlight, which causes stars to twinkle, and telescope images of stars to be blurry. We can avoid all of these nuisances by putting telescopes above the atmosphere, in space.

Plus, there are other benefits; A space telescope can make observations 24 hours a day, A space telescope can be put far enough away from the earth's infra-red warmth and then cooled down really cold so that it can take clean infra-red images, and a space telescope is a telescope we freaking put in outer space!

Of course, there are some downsides to space telescopes; It's hard and expensive to get them there, hard and expensive to fix them if they break or you want to upgrade to newer fancier parts, hard and expensive to take people there on tours, but really, How can you argue, with this and this and, this and this and this and even this and this and this. This too. And this.

Thank you so much for watching, This video was supported by the James Webb space telescope project at the space telescope science institute where they put telescopes into space so you don't have to deal with stuff like clouds, and rain. Thanks again for watching, and thank you again to the James Webb space telescope project for supporting this video.

Video #6
minutephysics
Immovable Object vs. Unstoppable Force - Which Wins?
What happens if an immovable object meets an unstoppable force? - is a popular question on the internet. Of course, relativity clearly tells us that there is no such thing as an immovable object - here's why: If you pick any supposedly immovable object, or just something like your house or the earth, I can make it move. All I need to do is start to move relative to it, for example I might ride a rocket, and suddenly from my perspective, I'm not moving and the earth sails by outside.

The laws of physics make no preference for inertial frame of reference, so from my perspective here, I do not stir, and yet it's clear: the immovable object moves! So because of relativity, "immovable objects" cannot be. But what I think people normally mean by "immovable object" is something that if it's not moving, you can't make it start moving by Pushing on it. So, not an immovable object, but an "un-acceleratable" one.

Using Newton's second law, we know that an object's acceleration is equal to the total force on it divided by its mass, though you've probably seen this as F=ma. So an "un-acceleratable" object would be an object with infinite mass; an object so massive that no matter how big the total force F is, when you divide F by m you always get zero.

Of course, as we've said, not being able to accelerate an object doesn't necessarily mean that the object isn't moving - it just means that you can't directly change its speed - if it's not moving, then it'll stay not moving. And if it's moving at 100 miles an hour, then it'll stay moving at 100 miles per hour.

So what about an unstoppable force? Well, all the fundamental forces in nature are actually caused by particles, like photons or gluons or gravitons, that interact with an object and change its momentum - the only way to not be affected by a force is to not interact with it at all, like how electrons don't interact with gluons so they aren't subject to the strong nuclear force. Even light itself is an unstoppable force - every photon that hits your body changes your momentum a tiny little bit, and there's nothing you can do about it other than avoid light altogether or become transparent.

So all forces are already unstoppable but my impression is that the phrase "unstoppable force" isn't really meant to imply anything about "forces" like electromagnetism or gravity, but rather, something that you cannot stop from barreling down on you. That is, an object whose velocity cannot be changed by pushing on it. So, if by an unstoppable force we mean an object moving at a speed that can never be changed, then that means the object cannot accelerate.

But wait a second, this sounds familiar! Recalling what we learned earlier, an unstoppable force must be an un-acceleratable object! And that means that an "unstoppable force" and an "immovable object" are really just the same, viewed from different reference frames!

Now, since infinite mass requires infinite energy, we don't know of anything in the universe that behaves like this, not the least because it would automatically be a black hole so big that everything in the universe would already be inside of it.

But what if we ignored gravity and imagined there were an un-acceleratable object? Well, first it would be a source of infinite free power and would allow us to live in a 100% happy utopian society and break the second law of thermodynamics and probably create portals and time travel, too. You can do a lot with infinite energy. But more importantly, if two of these infinitely massive un-acceleratable objects were moving towards each other and collided, then since by definition it's not possible for the velocity of either of them to change, the only possibility is that they must pass right through each other with no effect on each other at all.

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**Video #7**
**SmarterEveryday**
**How to FLY A SPACESHIP to the SPACE STATION** - Smarter Every Day 131
Hey it's me Destin, welcome back to Smarter Everyday. Most people know that if you're gonna go to the International Space Station you first get on this rocket in Russia called the Soyuz. You strap yourself in, you launch from Baikonur and you go straight up to the space station, you pop open the hatch and then you high-five all your astronaut buddies, right? But there's a lot more to it if you think about it. There's actually orbital mechanics and physics that are all figured out on the ground before they leave. So today on Smarter Everyday we're gonna talk about rocket science, and it's really not that hard, I promise.

US astronaut Scott Kelly, and Russian cosmonaut Mikhail Korniyenko are about to go to the International Space Station for an entire year. That's a really big deal. But before we talk about the orbital mechanics think about this. Astronauts are just people, like me, like you. What would you be thinking about if you were strapped into that rocket, knowing you're gonna leave warm showers for an entire year. How cool would it be to actually get inside this Russian rocket and have just a normal person to person conversation with a guy that's about to do this?

Even though his launch window is getting closer and closer, and his time on Earth is more and more precious at this point, Scott Kelly was gracious enough to volunteer some of his free time to just hang out with us in the Soyuz capsule and tell us what he's about to do.

This is astronaut Scott Kelly. - Hi. - Scott's about to do something no American has ever done, he's about to ride one of these, which is a Soyuz capsule, up to the International Space Station for how long? - I'll be there about a year. I'll launch in March of 2015, next March, this year, and land sometime in March of the following year, so it'll be almost a year.

Alright so there's a whole regime of different science experiments that's gonna happen because of this. The main goal is to get ready for Mars, a long duration mission, right? - Yep, that's correct. You know NASA's ultimate goal is one day to put people on Mars so there's a lot we need to still learn about that. Some of it has to do with how the space environment affects the human body for long periods of time, particularly with the growths of bone loss, muscle loss, effects of radiation on our genetics, our vision, we have problems with vision with crew members during long duration space flight. Our immune system, vestibular system, so that's kind of the human part of it, and there's also the hardware part of it.

You know travelling that far away from Earth is a, you know represents a challenge with regards to how we design our life support systems, you know how we produce oxygen, produce water, and you know those kind of things, electricity to keep us alive in space for long periods of time. - It's like camping for a year right? - Yeah, you know this flight will be camping for a year. Even though you're in space you're still 250 miles above the Earth, although you're going very fast at 17,500 miles per hour, but it still is a place that we can get resupplied fairly frequently, but when you're going to Mars you can't, so... - Are you gonna simulate any of that? Are you gonna, you know, change your underwear less frequently or anything weird like that? - Ahh... I wasn't planning on it. - These are important issues we need to know man. - Yeah, yeah...

But ah, are we simulating anything about... We're doing a lot of science that would relate to living in space for longer periods of time. As far as particular simulation, I'm gonna, you know personally I'm gonna try to imagine, OK it's six months, you know, we might be showing up at Mars and then I'd spend a year on the surface and it'd take me...

Because for you, this is different for you than any other astronaut. Obviously your twin brother Mark's on the ground, he's, you know, he's taking all kinds of data as you're doing that up there, but for you, I have looked at the duration of your space flights. If you graph them, you're gradually getting longer and longer, so I mean if you project that graph up, that's like a space, or a Mars trip type duration.
| 634 | - Yeah it was interesting, I mentioned that in a public affairs event, how my first flight was 8 days, second flight 13, third flight 159. My fourth flight will be around a year. And if you tried to draw a curve it's like a second order polynomial, and if I was to fly a fifth flight, you know, and flying along. - That puts you on Mars, wouldn't it. - It puts me at five years, over five years in space, so easily go to Mars. - That's awesome. - Which probably means I'm not gonna fly in space again right? - No I saw where you tweeted that. | 20, 21, 16, 29, 20, 21 |
| 640 | When you're actually flying here, you're gonna be under intense acceleration, so how the heck do you push that button right there for example? - The guy in this seat can kind of reach, but the guy in the center seat has a stick, he can push the buttons. - So he just grabs a stick and he sticks it up there. - Yeah, it's a fancy stick but it's a stick. And I can control some of his valves over here, I can reach them better from there than he can. - So you actually control docking and things like that from here? - Yeah the Soyuz commander can... The Soyuz docks automatically generally, but sometimes you have to downmode to a manual docking and you control it from here. | 16, 23, 20, 21 |
| 648 | OK that was pretty awesome, however we still don't know how the Soyuz gets up to the station. To figure this out let's go talk to Reid Wiseman. His expedition recently set the record for most research done in a single week on orbit. You just recently did this. - I did this. - OK - I did this May 29. - Is it awesome? - Oh it's awesome. - Alright, so what happens once you get to space? OK people know the rocket, and people know space station. People have no idea what happens in between. - There is a little bit that happens in between. - OK. | 20, 21 |
| 654 | - So the ride from ground to space, that's nine and a half minutes, and that's on a really powerful rocket, everybody's seen it, it's filled with fuel, a lot of fire, you go up, and at the end of that ride you're going about 17,000 miles an hour. - OK. - OK and from there though, you have to rendezvous with the International Space Station, and that's going just a little bit faster. - And that's what I want to talk about. - Let's talk about it. | 20, 21, 37 |
| 660 | - OK. I think what a lot of people think is that the rocket just gradually takes you up to the space station in this spiral orbit, and that's not what happens at all. - You know what I used to think? - What's that? - I used to think the rocket just launched straight up to the space station. - Yeah, I get it. - I never thought that it actually tracks down range. | 20, 21, 29, 20 |
| 664 | - What's that? - I used to think the rocket just launched straight up to the space station. - Yeah, I get it. - I never thought that it actually tracks down range. | 20, |
| 668 | - So what is the moment where you're like, "Holy cow I'm in space," when does that happen? - The moment, that moment is very clear. It's exactly when your third stage cuts off, so that's nine and a half minutes in, and you're no longer under powered flight, and your booster falls away, and you really, you actually feel like you're floating up because you're still strapped in your seat. | 14, 37, 20, 21, 36 |
| 669 | They're gonna put you up at a fairly safe altitude where you're outside the atmosphere and the rocket's not gonna fall back down. It's not gonna have a lot of drag on it so it'll just stay up there. And then from there, we're gonna do a series of burns, and in the Soyuz we do seven burns. OK, but the first two are just gonna be a straight up Hohmann Transfer. | 20, |
| 673 | - Okay gotcha. Let me explain that. A Hohmann Transfer, make sure I get this right, a Hohmann Transfer is like if you're in a circular orbit, and you want to go to a larger or smaller circular orbit, you draw an ellipse between the two circles right? - That's right. You're gonna do a burn on one side, and then 45 minutes later for us, you're gonna do another burn because you're gonna be on the other side of the planet. It's a little less than 45 minutes. - Gotcha. OK. - But then that'll perfectly, that'll turn one circular orbit into another circular orbit that's either a little bigger or smaller. - Got it. Two burns, Hohmann Transfer. Awesome. | 20, 21, 37, 22 |
| 681 | So then the second Maneuver... It's actually a little trick. We don't know on that booster. We don't know exactly where it's going to insert us into orbit So we could be a little high, a little low, A little fast, or a little slow. - Why is that? Is it because every rocket isn't the same? - Every Rocket is a little bit different These next two burns are just gonna correct for our dispersion errors. And now we're pha... what we call phasing with the space station. | 20, 21, 37, 22 |
So we're gonna stay in this phasing orbit until the space station is kind of where it needs to be. - Oh, OK I got it. If you are closer to the Earth you're actually orbiting the Earth quicker right? - That's correct. - OK so what is it, on station it's every 90 minutes you go around the Earth? - Once every 90 minutes. So when you're a little bit lower it's once every 86 minutes, you know it's a little bit faster. - OK so that's the purpose of the phasing orbit then. - Catch up with the space station. - OK, got it. So that's our timing. - That's our timing. - So now we're four burns in. - OK -

But now... - So we've done our Hohmann Transfer... - We've done our Hohmann Transfer to build our orbit up, we've done our next two burns to correct for any sort of dispersion on ascent... - Now we're on the perfect phasing orbit. - We're perfectly set, perfectly circular orbit if that's where we wanna be, and now we're just waiting, and when the space station is at the exact right spot we're gonna do one more Hohmann Transfer. Two burns.

And it would actually send us out in front of the space station. So what we'll do is we wait, and right when we get in front of the space station we turn the rocket around and we do a third burn now, and it sets us perfectly up in front of the space station. - So you do a U-turn in space? - You do a U-turn in space. And you actually see it. You watch the Earth go all the way by, you go backwards, you hit the brakes just a tiny bit, then you flip your space ship back around pointed at the space station, and now we're sitting right in front of the ISS and we're just waiting and then we're gonna go real, real slow.

Proximity operations and we're flying it just just like an airplane, and we go in and dock. - Sweet. OK so it's just X, Y, Z, roll, pitch, yaw at that point. - Exactly. - That's fantastic. How long does it take to actually dock to the space station? - It takes about a half an hour. From the time you get to prox ops, we're gonna go really really slow and it takes about a half an hour to get that docking completed. - OK is it... - You could do it much quicker but I mean when you have two big pieces of metal that are going 17,500 miles an hour, you want to make sure they touch each other pretty gently.

- Let's summarize.... The launch gets you into the insertion orbit where you do a Hohmann Transfer to get up a bit higher. You do some clean up burns to get into the perfect phasing orbit where you catch up with the ISS because you're going around the Earth faster. You chill right here until the time is right and then you do two burns which puts you out in front of the ISS. A flip and a braking burn then brings you in for docking and there you go. You now understand some rocket science.

So seriously, my goal for this video was to more than double the amount of followers on Instagram for Scott Kelly and send a bunch of people to his Twitter account. He's like a living science experiment on the International Space Station. So please go check those out, I'll leave links in the video description. I would greatly appreciate that. I'm Destin, you're getting Smarter Every Day. Have a good one.

OK we're in the ISS. This is where you dock? - Yeah so this is the Russian segment and a much higher fidelity mock up in Russia but there's a module that comes out of the top of the space station here called MRM2. My Soyuz will dock to that. The other Soyuzes are docked in other parts of the Russian segment. - Thank you very much sir, I appreciate your time. - You bet. - Have a good one. Bye.

Hey it's me Destin. Welcome back to Smarter Every Day. So ah first things first, let me show you that this weapon is unloaded. And I really like to think about firearms because there's a lot of science involved here. What causes muzzle flash?
Alright number one. We have powder inside the cartridge that's burning, that gas is expanding. It has to overcome the bullet to barrel friction here, in the barrel, and it has to accelerate the mass of the bullet, while pushing out the column of air that was inside the barrel. There's a lot of science there. So, muzzle flash is affected by the cartridge load and the barrel length if you think about it. Another thing that comes into play for muzzle flash is the geometry of the exit.

Now, this is just a plain right circular cylinder so you get a toroidal vortex, but if you think about something like this, you've got a fluted exit here at the muzzle you'll get more of a starburst pattern. Over the past year I've been playing around and I have perfected I think a way of taking muzzle flash photos. It involves this, which is a piezoelectric transducer mounted to a wooden box, and I use that to convert acoustic energy to an electrical pulse, which I then send through a pulse generator. And if you don't know what this is, I'll leave a link in the video description here.

I then take that output pulse from the pulse generator to create a flash and take a high speed photo. Now why would I want to do that you ask. Answer? Because it's awesome. I mean look at that. But after a while it gets kind of strange taking experimental photos of yourself with firearms all the time, so I invited some friends down to Alabama, that you might recognize, to take photos with me.

OK OK I changed it, and we're gonna see the kick, instead of the muzzle flash. I delayed my flash. Alright you ready to kill the lights buzz? -Yessir. Alright, hold on. Just, just so I know, what do you think you're gonna look like? -American hero. Alright. Kill lights. Ready for the count? -Ready. -Well? Let's see. -From my end that looked good. Yep it looked real good over here. -No I'm serious. It was like it was a flash of like, American pride. Let's put this on your website. -They're gonna sell posters of this.

Oh my goodness. -Oh... oh... That's not what I was expecting. -You afraid of the dark? I'm going with your camera dude. -There's like two of you. You're like you're ah -What's going on there? -You can put it on your website. That's all that matters man. -That camera's broke dude. You should take that into the shop.

OK now we're gonna do the same thing, only instead of a revolver or pistol, we're gonna use a .50 cal. -Yup. So this is Michael from V sauce and this is a Safety Harbor .50 cal. It's not the Beowulf round it's the BMG round so we've got a AR-15 lower, Safety Harbor upper and a whole lot of awesome. -Armed. Alright. 3...2...1... -Did you see the flash go? Flash went. -Nice. Nice. So uh That's a little bit of muzzle flash. I mean, it's not like an amazing amount. You know I mean, that's probably less than you're used to. We could do better I think we could do better.

-Well look at that. Look what the flash did. It made that smoke cloud more opaque. On the bottom right of the quantum composer, hit the blue button -Blinking. Alright. Come back over here and I'll put the round in the barrel. -Ready? Yep. -Alright. -and 3...2...1... -Awesome. -Wow. This is kind of like a man test, if you can do this with your eyes open. -Look how open your eyes are. Well yeah, I mean come on.

So there's a handful of you out there thinking well why don't you just take the output from the piezo and run it through a MOS FET or something like that. You can vary the threshold on that MOS FET and then send a trigger to your flash. Why don't you do that Destin? Answer, because I like taking pictures of the bullet itself. That's why.

This thing has a really really fine temporal resolution. It's like 25 picoseconds. So another thing you might deal with is bullet blur. Bullet blur is calculated by the velocity of the bullet as it exits the weapon, multiplied times the the flash duration. Now there's two ways to decrease the bullet blur. The first way is a faster flash, and the second way is to turn the weapon more acutely so that you're only dealing with the cosine of that bullet velocity rather than the full bullet velocity.

Now that's cool, but there's something you have to do if you do that. You have to use a remote trigger, because one of the major rules of gun safety is never be down-range of a weapon. So make sure you do that. Use common sense any time you do experimentation like this.
So there you are, now you're trained on how to take really cool muzzle flash photos. Do not do this if you and everyone around you is not heavily trained in weapons safety. Even if you are trained, just keep in mind, accidents do happen so use common sense. That is amazing, I didn't think we could do that. I did not think this would stop the bullet. but it did. - Get smarter every day y'all. Subscribe immediately.

Hey it's me, Destin welcome back to Smarter Every Day. Not really sure how this is gonna work out but I want to know a little bit more about tattoos. So I'm just walking up to a tattoo parlour and seeing if they will let me video a tattoo being applied in slow motion with a Phantom. Let's see how this works.

OK we're in the shop, this is… Leah? Right? - Mhm. Hi. - OK this is Leah and she's an artist. We're not supposed to say... What, is that what we call you? - A tattoo artist, tattooer, tattooist, in England they use tattooist. - Excellent. OK so, can you teach us how to tattoo somebody with... I guess this is the gun right? - Well machine, we don't call it a gun, that's a no no.

I used to think that a tattoo machine came to a single needle point and it injected ink under the skin. It's actually multiple needles and they're grouped together for lining, however for shading it's more like a paintbrush. Ink is held in between those multiple needle points using capillary action and when it punctures the skin it drags the ink down into the dermis.

Coil machines however are a bit more complicated. When Leah steps on this foot pedal, that direct current is applied to the two coils. This turns those coils into an electromagnet and it pulls this armature bar down, moving the needle. When the armature bar moves down, it breaks the circuit away from the contact screw and that causes the electromagnetic field to collapse. The spring then returns the armature and it reenergizes the circuit. This just happens over and over again and that's it. That's how a coil machine works. One word of caution though. Just because you understand how a coil machine works, doesn't mean you know how to use it.

Did you really tattoo yourself? You did it? Let me see. - Yeah it's ridiculous. - Oh that's... That's what happens. - So it's a bad idea? - It's a very bad idea. - What's your name? - Shawn. - Shawn says do not tattoo yourself. Go to a professional like Leah right. - Yes.

OK now that we know how the machines work it's time to investigate what the needles are doing to the skin. I brought special lights and a special macro lens so we can record it at first 1500 frames per second and then ramp it up to 3200 frames per second. This is why tattoos hurt.
OK I have decided that I want to feel what this needle feels like because it's actually going in the skin and pulling it up and you said you can do this without actually tattooing me. - Yeah I'm not gonna use… I'm just gonna use a needle. - I'm a little nervous. I want to know what it feels like, but I don't want a tattoo. This is the next best thing right? - Yeah exactly. - OK, deep breath in. - Deep breath in, breathe it out slowly. - Whewhoo. That wasn't bad. - OK. - OK I can handle that. - That was it. - OK what did you do? - See there? - Oh. I can see why people get addicted to that. Because it's like a... it's like fear. - Yeah.

- So this was the line needle and this was the shading needle. - Correct. - And how many needles were on the line needle? - Five. - And how many were on the shading needle? - Seven. - There you go. Smarter Every Day. - On the front of your forearm I think it hurts more than the back. - You think I could take it? - Of course you could.

Alright, so I hope you enjoyed this episode of Smarter Every Day. If you want to continue getting smarter by letting me do crazy stuff, please support Smarter Every Day on audible.com. So go to audible.com/smarter and you can download any audio book you want for free.

I have learned that Leah actually reads a lot. Do you have a book that you recommend? - Yes I'd recommend Native Son by Richard Wright. - Yeah? - Mhm. - OK just… just continue. - OK - Anyway, so uh... Anyway, audible.com/smarter that helps Smarter Every Day and it's probably gonna pay for Leah's work here. So, also, follow Leah and Seejay. I'll leave links in the video description. She has a really cool Instagram account.

- You see what I mean about the frosting right? I do. - How it elevates the top layer of skin there. - OK, so when you... - Are we getting Smarter Every Day? - Yeah. Do you actually know about Smarter Every Day? - Yeah I subscribe to it. - Oh fantastic. Was this done here? - It was. Leah did it. - Awesome. Crazy. Did I just get credit because that guy knew who I was? - Yes. - OK excellent. - You're not just some weirdo coming into my shop. Alright so this is your famous tattoo? - I posted on reddit and got a few hits. - That's awesome. Do you like macaroni and cheese? - Yes. - Anyway, I'm Destin. You're getting Smarter Every Day. Have a good one. This is fake by the way. We're not actually tattooing me. It was a good fake though.

Video #10
CGP Grey
Is Pluto a planet?

Pluto: Planet or not? Before we can answer this question we need to know what the word planet is for, and that takes us back to the ancient greeks who called Mercury, Venus, Mars, Jupiter, Saturn, the Moon and sun planets. Basically, if it moved across the sky and was bright, it was a planet. This is a terrible start for the word because, 1) it excludes Earth from the list and 2) it groups wildly different things together. But the Greeks couldn't know how different the Moon was from Saturn, because the best technology they had to observe the Universe was sadly limited.

It would take several thousand years until the industrious Dutch made the first telescopes and astronomy became much more interesting. Astronomers could now confidently rearrange the solar system - an elegant scientific advance that no one could possibly object to - and reclassify its parts, dropping the Sun and moon from the list of planets and adding Earth. Now, if it orbited the Sun, it was a planet.

As time went on and telescopes got better and better each new century brought with it the discovery of a new planet. Which brings us to this familiar solar system: nine planets orbiting one star. And looking at this model makes people wonder, why do astronomers want to ditch Pluto?

The problem is pictures like this in textbooks are lies. Well, not lies exactly, but unhelpful. They give the impression that the planets are similar-ish in size and evenly-ish spaced, but the reality couldn't be more different. Here, dear Terrans, is our home planet Earth, and this is Jupiter next to it at the correct scale - rather bigger than you probably thought.
If we take this diagram and adjust for the correct sizes of the planets it looks like this. Unless you're watching the video in fullscreen HD mode, you might not even be able to see Pluto. So size differences are vast, and Pluto is the smallest by far. But it's not just small for a planet, it's also smaller than seven moons: Triton, Europa, our own Moon, Io, Callisto, Titan, and Ganymede. Even if you show the correct relative sizes the distances are still a problem.

Think about it, if Jupiter was this close to Earth it wouldn't look like a dot in the night's sky but would be rather overwhelming - so it must be really far away, which makes drawing it to scale rather a challenge. If you want the length of a piece of paper to represent the distance from Mercury to Pluto, then giant Jupiter would be the size of a dust mite on that page, and Pluto a bacterium.

But excluding Pluto from the planet club just for being tiny and far away isn't reason enough and quickly brings out the Pluto defenders. In order to understand what Pluto really is, we need to first discuss a planet you've never heard of: Ceres. Back in the 1801, astronomers found a new planet in the huge gap between Mars and Jupiter - it was a small planet, but they loved it anyway and named it Ceres.

The next year astronomers found another small planet in the same area and named it Pallas. A few years later they found a third one, Juno, and then, funnily enough, a fourth one, Vesta. And for several decades children learned the 11 planets of the solar system. But, astronomers kept finding more and more of these objects and became increasingly uncomfortable calling them planets because they were much more like each other than planets the on either side, so a new category was born: asteroids in the asteroid belt - and the tiny planets were relabeled which is why you've never heard of them. And it was a good decision too, as astronomers have now found hundreds of thousands of asteroids, which would be a lot for a kid to memorize if they were all still planets.

Back to Pluto. It was discovered in 1930 making it the 9th planet. First estimates put Pluto about the size of Neptune, but with more observations that was revised down, and down and down. While Pluto shrank astronomers started to find other, similar objects orbiting in the same zone. Sound familiar?

While school kids kept memorizing the nine planets, some astronomers grew uneasy about including Pluto because the size estimates continued to shrink, they learned that Pluto is made mostly ice, and they continued to find lots and lots of icy objects at the edge of the solar system just like Pluto. This problem could be ignored as long as no one found an ice ball bigger than Pluto, which is exactly what happened in 2006 with the discovery of Eris.

Once again, astronomers recategorized the solar system and grouped these distant objects, including Pluto, into a new area called Kuiper belt.

And that's the story of Pluto - a miscategorized planet that finally found its home - just like Ceres. But this story is really less about Pluto than it is about realizing the word 'planet' isn't very helpful. The first four planets are nothing at all like the next four, so it's even a little weird to group these eight together which is why they often aren't and are separated into terrestrial planets and gas giants.

And now that we have telescopes that can see planets around stars not our own, and we've found rogue planets drifting in empty space and brown dwarfs - objects that blur the very line between planet and star - the word planet becomes even less clear.

So as we increase our knowledge of the Universe the category of 'planet' will probably continue to evolve, or possibly, fall out of favor entirely. But, for the time being the best way to categorize the stuff in our solar system is into one star, eight planets, four terrestrial, four gas giants, the asteroid belt, and the distant Kuiper belt, home to Pluto.
A calendar year is made of three hundred and sixty five days - a number that refuses to be divided nicely, which is why we end up with uneven months of either 30 or 31 days. Except for February - the runt of the litter - which only gets 28... except when it gets 29 and then the year is 366 days long. Why does that happen? What kind of crazy universe do we live in where some years are longer than others? To answer this we need to know: just what is a year?

Way oversimplifying it: a year is the time it takes Earth to make one trip around the sun. This happens to line up with the cycle of the seasons. Now, drawing a little diagram like this showing the Earth jauntily going around the sun is easy to do, but accurately tracking a year is tricky when you're on Earth because the universe doesn't provide an overhead map. On Earth you only get to see the seasons change and the obvious way to keep track of their comings and goings is to count the days passing which gives you a 365 day calendar.

But as soon as you start to use that calendar, it slowly gets out of sync with the seasons. And with each passing year the gap gets bigger and bigger and bigger. In three decades the calendar will be off by a week and in a few hundred years the seasons would be flipped - meaning Christmas celebrations taking place in summer - which would be crazy.

Why does this happen? Did we count the days wrong? Well, the calendar predicts that the time it takes for the Earth to go around the sun is 8,760 hours. But, if you actually timed it with a stopwatch you'd see that a year is really longer than the calendar predicts by almost six hours. So our calendar is moving ever so slightly faster than the seasons actually change. And thus we come to the fundamental problem of all calendars: the day/night cycle, while easy to count, has nothing to do with the yearly cycle.

Day and night are caused by Earth rotating about its axis. When you're on the side facing the sun, it's daytime and when you're on the other side it's night. But this rotation is no more connected to the orbital motion around the sun than a ballerina spinning on the back of a truck is connected to the truck's cruising speed. Counting the number of ballerina turns to predict how long the truck takes to dive in a circle might give you a rough idea, but it's crazy to expect it to be precise. Counting the days to track the orbit is pretty much the same thing and so it shouldn't be a surprise when the Earth doesn't happen to make exactly 365 complete spins in a year.

Irritatingly, while 365 days are too few 366 days are too many and still cause the seasons to drift out of sync, just in the opposite way. The solution to all this is the leap year: where February gets an extra day, but only every four years. This works pretty well, as each year the calendar is about a quarter day short, so after four years you add an extra day to get back in alignment. Huzzah! The problem has been solved. Except, it hasn't.

Lengthening the calendar by one day every four years is slightly too much, and the calendar still falls behind the seasons at the rate of one day per hundred years. Which is fine for the apathetic, but not for calendar designers who want everything to line up perfectly. To fix the irregularity, every century the leap year is skipped. So 1896 and 1904 were leap years but 1900 wasn't.

This is better, but still leaves the calendar ever-so-slightly too fast with an error of 1 day in 400 years. So an additional clause is added to the skip the centuries rule that if the century is divisible by 400, then it will be a leap year. So 1900 and 2100 aren't leap years, but 2000 is. With these three rules, the error is now just one day off in almost eight thousand years, which the current calendar declares 'mission accomplished' and so calls it a day. Which is probably quite reasonable because eight thousand years ago humans were just figuring out that farming might be a good idea and eight thousand years from now we'll be hopefully be using a calendar with a better date tracking system.

But perhaps you're a mathematician and a 0.0001 percent error is an abomination in your eyes and must be removed. "Tough luck" says The Universe because the length of a day isn't even constant. It randomly varies by a few milliseconds and on average and very slowly decreases by about 1 millisecond per hundred years. Which means it's literally impossible to build a perfect calendar that lasts forever.
In theory the length of a day will expand to be as long as a current month - but don't worry, in practice it will take tens of billions of years, and our own expanding sun will destroy the earth long before that happens. Sorry, not quite sure how we got from counting the days of the months to the fiery unavoidable end of all human civilization - unless of course we have an adequately funded space program. Hint, hint.

But there you have it. For the next eight millennia leap years will keep the calendar in sync with the seasons but in a surprisingly complicated way. You can learn a lot more about orbits, different kinds of years and supermassive black holes and over at Minute Physics. As always, Henry does a great job of explaining it all in his new video. Check it out.

Video #12
CGP Grey
The Difference between the United Kingdom, Great Britain and England Explained

Welcome to the United Kingdom, and a whole lot more, explained by me, C. G. P. Grey. United Kingdom? England? Great Britain? Are these three the same place? Are they different places? Do British people secretly laugh those who use the terms incorrectly? Who knows the answers to these questions? I do, and I'm going to tell you right now.

For the lost — this is the world, this is the European continent, and this is the place we have to untangle. The area shown in purple is the United Kingdom. Part of the confusion is that the United Kingdom is not a single country, but is instead is a country of countries. It contains, inside of it — four, co-equal, and sovereign nations.

The first of these is England, shown here in red. England is often confused with the United Kingdom, as a whole, because it's the largest and most populous of the nations, and contains the de facto capital city, London.

To the north is Scotland, shown in blue, and to the west is Wales, shown in white, and — often forgotten even by those who live in the United Kingdom — Northern Ireland, shown in orange. Each country has a local term for the population.

While you can call them all 'British,' it's not recommended; as the four countries generally don't like each other. The Northern Irish, Scottish, and Welsh regard the English as slave-driving, colonial masters, no matter that all three have their own, devolved, Parliaments; and are allowed to vote on English laws despite the reverse not being true, and the English generally regard the rest as rural, yokels who spend too much time with their sheep.

However, as the four constituent countries don't have their own passports, they're all British citizens, like it or not. They are British citizens of the United Kingdom, whose full name, by the way, is the United Kingdom of Great Britain and Northern Ireland. So where's Great Britain hiding? Right here, the area covered in black is Great Britain. Unlike England, Scotland, Wales and Northern Ireland, Great Britain is a geographical — rather than a political — term.

Great Britain is the largest island among the British Isles. Within the United Kingdom, the term 'Great Britain' is often used to refer to - England, Scotland, and Wales alone - with the intentional exclusion of Northern Ireland. This is mostly, but not completely, true, as all three constituent countries have islands that are not part of Great Britain: such as the Isle of Wight, part of England, the Welsh Isle of Anglesey, the Scottish Hebrides, the Shetland Islands, the Orkney Islands, and the Islands of the Clyde.

The second biggest island in the British Isles is Ireland. It's worth noting, at this point, that Ireland is not a country; like Great Britain, it's a geographical — not political — term. The Island of Ireland contains, on it, two countries: Northern Ireland, which we have already discussed, and the Republic of Ireland.
When people say they are 'Irish,' they're referring to the Republic of Ireland, which is a separate country from the United Kingdom. However, both the Republic of Ireland and the United Kingdom are members of the European Union — even though England, in particular, likes to pretend that it's an island in the mid-Atlantic, rather than 50 kilometers off the coast of France — but that's a story for another time.

To review: the two largest islands in the British Isles are Ireland and Great Britain. Ireland has, on it, two countries — the Republic of Ireland and Northern Ireland; while Great Britain, mostly, contains three: England, Scotland and Wales. These last three, when combined with Northern Ireland, form the United Kingdom.

There are still many unanswered questions: such as, why, when you travel to Canada, is there British royalty on the money? To answer this, we need to talk about empire. You can't have gone to school, in the English-speaking world, without having learned that the British Empire once spanned 1/4th the world's land and governed nearly 1/4th the world's people.

While it's easy to remember the parts of the British Empire that broke away violently, we often forget how many nations gained independence through diplomacy, not bloodshed. These want-to-be nations struck a deal with the Empire: where they continued to recognize the Monarchy as the Head of State, in exchange for a local, autonomous parliament.

To understand how they are connected, we need to talk about the Crown. Not the physical crown — that sits behind glass in the Tower of London, and earns millions of tourist pounds for the UK — but the Crown as a complicated, legal entity, best thought of as a one-man corporation. Who created this corporation? God did.

According to British tradition, all power is vested in God and the Monarch is crowned in a Christian ceremony. God, however, not wanting to be bothered with micromanagement, conveniently delegates his power to an entity called the Crown. While this used to be the physical crown in the Tower of London, it evolved, over time, into a legal corporation; sole able to be controlled only by the ruling monarch.

It's a useful reminder that the United Kingdom is still, technically, a theocracy: with the reigning monarch acting as both the Head of State and the Supreme Governor of the official state religion: Anglicanism. Such are the oddities that arise when dealing with a thousand year-old Monarchy.

Back to Canada and the rest. The former colonies that gained their independence through diplomacy, and continue to recognize the authority of the Crown, are known as the Commonwealth Realm. They are, in decreasing order of population: Canada, Australia, Papua New Guinea, New Zealand, Jamaica, the Solomon Islands, Belize, the Bahamas, Barbados, Saint Lucia, Saint Vincent and the Grenadines, Grenada, Antigua and Barbuda, Saint Kitts and Nevis, and Tuvalu. All are independent nations, but still recognize the Monarchy as the Head of State, even though it has little real power within their borders.

There are three further entities that belong to the Crown, and these are the Crown Dependencies: the Isle of Man, Jersey, and Guernsey. Unlike the Commonwealth Realm, they are not considered independent nations, but are granted local autonomy by the Crown, and a British Citizenship by the United Kingdom. Though, the UK does reserve the right to over-rule the laws of their local assemblies.

Are we all done now? Almost, but not quite; there are still a couple of loose threads, such as this place: the tiny city of Gibraltar on the southern coast of Spain. Famous for its rock, its monkeys, and for causing diplomatic tension between the United Kingdom and Spain.

But what about the Falkland Islands: which caused so much tension between the United Kingdom and Argentina, that they went to war over them? These places belong in the last group of Crown properties known as: British Overseas Territories, but their former name, 'Crown Colonies,' gives away their origin. They are the last vestiges of the British Empire. Unlike the Commonwealth Realm, they have not become independent nations and continue to rely on the United Kingdom for military and, sometimes, economic assistance.
Like the Crown Dependencies, everyone born within their borders is a British citizen. The Crown Colonies are, in decreasing order of population: Bermuda, the Cayman Islands, the Turks and Caicos Islands, Gibraltar, the British Virgin Islands, Akrotiri and Dhekelia, Anguilla, Saint Helena, the Ascension Islands, Tristan da Cunha, Montserrat, the British Indian Ocean Territory, the South Georgia and South Sandwich Islands, the Falkland Islands, the British Antarctic Territory, and the Pitcairn Islands.

For our final Venn diagram: the United Kingdom is a country situated on the British Isles and is part of the Crown, which is controlled by the Monarchy. Also part of the Crown and the British Isles are the Crown Dependencies. The independent nations of the former Empire that still recognize the Crown are the Commonwealth Realm, and the non-independent remnants of the former Empire and are the British Overseas Territories.

Thank you very much for watching!

Video #13
VSauce
Is Earth Actually Flat?

Hey, Vsauce. Michael here. In 2003, researchers did the measurements and found that Kansas is in fact literally flatter than a pancake. Of course, the Earth is not flat, the Earth is round. Otherwise travelers would be falling off the edge all the time. Right? Wrong.

If the Earth was not a ball shaped, but was instead a flat disk, like this plate, well with the weight, density and thickness, living in the middle could feel pretty normal. But as you move toward the edge, gravity on a disk Earth would slightly skew, pushing at a greater and greater angle back toward the center.

My friend Nick from Yeti Dynamics put together this great simulation. The person and buildings obviously aren't to scale but check out how such increasingly diagonal gravity would work. Although this is a flat disk, it would feel to a runner headed toward the edge, like they were fighting to climb up a steeper and steeper hill. The building foundations behind the runner reflect how you would have to build structures, closer and closer to the edge, so that people living in them always felt like down was at right angles to the floor - the way we feel it on our big, round Earth.

As you approach the edge, things would get scary. Remember, this is a flat Earth, but it would feel like a sheer drop off. What's really cool is that contrary to the "don't fall off the edge" fear, on a flat world because of gravity, the scary risk would actually be falling away from the edge and rolling all the way back to the center. Once you stepped over the edge, instead of falling off into space, you'd be able to relax. It would be a nice level place.

This model, of course, neglects the fact that such a planet shape would be impossible. Anything as massive as the Earth, shaped like a flat disc, would, under its own gravity, naturally collapse back into a ball. This is why in outer space everything more than few hundred miles in diameter is round. Or so we've been told.

What if gravity isn't real? What if the Earth is, in fact, flat and science has been wrong all along? It's a misconception that Christopher Columbus discovered that the Earth is round. Virtually every scholar and major religion in the West accepted Earth's rotundity, since at least the time of the Ancient Greeks, who, for instance, had noticed that boats disappear bottom first when sailing away. And, as you walk north and south, stars pop in and out of the view.

The misconception that only a few hundred years ago lots and lots of people believed the Earth was flat likely began in the modern era, as a sort of insult. "Well, your people recently thought the Earth was flat, so why should we believe you now?" The smear was repeated and published so often it became accepted as historical fact. "Flat-Earther" became synonymous with "Anti-science".
It might seem flat over short distances, but over longer ones, well the Earth is pretty darn curvy. The Verrazano–Narrows Bridge, connecting Staten Island and Brooklyn, had to be designed with Earth's roundness in mind. Its 2 towers, separated by 1300 meters, and perfectly vertical, are nonetheless 41 millimeters further apart at the top than at the bottom because of Earth's curvature.

In the 3rd century BC, Eratosthenes measured the differences between shadows cast by poles in Syene and Alexandria to calculate, more than 2000 years before rockets and space travel, the circumference of the entire globular Earth, with, for the time, impressive accuracy. Word got around that the Earth was a round shape after that.

But in 1906, Wilbur Glenn Voliva became head of a slightly bizarre religious sect that pretty much ran the city of Zion, Illinois. Voliva believed that the Earth was actually flat and he enforced flat Earth's teachings in schools in Zion. He also enforced that belief on really anyone who entered the city. Voliva believed not only that the Earth was flat, but that the sun was only few thousand miles away from Earth. Not 93 million. He also believed that the sun was only 32 miles across, not 860 000. He sounds crazy, or does he?

You see, the same phenomenon Eratosthenes measured could be explained by a flat Earth, if the sun were only few thousand miles away and 32 miles across - the math would work out the same. Today, with the power of the Internet, modern day flat Earthers have picked up where Voliva left off.

They have quite good explanations for any evidence you throw at them that the Earth is round. Circumnavigation is really just a flat circle path. The round shadow Earth casts on the Moon during a lunar eclipse could also be made by a flat disc. Time zones are caused by spotlight sun, and remember how gravity would be totally different on a disc-shaped planet? Well, they argue that gravity, as we know it, simply doesn't exist. The flat disc of Earth is merely accelerating up at 9.8 metres per second.

As for all of the photos and video evidence we now have that the Earth is round, thanks to space exploration, well all of that material is completely fabricated. A hoax, perpetrated by Big Globe. Space agencies, airlines, globe manufacturers. They are reaping the rewards of our ignorant belief that the Earth is actually round. They know, of course, that it's flat. And they're hiding that truth from us. Is it merely a coincidence that the logo used by the Flat Earth Society is a projection of Earth, centred on the North Pole, and also happens to be the projection used by the United Nations?

Are these people for real? Probably not most of them. But this is the crocks of Poe's Law. An adage that states that at their extremes, parody of extremism and sincere extremism are difficult to distinguish. Although clever, flat Earth theories are predominantly ad hoc explanations - excuses made up on the spot that only address one issue and don't fit all the evidence. Science, of course, rejects a theory if a better one fits more of our observations, but why the egoistical obsession with our observations?

One way we know this is that unstable muons, created in the upper atmosphere by the collision of cosmic rays with the atmosphere, should mostly decay before reaching Earth's surface. But yet, we detect a lot of them down here, because their crazy fast speed literally means that, from our perspective, their physics runs according to a slower clock; and to them, the distance they have to cover to the surface during their short lives is, from their perspective, much much shorter than it appears to us. If you're a cosmic ray proton travelling at 99.999999999991% the speed of light, Earth would appear to be only 17 metres thick in the direction you travel.
| 1178 | So Earth is flat to them, but round to us. It is ball shaped to some observers and flat to others. There doesn't appear to be a single most correct-est, in all circumstances, answer. | 6, 27, 17, 39, 29 |
| 1179 | Susan Haack compares knowledge to a crossword puzzle. New answers interweave with old ones, they all reinforce one another. The clues are the questions we ask, and the way the answers fall into a predetermined grid, well, that's our confidence that we're on the right track. But that doesn't mean one day there will be a finished puzzle - a complete answer. | 17, 29, 12, 33, 2 |
| 1181 | Recall The New York Times famous 1996 crossword puzzle that came out the day before the US election between Bill Clinton and Bob Dole. The clue for 39 across was pretty crazy. You seemed to need to be able to tell the future to answer it correctly. It simply said, "Lead story in tomorrow's newspaper (blank) elected". Well that blank could be Clinton or Bob Dole and who's to say which one until tomorrow? There's no way to know. But, as it turned out, the answer was Clinton, or Bob Dole. No matter which you wrote in, all the other clues fit. | 5, 17, |
| 1185 | For instance, a "black Halloween animal" could either be a cat or a bat. Our knowledge about the outside world might be the same. A puzzle with no answer key, just the reassurance that the answers we think we know fit together, so they're probably correct. Though there's always the possibility that the answer to one clue, or all of them, will fundamentally not have a single definite satisfying answer. The puzzle may be playable forever. | 30, 24, 1 |
| 1192 | I like what Richard Feynman says about this. "Some people say 'How can you live without knowing?' I do not know what they mean. I always live without knowing - that is easy. How you get to know is what I want to know." You know? And as always, thanks for watching. | Video #14 VSauce What is Déjà vu? |
| 1202 | Hey, Vsauce. Michael here. And today we're going to discuss déjà vu. What is it, and why does it occur? You know, those moments where the current situation feels like it's happened before? You're certain it has, but you don't know when, or how it became so familiar. | 1, 30, 25, 35, 29 |
| 1206 | It's difficult to scientifically study déjà vu because there's no reliable way to cause it to happen in people's heads in a laboratory. But here's what we do know: humans don't seem to experience déjà vu until they're at least 8 or 9 years old. It's most frequent in your teens and twenties, and then tapers off as you get older. So, it might have something to do with brain development. In fact, we should probably go get ourselves a brain. That was easy. | 27, 7, 38 |
| 1211 | Now, like a stomach ache, déjà vu may be a symptom with many possible causes. A lot of the popular theories about what causes it involve a disconnect that may be occurring between the deep structures of the brain that process our experiences unconsciously, and the parts of the brain that are conscious of what they experience, process it, and then tell us what we're seeing. | 5, |
| 1216 | For the sake of simplicity, let's begin with the visual system. Now, the brain sits in your head like this, and your eyeballs are over here seeing things, sending that signal to the back of the brain, the Occipital lobe, where visual cortex is. That's where the image is processed and we become aware of what we're seeing. | 29 |
| 1220 | But visual cortex isn't the first stop that information makes. Instead, we know that it stops in lots of other places. For instance, the amygdala, where it may be processed at an involuntary emotional level, and this fun little part right here, #31, the tectum. It's involved in preliminary visual processing and helps control eye movements. | 29, 38, 12 |
Now, that fact is incredibly important because what it means is that people with blindness caused by brain damage to the visual cortex cannot see anything. They don't report seeing or recognizing anything; however, the other preliminary parts of the brain get that message are still healthy, and so, despite being legally blind, these people exhibit what is known as blindsight. They can defy all odds and avoid an obstacle course on the ground. They can also be presented faces showing joy, or anxiety and fear, and feel, without knowing why, at all, on Earth they feel that way, a similar emotion. So, a lot is going on when we look at things, and if those preliminary structures in the vision system allow certain blind people to be oddly and unconsciously aware of what they're looking at, we may have the ingredients we need for this disconnect. Think of it this way. If I experience event A and then B and then C, and the inner parts of my brain commit it to memory and generate an emotional response, but then, a fraction of a second later, out-of-sync, my visual cortex finally gets around to telling me, the conscious aware part of my brain, what I'm seeing. It will say "Ok guys, we're looking at A, and then B, and then..." and then the brain says "Whoa, whoa, whoa, wait, wait, and then C, right? That's already happened I thought?" and that may be déjà vu. But what could cause these processes, dealing with the same information, to get temporarily out-of-sync like that? Well, it's probably a neurological abnormality, possibly an epileptic episode where neurons all fire in sync. We also know that patients who experience chronic and persistent déjà vu tend to have brain damage in the temporal lobes of their brain - these lobes on either side. Well that sounds kinda bad, right? I mean, when I experience déjà vu, should I run to the doctor right away? Well, not at all. In fact, minor epileptic events are quite common. You've probably experienced a similar phenomenon known as a hypnagogic jerk. That's a fancy name for what occurs when you're about to fall asleep and then all of the sudden you feel like you're falling, or that you tripped, and your body jolts itself awake. Oh, and déjà vu is not the only "vu" out there. There's also something known as presque vu, or "tip of the tongue," and this is what happens when you're familiar with something, you know you know it, but, for the life of you, at that moment, you cannot recall it. It's like "what's that actor's name from that movie? I've seen it 18 times, how can I not remember it? Wow." One explanation of how that happens is that other words similar to the target word are being remembered, and to help you out your brain is actively blocking other stuff around it, including the word you're actually looking for. Now, this explanation is really nice 'cause it might actually explain why presque vu has a shared or social aspect. Even a bunch of people in a group, all with separate brains, if they're given the same "blocking words" that are related, no one in the group can come up with the name until the subject is changed and those words are no longer blocked, and then all the sudden someone goes "Oh, Gary Sinise, that's who it was. Yup, there you go." Ok, finally, jamais vu. This is when something that you know, something that you're familiar with, all of a sudden seems brand new and bizarre. Schizophrenic patients will sometimes see people they know and insist that it's not the person they know. Instead, it's an imposter. But all of us have probably experienced jamais vu to a certain extent, for instance, when you repeat a word over, and over, and over, and over again, the word starts to lose its meaning and you start to think "What? How is this even a word? It's so weird!" Well, scientists believe that happens because continuing to excite the neurons responsible for that word causes them to become inhibited, and further use is less intense.
| 1276 | It is just crazy to think that there is so much out there in the world, in the universe, that we don't know, that we don't understand, that we haven't yet discovered. But yet that very feeling of familiarity for what we do know can't always be trusted. About the only constant seems to be: As always, thanks for watching. | 12, 29, 27, 19 |
| Video #15 |
| VSauce |
| What If Everyone JUMPED At Once? |
| 1280 | Hey, Vsauce. Michael here. And what if every single person on Earth jumped at the exact same time? Could it cause an earthquake or would we not even be able to tell? Well, first things first, let's talk about the Earth's rotation. The Earth spins, that's why we have night and day, and it spins quickly. At the equator, the Earth is spinning at more than 1,000 MPH. | 1, 30, 35, 39 |
| 1285 | Now, a spinning ice skater can speed up by moving mass closer to the center and the Earth is no different. In fact, if you get down on the ground right now and move your mass closer to Earth's center, technically, you will speed up Earth's rotation, making this day shorter. Now, the change that you would make to the Earth's rotation is way smaller than we could even measure, but it is calculable, and the impact can be quite impressive when you talk about redistributing more mass than just one person. | 17, 12, 1, 30, 35 |
| 1290 | For instance, last year, the earthquake in Japan redistributed so much of Earth's mass towards the center, that every day since then has been 1.8 microseconds shorter. But that was a giant geological event. What can us humans do to the Earth all on our own? I mean, there are more than 7 billion of us now. What if we all got together in one place and jumped? Well, what would that even look like? | 13, 39, 29, 35 |
| 1296 | Interestingly, if you took the entire human population of Earth and had them all live in one place with the same density that people live in in New York City, you could fit everyone - all of us - into the state of Texas. But that's living, not standing around in a crowd, which is how we would probably want to do the jump. If every single person alive right now on Earth stood shoulder to shoulder, you could fit all of us into the city of Los Angeles. It would be an incredible sight to behold - a mere 500 square miles containing every single person on Earth. | 12, 39, 7, 39 |
| 1303 | Ok, so, then we jump. What happens? Unfortunately, not much. I mean, we're all awesome people here on Earth, but our collective mass compared to the mass of the entire Earth? It's like nothing. In fact, Dot Physics calculated that if all of us were to get together in one location and all jump 30 cm into the air at the exact same time, we would push Earth away from us a tiny amount. Earth would only move away from us about 1/100th of the width of a single hydrogen atom. | 39, 33, 29, 12, 9, 39, 33 |
| 1309 | And here's another thing. Because we're all jumping and then going back to where we started, Earth is just going to move back to where it started. So, our big jump won't be able to change Earth's position in space, but, c'mon, 7 billion people all jumping together? That's gotta be able to cause some sort of seismic activity, right? | 39, 29, 33 |
| 1313 | So let's say you have a lot of people all together in one place and you have them all jump on: 1-2-3! Did you feel that? Well, the BBC did this with 50,000 people and discovered that a kilometer and a half away, it only registered a .6 on the Richter scale. You would need 7 million times more people than even live on Earth right now to jump at once to recreate the earthquake that recently happened in Japan. | 9, 29 |
| 1318 | So, even though we're all awesome, compared to the size of the Earth, we're not much. But don't get too discouraged. Our collective jump would contain a lot of energy. The Straight Dope calculated that even if only the people who lived in China got together and jumped, their jump would be the equivalent of 500 tons of TNT. Of course, 500 tons of TNT doesn't do much to an Earth that weighs 6 sextillion 588 quintillion tons. | 39, 3, 9, 39 |
To make yourself feel more powerful, pick a card. I've got 10 of them here, let's say, hmm, you choose this one. Boom, congratulations, we have just decimated this deck of cards.

Why? Well because, technically, decimate does not mean "obliterate completely." Deci=10. It means to take away 1/10th of something. So, the next time you take a quiz and don't do so well on it, you only get 10%. Well, sure, that's an "F", but by getting 10% of them right, you decimated that quiz.

And since we've been talking about crowds, let's talk about YouTube crowds. YouTube audiences, that view count that you see at the bottom of every video, and get some perspective on it.

We'll begin with Dunbar's Number. It's an estimation of the maximum number of people we can have stable, social relationships with at a given moment and it's based on the size of our neo-cortex. These aren't just acquaintances, these are people you have social contact with - a network where you know how everyone relates to everyone else. And the number is usually given to be somewhere between 100-230, which means that when a YouTube video receives more than 230 views from different people, more people have seen that video than you could ever realistically hope to know well, at a given moment.

If a video has more than 100,000 views from different people, more people have seen that video than you will ever meet in your life. And by meet, I mean shakes hands with, learn their name, talk with them for a bit. I mean, think of it this way. You and me, we're only statistically expected to live around 28,470 days. So, even if you were to meet someone, 2-3 people every day of your life, including when you were a baby, you still wouldn't meet as many people as have seen that YouTube video with 100,000 views.

But keep this in mind. Even though you, or even a large group of us, can't do much to change Earth's location or rotation, we can affect it a little bit. Newton's Third Law guarantees this. If you weigh 150 pounds, the Earth is pulling you down with a force of 150 pounds. But you are also pulling up on the Earth with a force of 150 pounds. If you fall 3 meters, the Earth has pulled you down 3 meters. But you have also exerted an equal and opposite force on the Earth. Of course, it's a lot bigger. So, if you fall 3 meters, you pull the Earth up about a billionth of the width of a proton, which ain't bad.

So the next time you move your body, the next time you jump, Felicia, think about this. You just affected the Earth as much as it affected you. You've got that kind of power. Speaking of power, you all should go check out "Geek & Sundry", Felicia's new channel. It's one of my new favorite things. And as always, thanks for watching.